

# Seed Production Technology

International Center for Agricultural Research in the Dry Areas

# SEED PRODUCTION TECHNOLOGY

Proceedings of

the Seed Production Training Course-1

ICARDA, Aeppo, Syria

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The Government of the Netherlands

and

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# Organizing committee's note

The Seed Production Training Course-I was jointly sponsored by the Government of the Netherlands and ICARDA, at ICARDA's headquarters in Aleppo, from 20 April to 6 May, 1982. A number of scientists including plant breeders, seed production specialists, agronomists, pathologists, and entomologists contributed to the success of this course. The participants from different countries brought rich experience and greatly helped in improving the overall understanding of the problems and scope of seed production. Although much information is available in technical books and journals on how to grow, certify, process, test, and market seeds, very little has been written in simple, easy-to-understand form suitable for technicians without sufficient prior exposure. We sincerely hope that this volume will meet that need.

We wish to gratefully thank the Government of the Netherlands for providing financial support, the Government Seed Testing Station, Wageningen, The Netherlands for shouldering the major teaching responsibilities, the Indian Council of Agricultural Research for making the services of Dr. P.K. Agrawal available to coordinate the course, Dr. W.J. van der Burg for his active interest and support, Dr. Farid Khoury for demonstrating the seed processing plants to the trainees, and Ir. A. Heydendael, Agricultural Attache and Ir. G.J. Koopman at the Embassy of the Government of the Netherlands in Damascus for their encouragement and support.

Mr. Khalid El-Bizri provided computer facilities to prepare the camera-ready copy for this volume and Dr. S. Varma followed it through the press.

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# STATUS OF SEED PRODUCTION IN THE ICARDA REGION AND NEARBY COUNTRIES

J.P. SRIVASTAVA

CEREALS IMPROVEMENT PROGRAM

ICARDA, ALEPPO, (SYRIA)

Quality seeds of improved varieties are the key to agricultural progress. It is the production potential and other desirable characteristics of seeds that set the limit to production. Other inputs such as fertilizers, pesticides, herbicides and overall crop management, help in the realisation of the production potential of seeds.

Seed has been an important agricultural commodity since the first crop plant was domesticated by pre-historic man. A farmer's entire crop depends on the quality of the seed he plants. If the seed is of a low yielding, unadapted variety, he will not get good yields inspite of his good management. If he plants a mixture of disease-susceptible varieties with different crop duration and plant heights, his yields will be low and the diseased plants may contaminate his entire production. If his seed has low viability, the plant stand will be poor. Similarly, if his seeds contain inert matter or weed seeds, his crop will be infested with weeds and yields will go down.

Farmers are slowly becoming seed-conscious and are willing to pay higher prices for quality seeds of improved varieties. The seed industry covers a broad range of agrobusiness such as crop improvement, production and certification. Seed quality control, processing and marketing are other areas that form integral parts of seed production infra-structure.

The ICARDA region covers all the countries in West Asia and North Africa (Fig 1). The region stretches from Morocco in the west to Pakistan in the east and from Turkey in the north to Sudan in the south. In general the seed production and related activities are poorly developed and vary from country to country. It can be stated that non-availability of seeds of improved varieties to the farming communities stands as one of the most important constraints to increasing productivity. Because of this bottleneck, a majority of the countries in the region are unable to utilize the fruits of crop improvement work being done at the National & International Centers. Several countries have good crop improvment and testing programs but without proper facilities to multiply the varieties identified as superior lines by these programs. Therefore, in spite of considerable expenses incurred in research activities, a majority of the area under commercial cultivation is still under age-old indigenous cultivars that do not respond to improved agricultural practices, and their productivity is reduced due to susceptibility to diseases and pests.

It is imperative to develop a functional seed production with program side by side with crop improvement and varietal testing activities. In general there is an awareness of this weak link in the overall agricultural production activities. Most of the countries of this region are interested in improving the overall seed production, certification, quality control, processing, storage and marketing facilities. A sound seed production program requires suitable legislation, aggressive crop improvement activities, proper certification and quality control agencies and a thorough marketing and distribution network.

The extent to which these factors are operative country by country, is shown in Table 1. It is apparent that in most of the countries in this region the seed production is adversely affected by

disease problems and the insect problem is not very severe. The improved seed is not available in most of the countries in this region. The lack of trained manpower and the facilities are apparent constraints to seed production. The majority of the countries still will have to develop effective seed legislation in order to regulate the production and marketing of quality seed (Table 1) and adequate facilities for testing, processing, storage, transporatation network, marketing, field inspection, and credit are not available in most of the countries in the ICARDA region (Table 2). It is important to note that in a majority of the countries listed in the table the facilities are inadequate.

However, in most of the countries in the region facilities for varietal improvement and testing do exist (Table 3). Almost all of them have regulations for varietal release. It is important to mention that nucleus (breeder) seed of released varieties is produced by the respective research stations. However, from then on in some coutries the link from nucleus seed-foundation seed-certified seed is poor. The reason appears to be the lack of a proper seed production and certification agency (Table 3). Also, the non availability or inadequate facilities with regard to quality control, seed processing, marketing and distribution systems makes the necessary infrastructure for seed production very weak.

The current extent of the development of seed production in the 20 countries is presented in Table 4 for each of wheat, barley, forages and food legumes. Four classes of production system are indicated; developed, semi-developed, poorly developed and not existing. Only three countries are fully developed and eleven semi developed in wheat, only one in barley, and none are fully developed in forages and food legumes seed production. Overall, it is a unsatisfactory situation.

Twenty countries are listed in Table 5 which shows the percentage seed requirements being met by exsisting facilities for several crops. Among the 134 entries in the Table, there are 104 instances of negligible and non-existing facilities i.e about 78 per cent cases.

The data presented in the first five tables clearly highlight the need for improvements to be made in seed technology and production among the coutries located in the ICARDA region.

## CROP AREAS AND SEED NEEDS

Tables 6 to 10 show the total area under the following crops and the estimated seed requirements: wheat, barley, total pulses, chickpea and lentil. For each country, seed requirement based on annual, five year, and 10 year replacement, is presented.

Wheat is the most important crop in the area, and is grown in about 55 million hectares. The total annual seed required is 5.5 million tonnes. Working on a five-year replacement period, 1.1 million tonnes are needed, and working on a 10 year replacement period, the requirement is 553,000 tonnes.

The same analysis is applicable to all the other crops.

These data clearly indicate and confirm that only a fraction of all the seed needs are presently being met; and they also reveal the urgency of improving seed production in the region.

It is realised that this picture could be corrected only by the concentrated efforts of the national programs. However,

International centers like ICARDA and other agencies could play a catalytic role and help in improving the picture of seed production within the countries of the region.

Table 1 clearly indicates that lack of trained manpower is the crucial limiting factor in a majority of the countries. Therefore, it is apparent that the first step towards developing a sound seed infrastructure would be to help national programs develop skilled manpower.

ACKNOWLEDGEMENT

The author is grateful to scientists from the national programs who provided valuable information for compilation of the above information. Relevant information was also taken from the FAO Production Yearbook, Volume 33, 1979. Some of the information provided in this paper is based on personal observations of the author.

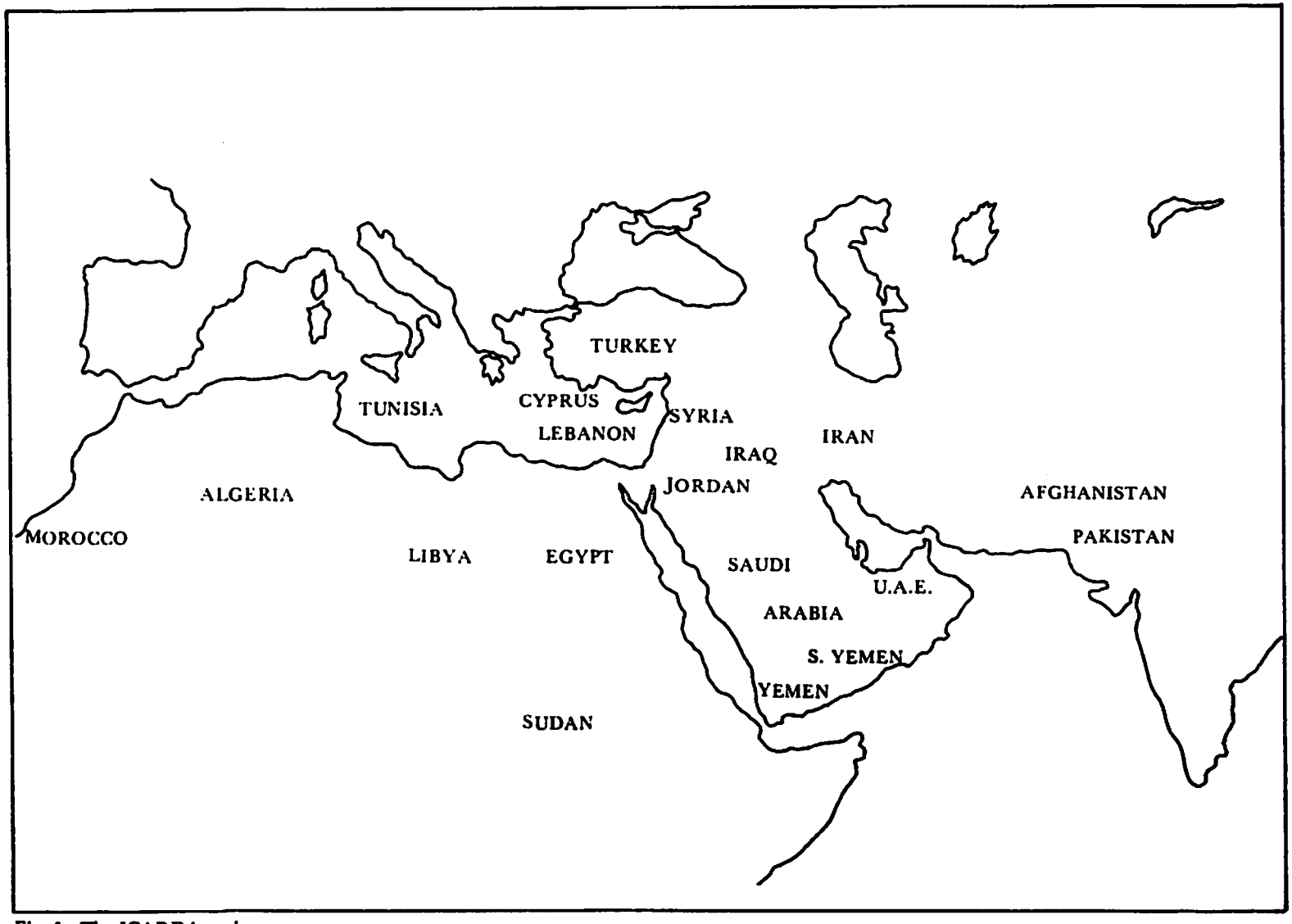



**Fig. 1. The ICARDA region.**

Table 1: Availability of Factors Affecting Seed Production.

| Country | Disease | Insects | Improved seed availability | Seed (Price) & | Laboratory processing | Trained manpower | Labour | Seed laws effective |
|---|---|---|---|---|---|---|---|---|
| Afghanistan | Yes | No | Yes | NA | Yes | Yes | No | Yes |
| Algeria | Yes | No | Yes | NA | Yes | Yes | Yes | Yes |
| Bangladesh | Yes | Yes | Yes | Yes | Yes | Yes | No | NA |
| Cyprus | Yes | Yes | Yes | No | No | No | Yes | Yes |
| Egypt | Yes | Yes | No | NA | No | No | No | NA |
| India | Yes | Yes | No | No | No | No | No | Yes |
| Iran | Yes | No | Yes | NA | Yes | Yes | Yes | NA |
| Iraq | Yes | No | Yes | NA | Yes | Yes | Yes | NA |
| Jordan | No | No | No | No | Yes | Yes | No | No |
| Lebanon | No | No | No | No | Yes | Yes | Yes | No |
| Libya | Yes | No | Yes | No | No | Yes | Yes | NA |
| Morocco | Yes | Yes | Yes | No | No | Yes | No | Yes |
| Pakistan | Yes | Yes | No | Yes | Yes | Yes | No | Yes |
| PDRY | Yes | No | Yes | NA | Yes | Yes | No | Yes |
| S. Arabia | No | Yes | Yes | No | No | Yes | Yes | No |
| Sudan | No | No | Yes | No | Yes | No | Yes | No |
| Syria | Yes | Yes | Yes | No | Yes | Yes | No | No |
| Tunisia | Yes | No | No | Yes | Yes | Yes | No | Yes |
| Turkey | Yes | No | No | NA | NA | Yes | No | NA |
| Arab Republic of Yemen | Yes | Yes | Yes | No | Yes | Yes | Yes | No |

NA = Information not available
PDRY = People's Democratice Republic of Yemen (South Yemen)

Table 2: Present Status of Seed Industry Facilities.

| Country | Testing lab. | Processing facilities | Storage facilities | Trained Personnel | Transportation network | Marketing facilities | Field inspection | Credit |
|---|---|---|---|---|---|---|---|---|
| Afghanistan | * | * | * | * | * | * | * | * |
| Algeria | * | * | N.A | * | * | * | * | * |
| Bangladesh | * | * | * | * | * | * | 0 | * |
| Cyprus | 0 | 0 | * | 0 | 0 | 0 | 0 | 0 |
| Egypt | N.A | * | N.A | 0 | 0 | * | 0 | * |
| India | 0 | 0 | * | 0 | * | 0 | 0 | * |
| Iran | * | * | * | * | N.A | * | N.A | N.A |
| Jordan | * | * | * | * | * | * | * | * |
| Lebanon | 0 | 0 | * | * | 0 | 0 | * | 0 |
| Libya | * | N.A | N.A | * | N.A | N.A | N.A | N.A |
| Morocco | * | * | * | * | * | * | * | * |
| Pakistan | 0 | * | * | * | * | 0 | * | * |
| PDRY | * | * | * | * | * | * | * | * |
| S. Arabia | * | * | * | * | * | * | * | 0 |
| Sudan | * | * | * | * | 0 | * | 0 | * |
| Syria | * | 0 | * | * | * | * | * | 0 |
| Tunisia | 0 | 0 | * | * | * | 0 | 0 | 0 |
| Turkey | * | * | N.A | * | N.A | * | N.A | N.A |
| Arab Republic of Yemen | * | * | * | * | 0 | 0 | * | * |

0 Adequate.
* Inadequate.
N.A Information not available
PDYR People's Democratice Republic of Yemen (South Yemen)

Table 3: Seed Production Infrastructure in the ICARDA Region.(primarily for wheat).

| Country | institutions | | | Seed Production | | | Certification Agency | Process-ing | Testing Lab | Distri-bution |
|---|---|---|---|---|---|---|---|---|---|---|
| | Breeding | Varietal testing | Release | N | F | C | | | | |
| Afghanistan | * | * | * | * | * | * | N.A | * | * | N.A. |
| Algeria | * | * | * | * | * | * | N.A | * | * | N.A. |
| Bangladesh | * | * | * | * | * | * | * | N.A | * | * |
| Cyprus | * | * | * | * | * | * | * | * | * | * |
| Egypt | * | * | * | * | * | * | * | * | * | * |
| India | * | * | * | * | * | * | * | * | * | * |
| Iran | * | * | * | * | * | * | N.A | * | * | N.A |
| Iraq | * | * | * | * | * | * | N.A | * | * | N.A |
| Jordan | * | * | * | * | * | - | - | * | N.A | * |
| Lebanon | * | * | * | * | * | * | N.A | * | N.A | * |
| Morocco | * | * | * | * | * | * | * | * | * | * |
| Pakistan | * | * | * | * | * | * | * | * | * | * |
| PDRY | * | * | - | * | * | - | - | - | - | - |
| S.Arabia | * | * | * | - | - | * | - | * | - | * |
| Sudan | * | * | * | * | * | * | * | * | * | * |
| Syria | * | * | * | * | * | * | * | * | * | * |
| Tunisa | * | * | * | * | * | * | * | * | * | * |
| Turkey | * | * | * | * | * | * | - | - | - | - |
| Arab Republic of Yemen | - | * | * | * | * | * | - | * | - | * |

* Exist
\- Do not exist
N.A. = Information not avaible

N Nucleus
F Foundation
C Certified

Underline = Same Institutions carrying out the responsibilities.

Table 4: Current Seed Production Situation.

| Country | Wheat | | | | Barley | | | | Forage | | | | Food Legumes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Afghanistan | | | | • | | | | • | | | | | • | | | • |
| Algeria | | • | | | | | • | | | | | | • | | | N.A |
| Bangladesh | | | • | | | | | • | | | | | • | | | • |
| Cyprus | • | | | | • | | | | • | | | | | • | | |
| Egypt | | • | | | | | • | | • | | | | | | • | |
| India | • | | | | | | • | | | | • | | | • | | |
| Iran | | | • | | | | | • | | | | | N.A | | | N.A |
| Iraq | | • | | | | | • | | | | | | N.A | | | N.A |
| Jordan | | | | • | | | • | | | | | | • | | | • |
| Lebanon | | • | | | | | | • | | | | | • | | | • |
| Libya | | • | | | | | | N.A | | | | | N.A | | | N.A |
| Morocco | | • | | | | | • | | | | • | | | | • | |
| Pakistan | | • | | | | | | • | | | | | • | | • | |
| PDRY | | | • | | | | | • | | | | | • | | | • |
| S.Arabia | | | • | | | | | • | | | | | | | | • |
| Sudan | | • | | | | | | • | | • | | | | | • | |
| Syria | | • | | | | | | • | | | | | • | | | • |
| Tunisia | • | | | | | | • | | | • | | | | | | • |
| Turkey | | • | | | | | • | | | | • | | | | | N.A |
| Arab Republic of Yemen | | • | | | | | | • | | | • | | | | | • |

1- Developed
2- Semi-developed
3- Poorly developed
4- Not Existing

N.A = Not Avaiable

Table 5: Percentage Seed Requirements Met by Existing Facilities.

| Country | Bread Wheat | Durum Wheat | Barley | Forage | Chickpea | Broadbean | Lentil |
|---|---|---|---|---|---|---|---|
| Afghanistan | N | N | 0 | 0 | N | 0 | N |
| Algeria | N | N | 0 | 0 | 0 | 0 | 0 |
| Bangladesh | N | 0 | 0 | 0 | 0 | 0 | 0 |
| Cyprus | 60 | 45 | 60 | 60 | 0 | 0 | 0 |
| Egypt | 70 | 20 | N.A | N.A | N | N.A | N.A |
| India | 10 | N | N | N | N | 0 | N |
| Iran | N | N | 0 | N | 0 | N | 0 |
| Iraq | 20 | 10 | N | 0 | 0 | 0 | 0 |
| Jordan | N | N | N | 0 | 0 | 0 | 0 |
| Lebanon | 25 | 25 | 10 | 0 | 0 | 0 | 0 |
| Libya | 40 | N | N | N | 0 | 0 | 0 |
| Moroco | 50 | 10 | 0 | 0 | 0 | 0 | 0 |
| Pakistan | 10 | 0 | N | N | 5 | 0 | N |
| PDYR | N | N | 0 | 0 | 0 | 0 | 0 |
| Syria | 20 | 20 | 0 | 0 | 0 | 0 | 0 |
| Saudia Arabia | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sudan | 50 | -- | -- | 5 | 0 | 8 | 0 |
| Tunisia | 50 | 50 | 0 | 70 | 0 | 10 | 0 |
| Turkey | N.A | N.A | N | N | N | N | N |
| Arab Republic of Yemen | 25 | 0 | 0 | N | 0 | N | 0 |

N - Negligible. N.A - Information not available.
0 - Non - Existent. PDYR - Peaples Democratic Republic of Yemen. (South Yemeb)

Table 6: Total Area Under Wheat And Estimated Seed Requirement.

| Country | Area* (1000 ha) | Certified Seed Requirements ( 1000 tones) Annual 5Yr. Replacement | 10Yr. Replacement |
|---|---|---|---|
| Afghanistan | 2400 | 240 | 48 | 24 |
| Algeria | 1700 | 170 | 34 | 17 |
| Bangladesh | 265 | 27 | 5 | 3 |
| Cyprus | 29 | 3 | 0.6 | 0.3 |
| Egypt | 584 | 58 | 12 | 6 |
| Iran | 4550 | 455 | 91 | 46 |
| Iraq | 1750 | 175 | 35 | 18 |
| India | 22220 | 2222 | 444 | 222 |
| Jordan | 94 | 9 | 2 | 1.0 |
| Lebanon | 50 | 5 | 1 | 0.5 |
| Libya | 340 | 34 | 7 | 3 |
| Morocco | 1656 | 166 | 33 | 17 |
| Nepal | 356 | 36 | 7 | 4 |
| Oman | 2 | 0.2 | 0.04 | 0.02 |
| Pakistan | 6696 | 670 | 134 | 67 |
| Saudia Arabia | 85 | 9 | 2 | 0.9 |
| Sudan | 248 | 25 | 5 | 3 |
| Syria | 1441 | 144 | 29 | 14 |
| Tunisia | 1134 | 113 | 23 | 12 |
| Turkey | 9300 | 930 | 186 | 93 |
| N.Yemen | 75 | 8 | 2 | 1.0 |
| S.Yemen | 15 | 2 | 0.4 | 0.2 |
| Total | 54990 | 5501 | 1101 | 553 |

* From FAO Production Year Book, Volume 33, 1979.
** Seed Rate 100 kg per hectare.

Table 7: Total Area Under Barley And Estimated Seed Requirements.

| Country | Area* (1000 ha) | Certified Seed Requirements ( 1000 tones) Annual | 5Yr.Replacement | 10Yr. Replacement |
|---|---|---|---|---|
| Afghanistan | 320 | 32 | 6 | 3 |
| Algeria | 800 | 80 | 16 | 8 |
| Bangladesh | 20 | 2 | 0.5 | 0.25 |
| Cyprus | 40 | 4 | 1 | 0.5 |
| Egypt | 45 | 5 | 1 | 0.5 |
| Iran | 1200 | 120 | 24 | 12 |
| Iraq | 920 | 92 | 18 | 9 |
| India | 1836 | 184 | 37 | 19.0 |
| Jordan | 42 | 4 | 1 | 0.5 |
| Lebanon | 5 | 0.5 | 0.1 | 0.05 |
| Libya | 450 | 45 | 9 | 5 |
| Morocco | 2193 | 219 | 44 | 22 |
| Nepal | 26 | 3 | 0.6 | 0.3 |
| Pakistan | 177 | 18 | 4 | 2 |
| PDRY | 2 | 0.2 | 0.04 | 0.02 |
| Saudi Arabia | 13 | 1 | 0.2 | 0.1 |
| Syria | 1102 | 110 | 22 | 11 |
| Tunisia | 642 | 64 | 13 | 7 |
| Turkey** | 2750 | 275 | 55 | 28 |
| Yemen | 65 | 7 | 1 | 0.5 |
| Total | 12648 | 1265 | 258 | 129 |

* From FAO Production Year Book, Volume 33, 1979.

** PDRY = People's Democrative Republic of Yemen (South Yemen). Arab Republic of Yemen

Table 8: Total Area Under Pulses ** And Estimated Seed Requirements.

| Country | Area (1000 ha) | Certified Seed Requirements ( 1000 tones) Annual | 5Yr.Replacement | 10Yr. Replacement |
|---|---|---|---|---|
| Afghanistan | 35 | 4 | 1 | 0.5 |
| Algeria | 111 | 11 | 2 | 1 |
| Bangladesh | 361 | 36 | 7 | 4 |
| Cyprus | 8 | 1 | 0.2 | 0.1 |
| Egypt | 149 | 15 | 3 | 3 |
| Iraq | 52 | 5 | 1 | 0.5 |
| India | 23429 | 2343 | 469 | 234 |
| Jordan | 18 | 2 | 0.4 | 0.2 |
| Lebanon | 13 | 1 | 0.2 | 0.1 |
| Libya | 8 | 1 | 0.2 | 0.1 |
| Morocco | 434 | 43 | 9 | 4 |
| Nepal | 112 | 11 | 2 | 1 |
| Pakistan | 1687 | 169 | 34 | 17 |
| Saudia Arabia | 4 | 0.4 | 0.1 | 0.05 |
| Sudan | 76 | 8 | 2 | 0.8 |
| Syria | 230 | 23 | 5 | 2 |
| Tunisia | 152 | 15 | 3 | 2 |
| Turkey | 694 | 69 | 14 | 7 |
| Arab Republic of Yemen | 84 | 8 | 2 | 1 |
| Total | 27657 | 2765 | 582 | 277 |

** From FAO Production Year Book, Volume 33, 1979.
Crops included are chickpea, broadbean, pea, lentil and other beans.
For simplicity the average seed rate has been taken as 100 kg/ha

Table 9: Total Area Under Chickpea And Estimated Seed Requirements.

| Country | Area* (1000 ha) | Certified Seed Requirements (1000 tonnes) Annual | 5Yr. Replacement | 10Yr. Replacement |
|---|---|---|---|---|
| Algeria | 42 | 4 | 1 | 0.5 |
| Bangladesh | 56 | 6 | 1 | 0.6 |
| Cyprus | 1 | 0.1 | 0.02 | 0.01 |
| Egypt | 6 | 0.6 | 0.12 | 0.06 |
| Iran | 39 | 4 | 1 | 0.4 |
| Iraq | 14 | 1 | 0.2 | 0.1 |
| India | 7871 | 787 | 157 | 79 |
| Jordan | 1 | 0.1 | 0.02 | 0.01 |
| Lebanon | 1 | 0.1 | 0.02 | 0.01 |
| Morocco | 62 | 6 | 1 | 0.6 |
| Nepal | 68 | 7 | 1 | 0.7 |
| Pakistan | 1224 | 122 | 14 | 7 |
| Sudan | 3 | 0.3 | 0.06 | 0.03 |
| Syria | 47 | 5 | 1 | 0.5 |
| Tunisia | 37 | 4 | 1 | 0.4 |
| Turkey | 180 | 18 | 4 | 2 |
| Total | 9652 | 965 | 182 | 92 |

*From FAO Production Year Book, Volume 33, 1979.

Table 10: Total Area Under Lentil And Estimated Seed Requirements.

| Country | Area* (1000 ha) | Certified Seed Requirements (1000 tonnes) Annual | 5Yr. Replacement | 10Yr. Replacement |
|---|---|---|---|---|
| Algeria | 16 | 2 | 0.4 | 0.2 |
| Bangladesh | 85 | 9 | 2 | 1.0 |
| Egypt | 9 | 1.0 | 0.2 | 0.1 |
| Iran | 35 | 4 | 1 | 0.5 |
| Iraq | 10 | 1 | 0.2 | 0.1 |
| India | 925 | 93 | 19 | 9 |
| Jordan | 12 | 1 | 0.2 | 0.1 |
| Lebanon | 3 | 0.3 | 0.06 | 0.03 |
| Morocco | 29 | 3 | 0.6 | 0.3 |
| Pakistan | 106 | 11 | 2 | 1 |
| Syria | 89 | 9 | 2 | 1 |
| Tunisia | 3 | 0.3 | 0.06 | 0.03 |
| Turkey | 200 | 20 | 4 | 2 |
| Total | 1522 | 155 | 32 | 15 |

* From FAO Production Year Book, Volume 33, 1979.

# PLANNING, ORGANIZING AND MANAGING A SEED PRODUCTION PROGRAM.

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6700 HE WAGENIGEN THE NETHERLANDS.

## Introduction

Seed is a living unit and the first link in the food production chain. That is why good seed is so extremely important. A start with seed of minor quality, leading to a crop with less production capacity, can not be compensated for later on. So seed is not just something planted by farmers. It is the carrier of the genetic potential for higher crop production. To ensure sufficient production however, the seed supply pipeline must flow as freely as possible. And that means that adequate decisions have to be made to make sure that a seed program develops and as a result the seed supplies receive the priorities they deserve. To start a seed program the first step must always be an examination of a nation's seed situation. Questions like: the present-day seed production, crop by crop, import, export, supply to farmers, possibities of seeds production, nation's policy, available manpower, organizations, have to be answered first. If a seed program will be successful, it has to be developed from small beginnings. Taking the right decisions at the right time, reiewing the stage of development year after year, setting guidelines for the near future and adapting those lines if necessary, are important points to take into account.

Crop research

Although crop research is the foundation of a seed program, it is not the program by itself. Crop research has a liason with intoducing varieties and breeding, but it is more than that. Research on cultural measurements (ploughing, fertilizing, planting density, weed control, harvesting) is also important. Both lines should go hand in hand. If the best variety (or varieties) has been chosen and farmers are motivated to accept the variety (demonstration plots on-farm or on special fields are important) the first success is there. It should be emphasized that cooperation between all research on crops and varieties and the introduction of new varieties through breeding is one basis for improvement of seed production. I will pass the initial seed multiplication, because you have been told the main points during the course. The breeder remains responsible for trueness and pureness of a variety. Variety maintenance is a must for them. Sometimes a basic seed organization might be formed for further multiplication of the breeder seed, but even then the breeder must remain a working partner. Needless to say a seed processing plant is necessary to handle small seed lots and larger quantities of basic seed. The number of multiplications from breeder seed depends on the stage of development of the seed program and of course upon the kind of crop. From basic seed onwards seed is multiplicated to certified or commercial seed.

Coming to building the seed supply I would like to say that it is difficult to increase the seed production capacity from the initial stage of a seed program onwards. It requires persistent effort to generate interest among everyone who is involved in a seed program; agricultural leaders have an important task in this respect. One of the main points should be the establishment and growth of seed enterprises in the private or public sector, or both. Seed

enterprises can be family operations, partnerships, cooperative, companies or corporations, depending upon the nation's policy and on the scope of activities in seed production. When talking about a seed production program it should be emphasized that no text book solution is really available to any given condition. This means that after having got through the general and important points of action, every program should be realized according to local existing conditions and the possibilities of development there of. If the initial work has been done: amount of seed demand, availabitity of varieties, kind of crops , ecological and other possibilities for seed growing, availibities of farmers - seedgrowers, way of harvesting, processing and storage, supply of seed to the farmers, one can think about seed enterprises as a reality. To run a seed enterprise is even more difficult than to do the initial work. Although the management is similar to that of the other organization, it is complicated by several factors such as: dependence upon weather conditions, seasonal nature of the work, timing and sequence of activities, extension to seedgrowers. Needless to sat that personnel should be properly trained to improve their managerial and technical skills, this means, depending upon the size of the enterprise, training of specialized personnel for the different jobs that have to be done.

A seed enterprise might have its own farms for seed production or they produce seed via contract_growing, or both. In the case of contract_growing the seed organization has to make sure that the grower receives an adequate compensation for his efforts, otherwise he may lose interest. The level of the premium (above a commercial crop) is laid down in a contract.

No job can be done without risks. What can generally be considered the risks of seed production?

a. Risks of seed growers After the basic inputs have been done, the grower expects an economical return. If the crops fails, he may loose money and may be less inclined to start again next season. It is of the utmost importance therefore that planning and execution of seed production is carried out in a systematic and professional manner. A part from unfavourable weather conditions, which are beyond human control, the following precautions can be taken.

1. Proper Basic Seed, free of diseases and viable.
2. Choose a suitable area for seed production.
3. If possible choose farmers who are genuinely interested in seed production.
4. Make sure the necessary equipment for land preparation, crop husbandry, harvesting and drying is available.
5. Have trained extension staff available who can guide the seed grower throughout the season.
6. Endeavour to compensate the grawer adequate in line with the of price commercial crops.
7. If possible also compensate the grower to a certain extent in the case of crop failure. This is particularly important when a new crop or new variety is introduced.

b. Risk of Central Organization or Seed Comapny.
The manager must try to limit or avoid the risks which can be forseen. Once that has been done the so called calculated risks remain.

1. Supplies

Once a market has been developed, a steady supply is of utmost importance. If shortages occur, the organization may loose creditablity.

Over - supply should be avoided if possible, but if adequate storage facilities are available, most seeds can be kept over a certain period. Both might have financial consequenses for the organization.

2. Financial

In the planning stage the funds required are:
Capital inputs: building, machinery, transport equipment, infra-shuctive- "Working" capital: running expenses, funds for purchasing seed and other raw materials. The funds for capital inputs can usually be estimated without too many problems. Care should be taken not to overcapitalize in the early stages, because the return on capital employed should be reasonable.

Profitability

This aspect can be tackled with various objects in mind. Overall, in seed production and marketing the following participants have to make a profit when all goes well.

1. Seed grower.
2. Seed organization or company.
3. Seed distributors.
4. Seed-user which is the farmer.

The cost of good seed is however usually relatively low in comparison with the cost of other agricultural inputs like fertilizer and equipment, consequently the seed organization has no economical reason not to be viable or profitable.

No commercial organization can survive without making a profit, particulary if we think of profit " as the money required to cover the costs of the future. "It is rather immaterial in this respect whether the organization is owned by the State or by a private indvidual, or by a combination of both. Whatever the ownership structure or ideology behind an organization, the duty of any leader is to make sure that the organization will serve its purpose in the future. To ensure this goal being achieved the most efficient and satisfactory way for any undertaking is to make a kind of profit. Profits can be calculated in several ways, one common criteria used is the "Return on Capital employed".

## Risks in defining seed demands

Many factors may influence the ultimate demand in any one year. In addition, to plan demand properly, a long term view is advisable.

## Risks

1. Over-production i.e. actual demand is lower than estimated. This can be caused by several factors including:

   a. Seed distribution problems.
   b. Farmers switching to other crops which are suddenly more profitable.
   c. Marketing problems of the final product.
   d. Non-realistic estimates.

   It is important that the Management of a Seed Organization detects any change of trend in demand as early as possible.

2. Under-production

This is the case where seed shortages exist and the factors contributing to this can be:

a. Under estimate of farmers response to introduction of "New seed".
b. Unfavourable growing conditions therefore lower than expected seed yield.
c. In-adequate harvesting equipment therefore large harvest losses.
d. Sub-standard storage facilities causing by storage losses.
e. Inadequate flexibility in deciding on seed growers, compensation and subsequent inability to get good seed growers.

A slight shortage of seed is financially often more interesting than a surplus, but still I would say that a shortage has to be avoided as much as possible, because this can have a serious impact on the country, food situation.

The definition of future demand is probably one of the most difficult problematic and hazardous exercises in the entire seed industry. Briefly one can choose for a minimum, medium or maximum situation.

| | minimum | medium | maximum | |
|---|---|---|---|---|
| seed to be sold | x | x | x | KG |
| seed to stock | Y | Y | Y | KG |
| Seed to be produced | z | z | z | kg |

It will be up to the management to decide the size of the variation which can be accepted. The definition of the demand is even more difficult in a new organization than in a concern already going for many years. Any method to decide on future demand will have to be related to various factors.

To name a few:

1. Status of Seed to be produced

In the case of basic seed one should aim to have a strategic reserve of one season's supply. This is necessary to insure against any disaster, natural or otherwise, during the growing season.
Non-availabiltiy of Basic Seed can put the entire seed production effort in jeopardy. It is therefore of utmost importance that ample stocks of viable Basic Seed are available to fall back on.

2. Production Methods

If the seed crop is grown in an area where rainfall is unreliable and if no irrigation facilities are available a higher margin should be allowed than would be the case under more reliabl conditions.

3. Quality of Storage available

If high quality storage is available one has more room to manuoevure than in the case of very poor storage conditions, where seed will deterioate quikly.

4. Characteristics of the seed

If seed is produced which cannot be stored for a long period one has to be very careful not to over produce, in which case it is advisable to aim for a "planned shortage". On the other hand some crop species produce seed a which remain dormant and a certain storage period will be required before this seed can be sold.

## Seed marketing and distribution channels

Marketing of seed is a difficult task in the process of improving the seed supply. If marketing is not successful, all other efforts of research, production, processing, storage and even extension are wasted. The activities in the case of marketing can include:

extension
demonstration plots
sales promotion
point of sales storage
seed distribution, including transport
education of dealers (wholsale and retail)
financing arragements including credit
price negotiations
marketing costing
post-sales market surveys

Seed distribution has its own particular problems, since most seed is required at the beginning of the planting season and a very big "peak" in demand has to be created for ever a short span of time.

This means careful planning and different kinds of seed need a different approach in many respects. A serious marketting effort will need specialized staff. It is not a side line in the total production activities. Follow-up visits during the off-season and making preparations of next season's distribution well in advance are two main points.

To finalize the story I would like to emphasize once more the importance of the development step by step and quick adaptation to any changes. In the meantime the suidelines for the future can be set out. Keep all people involved in agricultural interest, cooperate as much as possible and do not forget the extension to the farmer.

# THE SEED INDUSTRY IN SYRIA

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## Introduction

The term "seed industry" covers a range of activities involving an amalgam of scientific and technical knowledge and skill and commercial expertise. It requires considerable investment and continuing financial liquidity to purchase, process, hold and sell seed. It invariably calls FOR activities by more than one agency. The sectors of a seed industry include:

- Plant breeding and selection: to provide varieties of crop plants adapted to varying evironmental conditions, and to maintain a pipeline of varieties to cater for changing needs.

  Multiplication: to increase the small quantities available initially from the plant breeder to a level where they can be purchased in bulk by farmers. This can amount in the final stages to many thousands of tonnes and it is carried out on farms which may be privately, state or cooperatively operated.

- Processing: is needed to clean the crop seed from weed seeds, dirt, straw, inert matter, stones and so forth and to grade them according to size. This should result in a product which has high germination capacity from which an even crop can be obtained. Processing also involves chemical treatment to eliminate seed-borne diseases and pests.

- Storage: to maintain the seed between harvest and sowing the new crop, under conditions which prevent deterioration from damp, rodents pests and diseases. Stores are also the base for the processing operation.

- Marketing: to provide facilities to get the seed from the stores to the distribution points where storage may also be needed and a commercial structure for distribution and sale.

- Quality Control: to ensure that at all stages of growing and handling the seed, checks can be made on the quality so that the end-user farmer can be certain that the commodity he buys has the potential to produce what he wants. The control of quality must be backed by legislation.

## Organizations

Syria has a sound certified cereal seed industry with all the components listed above, which is meeting substantial wheat and barley seed needs. Four organizations play a role in the seed industry in Syria which are as follows:

a) Research Directorate of the Ministry of Agriculture
   Plant breeding and selection, the release of new varieties, and the production of the breeder seeds for the General Organization for Seed Multiplication.
b) General Organization for Seed Multiplication (GOSM),seed multiplication, quality control, storage, and some marketing.
c) General Organization for Silos and Seed Plants, seed processing in cooperation with the GOSM.
d) Agriculture Cooperation Bank, Credit and some marketting.

## Activities in the various components of the seed industry

### a) Policy

The ultimate responsibility for the seed industry rests with the Minister of Agriculture and Agrarian Reform, and he is advised by a national seed committee. This advice covers all matters pertaining to the seed industry, including general policy, seed targets, and registration of varieties in the official catalogue.

### b) New Varieties

Varietal development is based on local breeding and selection work carried out by the Research Directorate from material produced in Syria or introduced from international organizations such as ACSAD, ICARDA, and CIMMYT. Up to 1980/1981 the varieties included in the multiplication program are durum wheat (Jori 69, Gizera 17, Horani), bread wheat (Mexipak, Siete Cerros) and barley (Pitcher).
However, in the season of 1981/1982 six new varieties, two durums (plc/Ruff/Gta's 'rtte (WAHA) G's' T. diaccum V. vermum /G115) two bread wheat (5311/ Norteno, (GOLAN), H.D 2172 (BLOUDAN): and two barleys (Beecher/2762-9L, (BADIA), Beecher) were obtained from ICARDA and included in the multiplication program after being approved by the Research Directorate.

### c) Multiplication, quality Control, and processing

Seed for multiplication is supplied by the Research Directorate as the base of the initial multiplication. The various stages of multiplication may have different names, but for cereals they are termed in Syria as: nucleus, nuclei foundation, certified improved seed.

Contracts are made with selected farmers, cooperatives, and state farms for seed production. Several inspections are made of crops during the production phase with a final inspection made by a committee representing personnel from the GOSM, the Research Directorate and the Directorate of Agriculture offices.

The following specific requirements must be applied as minimum field standards for the certification of wheat and barley crops:

| Specific field Requirements | Stages | |
|---|---|---|
| | Nuclei Foundation | Certified Improved |
| Other wheat varieties | 1: 3000 Plants (heads) | 1:1000 Plants (heads) |
| Acceptance Level | 1: 3000 Plants (heads) | 1:1000 Plants (heads) |
| Rejection Level | 1: 1500 Plants (heads) | 1:1500 Plants (heads) |
| Inseparable other crops | 1:10000 Plants (heads) | 1: 200 Plants (heads) |
| Objectionable weeds | None | None |

After the fields are inspected a staff member is to be on hand when the seeds are harvested, so the individual bags can be properly labelled for seed purpose. Seeds are purchased from growers fro 20-25% premium. Seeds are inspected for germination, purity, insect damage, and other routine tests before payments are made to the seed growers and the seed is officially approved for use.

The following are the acceptable seed standards:

| Seed Standards | Nuclei Foundation | Certified Improved |
|---|---|---|
| Pure seed (minimum) | 98% | 96% |
| Other distinguishable Varieties (maximum) | 2 seeds /kg | 24 seeds/kg |
| Other small grain crops (maximum) | 2 seeds /kg | 12 seeds/kg |
| Inert matter (maximum) | 1.0% | 4.0% |
| Total objectionable weeds (maximum) | None | None |
| Germination (minimum) | 85% | 85% |

Seeds are processed in the seed plants. The eleven seed processing plants are the responsibility of the General Organization for silos and Seed Plants.

Three of the plants process certified seeds and eight are used to clean farmer seeds. Each plant has a capacity of 1000 tons per season. The plants are quite adequate to meet the needs for processing commercial and certified seeds of cereals.

After processing (cleaning and treatment), Seed is bagged in woven plastic bags and tagged. The tags contain the following information:

1. Kind of seed
2. Variety
3. Multiplication class
4. Name of the person responsible at harvest.
5. Original farm identification number and village.

6. Date of bagging
7. Seed treatment
8. Syrian Arab Republic
9. Ministry of Agriculutre
10. GOSM
11. Name of Seed processing plant

d) Marketing and Pricing

Seeds are marketed in several ways. The Agriculture Cooperative Bank has 52 branches and recieves 3% commission for marketing seeds. Seeds can be obtained from them if a loan is involved. The GOSM has eight branches where seeds are sold directly to farmers.

Seeds are priced by the high council of Agriculture. In this season, 1981/1982, the seeds were sold at prices slightly above the commercial grain prices. However, the cost of processing, transportation and related costs were included and the GOSM was re-imbursed for losses it incurred.

In 1981, the GOSM was able to produce 16000 tons of durum wheat seeds, 13000 tons of bread wheat seeds, and 1000 tons of barley seeds which covers 20%, 20%, 2% of the total requirements, respectively.

Plans have been prepared for increasing the production of cereal seeds by 20% annually.

During the last three years 1250 tons of wheat seeds were exported to Jordan, 150 tons to Saudia Arabia, and 40 tons to Lebanon.

As the seed program gains strength it is hoped that a stronger export market will develop and that Syria can play an increasing role in the export of seeds.

# THE ORGANIZATION OF THE SEED INDUSTRY IN THE NETHERLANDS WITH EMPHASIS ON CEREALS.

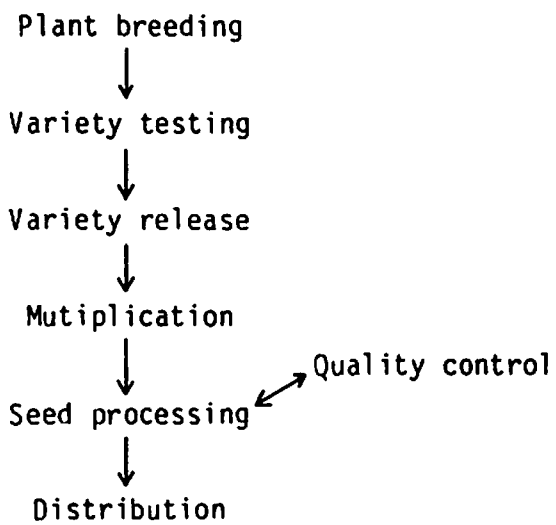
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## Introduction

In this paper we are going to have a bird's-eye view of the components of the Dutch seed industry. These components constitute a chain of links, and , as in any other industry, the prerequisite for a chain to function is that all links are solid and matching one another. Seven of the main steps (links) from the breeding of a new variety towards the use by the farmer, are given in the diagram below.



In Holland most of the components of the seed industry have evolved over a long period of time, usually not forced by external pressure but by the natural course of events. As in nature such a situation can produce different solutions to the same problem. This is the reason why the situation in our country is different from other countries in the same stage of development. Over the last few decades, and mainly because of extensive communication and trade with other countries, one can see an adaption towards a more or less standard international approach. One can take the Dutch structure as an example but due to many dissimilarities (climatological, ecological, social political, etc.) each country should try to evlove its own system that fits into its own socio-political structure in a natural way. However, it is also worth looking at other solutions. It is very important to try to meet international standards in order to be able to adopt the procedures followed internationally when the country wants e.g. to export seed. In such a case varietal evaluation, but certainly seed testing and labelling should conform to international agreements.

## PLANT BREEDING

Let us take a closer look at the various components of the Dutch seed industry. In Holland plant breeding is for the larger part a private enterprise. It always has been. For centuries farmers, as in any other country, made their own selections of crops. The organized breeding, private or public, made selections in the already existing land-races, and further refinements as to resistance, yield, homogenity etc., resulting in new cultivars (in agricultural practice referred to as "varieties").

Breeding as a profession gradually developed in the 1920's, and made a large leap ahead during the 1940's. Private initiative has always been supported by the Government, through research by specialised institutes and the Agricutural University. Apart from the breeding department of the University there are two breeding institutes under the Ministry of Agriculture, viz. one for arable crops and one for horticultural cops. Priorities in basic breeding research are set upon general priorities in agricultural research on the one hand and upon signals from the private breeding firms, farmers and growers on the other.

Basic breeding material with a new property, e.g. a new resistance, but not yet stable in all its characters, is released to the private breeding companies. These have the experience and facilities to breed true varities in order to meet the demand. There is a close cooperation between the institutes and the private companies and in that way progress in breeding projects is regulary discussed. On the other hand there is a confidential relationship between the institutes and the private companies: the institutes can have a look into the kitchen of the breeding work of the companies. When basic material is ready for release, the institute gives an explanation of the back-ground of the material , the available quality of seed or plants and the price.

Thus cooperative focusing of priorities for the benfit of farmers and growers is achieved. Of course the economic prospects have also to be taken into account. Because this point is of vital interest to the private companies, there is alway pressure to release basic materials as soon as possible. The institutes on the other hand, have the reponsibilty to prepare basic material up to a certain stage of development, in order to be certain that it can be taken over by the private breeder, and no valuable material is lost.

Other institutes, experimental farms,etc. also contribute, often indirectly, to the breeding programmes. This, for instance, is the case with a phytopathological institue that provides sister institutes as well as private companies with infection material, thus enabling breeding for resistance to diseases.

## VARIETY TESTING AND RELEASE

At a certain moment a breeder thinks his new variety is ready to be multiplied and brought on the market. This, however, is not possible without approval through extensive variety research.

The farmers, the grower of a crop, benefits from a choice of vaieties, because the conditions vary from farm to farm (from the point of mechanisation as well as edaphic and climatologicalconditions ). He may also be interested in e.g. early sowing, or very late harvests. When there are many varieties the choice the farmer has to make is very difficult, not being able to carry out extensive comparative trials. Here we see a very logical function for the government. Institutes with trial farms all over the country are therefore established to make this evaluation, resulting in advice from the advisory services.

On the other hand one has to investigate whether the proposed variety, submitted by the breeder, is a new one. Botanical variety research is needed to look for distinguishing characters, and at least one character should be found in order to decide that it is a new, independent variety. The identity is then established, and there is now a possibilty to protect this very valuable breeing work with Plant Breeder's Rights, a protection that, for cereals, lasts for 20 years. The Board for Plant Breeder's Rights decides whether

the vaiety will be registered. Not only distinguishability (identity),also uniformity are essential. If all the requirements are met the Board can put the variey in the register of vaieties. Varieties considered to be valuable for growing in the Netherlands will be put on the list of varities.

Finally for agricultural crops also the agricultural value must be established and must be better than already existing varieties in order to appear on the variety list. The variety list for agricultural crops is binding, this means that only varieties on that list can be brought into commerce, with some exceptions for grasses, clovers, and for limited qualities of new varieties still subject to varietal research (small scale trials in practice). The lists for horticultural crops is not binding and trade of unlisted varieties is possible. These lists however have an advisory function, especially for the crop grower. Varieties listed on the so-called common list of the European Economic Community can automatically be traded in all member states.

## MULTIPLICATION, PROCESSING AND DISTRIBUTION

Since seed production is entirely the work of private companies, and because these companies usually also do the breeding, the multiplication, processing and distribution is also in their hands. This has the advantage that the government does not need to maintain a seperate seed distribution system alongside the private lines. There is, however, a restriction that every company or shop or person trading in seed should be affiliated with one of the inspection services (= certification authorities). There are four different inspection servies each for a seperate group of crops.

- General Netherlands Inspection Service for agricultural seeds and plants N.A.K.
- General Netherlands Inspection Service for vegetable and flower seeds NAKG
- General Netherlands Inspection Service for ornamental plants NAKS

- General Netherlands Inspection Services for arboricultural produce NAKB

Let us take a closer look at the inspection of cereals. The breeder is responsible for the maintenance of the variety. The production of basic seed is done under the responsibility of the breeder on special mutiplication farms. Varietal maintenance is controlled on the central control farm of the inspection service by special pre-control plots of the generation before basic seed. There are two classes of basic seed (super elite and elite) and two classes of certified seed (1st and 2nd generation). In practice certified seed 2nd generation is produced, but only used in case of shortage.

Post control is carried out on each certified lot of basic seed. The results are used as a pre-control for the inspection of certified seed 1st generation. For certified seed the post-control is at random at a rate of + 1:5. In this scheme the administrative control is necessary for a control on the origin of the propagating material. Therefore an application form and all the cerificates of the used seed have to be sent in by the farmer. All operations, such as harvesting, storage, transport, cleaning, etc. are under supervision of the inspection serivce. Adequate regulations have been developed to safeguard the identity of the seed lots. During lot inspection and sampling special attention is given to homogeneity. Only uniform lots can be certified. Sampling is done according to the ISTA Rules. When the lot meets the standards for

moisture content, germination capacity, health condition, etc. the lot is ready for certification. Labelling is done by the inspector himself or under his direct supervision. After sealing, the lots can be marketed.

## QUALITY CONTROL

Many aspects of quality control have already been mentioned in the preceding paragraph: certification is part of quality control. One aspect of quality control however has not yet been mentioned: laboratory seed testing. Seed testing is not a program in itself, it is a part of seed certification on the one hand but also has some other functions. Because seed testing in Holland is done by only one institute, and done according to the ISTA Rules there is no need to dwell on procedures and regulations. The ISTA Rules will be treated in detail during this training course.

There is one aspect which should be stressed. A seed testing station, in a starting as well as in an advanced seed industry, has an advisory function. This advisory function, especially at the start of the seed industry development, may even be bigger than its regular task: which is routine seed testing. Sometimes things go wrong and it is not clear why or where the problems arose: high temperatures?, high moisture content?, fraud?. For all or most of these and many other problems there are two main causes: ignorance and negligence. People do not know what they are doing and they don't care. In many cases the seed testing station can assist, through ad hoc applied research, in solving the "mystery". There is always a logical answer , and by checking the several stages of the production, e.g. through germination tests from before and after harvest, from before and after drying, etc., etc. these questions can be easily solved. Ignorance will decrease, and with that, hopefully, negligence also.

# SEED PRODUCTION AND TECHNOLOGY IN INDIA

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## Historical background

In recent years India has made rapid progress in seed production and technology. The first analysis of seed production needs and problems in India is contained in the report of the Royal Commission on Agriculture which was published in 1982. In 1957 the Indian council of Agricultural Research (ICAR) in collaboration with the Rockefeller Foundation introduced the All-India Coordinated Maize Project. This marked the beginning of an intensive, integrated and multidisciplinary approach to crop improvement in India. In ICAR 1960 started a similar project for Sorghum and Bajra (Pearl millet), and Sorghum and bajra hybrids were released in 1964 and 1966 respectively. The complexity of the seed production process needed for these hybrids led to the realisation that the existing seed production system was inadequate.

Therefore the Government of India (GOI) decided to set-up a seed corporation and in 1963 the National Seed Corporation (NSC), a Government of India undertaking, incorporated under the companies Act, was established. The NSC was to be responsible for the seed industry development in India and was to initiate measures leading to the production, processing and marketing of high quality seeds particularly single crosses of hybrids maize.

The period between 1963-1969 saw a rapid development of the seed industry in India, both public and private. In 1965 the first 250 tonnes of dwarf wheat seed was imported from Mexico, followed in 1965 by a bulk shipment of 18,000 tonnes. In 1965 the first dwarf paddy variety was imported from Taiwan. In 1966, the seeds Act was passed by the Indian Parliament.

Between 1963-1969 the NSC was mainly concerned with Foundation Seed Production. This period also saw increase in certified seed production from about 360 ha to 35,000 ha. The certified seed production was concentrated in the private sector and the Tarai Development Corporation (TDC) which was established in 1969, with World Bank assistancce, centring around the University associating progrssive farmers of the area and NSC. The project aimed at the development of 16,000 ha for seed production including 5,000 ha of the University farm. The main seed to be produced was wheat with substantial amounts of paddy, maize and Soybean. This was the first attempt to develop a compact area for seed production. From the first year of enforcement of the seed Act, NSC functioned as the certification agency in all states except one. NSC has also established a scientific seed processing industry in India and helped manufacturers to produce seed equipment locally.

The seed situation in India was reviewed in 1968 (Seed Review Team's Report) and in 1971 by the National Commission on Agriculture. The National Commission on Agriculture's report stressed the necessity of maintaining seed purity considering the rapid deterioration of the seeds of high yielding varities. In the light of various recommendations the GOI decided to organise seed production agencies in different states of India so that seed support to the planned crop production program could be assured. These events are briefly summarized in Figure 1.

Fig.1. Summary of the seed production and technology development in India.

| | |
|---|---|
| 1. 1928 | Royal Commission on Agriculture Report was submitted in which it was reported that (1) facilities for increasing the supply of breeder seed were inadquate. (2) Varietal purity of seeds was not maintained. |
| 2. 1957 | All India Coordinated maize improvement project started. |
| 3. 1960 | Similar projects on Sorghum and pearl millet were started.<br>Training in Seed Technology started. |
| 4. 1961 | Four maize hybrids were released. |
| 5. 1963 | National Seeds Corporation was established. |
| 6. 1964 | First Sorghum hybrid was released. |
| 7. 1965 | First Pearl Millet hybrid was released. |
| 8. 1965 | 250 tonnes of dwarf wheat seed was imported from Mexico (CYMMIT). |
| 9. 1966 | The Seeds Act was passed but came into force in 1969 |
| 10. 1966-1969 | Certified seed production increased from 360 ha to 35000 ha. |

11. 1968 Seed review teams report was submitted .

12. 1969 Tarai Development Corporation was established by World Bank assistance to produce primarily certified wheat seed. Concept of Compact Area Development for seed production
was initiated.

13. 1971 The National Commission on Agriculture submitted its report.
Government decided to reorganise seed production in India.
The Indian Society of Seed Technology (ISST) was born.
Six All India Seed Seminars were held.

14. 1972 The ISST organised the first All India Seed Seminar.

15. 1975 Project Report on National Seeds Program (NSP) was submitted.

16. 1981 The first workshop on seed technology under NSP was held.
Certified seed production increased from 137,000 tonnes in 1974-1975 to about 350,000 in tonnes 1980-1981.

The Seeds Act and Quality Control

The seeds Act came into operation in October 1969 although it was passed in 1966. The Act, and the subsquent Rules, envisaged that for notified varities of crop no person would sell offer to sell, or exhibit for sale any seed not conforming to certain minimum standards of germination and purity laid down by the central seed committee.

Seed certification in India is linked with notification of variety . Variety release is not sufficient for certification. The responsibility of notification rests with the Central Seed Committee. The Central Seed Committee also lays minimum standards for certification. Such standards have been fixed for various crops and detailed methods for field inspection have been envolved which are published in the form of two booklets called "Minimum Seed certification standards" and "Field Inspection Manual". The GOI has established a central seed certification Board to help the State Government in matters of seed quality control and legislation.

All state governments have set-up state Seed Testing Laboratories.
In some states there is more than one seed testing laboratory. One central seed testing laboratory has also been established. The function of these laboratories is to check the seed standard for certification under the Act. Seed certification is voluntary, but truthful labelling is compulsory.

However, the bulk of seeds which are produced in India are certified except vegetable seeds which are truthfully labelled. The generation System of seed production is followed and for hybrids, and where rapid deterioration of varieties is expected, the following generation system is followed:

Breeder ---> Foundation---> Certified.
Whereas in highly self pollinated crops the following system is followed:
Breeder ---> Foundation I---> Foundation II--->
Certified I ---> Certified II---> Certified III.

Steps in the production of quality seeds in highly self-pollinated crops, like wheat and barley are shown in Fig. 2.

Fig.2. Relationship between plant Improvement and Seed Production in a highly self pollinated crop.

| | |
|---|---|
| | Variety Development |
| | (Breeding,Introduction etc.) |
| | New variety |
| PLANT IMPROVEMENT | All India Crop Improvement Projects |
| | Testing of Varieties |
| | Variety Release |
| | Variety Notification<br>(makes a variety eligible for certification) |
| | Breeder Seed |
| | Foundation Seed Stage I (seed certification and Quality Control) |
| SEED PRODUCTION | Foundation Seed Stage II |
| AND | Certified Seed Stage I |
| TECHNOLOGY | Certified Seed Stage II |
| | Certified seed Stage III |
| | (not eligible for futher certification) |

## Production of Breeder and Foundation (Basic) Seed

production of the state and/or local varieties is the responsibility of the state universities and the state seed corporations.

Foundation seed of the national and/or regional varieties is produced and coordinated by the NSC.

The quality of breeder seed is monitored through field inspection by a team consisting of the crop coordinator, the breeder and the representive of the NSC because breeder seed is not a certified seed whereas foundation seed is certified.

The repsonsibilty for the production of breeder seed rests with the ICAR. Breeder seeds thus produced are handed over to the National seeds corporation/state seed producing agencies for further multipliction. Funds have been provided under the NSP to several agricultural universities (eleven in number) to start or strengthen seed technology research. The division of seed technology at IARI coordinates the research activities of these universities. The World bank has also provided consultants to identify the specific areas of which should be taken up at these universities. Training in seed technology is also provided under NSP.

## Formation of the Indian society of seed technology

Hundreds of seed technologists are engaged in the seed industry. To provide a forum for these people to share experiences and grow professionally and to provide a link an Indian society of

seed technology was formed in 1971. The society has about 500 active members and publishes a quarterly semitechnical news bulletin and a half yearly research journal called the Seed Tech News (Started in 1971 and the seed research (started in 1973) respectively. So far the society has conducted six all Indian seed seminars and the last one was conducted by the author in Nagpur from April 7-9 1982. The theme of the last seminar was post harvest technology of seeds in which about 150 delegates from different parts of India participated. Earlier seminars were held on varietal identification including grow out tests (in 1980), seed certification (in 1978), seed storage and processing (1967) etc. From 1980, the society has started giving annual awards to the best research paper published in seed research in order to encourage publication of good papers in the journal.

So far about 400 research papers have been published in the seed research in 9 volumes and the tenth one is in press.

## Training of personnel and seed research

In the early 60's the need for trained manpower for efficient functioning of seed programs was realized. Since then several training courses in seed production and technology have been conducted by the Indian Agricultural Research Institute, the NSC, the G.B. pant University of Agriculture and Technology (GBPRUAT) etc and many people have been trained. An elective undergraduate program in seed technology is offered by the GBPUAT. Pantnagar and post graduate programs in seed technology are offered by the Tamil Nadu Agricultural University, Coibatore the and Univeristy of Agricultural Sciences, Bangalor. In addition to these, several agricultural universities offer extension education in seed technology.

Seed research is carried out both at ICAR's institutes as well as at the agricultural univeristies. 24 central research institutes and 21 agricultural universities are engaged in research on various aspects of seeds. Most of these institutions carry-out research on isolation distances, planting ratio, seed storage, germination, dormancy, vigour, seed maturity, various aspects of seed pathology, processing, drying and quality control, control of insect pests, marketing and seed extension.

## Seed industry in the private sector

The private seed industry has an important role to play in the overal seed industry developments in India. Over the last 10 years the seed industry has enlarged considerably and it is estimated that about 2,000 seed dealers, small, medium, and big, are doing business of which about 200 appear to have a permanent stake in the seed business in India. The Indian society of seed technology has published a directory of seedmen in India in February, 1980. A similar directory has been published by the all Indian seed growers, merchants and nurserymen association. The private seed industries are playing an important role not only in the spreading of certified seeds in India but exporting seeds to different countries. Custom seed production has been taken up by various Indian seed companies including the NSC.

## The National Seed Program (NSP)

The aim of the NSP is to develop a seed production infrastructure that is able to respond rapidly to fast changing

demands for seeds of all kinds. It was estimated that demand for certified seeds of the 5 main cereals (wheat, barley, maize, sorghum and pearl millet) will rise from the 1974-75 level of 137,000 tonnes to 290,000 in 1981. To meet this increased responsibility for certified seed production a number of state seed cooporations were developed. These corporations are 35% owned by the state governments or its agencies, 35% by the growers and 30% by the central government through NSC. Within each state compact areas of high productivity have been selected for development. The project has provided funds to bring this compact area to a state of high productivity, long term funds for development or on farm development and short term funds for current inputs. Under the NSP, the ICAR coordinates the production of breeder seeds.

# SEED TESTING AND QUALITY CONTROL IN THE NETHERLANDS

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We are Government Station, belonging to one of the Directorates of the Ministry of Agriculture and Fisheries, namely the Directorate of Arable Farming and Horticulture.
Our special field concerns seeds; the other Research Stations belonging to the same Directorate also have a special field of activity: arable farming and field production of vegetables, horticulture under glass, floriculture, arboriculture, bulbs, fruit, mushrooms.

The Research Institutes deal with special disciplines, such as breeding phytopathology, mechanization, soil science etc.; they belong to another Directorate of the Ministry, namely that of Agricultural Research.

## Main activities

- Quality analysis of already cleaned seed samples of the seed trade and issuing of analysis certificates, including issuing of ISTA analysis certficates (moisture, purity, germination, seed health) (ISTA = International Seed Testing Association )
- Quality analysis of uncleaned samples of contract-grown seed lots.

- Development and improvement of analysis methods, including co-operation with ISTA in this field (technical committees)
- Research on seed problems
- Advice in seed handling
- Training in seed testing and seed technology
- Assistance in different aspects of Seed Industry Development in developing countries.

From these activities it will be clear that a part of our work is routine, the other part is research, training and advice. As far as research is concerned, this is done for the benefit of routine methods on the one hand and for the solution of basic problems on the other.

There about 70 personel at the Station; more than 50% are involved in routine testing. The number of samples tested by the Station is about 18,000 (7,500 for contract grown seed lots, which arrive uncleaned, and 15,500 for trade samples, which arrive already cleaned).

The different departments are:

- Cleaning, purity, identification and cytology
- Germination, storage,packing and moisture
- Seed health
- Certification
- Administration

Some General Remarks

Seed is a living unit with a rather complicated structure and manifold activities. It harbours the germ of a new plant and guarantees continuity of the species. Good seed is the basis for a

good crop and within the seed industry it is the first link in the food production chain. Other links are breeding, variety research, crop production research, extension and to close the circle crop inspection and seed quality control. Every cultural measurement will not have a full effect unless top quality seed has been sown.
A bad start due to inferior seed cannot be compensated for later on. To guarantee seed of good quality, seed testing is necessary.

Seed Testing was started in 1864, in Germany, followed by the Netherlands in 1877. So this station is just over 100 years old. In the beginning quality control was restricted to external appearance and origin of the seed. This was soon followed by purity and germination, which are now the main standards for the value of seeds under agricultural conditions. Nowadays testing also includes cleaning, presence of kind of weeds and other seed moisture, presence of pathogens. Quality control,on the way to seed production, testing, certification and marketing starts in the field and has to be continued in seed testing laboratories.
In this respect there is close cooperation between the Netherlands Inspection Services (NAK) and our station. Both can issue certificates. Only our station is authorized to issue international certificates (export), in accordance with the rules of the International Seed Testing Association (ISTA).

Field inspection is always done by the Certifying Agencies. The Netherlands Inspection Services (NAK) for agricultural seeds (including seed potatoes) and the NAK-G for vegetable and flower seeds.

The NAK (NAK-G) is a foundation of the farmers (growers), partly subsidized by the Government as far as testing analysis is concerned. Agricultural seed for inland use is mainly tested in regional laboratories of the NAK, for export this is done by the Government

Seed Testing Station (the Station which is authorized to issue ISTA certificates). Horticultural seed is mainly tested in the NAK-G laboratory. This agency guarantees good seed quality by a NAK-G certificate. If an orange international certificate is asked for, the sample has to be tested by our station.

Besides those certificates, the International Phytosanitary Certificate exists. This is issued by the Plant Protection Service (Government Institute) only. Testing of the seed is done by our station for agricultural and some horticultural seeds and by the P.P.S. for horticultural seeds.

## Developments in seed testing

Purity investigation has been an important aspect of seed evaluation. Impurities in a seed lot can be: seeds of other crop species, weed seeds, inert matter such as broken seeds, chaff, pieces of leaf, soil particles and so on. The presence of other seed requires a thorough knowledge of seed taxonomy. We have our own 2-year course in our laboratory; we also give advice to the laboratory workers of seed firms, who have their own labs for testing.

The requirements concerning purity have stimulated the development of seed cleaning. In modern cleaning plants the goal is to obtain a high quality product with a minimum loss of good seed and at a limited expense. One should be aware of the fact that cleaning machines are not able to remove everything. It is always a compromise, because the more inmpurities one wishes to remove, the more seed of the crop itself will be removed . But cleaning is one of the first and one of the most effective weapons in a new seed

industry to combat bad quality.
In conclusion: a high purity level is justified, but demands should not be unduely severe.
The station has a cleaning laboratory with small scale machinery, which gives comparable results with cleaning plants in practice.

Another important quality aspect is seed germination. The germination test is actually made in the laboratory, and for every kind of seed the most favorable germination conditions are used. In the official test the distinction between normal and abnromal seedlings is very important. It appears that in general there is a close relation between the figures obtained in the laboratory test and field emergence, which of course should be high and uniform. Every kind of seed behaves in its own way with regard to temperature, illuminaton, moisture; often seed dormancy is present and has to be eliminated befor determining the real germination capacity.

The problems of germination biology, seed dormancy, seedling abnormality, vigour of the seed as well as packing and storage conditions require continued research.

Control on seed health is also very important in testing for seed quality. A number of plant diseases can be seed-transmitted. This is true for fungal, bacterial as well as virus diseases.
Then the disease may be seedborne. This item is of special interest for the health department. Of course a disease in a given crop can also be air-borne or soil-borne. This depends mainly on the biology of the pathogen. It is obvious that the significance of seed transmission of pathogens has been underestimated in earlier years. Nowadays the demand for seed health testing is increasing, the reason being that even minor occurrence of a pathogen in a seed lot may cause severe damage to a crop.

## International Cooperation

It is important for international trade that in various countries the same seed testing methods are used. In 1921 the European Seed Testing Association was founded; in 1924 the name was changed to the International Seed Testing Association (ISTA). At present 136 official seed testing stations are accredited to ISTA in 59 countries. In these stations seed samples are tested in accordance with the very detailed ISTA-rules, and they have the right to issue ISTA analysis cerificates. It is mainly the orange seed lot certificate of ISTA which is used in international trade.

There are several ISTA technical committees, with members from different countries who contribute by research, referee testing and discussions for improvement of international agreements and rules. Some of the committees are: rules, germination, purity, moisture and storage, plant diseases, equipment.

## Relationship between Breeding and Seed Testing.

Although the discipline of plant breeding is quite different from the work on the seed testing, there are some points of interest to both fields. A plant breeder is not only working with plants, but also with seeds. It is obvious that on the way to a new variey, seed quality should meet the interest of the breeder. Following the sequence breeders seed- basic seed- certificated or commercial seed, seed quality plays a role in the production of seed of a certain variety of a given crop. Seed quality, as far as storage conditions and germination are concerned, is also of importance in the scope of the activities of gene banks.

## Plant Breeding

In the Netherlands plant breeding is done for the larger part by private companies. Breeding is supported by the Government, through research by specialized Institutes (one for arable crops and one for horticultural crops) and the Agricultural University.
Basic breeding material with a new character is released by the Institutes to the private breeders. The Institute gives an explanation of the background of the material, the available quantity of seed or plant and the price.

# SEED ANATOMY,DEVELOPMENT AND COMPOSITION*

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## INTRODUCTION

Seeds have always been the great staple food of the world; feeding more people than any other type of food.

The endosperm and cotyledons with their rich food reserves for the developing embryo and seedling, offer man and other animals a highly nutritious food that can be easily stored. Of particular importance are the carbohydrate-rich cereals and the protein-rich legumes which man uses directly for food.

Many other seeds provide fibre, spices, beverages, oils, drugs, and plants for flowers and many other aesthetic reasons.

The seed is a unique organism; providing, in many cases, its own method of disposal. Most importantly, the seed provides within itself an embryonic plant, a link between generations, with all its capacity for growth under specific conditions of time, place and environmental forces.

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* Adapted from "Introduction to Seed Science and Technology". Technical Manual No. 10, ICARDA.

As seeds are most important for the continuance of life, their make up and behaviour must be studied and understood by all plant scientists. Failure to do this will inevitably lead to failure to develop the agricultural technology required to feed mankid in the future.

## 1.1 Seed formation and development

### 1.1.1 Seed fromation

The formation of a seed is shown in Figures 3 and 4 and 5 with the formation of a grass seed as a typical example.

Essentially the same process occurs in both grasses and legumes.

The seeds of angiosperms originate from meristematic tissue of the ovary wall. One cell in this tissue devides twice to ultlimatiely form four haploid (1N) megaspore cells. Normally, only one megaspore is functional, while the other three degenerate.

The megaspore cell enlarges to become the embryo sac and the nucleus divides three times to give eight haploid nuclei (1N). Cell walls form between the nuclei, resulting in three antipodal cells at one end, two polar nuclei (without cell walls) near the center, and the egg apparatus at the other end. The two polar nuclei fuse to give a diploid nucleus (2N).

The ovule (s) around the embryo sac develops by the growth of collars or integuments which ultimately fuse to become the testa (seed coat) of the mature ovule.

The developing ovule is attached to the placenta of the ovary by the funiculus which when detached at maturity forms the hilum. THe point where the integuments meet, is the micropyle and the region of integumental origin and attachment, usually opposite the micropyle is the chalaza.

During the period of flower development, haploid (1N) pollen microspores are produced in the microsporangia of the anther. At maturity the microspores are released to effect the process of fertilization of the developed ovule.

When the pollen lands on the stigma of the ovary, it germinates sending the pollen tube down the syle through the micropyle, into the embryo sac. Double fertilization occurs as shown in Figure 4.

The ovary wall, or pericarp, of angiosperm fruits is composed of three more or less distinct layers: the exocarp, (outer layer); the mesocarp, (middle layer), and the endocarp (inner layer). THe relative development of each in various species, often determines fruit structure and morphology.

A true seed is a fertilized mature ovule that possesses an embryonic plant, stored food material and a protective coat, or coats.

The embryo is made up of one or more cotyledons, a plumule (embryonic bud), hypocotyl (stem portion) and radicle (rudimentary root).

The structures of a wheat seed and a bean seed are shown in Figures 1 and 2.

The wheat grain is a caryopsis where the single cotyledon is modified to form the scutellum which functions by absorbing food from the endosperm.

The bean seed, one of several contained in the legume fruit, is representative of a complex of seed types found in the family leguminosae. Figure 2 shows external structural features which are found in most of the species of the family.

The hilum is the remainder of the attachment point of the seed in the pod and may vary in colour, size and position on the seed.

The micropyle is a minute pore at the radicle end of the hilum and appears to have no diagnostic value.

The strophicole at the other end of the hilum is a point of weakness in the seed coat associated with breakdown of impermeability in some pasture legumes e.g. subterranean clover.

The raphe is evident in certain species as a raised ridge between the strophicole and chalaza and has no known function.

The chalaza is evident as a small dark coloured area on the surface of many legume seeds near the upper end on the cotyledons where it may be an important diagnostic feature as in the vetches.

The external variations in seed size, shape, colour and surface are myriad and may be important functional and diagnostic differences.

Seed size in terms of weight may vary from almost 10 kilograms for a double coconut seed, to 0.08 miligrams for a tobacco seed.

Common seed shapes are ellipsoid, globose, lenticular, oblong, ovoid, reniform and sectoroid. Seed surfaces vary from highly polished to greatly roughened, with attached appendages including wings, spines and hairs.

Seed colour may vary form black through red, green and yellow to white, although browns and blacks are most common.

1.1.2. Seed development:

The zygote begins devision to ultilmately form the embryo of the seed.

Although the mature embryo of monocots (grasses) and dicots (legumes) appear to be considereably different, their patterns of development are similar.

However the development of the endosperm and other tissues is quite different; leading to the structural differences which can be seen in the mature seed.

The endosperm of monocots usually reaches its maximum development at physiological maturity and persists to comprise the major part of the seed. In dicots, the endosperm may not develp or may be used up by the developing embryo and comprise none, or only a small part, of the mature seed.

The outermost layers of the endosperm are known as the aleurone layer. This layer functions both as a storage tissue for protein granules and for secretion of hydrolytic enzymes, which upon activation during germination help to break down storage tissues.

1.1.3.Seed Growth:

After sexual fusion, the developing seed begins to increase weight as a result of soaking up nutrients and water associated with rapidl.y accelerating cell division and elongation.

Changes occuring, can best be illustrated by referrring to growth of wheat and pea seeds as representative of monocot and dicot seeds.

Changes in weight of whole grains and their parts are shown in Figure 5. Maximum dry weight is achieved at about 40 days from flowering.

Initially, amounts of sucroses and reducing sugars are high in both the endosperm and testa-pericarp but they decline markedly as they are converted to starch.

In the case of nitrogenous substance, there is a steady increase with time in protein accumulation in the endosperm, but little increase into the testa-pericarp.

The general metabolic activity of the grain is mirrored in the dramatic decreasess with time in RNA and DNA found in the endosperm compared with the testa-pericarp.

Changes in weight and certain metabolites in pea seeds are shown in Figure 6.

## 1.2 The chemistry of seeds

A knowledge of the chemical composition of seeds is essential because:

* Seeds are a basic source of food for both man and animals.

* They are an important source of chemicals for industrial uses and medicines, drugs and various antimetabolites which affect human and animal health and nutrition.

* They contain reserve food supplies and growth substances that influence seed germination and seedling vigor and seed storage and longevity.

Most of man's knowledge of the chemical composition of seeds is for cultlivated species, since these comprise a large part of the supply of food and industrial raw materials. Information for the seeds of wild species is relatively rare.

The primary chemical constituents of seeds are water, protein, lipids, fibre, and carbohydrates. The general chemical composition of a range of seeds is shown in Table 1.

Essentially, agriculturally important seeds may be divided into three groups: (i) the carbohydrate-rich seeds which are all grasses, (ii) the protein-rich seeds of legumes and (iii) the oil rich group. However some seeds, as soybean and peanut, have relatively large amounts of both protein and lipid.

Table 1. General chemical compostion of seeds
(% by weight)

| Species | Water content | Protein | Fat | Fibre | Carbo-hydrate | Mine-rals |
|---|---|---|---|---|---|---|
| Carbohydrate-rich | | | | | | |
| Corn, (Dent No.1) | 13.0 | 8.9 | 4.0 | 2.0 | 70.8 | 1.3 |
| Japanese millet | 10.2 | 10.6 | 4.9 | 14.6 | 54.7 | 5.0 |
| Oats | 9.8 | 12.0 | 4.6 | 11.0 | 58.6 | 4.0 |
| Rice, (brown) | 12.2 | 9.1 | 2.0 | 1.1 | 74.5 | 1.1 |
| Rye | 10.5 | 12.6 | 1.7 | 2.4 | 70.9 | 1.9 |
| Sorghum, (grain) | 10.4 | 10.8 | 2.8 | 2.3 | 71.7 | 2.0 |
| Wheat, (average all types) | 10.5 | 13.2 | 1.9 | 2.6 | 69.9 | 1.9 |
| Protein-rich | | | | | | |
| Alfalfa | 11.7 | 33.2 | 10.6 | 8.1 | 32.0 | 4.4 |
| Beans, (faba type) | 10.0 | 22.9 | 1.4 | 4.2 | 57.3 | 4.2 |
| Clover, (red) | 12.5 | 32.6 | 7.8 | 9.2 | 31.2 | 6.7 |
| Cowpea | 11.0 | 23.4 | 1.3 | 3.9 | 56.8 | 3.6 |
| Lupin,(sweet,yellow) | 11.1 | 39.8 | 4.9 | 14.0 | 25.7 | 4.5 |
| Pea, (field) | 9.3 | 23.4 | 1.2 | 6.1 | 57.0 | 3.0 |
| Soybean | 10.1 | 37.9 | 18.0 | 5.0 | 24.5 | 4.6 |
| Vetch | 9.3 | 29.6 | 0.8 | 5.7 | 51.5 | 3.1 |
| Oil-rich | | | | | | |
| Cotton seed | 7.3 | 23.1 | 22.9 | 16.9 | 26.3 | 3.5 |
| Linseed | 6.2 | 24.0 | 35.9 | 6.3 | 24.0 | 3.6 |
| Mustard,(yellow) | 4.1 | 23.0 | 38.8 | 5.0 | 23.6 | 5.5 |
| Peanut | 5.4 | 30.4 | 47.7 | 2.5 | 11.7 | 2.3 |
| Rape | 9.5 | 20.4 | 43.6 | 6.6 | 15.7 | 4.2 |
| Safflower | 6.9 | 16.3 | 29.8 | 26.6 | 17.5 | 2.9 |
| Sesame | 8.0 | 22.3 | 42.9 | 10.3 | 10.9 | 5.6 |
| Sunflower | 6.4 | 16.8 | 25.9 | 29.0 | 18.8 | 3.1 |

As well as these main groups of chemical substances many others are found in mature seeds in smaller amounts, e.g. a wide range of metabolic enzymes, tannins, alkaloids, growth regulators and vitamins. All of these compounds are important in the ultimate use of the particular seed species.

## SUGGESTED READING

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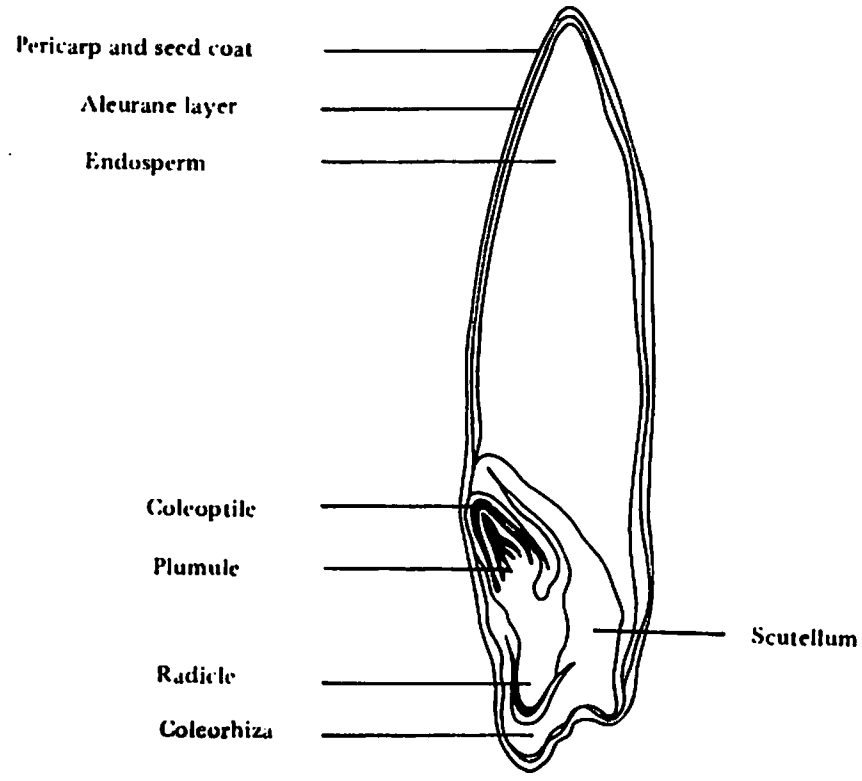



Figure 1. Structure of a wheat seed

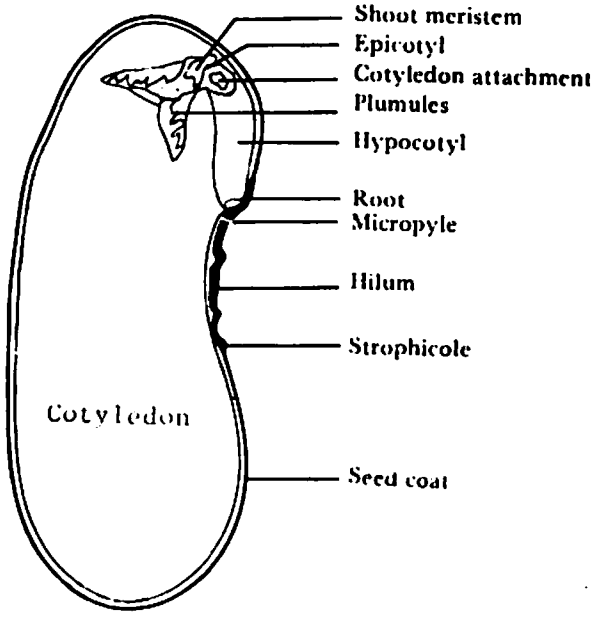



Figure 2. Snap bean seed (Phaseolus vulgaris) showing structures commonly present on legume and other dicotyledonous seeds.

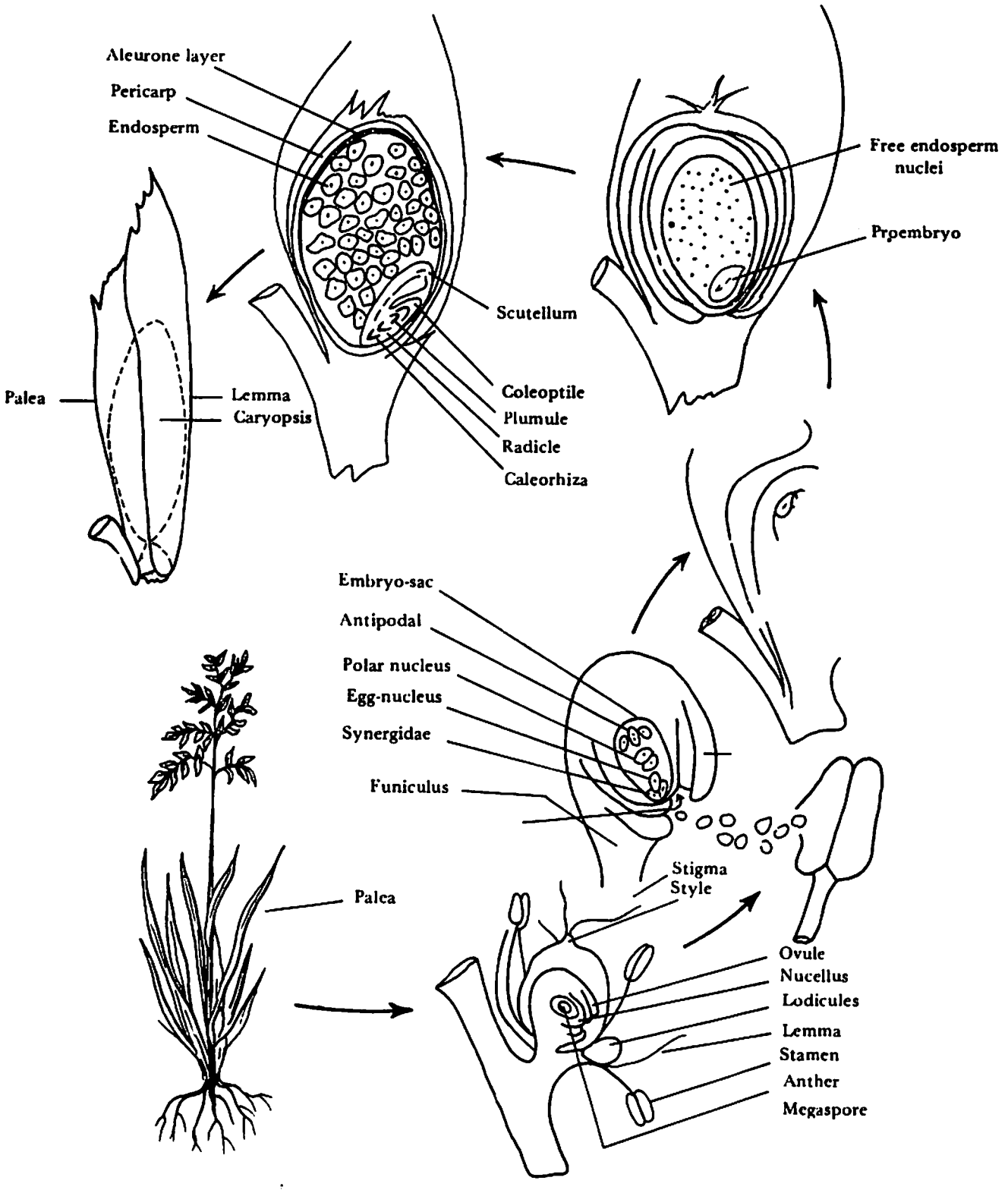



Figure 3. Formation of grass seed.

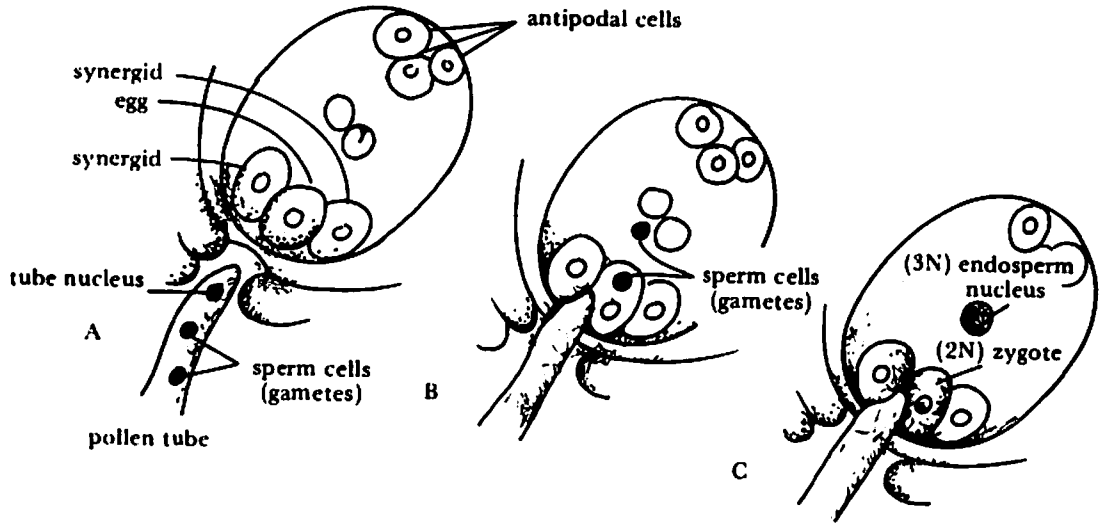



Figure 4. Double fertilization: A, pollen tube with its two sperm cells and tube nucleus approaching the micropyle: B, sperm cells approaching egg and polar nuclei : C, double fertilization has occurred.

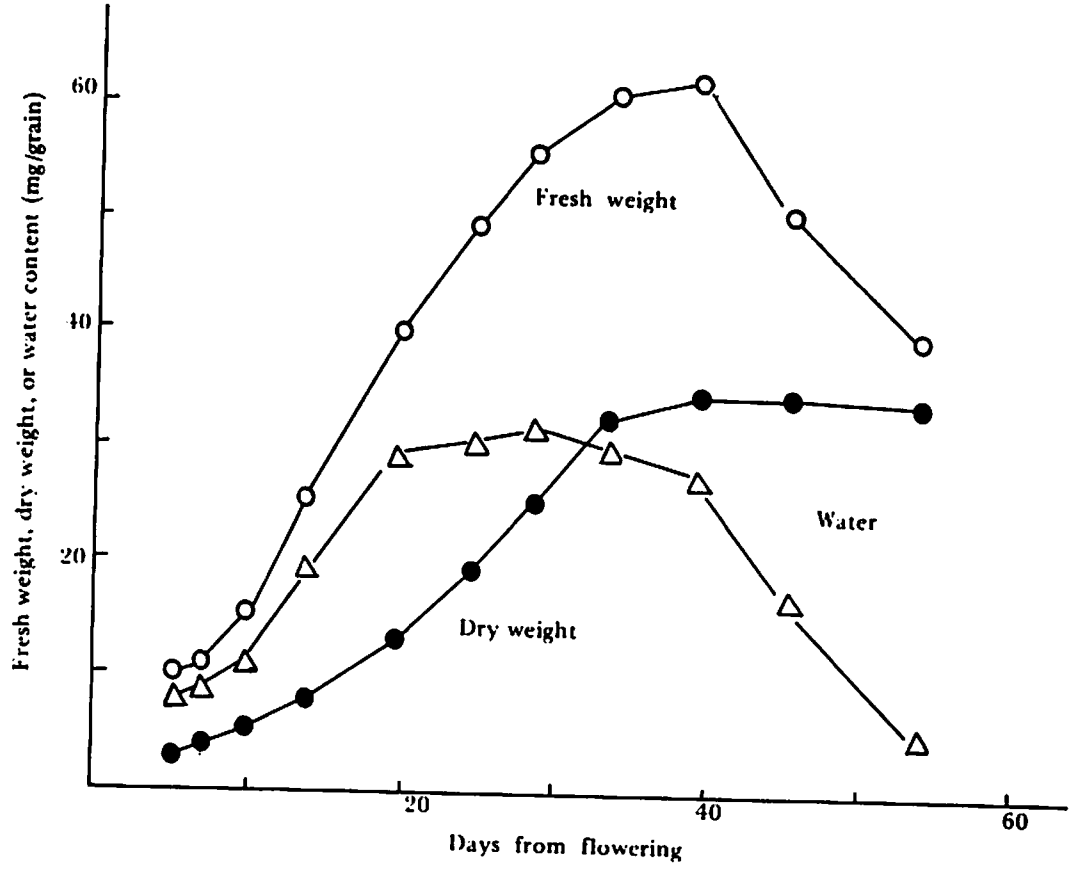



Figure 5. Changes in weight of whole grains and their parts.

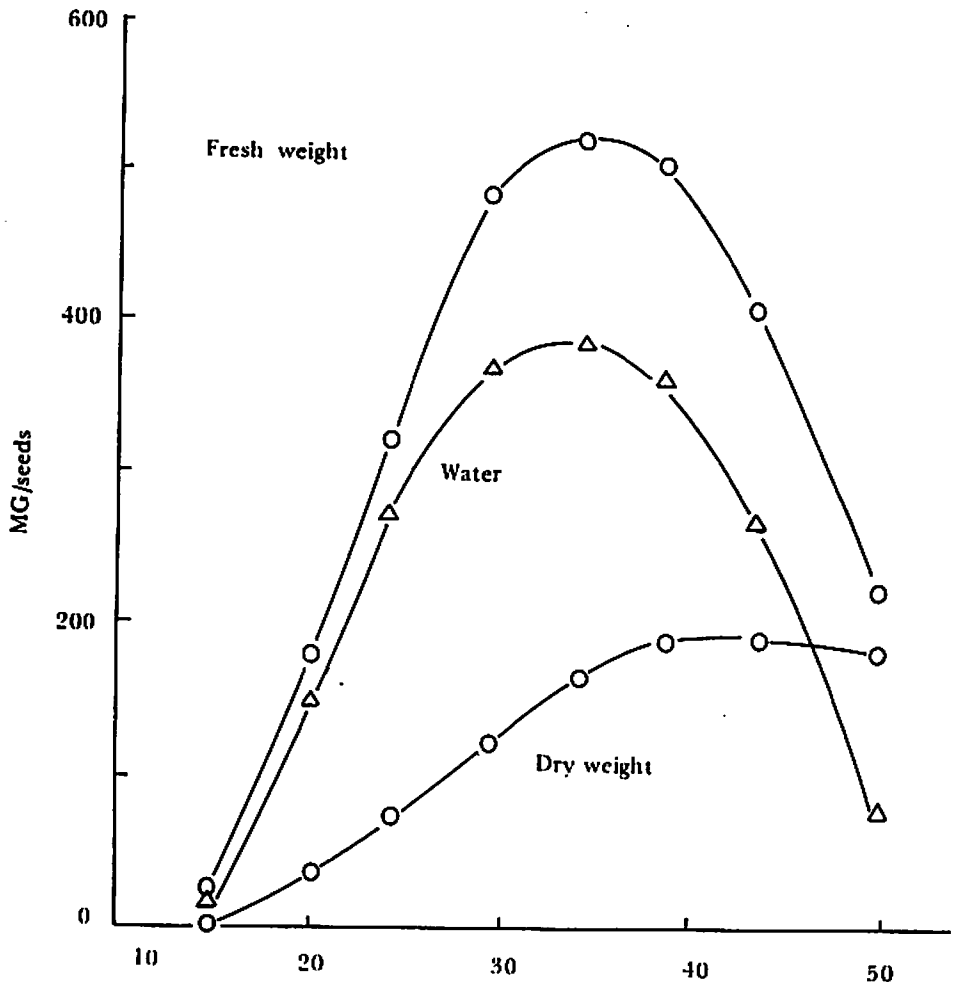



Figure 6. Changes in fresh weight, dry weight and water in PEA seeds during development (Turner, 1969 a)

# SUITABLE AREAS FOR SEED PRODUCTION

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Seed multiplication should be in the most favourable climatic regions° in order to obtian:

- full expression of cultivar characters.
- maximum possible yield,
- and good harvest conditions. Commercial seed production should be localized in relatively dry and cool places.

A crop plant has two distinct phases viz - vegetative and reproductive. When a plant switches from the vegetative to the reproductive phase, veg°etative growth becomes less and may even stop. Change from the vegetative to reproductive phase is dependent primarily on light (duration as well as intensity) and temperature.

However, while considering an area suitable for seed production, the following factors may be considered:

1. Light
2. Temperature
3. Rain fall (total as well as distribution)
4. Wind (direction and velocity)
5. Soil

1. Light:

Plants have been divided into short-day plants (SDP), long-day plants (LDP) and day neutral plants. In SDP and LDP categories, if plants are not grown under correct day-length they remain vegetative and do not flower. Plants grown in temperate regions tend to flower in the long-day while those grown in tropical regions requires a shorter day. Generally, requirements for the day-length is typical of the species but within species, cultivars adapted to different day-lengths have been developed. For example, wheat cultivation is spread throughout the world because cultivars adapted to different day-lengths have been developed.

Light intensity also influences seed production through photosynthesis (e.g. the flag leaf and ear of wheat accounts for the entire photosynthesis responsible for the grain yield), and its effect on drying and ripening of seeds. Therefore, adequate light intensity is necessary for photosynthesis, for pollination and for drying and ripening of seeds.

2. Temperature:

The changeover from the vegetative to the reproductive phase is also influenced by temperature. Temperature influences not only seed germination but crop growth and development also. For example, in the U.S.A. during cotton seed germination, soil temperature falls considerably lower thus giving lower emergence (basis for cool germination test for cotton). Certain varieties of wheat have a chilling requirement and are sown in early winter thus satisfying this requirement at an early stage of growth but appearance of ears

requires relatively warmer temperatures. If these cultivars are sown after the cold weather has passed, the plants remain vegetative and no ears are formed. However, cultivars are also available which do not require chilling temperature°s and can be sown in the warm days of spring.

Temperature influences many other biological processes e.g. pollination, seed setting and ripening are all favoured by warm weather at the appropriate time. For example, 18-19 $^{o}$C for 4-5 weeks has been found to be most suitable for maturity of the wheat seed crop. Too high a temperature may, however, inhibit the development of ovules and fruits and cause shedding of flower buds or young fruits, e.g. in pulses.

3. Rainfall:

Rainfall is important for crop growth, it influences not only the water supply to the crop but also humidity. Flowering, pollination and seed setting require a moderate humidity, but low humidity is required for seed maturity. High humidity encourages the production of diseased seeds. Dry climate°s encourage the production of healthy seeds.

Excessive rainfall leads to a higher incidence of diseases and makes seed harvesting extremely difficult. Excessive rainfall also

- Interferes with pollination,
- may result in delayed maturity,
- may result in pregermination of seed,
- shattering may be due to heavy rain.

4. Wind

Strong winds are undesirable for seed production. they causes damage to the seed crop by lodging, shattering and shedding of seeds. Wind direction influences pollination of the crop.

5. Soil:

Soil should be well drained and fertile. Acidic and alkaline soils should be avoided. In those cases where the spread of disease is both through seed and soil, it should be ensured that the soil is free from pathogens. E.g. Fusarium wilt on many food legumes (e.g. Cicer) is spread from seed to soil, it gets established in the soil through seeds and thus spreads further from the soil.

Some mineral nutrients are known to influence seed quality. Therefore, soil should have an adequate mineral nutrients supply. Trace element deficiencies are usually encountered in soil. Hence care should be taken to choose an area in which soil is not deficient in trace elements. For example, "hollow heart" defect in pea seed is due to the deficiency of boron in the soil.

The soil must also be free from weed seeds. It is much easier to produce seeds on such soils than to control weeds on soils full of weeds.

While selecting the seed plots, therefore, the following points may be considered:

- Soil texture and fertility of the plot should be according to the need of the seed crop.
- The seed plot Should be free from volunteer plants, weed plants and other crop plants .
- The seed plot should be free from soil borne diseases, insect pests and weed seeds.
- Isolation distance must be available.
- The Seed plot must be levelled.

# ASPECTS OF SEED QUALITY CONTROL

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Seed testing started 112 years ago in Germany, 105 years ago in The Netherlands and in other European countries at about the same time. People in developed countries are so accustomed to testing and certification that it is not always realized how much daily effort is put into it and how difficult it was to grow to the present situation. In countires where seed industries are in the establishment or early growth stage, people find that testing and certification are very dependent on all other activities of a seed industry, and will not work until all wheels of the seed industry machine match and turn at the same spead.

The following eight factors are involved in the control of seed quality:

1. Analytical purity (Physical purity, machanical purity)

Farmers do not want seed contaminated with seed of different species, pieces of straw, sand and weed seeds. To be sure that farmers do not get such a mixture, there is a manual test to determine the degree of admixture with foreign material. Hundred percent pure seed is the supreme quality but is not often attained since in most cases cleaning machines are not able to remove everything. The more one wishes to remove contaminants, the more

seed of the crop itself will also be removed. Cleaning is a compromise and when starting a seed industry, cleaning is one of the first and most effective weapons against bad quality. It is not expensive when compared with the benefits obtained from it. The purity test is the test to determine the effectiveness of the cleaning operations which also provides pure seed for a germination test.

The purity test on a small sample in the laboratory determines the percentage by weight of the amount of intact seed of the species named on the label. The impurities are seeds of other crop species, weed seeds and inert matter such as broken seeds, chaff, pieces of leaf, soil particles, etc. The percentages of all components are calculated and their nature is recorded. In the case of seeds, the scientific names are stated.

2. Content of other seed

The degree of admixture with seeds of other spieces is determined by the number count test which gives only seed numbers per unit weight. The test can be used for other crop seeds or weed seeds, or both. The purity test in some cases is not sufficiently precise. The purity test percentage is expressed to the nearest tenth of a percent, which is equivalent to the occurence in the sample of two or three seeds of a size similar to the pure seeds. For example when barley is present as an impurity in wheat, one or two seeds would be noted, but might not be reported as a separate percentage. Furthermore, the sample analysed is so small that significant impurities may be missed altogether. In cereals, the sample is about one thousandth part of the quantity of seed sown on a hectare; so there could be about a thousand barley seeds in this quantity of wheat seed, and yet none might appear in the analysed sample.

Consequently, when it is especially desirable to avoid contamination of one crop species by another of similar type, a larger sample is examined and the number of seeds of the other spieces is counted. The result is then expressed as the number of seeds in the weight of seed examined, e.g. two per kilogram.

The test is also very useful to determine the amount of contamination with weed seeds. Although all farm land already contains weed seeds and some weed seeds in the sowing seed will not be harmful, there are cases where certain seeds should be absolutely avoided e.g. noxious weeds, and very well known examples are wild oats and smothering plants like Orobanche, Cuscuta and Striga. On the other hand, cleavers (Galium aparine) are acceptable at low levels, but may be very harmful at higher levels - they are very competitive, promote lying down of the crop, and the seeds will again be included in the harvested crop.

Weed seeds are best expressed as the number in the weight of seed examined, partly for the same reasons as seeds of other crop species are expressed in this way, and partly because weed seeds differ so much in size that a percentage by weight is meaningless. The very samll seeds of loose silky bentgrass (Apera sipca-venti) for instance will give rise to plants as harmful and tall as wild oat species (Avena fatua, A. sterils, A. Sterilis ssp Ludoviciana) One percent of silky bentgrass in a cereal sample of one kilogram may represent as much as 100,000 seeds, while one percent of wild oats will represent only 500 seeds. What is of importance is not the weight of weed seeds sown in a field, but the number.

3. Cultivar Purity

This quality aspect is best controlled in the field by field inspection and tested in the field in field plot tests, because a cultivar can be identified with more certainty by examination of growing plants, than as dry seed in the laboratory. Cultivar certification schemes have been established in which the mother plants are examined in a general way on the production farm (field inspection). A plot is sown near the laboratory with a sample of the same seed for more careful examination. Cultivar purity determined in this way, however, cannot give the same assurance as a (theoretical) laboratory test carried out on a sample drawn from the actual bags supplied to the farmer. It is therefore supplemented by controlling the source of the seed sown for multiplication.

4. Germination Capacity

This is the percentage by number of pure seeds which produce normal seedlings in a laboratory test; weak or abnormal seeds are ignored. The germination percentage indicates the potential of a seed lot for establishing seedlings in good field conditions. However, in most cases field conditions are not optimal, and even if they are, some seeds will still be attacked by rodents, birds, insects, or will fall on or under a stone or will fail because of competition from weeds. Therefore, most seed lots will not attain the predicted value. However, seed lots with a higher germination capacity will prove to establish more seedlings under suboptimal conditions than those with a lower germination capacity.

Germination capacity is one of the most important features to examine when buying seed. But since the germination test is carried out with pure seed prepared during the purity test, it means that we

are talking about the germination capactiy of the pure seed. Since pure seed is not at all equivalent with the seeds as they are in the bag, the combination of these two, the "pure live seed content" or PLS, is the decisive criterion whether we are dealing with a good or a bad seed lot. In the case of 90% purity and 90% germination, PLS= 90 x 90-100= 81; only this weight of the mass in the bag is capable of producing normal seedlings of the named species. The price paid for seed should especially be calculated as price per unit of PLS, in order to judge which seed is the best buy. Moisture content is another major factor in determining which seed to purchase.

## 5. Vigour

While germination capacity indicates the ability to produce seedlings in good field conditions, vigour indicates its ability to do so in poor conditions. Lots with the same germination capcity may perform quite differently under adverse or suboptimal field conditions especially when dealing with lots of lower germination capacity.

A general rule is that high germination capacity is associated with high vigour and if there is not an appropriate vigour test, it is wise to buy only lots with high germination capacity. Vigour may be influenced by damage to the embryo or to the seed coat during harvesting and processing. Other factors affecting vigour are environment and nutrition of the mother plant, stage of maturity at harvest, seed size, senescence caused by long storage, pathogens, etc. Discrepancies between germination capcity and field performance are not equally important between species; in pulses the phenomena is much more common than in cereals.

6. Moisture Content

This should also be taken into account when buying seed. As seed is mostly traded by weight, moisture content is an indication of the amount of water purchased; one percent more moisture in a lot of 10 tonnes represents 100 kg of water that could have been seeds. During production, moisture content should be kept at a low level at all stages to prevent fungi developing and to limit the growth of insescts.

It is the main factor that determines whether seed will keep its germiantion from harvest to sowing time. The moisture test in itself is simple and can be carried out accurately in the laboratory. In seed stores and during processing, portable moisture meters are available to make quick, on the spot determinations that are reliable enough to take the necessary measures.

7. Health

In certain crops, seed health is an important factor in the control of crop diseases and field establishment. Fortunately not all crop diseases are transferred by the seeds, but if so, they are termed seed-borne diseases. Different diseases produce different effects. For instance, the symptoms of smut and bunt diseases of cereals do not appear until the flowering stage and will then spread the infection throughout the crop. Other diseases however, affect the seedlings at an early stage by limiting their growth or even by killing them, whereafter, the infection will spread and the remaining plants will produce infected seeds. This occurs with many leaf-stripe and rootrot diseasees of cereals. It is clear from the first example, that when seedlings are not showing any sympotoms, they will pass the laboratory germination test. The second group of

diseases may produce abnormal seedlings but the true effect on seedling establishment in the field cannot be sufficiently predicted by the standard germination test.

Seed may also carry viruses e.g. the mosaic or the leaf-stripe viruses which usually do not effect the seedlings but appear at a much later stage and may be infectious a long time before that. They may already have been passed on to other plants many times by insects such as aphids.

Chemical treatment may seem a good solution, but in principle it is only a last resort. It is better to have a good field inspection for diseases, which generally is easier because the symptoms appear on the plants. Any lots showing disease on inspection should be discarded depending on the type and level of disease. It is possible to demonstrate almost any pathogen in the laboratory, although the techniques may become very complicated Pathogenic fungi are often difficult to distinguish from totally innocent saprophytic ones. An academic who is very experienced in pathoglogy and can distinguish between innocent and harmful fungi should have the supervision under all circumstances. If there are no such persons or if continuity is uncertain, seed health testing will do more harm than good. Therefore only in advanced seed industries will laboratory tests be beneficial to agriculture.

## 8. Size and Uniformity of Size

In many species, the smaller seeds are inferior to the larger ones because they produce smaller seedlings that are less competitive, are affected earlier by disease and give smaller yields. In may cases, e.g. cereals, the smaller seeds are often shrivelled because they were immature at harvesting time or were the produce of

diseased plants. All material going through the bottom screens of the cleaning machines should not be sown. Because of climate uncertainties, the certifying authority may prescribe a smaller size of perforations in years where the seed supply may be short. Laboratory sieving machines can be used to check whether a lot meets the standards. The farmer may be interested to know how many seeds he will sow when sowing one kilogram. This is easily estimated from the weight of a thousand seeds.

The importance of uniformity of size increases when going from hand planting, to automatic broadcasting, to automatic planting in rows, and to the ultilmate i.e. precision planting.

ISTA- International Seed Testing Association

It was established in 1924 to improve uniformity of seed tesing in order to facilitate international trade. As with all testing, the results differ with the method applied. Therefore we now have ISTA Rule decribing how to test seed when testing for an international ISTA certificate. The use of ISTA certificates is very widespread especially in international agriculture; the certificate is a type of passport for the seed and a guarantee for banks in the settlement of international payments. At present there are about 60 member countries of ISTA, and the number is increasing annually mainly because developing countries are establishing seed testing stations that fulfill the requirements for becoming an accredited station. There are now some 130 accredited stations that are allowed to issue international certificates. ISTA does not fix standards it only prescribes methods of sampling, sealing and testing when an ISTA certificate is to be issued.

OECD - Organisation for Economic Cooperation and Development

It launched its certification scheme in 1958. There are now 30 member countries and the scheme provides for all the major crop species. Like ISTA, it mainly defines the procedures to be followed and the grade names (pre-basic seed, basic seed, etc.) to be used. When a seed lot has been certified in accordance with OECD's directions it is entitled to an OECD label, which is recognized by the import control authorities of participating countries. Member countries adapt their national certification schemes to comply with OECD directives.

In a seed industry which is establishing itself and when it is not yet an OECD member, it is wise to fllow the OECD procedures as much as possible in order to facilitate a membership in the future; the same is true for the procedures of laboratory tests in relation to an eventual future ISTA membership.

# SEED CERTIFICATION

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Seed production is different from crop production. A seed program is successful if it can make available a sufficient quantity of high quality seed at the required time, at reasonable cost and at the place where it is needed. Better seed companies have systems or schemes of quality evaluation to ensure that the seed they sell to the farming communities is of good quality. Good quality seed means seed that is:

1. High in germination and vigour.
2. Reasonabls pure: genetically and physically.
3. Free from seed borne diseases.
4. Free from insect damage.

The good quality seed can be produced by controlling the seed production. This control is exercised in two ways:

1. Seed multiplication and processing is arranged in such a way so as to avoid or minimize the risk of mechanical or genetic contamination.

2. By fixing minimum standards and checking each seed lot against these standards at a stage in which cultivars can be distinguished. This can be done with reasonable accuracy by examining the plants, at an appropriate stage of crop growth, from which the seed is to be harvested.

To ensure and excercise this control seed certification is necessary. Seed certification is the process designed to secure, maintain and make available high-quality seed and propogating materials of superior crop plant varieties, so grown and distributed as to ensure desirable standards of genetic identity, physical purity and other quality attributes. (Mehta et al. 1972). Certification is performed in five phases.

A. Verification of land requirements;
B. Verification of seed source;
C. Inspection of the seed crop in the field;
D. Inspection and testing of each seed lot and seed sample during processing and bagging; and,
E. Tagging, labelling and sealing to identify the seed.

Inspections are made in the field on the standing seed crops; later inspections and tests are made in the laboratory on representative seed samples collected from seed lots produced from the seed crops which were inspected and approved at the field stage for conformity to prescribed standards.

In many countries seed of only certain kinds and varieties called "notified kinds and varieties" is eligible for certification in the region for which they are notified.

Seed certification is the function of the certification agency. Irrespective of the eligibility of a variety for certification and of the authority to perform certification the principles and procedures involved in certification follow a common pattern.

## WHY INSPECTIONS ARE NECESSARY

The primary objective in conducting field inspections is to confirm that seed produced from a crop grown for seed purpose is of the designated variety, and that it has not been contaminated genetically and or physically beyond certain specified limits.

Genetic contamination of a seed crop is prevented by permitting pollination by pollen from a specific desirable source recognized as the pollinator, and conversely, by preventing pollination by pollen from an undesirable or unrecognized source, through controlled pollination. Physical or mechanical contamination in the field is avoided by preventing admixture during sowing and harvesting. Field inspections ensure that steps necessary to overcome genetic and physical contamination have been taken in time to make them effective.

The objective of field inspection is fulfilled by verifying that the seed crop is:

A. Grown on a field area which satisfies the prescribed land requirements as to previous crop, to prevent contamination by volunteer plants and disease spread by pathogens.

B. Raised from seed whose source is approved.

C. Provided with the prescribed isolation and /or with the prescribed number of border rows in hybrid seed production.

D. Planted in the prescribed ratios of female (seed) and male (pollinator) parents in the case of hybrid seed production.

E. Properly rogued to remove contaminating factors such as plants/ears, objectionalbe weeds, and inseparable other crop plants so as to conform to the standards prescribed for these factors.

F. True to the varietal characteristics descriptive of that variety.

G. Harvested properly to avoid mechanical admixture.

H. Grown in compliance with other special requirements for the crop concerned.

The field observations made for these are compared with a set of prescribed norms for certification which are specific for each crop. The Seed Certification Standards specify the requirements for seed crops as to previous crops, isolation, varietal purity, other crop plants, objectionable weeds and freedom from certain designated deseases. They also specify the requirements for seed lots for physical qualities including pure seed, inert matter, other crop seed, weed seed, and objectionable weed seed, and for germinantion and moisture.

## WHO SHOULD INSPECT WHAT

The authority of an agency to inspect a seed crop depends basically on whether the inspection is for certification under the legislation or is only to assure production of high-quality uncertified seed. If the inspection is for official certification, only the officially notified agency for the concerned region has the authority to perform the inspection. If the inspection is only to ensure high qualitly in uncertified seed, any qualified agency such

as the seed production or contracting agency may make the inspection. If the inspection is for certification under the legislation the seed crop should be of the variety eligible for such certification. If the inspection is only to ensure high quality in uncertified seed any crop recognised by the qualified agency as for seed production can be inspected.

## Eligibility of Crop Varieties for Inspection for Certification

In addition to being of a kind and variety notified for the region concerned, a foundation seed crop must have been grown from breeder seed from an approved source recognized by the certification agency, or from foundation seed which can be clearly traced to breeder seed, and a certified seed crop must have been grown from foundation seed from an approved source recognized by the certification agency, or, if approved by the certificaiton agency, from certified seed, provided the genetic identity and purity will not be significantly altered. These classes must conform to the following descriptions:

A. Breeder Seed:
   Breeder seed is seed or vegetative propagating material directly controlled by the originating or sponsoring plant breeder of the breeding programme or institution and / or seed whose production is personally supervised by a qualified plant breeder and which provides the source for the initial recurring and increase of foundation seed.

B. Foundation seed shall be progeny of breeder seed or foundation seed which can be clearly traced to breeder seed. Production shall be supervised and approved by the certification agency; it shall be so handled as to maintain specific genetic identity

and purity and shall conform to certification standards specified for the crop being certified.

C.1. Certified seed shall be the progeny of foundation seed; its production shall be so handled as to maintain specific genetic identity and purity according to standards specified for the crop being certified.

2. Certified seed may be the progeny of certified seed, provided this reproduction does not exceed two generations beyond foundation seed, and provided further that it is determined by the certification agency that genetic identity and purity will not be significatly altered. However in the case of highly self-pollinated crops certification of one further generation may be permitted. Certified seed produced from certified seed shall not be elilgible for further seed increase under certification, except in the case of highly self-pollinated crops where certification of one further generation may be permitted. Certification tags for certified seed not eligible for further certified seed increase shall carry the words, "Not eligible for further seed increase under certification" (Menta et al. 1972). However, deviation from this may be made so long as the genetic identity and purity is maintained.

## When to make inspections

Verification of all factors affecting seed quality in the field may not normally be possible or necessary in a single inspection, since, all factors in the field may not be apparent or may not occur at the same time, or all of them may not be capable of affecting seed quality at a particular stage of crop growth. Hence, more than one inspection, phased to cover all the important stages of crop growth, are required in most crops. The number of inspections and the stages

of crop growth at which they should be conducted vary from crop to crop, depending on the crop's duration, nature of pollination, susceptibility to contamination, disease susceptible stage (s), nature of the contaminating factor (s), etc.

For convenience, the stage of crop growth at which inspections are generally made in sexually-propagated species are classified as follows:

A. Pre-flowering stage:

The entire period preceding flowering is obviously the preflowering stage. However, for inspections, this includes seedling stage, vegetative stage, flower bud initiation stage, and all such growth phases prior to emergence of the panicle or inflorescence. In Graminaeceous crops this stage extends upto the time of emergence of flag leaf.

B. Flowering stage:

In this phase, the flowers or spikelets of the inflorescence or panicle have opened, the stigma is receptive, and the anther is shedding pollen.

C. Post-flowering stage:

In this stage, the receptivity of the stigma and the pollen-shedding of the anthers have ended, and the fertilized ovule starts to develop into a seed. This includes both the milk stage, when the contents of the fertilized ovule are in the form of a white milky fluid and the dough stage,when the seed contents are being transformed into a more solid, pasty substance which yields to pressure.

D. Pre-harest stage:

In this phase, the seed becomes harder and reaches or approaches physiological maturity. The seed is fully formed, but is high

in moisture content.

E. Harvest stage:

In this phase the seed is physiologically mature and is sufficiently dry to permit safe and easy harveting and threshing, or is physiologically mature and can be dried for relatively safe storage. The crop is ready for harvest.

In vegetatively or sexually -propagated crops such as potato, stages such as pre-flowering, flowering and post-flowering may not be relevant. Instead, they are classified as sprouting, seedling, tuberisation, tuberhardening and haulm-cutting or de-haulming stages. In root and bulb crops the enlarged-root or bulb-formation stage preceded pre-flowering; lifting and replanting are done after complete root-formation. In these crops, inspection at lifting and re-planting is essential.

In cross-pollinated crops, inspections during flowering are essential to verify freedom from genetic contamination; in self-pollinated crops, inspections during flowering are helpful in distinguishing offtypes by plant characters.

If inspections of loose-smut-susceptible wheats and cross-pollinated crops in the flowering stage are to be most effective, they must be made without prior intimation to the seed grower. With the self-pollinated crops (except loose-smut-susceptible wheats), vegetatively-propagated crops, and for lifting and re-planting inspections in root and bulb crops, advance intimation helps to reduce the number of inspections required, so advance intimation could be made, except when loose-smut-susceptible wheats are to be inspected. Advance intimation is helpful before re-inspections are made to confirm removal of contaminating factors for which removals is allowed.

## Observations during inspections

Factors to be observed during field inspections vary among crops and among stages of crop growth. In general, sources of genetic and physical contamination must be observed and the degree of occurance estimated. Genetic contamination is common in cross pollinated crop species.

Sources of physical contamination are seed from plants of other varieties of the same crop species, plants of other kinds, weed plants, and plants/heads with seed carrying disease-causing pathogens. Seed of other varieties/kinds may occur physically mixed with the crop seed without altering the genotype of the crop seed. This type of contamination is common in both self and cross-pollinated crops. While genetic contamination cannot be rectified without tedious repurification over several generations, rectifying physical contamination is often easier, since it may be possible to separate and remove the contaminating seed mechanically.

Sources of both genetic and physical contamination can usually be detected in the field, but only the physical contamination can sometimes be detected after it has taken place. Such sources of contamination can be present either within or outside the seed field, but close enough to cross-pollinate or cause mechanical admixture with crop plants in the seed field. Their ability to cause contamination decreases as their distance from the seed field increases. After a certain distance, their presence may cease to cause any significant contamination of the seed crop. This distance is called the isolation distance, and is specific for each crop species. Prevention of genetic contamination is the reason for isolation cross-pollinated crops and prevention of physical contamination is the reason for isolating vegetatively-propagated and

self-pollinated crops. Loose smut infection in wheat is also minimized by providing adequate isolation. To ensure that the seed crop is not contaminated, it is necessary to look for sources of contamination both in the seed field and within the specified isolation distance on all sides of the seed field.

Sources of contamination can be broadly classified into one of the following specific categories (for self-pollinated crops):

A. Offtype:

Plant of the same crop species as the seed crop but deviating from the seed crop in the expression of morphological characteristics.

To designate a plant as an offtype, it is not necessary to identify it definitely as of another variety. However, plants identified as of a different variety are also included under offtypes.

B. Inseparable other crop plants:

Inseparable other crop plants are plants of cultivated crops found in the seed field, and whose seed are so similar to the crop seed that it is difficult to separate them economically by mechanical means.

C. Objectionable weed plants:

These are plants of weed species which are harmful.

D. Diseases:

Plant diseases are caused by fungi, bacteria, viruses, or nematodes and may become pronounced under nutritional deficiencies. Seed is known to be partly or wholly responsible for transmitting the disease-causing pathogens of some diseases from one generation to another. Seed may carry the pathogen either internally (internally seed-borne) or externally (externally seed-borne) or by both means. Although economical and effective measures for prevention and or control of seed-borne infection are available for some such diseases, practical and effective measures are not available to prevent seed-tranmission of some disease-causing pathogens. In such cases, an effective method to prevent seed-transmission of the pathogen is to ensure that seed possibly carrying disease-causing pathogens is not mixed with disease-free seed. This can be done by eliminating from seed fields all plants whose seed is suspected to carry pathogens.

Taking field counts

Examining all plants in the field is not possible. Therefore, a random method should be followed. The number of counts taken and the method of taking counts varies form crop to crop. For example, for all crops, 5 counts may be taken up to an area of 5 acres and an

additional count is taken for each additional 5 acres. For, wheat and barley 1000 heads per count may be examined for each factor (see earlier description on observations during inspection) considered in the field inspection. After entering the field at a randomly selected site, the average number of heads or plants in a row per step may be counted and number of steps required to include 1000 heads (for wheat or barley ) or 500 plants (for Cicer) is determined. Then one row may be selected randomly and from any point in that row enough consecutive steps may be taken to include 100 heads or plants or ten consecutive steps may be taken in that row and number of off-types etc, may be counted. Then pre-determined number of rows (say 3) may be crossed over and the same number of consecutive steps in that row from a point approximately parallel to the last step counted in the previous row may be made. Count is taken and the process may be repeated as many times as required to include 1000 heads. This completes one count. An example of minimum seed certification standard for wheat and barlely is given in annexure 1.

Minimum seed certification standard for wheat and barley:

Land requirements: A crop of barley or wheat shall not be eligible for certification if planted on land on which the same kind of crop was grown in the previous season unless the crop in the previous season was of the same variety and was approved by the certification agency to have certifiable standards of variety purity.

Field inspection: A minimum of two inspections shall be made from flowering until it is ready for harvest.

Field standards:

A. General requirements:

1. Isolation:

(a) 3 meters shall be provided all around a seed field to seperate it from fields of other varieties and fields of the same variety not conforming to varietal purity requirements for certification.

(b) In addition to an isolation of 3 mts., seed fields of wheat varieties susceptible to loose sumt (Ustilago tritici) shall not have within 150 mts. any wheat field with infection by loose smut disease in excess of 0.10% in the case of foundation seed production and 0.50% in the case of certified seed production.

B. Specific requirements:

| Factor | Foundation certified | Maximum permitted (%)* |
|---|---|---|
| Off-types (ear heads) | 0.050 | 0.30 |
| Inseperable other crop plants | 0.010 | 0.050 |
| Objectionalbe weed plants | 0.010 | 0.020 |
| Plants affected by seed-borne diseases | 0.10 | 0.50 |

* Standards for off-types, inseperable other crops and objectionable weeds should be met at the final inspection and those for loose smut of wheat should be met at any inspection conducted between commencement of flowering and harvest.

C. Seed Standards

| factor | Standard for each class | |
|---|---|---|
| | Foundation | Certified |
| Pure seed (minimum) | 98.0% | 98.0% |
| Inert matter (maximum) | 2.0% | 2.0% |
| Other crop seeds (maximum) | 10/kg | 0.10% |
| Total weed seeds (maximum) | 10/kg | 0.10% |
| Objectional be weed seed (maximum) | 2/kg | 5/kg |
| Germination (maximum) | 85.0% | 85.0% |

Acknowledgement:

Most of the material presented in this paper is taken from the book entitled "Field Inspection Manual" by Y.R Menta et al. (1972) published by the National Seeds Cooperation Ltd., USAID and the ROCKEFELLER foundation, New Delhi, India.

# CULTURAL PRACTICES FOR CEREAL SEED PRODUCTION

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In a Breeding program a new selection which has proven to be superior after two years for disease, yield and adaptabilitly for a region or regions, should immediately go under increase for possible release. By this time it will be $F_6$ or $F_7$ and relatively stable genetically. Head selections should be made during the third year of trials from seed increase blocks of the third year trials. At least 1000 heads should be selected for plant row increase to produce breeders seed. By now three years of data are available and a decision should be made to begin head row increase. When this seed has been produced, at least four years of yield data, five or six years of desease information, and two or more years of quality evaluation will be available. The decision should be made then whether to proceed with variety release and final seed increase. Once this decision has been made, every effort should be pushed for maximum increase of the breeders seed to get the variety to farmer production as soon as possible. The value of a breeding program is not realilzed until the improved variety is in production. This can only be accomplished by an aggresive evaluation program of prospective selections and a vigorous seed increase program.

High quality pure seed production is the result of proper techniques in all phases of the production. The agronomy of the production will determine the purity and quality of the seed delivered to the processing plant. The processing plant can only

upgrade the seed it receives by removing foreign material and sizing the seed; it is difficult to remove admixtures of varieties and 100 % of all weed seeds.

## Land selection for seed multiplication

Seed should be produced on well selected land that is free of volunteer cereal of the same class. The earlier the generations, the more care should be exercised in the selection of the land. For breeders seed, only a limited area is needed. This land must be as weed and volunteer free as possible. Only high production land in a good rainfall area should be selected.

If irrigation is available, the production of the first generation seed will be insured against drought, and maximum increase is possible. Areas of climatic hazards of frost, hail and drought or flooding should be avoided for initial increases.

The previous cropping history is valuable in the land selection. Wheat should be planted after one year of clean fallow or following dry legume, vegetable or industrial crop. Land irrigation, following alfalfa, that has been in production three or more years, is ideal. For seed production, wheat should not follow a forage crop of vetch and oats or another cereal crop.

The quantity of land for seed production increases with each generation. Obviously, the more land that is needed, the more difficult it is to maintain high standards of land selection. If land is available that meets the standards of rotation and freedom from volunteer, the next criterion must be on weed problems. Fields with noxious perennial weeds should be avoided , especially if seed

produced by these weeds is difficult to remove by processing. Land heavily infested with wild oats and grassy weeds causes difficulty in rogueing short statured varieties and reduces yields. Fields with a history of wild oats must be rejected for the increase of basic and registered cereal seed. Fields selected for later generation should avoid weed problems as much as possible and herbicides must be availble for the control of wild oats and other grassy weeds as well as for broad leaf weeds in cereal production.

Experiment stations should be used for seed production only if the land and climatic conditions meet seed production standards. If experiment station land is used to produc seed, then the land must be rotated and managed for seed production. Seed multiplication is as important as the breeding programs and is not something an experiment station does without proper planning. The multiplication of breeders and basic seed should be under the control and supervision of the breeding and increase staff, but it does not have to be on the experiment station. Too often cereals are multiplied in the early generations on land that does not meet the standards for maximum increase of breeders and basic seed.

Table 1: Effect of seeding rate and row spacing on Anza wheat, Khroub Station 1975-76.*

| | Seeding rate Kg/ha | Row spacing cm | Emergence Plants per $m^2$ | Heads per $m^2$ | Caculated tillers per plant | Yield kg/ha | Yield in kg. per 100 kg. seeded |
|---|---|---|---|---|---|---|---|
| | 120 | 17.5 | 258 | 624 | 2.4 | 55 43 | 46 19 |
| | 80 | 17.5 | 172 | 562 | 3.3 | 53 93 | 67 37 |
| | 40 | 17.5 | 86 | 453 | 5.3 | 46 83 | 117 08 |
| CV% | | | 2.6 | 6 | - | 3 5 | |
| LSD 05 | | | 8.26 | 30.8 | - | 4 30 | |
| | 100 | 17.5 | 236 | 590 | 2.5 | 51 52 | 51 52 |
| | 50 | 35.0 | 115 | 391 | 3.4 | 42 67 | 85 34 |
| | 33 | 52.5 | 80 | 325 | 4.1 | 35 62 | 105 94 |
| CV% | | | 7.8 | 9.3 | | 8 5 | |
| LSD 05 | | | 30.8 | 72 | | 6 41 | |

* Annual Report, IDGC, Algeria 1975-76

The yield was decreased about 10% (51.52 to 46.83) when the seeding rate was decreased from 100 kg/ha at the same row spacing of 17.5 cm. Since the seeding date of January 5, 1976 was about one month late, tillering was reduced and the yield decrease was more than might be expected at an earlier seeding date. Increased row spacing with the same density withing the row had more effect on the yield, yet the seed increase per kg of seed seeded was greater when ever the seeding rate was decreased regardless of the row spacing.

Decreasing the seeding rate appears to be the best method of increasing multiplication of a given quantity of seed.

Table 2: Effect of plant density on yield of five varieties at five different seeding rates. Tel Hadya 1980-81, (Unpublished Data W. Anderson. ICARDA).

| Variety | Seedin Rate kg/ha | Yiel kg/ha | Ratio yield/kg seed |
|---|---|---|---|
| | 16 | 3034 | 190 |
| | 26 | 4030 | 155 |
| Veery"s" | 65 | 6863 | 75 |
| | 126 | 4154 | 33 |
| | 191 | 4032 | 21 |
| | 17 | 3093 | 182 |
| | 29 | 3957 | 136 |
| Alondra"s" | 73 | 3664 | 50 |
| | 144 | 3979 | 28 |
| | 214 | 3259 | 15 |
| | 18 | 4067 | 226 |
| | 31 | 3957 | 128 |
| Con dor"s" | 66 | 4579 | 69 |
| | 177 | 4175 | 36 |
| | 205 | 4211 | 21 |
| | 19 | 3934 | 207 |
| | 29 | 4054 | 140 |
| Buck buck"s" | 64 | 4076 | 64 |
| | 119 | 3919 | 33 |
| | 185 | 3299 | 18 |
| | 13 | 3238 | 249 |
| | 24 | 4731 | 197 |
| Jup "cross" | 46 | 4105 | 89 |
| | 84 | 4482 | 53 |
| | 135 | 3939 | 28 |
| | 17 | 3437 | 204 |
| | 28 | 4146 | 148 |
| Ave 5 Varieties | 63 | 4258 | 68 |
| | 118 | 4142 | 35 |
| | 186 | 3728 | 20 |

Special management for seed multiplicaiton

Seedbed preparation, fertilizing, and weed control practices are the same seed production as for maximum cereal production. A weed prepared seedbed free of weeds and germinating seeds is requird. Seeding should be timely and all other operations of fertilizing, herbicide applicaitons, rogueing and harvest must be timely and with welll adjustesd equipment.

Seeding rate and row spacing are an important managment practice in seed multiplication. The rapid increase of early generations can reduce the time necessary to produce the volume of seed necessary for commercial production. In the production of breeders, basic and certified seed, maximum multiplication from the limlited seed supply is more important than maximum yield per hectare. THe seed should be planted at a rate and in amanner that will give meximum multiplication per unit of seed available. Decreasing seeding rate is the most practical way of increasing early generation multiplicaiton on both dry land and irrigated production.

In 1976, a row spacing and seeding rate experiment at El Khroub, Algeria, studied the effect of reducing rate and increasing row spacing to seed multiplication in the early generations. Seeding rates of 40, 80, 120 kg/ha at 17.5 cm row spaicng, and 33, 50 and 100 kg/ha at row spacings of 51.5, 35, and 17.5 cm respectively were studied. In one experriment the row spacing remained the same but seed density within the row varied. In the other experriment, the row spacing varied but the seed ensity within the row remained the same. Rainfall was adequate for maximum production. A fertilizer application of 100kg/ha of nitrogen was applied in two equal applications at seeding and tillering. Phosphate was applied with the seed at seeding at the rate of 45 kg/ha. The results are given in Table 1.

In Table the effect of five seed densities on five varieties are given for a trial at Tle Hadya in 1980-81. Actual seeding rate in kg/ha varied for each variety at each density but the same numbre of viable seed were planted at each density. All other production factors remained the same for all varieties. The seeding rates were calculated from the actual counts perr $m^2$ by converting from seed weight per 1000 kernels and assuming 80 percent germination.

The data in Table 2 show that seeding rates below 20 kg/ha are even more effective for maximum seed increase than the data in Table 1. More research on row spacing combined with low seed rates need to be conducted to find the optimum combination for production of basic seed.

By taking advantage of cereals, (especially wheat with the relatively small seed size), ability to y ield high at low seeding rates, very rapid increase is possible. This was demonstrated when the variety Gaines was released in U.S. in 1960. Over two years, 1.36 tons of seed was increased to 15,000 tons with two crops. THis is a ratio of increase of 11,000 to 1 in two cycles.

For rapid increase the following is recommended:

1. Increase the number of head rows and spacing between rows to double the breeders seed available.
2. Increase the breeders seed at the seeding rate of 20 kg per hectare under high production conditions as possible.
3. Increase the basic seed at 40 kg/ha also under good management in as high productions conditions as possible.
4. Provide for blank rows to facilitate rogueing, application of herbicides and top dressing of fertilizer. If the rows blanked out match the tractor tread and are wide enough for the tractor tires, these operations will cause minimum damage to the cereal crop.

A comparison of increasing seed at 100 kg/ha to using lower rates suggestesd by Table 1 and 2 are given in Table 3.

Table 3: Estimated seed increase comparing normal seeding rates with reduce rates with similiar production potential.

| Generation | Quantity of Seed Q | Seeding Rate | Area Seede (ha) | % Area increase | Est,yield Q/ha | Yield |
|---|---|---|---|---|---|---|
| Breeders Seed | - | - | - | - | - | 1 |
| Basic Seed | 1 | 100 | 1 | 0 | 40 | 40 |
| Registered Seed | 40 | 100 | 40 | 0 | 35 | 1400 |
| Breeders Seed | - | - | - | - | - | 2 |
| Basic Seed | 2 | 20 | 10 | 1000 | 30 | 300 |
| Registered Seed | 300 | 40 | 750 | 1875 | 30 | 22,500 |

By increasing breeders seed 100 percent and then decreasing seeding rates, about 16 times as much seed could be produced at conservative yield estimates for the production at the lower seeding rates. The exact yields could vary but the ratio of increase would approximate the above illustration based on the data in Tables 1 and 2 and also by actual records of seed increase of new varieties.

The purity of seed produced decreases with each generation of seed increase through mechanical and volunteer mixtures. If the number of generations needed to multiply the seed for commercial production is decreased, the purity of the seed will be better when it goes into commercial production.

The multiplication of seed of an improved variety is perhaps the most important part of teh variety development program. It is only suceessful when it involves caul land selection suitable for seed production. The loss of an early generation seed source due to faulty land selection will delay the increaes by one to two years. The selection of these early generation increase sites must avoid all possible hazards that can be controlled to insure against the loss of the early generation. It is important that all possible means are employed to get the maximum seed increase in the first two or three generations increase. No compromise can be tolerated in the selectio n of the land, land preparaton, seeding methods, fertilizing and spraying operations. Doing so, only reduces the rate of seed multiplication, delays the benefits to the country of the new improved variety and can result in complete loss of a valuable seed source.

A multiplication program that rapidly increased new improved varieties and maintains reserve stocks of recommended varieties will help stabilize and improve production. It is especially important to have reserve stocks of early varieties that can be used to fill the need when weather conditions make late seeding necessary. A good seed production program helps stabilize production by rapid increase of new varieties and a reserve stock of good seed of older recommended varieties.

# TECHNIQUES OF SEED PRODUCTION IN LENTIL

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## Introduction

Lentil (Lens culinaris Med.) is an annual self-pollinated legume which is grown throughout the Mediterranean and West Asian region. The crop is still under-exploited, and breeding efforts in the region have resulted in the release of only a handful of cultivars all of which are selections from local populations or land races. Thus, most of the lentil area is sown with land races, each of which contains considerable variability maintained in a mixture of pure lines, since the rate of outcrossing does not exceed one percent (Wilson and Law. 1972). The released varieties in the region include Giza 9 (ILL 784) from Egypt and the Kislik series from Ankara: Pull 11, Yesil 21, Yesil 31 and Kirizi 51. Lentil improvement is now receiving more attention in national breeding programmes and at ICARDA, and as a consequence improved varieties will become available. However, at present, there is a lack of information on seed production and certification in the crop. Seed for certification is tested in the laboratory and also grown in the field for inspection.

## Laboratory Tests

The laboratory tests establish the composition of a sample for purity, test its validity with a known standard and measure its viability through germination, moisture and seed health tests.

### 1. Sample Composition:

Seed may be defined as a seed if it is more than half the original size with testa attached. Decorticated and or split seed are common impurities of roughly threshed lentils. Seeds damaged by weevils (Bruchus spp. and Callosobruchus spp. (Hariri, 1981) are also considered impurities.

Other impurities include seeds of weeds and other crops, and inert matter. Standards for these factors are given in Table 1 (P.K. Agrawal, personal communication). Amongst these impurities some legume weeds pose a particular problem in lentils, because of their similarity in seed characters. For example a variety Chilean in Washington State, U.S.A. become so infested with Vicia sativa seed, that it was withdrawn; and thereafter the indentical but cleaned seed of Chilean '78 was released.

### 2. Sample validity:

Validity is measured by comparison with a description or pure seed. The following characters may be used to test validity .

a). Seed weight (g.) of 1000 random seeds

b). Background colour of seed testa (green, pink, brown , grey or black) (All colour characters should be examined in day-light.)

c). Pattern on testa (absent, dotted, spotted, marbled, or complex)
d). Colour of pattern on testa (olive-green, grey, brown, or black),
e). Cotyledon colour (red, yellow or green (Turns yellow with age). Destructive sampling by removal of testa to seed cotyledon colour.

A minimum of 98% of seed must conform to type for both foundation and certified seed.

3. Seed Viability:

Germination tests on lentil should be done at $20^{0}$c between paper after pre-chilling to $2^{0}$C with first count of germination after 5 days and final count after 10 days. A minimum of four batches of 100 seeds are required for germination tests. For seed health either the blotter method or agar plate method may be used (Anon., 1076 a and b). Moisture tests may also be run (Anon., 1976 a and b).

Field Test

The crop should not be eligible for certification if is planted on land where the same species was grown within the previous two seasons unless the crop was grown from certified seed of the same variety. It is also important sites with a previous history of orobanche infestation be avoided. Two parcels of land in separate fields are preferable to one area in case of crop failure. An isolation distance of 10 metres for certified seed and 20 metres for foundation seed should be left around the plot from fields of other

varieties. Sowing should be in rows at local crop density. Inoculation of the seed with Rhizobium may be necessary in some cases. At flowering a contact insecticide like Endosulphan or Methidathion should be applied regularly to control Bruchus spp. The appropriate control measures for other pests and diseases should also be taken. Strict control of broomrape (Orobanche Spp) by hand pulling of the inflorescences prior to seed setting should be undertaken whenever necessary.

Inspection of the field should be made at or after flowering. A minimum of two inspections should be done. Characters which may be used during field inspections are:

a). Anthocyanin pigmentation of stem, leaf and pod (presence/absence)
b). Leaf pubescence (presence/absence)
c). Colour of flower standard (white, white with blue veins, blue, violet, pink, or rose)
d). Plant hieght (cm)
e). Time to first flower (days)
f). Size of the Leaflets as observed at flowering.

The maximum off-type content allowed in a sample is 0.10 per cent for foundation seed and 0.20 percent for certified seed.

Table 1: Seed standards (Agrawal, personal communication).

| Factor | Standards for each class (%) | |
|---|---|---|
| | Foundation | Certified |
| Pure seed (minimum) | 98.0 | 98.0 |
| Inert matter (maximum) | 2.0 | 2.0 |
| Other crop seeds (maximum) | 0.10 | 0.20 |
| Weed seeds (maximum) | 0.10 | 0.20 |
| Germination including hard seeds (minimum) | 75 | 75 |
| Moisture (maximum) | 9.0 | 9.0 |

If a sample meets the above requirements in both laboratory and field tests it may be stated that the name given by the sender does not seem incorrect, and the seed may be certified.

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# PRINCIPLES AND TECHNIQUES FOR SEED PRODUCTION IN CHICKPEA

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## Introduction

Chickpea (Cicer arietinum L.) is a self-pollinated annual species. Natural cross-pollination has been reported to be below 2 % (Gowda, 1981). It is widely grown in the Indian sub-continent, the Mediterranean region, Ethiopia, and Mexico. Efforts are underway to make it more popular in north America, Australia, and parts of east Europe and south America.

In recent years the research effort on breeding for the development of improved cultivars has been increased substantially. Many countries, which have not yet produced improved cultivars, are at a stage to release them. The impact of these cultivars on production will greatly depend on the seed industry. Unfortunately, the seed industry for chickpea has been developed only in a few countries, such as India, Pakistan, Iran, Egypt, and Mexico. Therefore, this paper aims at the development of norms that may be helpful in setting up seed industries in various countries of the region.

## Development and Release of Cultilvars

It is not intended to discuss in detail about the development of improved cultivars. But it would be appropriate to mention here at least how cultivars in chickpeas are usually developed: (i) through introduction of finished or segregating materials followed by pure line selection and (ii) through hybridization followed by pedigree, bulk or backcross methods of selection.

Once a range of pure lines are developed, they are evaluated for a number of years in areas of adaptation. If a new line is found superior to standard cultivars in grain yield or quality or disease resistance or any other important traits, it is released for cultiviation. Thereafter the seed production agency can play an important role in popularizing the cultivar and increasing the production.

As mentioned earlier, the seed production industry for chickpea in west Asia and Northe Africa is highly under developed. The introduction of high yielding, Ascochyta blight resisitant, cold tolerant, and widely adapted cultivars, such as ILC 482 and ILC 484, from ICARDA for winter sowing provides an excellant opportunity to develop the seed industry in these regions. These cultivars are capable of producing a minimum of 50 percent more yield than the best local spring sown cultivar. Thus they can act as a catalyst for the development of a chickpea seed industry.

## Identification of Cultivars

Two types of chickpea, viz. desi (small size, angular and coloured seed) and kabuli (large size, ram-shaped and beige coloured) are grown in the world. Generally the chickpea plant is the semi-erect and bushy type. It is relatively easy to differentiate between desi and kabuli types but it is often difficult within a given type to differnetiate from one cultivar to another. Nevertheless, there are certain criteria which could be helpful in identifying the cultivars. It is, therefore, suggested that detailed records of various characters may be documented at the time of release of a cultivar. Some of the important characters are mentioned below.

1. Morpho-agronomic characters:

(a) Plant type: erect, semi-erect, semi-spreading and spreading
(b) stem: colour, thickness
(c) Leaf: colour, size (large, medium, small)
(d) Branches: number of primary, secondary and tertiary branches per plant.
(e) Plant height: in centimeters; and tall, mid-tall and conventional type.
(f) Flower: days to 50 % flowering, colour, and size
(g) Maturity: number of days to mature
(h) Pod: number/plant, number of seeds/pod and size
(i) Seed: 100-seed weight, roughness, shape, and colour
(j) Any marker gene: for example simple leaf.

2. Resistance/tolerance to stress characters

(a) Diseases: They may be rated on a 1-9 scale for major diseases, such as Fusarium wilt, Botritis blight, rust, pea leaf role virus (stunt virus), and various types of root-rot diseases.

(b) Insect-pest: These may also be rated on a 1-9 scale for major insect-pests, such as pod borer and leaf miner.

(c) Thermosensitivity: For cold and heat

(d) Photosensitivity: Sensitive and reduced sensitivity

(e) Drought: Tolerant or susceptible

(f) Salinity: Tolerant or susceptible

(g) Any other character.

3. Quality characters

(a) Protein content in percentage

(b) Other characters depending upon the facility; such as,

  (i) Amino acids-methionine, tryptophane, and lysine

  (ii) Cooking time

  (iii) Suitability for the preparation of Hommos-bi-tehineh, for parching and roasting, for flour etc.

Classes of Pure Seed

Generally, three classes of pure seed are recognized, (1) breeder seed, (2) foundation seed, and (3) certified seed. Hayes et al. (1955) have described them as:

(1) Breeder seed: Breeder seed is seed which is directly controlled

by the originating or in certain cases sponsoring plant breeder institution and which provides for the initial and recurring increase of foundation seed."

(2) Foundation seed: Foundation seed shall be seed stocks that are so handled as to most nearly maintain specific genetic identity and purity, and that may be designated or distributed by an agricultural experiment station. Production must be carefully supervized or approved by representatives of an agricultural experiment station. Foundation seed shall be a source of all other certified seed classes.

(3) Certified seed: Certified seed shall be the progeny of foundation or certified seed that is so handled as to maintain satisfactory genetic identity and purity and that has been approved or certified by certifying agency.

## Purification of Breeders Seeds

Often the seed of a cultivar becomes impure to some extent due to natural outcrossing or mechanical mixture or mutation etc. This necessitates purification of the cultivars from time to time. The method commonly followed is described below.

Approximately 2500 seeds are sown in a bulk plot providing enough space between and within rows (45 x 20 cm ) so that observatins on individual plants can be taken up. Five hundred phenotypically similar plants are chosen with the characteristics described for the cultivar at the time of release. The plant-rows are sown the following year and detailed observations are recorded on each of them. Any progeny that differs from the original description is rejected. The seed from each progeny is then tested the following year for any special characteristics, such as, disease resistance or

any quality characters. The seeds of the progenies which are similar for agro-morphological and quality characters, resistance to various stresses, and yield are then bulked and treated as pure seed of the cultivars.

The above process is periodically repeated.

## Seed Certification

The following steps are suggested for chickpeas.

1. Selection of land: Due to volunteer problem from the previous season's crop, it is essential to avoid a field for seed certification purposes, which was under chickpea in the preceding season.
2. Disease free soil: Some of the diseases, such as Ascochyta blight and Fusarium wilt, are seed borne. Therefore, seed prouced from the plots infested with these diseases should be rejected. It is also desirable to produce seed of chickpeas, if possible, in nonendemic area.
3. Field inspection: Generally a minimum of two inspections are done between flowering and harvest. During field inspection observations on a few key points are recorded. Some of them are off-type, objectionable weed plants, seed borne diseases etc. The number of counts which have to be taken during field inspection has been covered in a companion paper on seed certification. However, a minimum of 500 plants should be taken per count for recording observations.
4. Isolation distance: Since chickpea is a self-pollinated crop and natural cross-pollination is either negligible or none, isolation distance between two cultivars helps in maintenance of purity by avoiding mechanical or manual mixing at harvest.

Therefore, a minimum isolation distance of 20 m for increase of foundation seed and 10 m for certified seed class between different cultivars should be maintained.

5. Off-types: The off-types should be as far as possible eliminated. In case it cannot be avoided fully, then maximum permitted percentage is 0.10 for foundation and 0.20 for certified class.
6. Seed standards: The seed standards for foundation and certified classes are shown in Table 1. As regards breeder seed 100 per cent pure seeds are required and no inert matter is acceptable.
7. Seed dressing: It is known that Ascochyta blight and Fusarium wilt diseases are transmitted through seed. It is therefore advisable to treat the seed with suitable fungicides, if the seed has been harvested from the plots infested with these diseases. Calixin M for Ascochyta blight (Reddy, 1980) and Benlate T (benomyl and thiram) (Haware et al ., 1978) for Fusarium wilt have been found effective. Bruchids (Callosobruchus chinensis) are known to reduce the germination and the seed dressing with Actellic insecticide is known to eliminate this insect.

## Setting up of a Seed Laboratory:

For the purposes of seed certification, a seed laboratory is required. The laboratory is generally used for determining purity of seed, germination, moisture, weed seed, seed health etc. In most countries such laboratories do exist and can be used for chickpea seed certification work as well.

Production of Seed:

There are no fixed standards how many times certified seeds acquired by the farmer can be used but generally it is accepted that he can use it for four years and should replace it every fifth year. The land requirements for different classes can be determined as follows:

Assumptions:

1. Acrage: 100 ha
2. Certified seed required for each year = 100/5= 20 ha
3. Seed size: 30 g/100 seeds
4. Seeds required for 1 ha = 100 kg
5. Multiplication ratio = 20 times

Requirement of area: Certified seeds: 20.00/20 = 1.0 ha
Foundation seeds" 1.00/20 = 0.05 ha
Breeder seed: 0.05/20 = 0.0025 ha

As the seed size is highly variable, the area required for seed increase will vary. The area required for seed increase of various classes at three seed sizes, 15,30 and 45 g/100 seeds for 1000 hectare land has been estimated (Table 2). The area required for other seed sizes and areas can be calculated from this table.

## Concluding Remarks

The chickpea production in the world has remained static for the past three decades. Lack of seed industry is one of the causes for this sorry state of affairs. There is a strong possibility of building up a seed industry using cultivars developed for sowing during winter as a base in the Mediterranean region. Another favourable factor is high selling price for chickpeas which has made its cultivation more remunerative. It is therefore emphasized that the scientists working in the national programs may exploit this opportunity to built up a seed industry for chickpeas.

## Acknowledgement:

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Table 1. Seed Standards for Chickpeas[1]

| Factor | Standards for each class | |
|---|---|---|
| | Foundation | Certified |
| Pure seed (minimum) | 98.0% | 98.0% |
| Inert matter (maximum) | 2.0% | 2.0% |
| Other crop seeds (maximum) | None | 0.050% |
| Weed seeds (maximum) | None | None |
| Germination including hard seeds (minimum) | 85% | 85% |
| Moisture (maximum) | 9.0% | 9.0% |

[1] Personal communication from Dr. P.K. Agrawal

Table 2. Land requirement for production of breeder, foundation and certified seeds for 1000 hectare chickpeas.

| Seed size | Area (ha) | | |
|---|---|---|---|
| g/100-seed | Certified | Foundation | Breeder |
| 15 | 5.000 | 0.250 | 0.012 |
| 30 | 10.000 | 0.500 | 0.025 |
| 45 | 15.000 | 0.750 | 0.037 |

# PROBLEMS OF SEED PRODUCTION IN FORAGE CROPS

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## INTRODUCTION

The impact of any breeding program on agriculture is fully realized only when farmers decide to replace an old variety with a new one. This is possible only if the breeder is able to maintain the genetic integrity of a new variety, and if the seed is produced and distributed in commercial quantities.

The maintenance of the genetic integrity of a new variety is important because it is the base of the certification procedure, and certification is important because it is the only guarantee of the name and the genetic qualities of a new variety.

The complex process by which the small amount of breeder's seed is multiplied into tons of certified seed, requires the solution of both genetic and agronomic problems, which are different in species having different mating systems.

The main difference between the problems of variety maintenance and seed production in vegetatively propagated, cross-pollinated, and self-pollinated species, is related to the different meaning of the term "variety" in these groups of species.

## THE MEANING OF 'VARIETY' IN DIFFERENT SPECIES

### 1) Vegetatively Propagated Species

In vegetatively propagated species, a variety is a "clone" i.e. the progeny obtained by vegetative propagation of a single plant. Such a population will display only environmental variability, except for new mutations which in turn can be rapidly and easily used to create new varieties.

The maintenance of varieties of vegetatively propagated species does not present problems from a genetic point of view, but may be complicated by the possiblility of transmitting viruses, bacteria etc.

### 2) Self Pollinated Species

In most self-pollinated species a variety is, genetically speaking, a "pure-line", which is defined as the progeny obtained by selfing an homozygous plant. Theoretically such a variety should show only environmental variability like a clone, from which it differs because the genotypes of a pure line are all homozygous while those of a clone may be either homozygous or heterozygous depending on the genotype of the mother plant.

Actually the varieties of a pure line do not follow strictly expectations of Johannsen's experiments, and show a variability which is not only environmental. A series of experiments has shown that either because of heterozygotes's advantage (Allard et al., 1968) or because of micro-mutations (Gaul, 1969) the amount of heterozygosity in varieties of self-pollinated species is higher than expected. This has led

some authors to claim that the "pure line" is an abstract concept (Gaul, 1969) and it is now widely accepted that the maintenance of the genetic integrity of these varieties must rely upon a careful maintenance selection.

## Cross-pollinated species

The populations of cross-pollinated species have a different genetic structure, as compared with self-pollinated species. These populations have been in fact defomed as "reproductive communities which share a common genetic pool" (Dobzansky, 1951). A peculiar characteristic of cross-pollinated species is the amount of genetic variability within populations, which is much higher than in populations of self-pollinated species. This variability has an enormous importance in both the breeding work and in seed production. Genetically speaking a variety of cross-pollinated species can be either a "clone", or a hybrid", or a population more or less in genetic equilibrium (synthetic varieties, varieties produced by mass selection or by recurrent selection).

With the exception of hybrid varieties and clones, the varieties of cross-pollinated species are not, and can not be, genetically homogeneous, and they are in fact composed of a multitude of different, highly heterozygous genotypes.

This is due to the mating system, which maintains a high level of heterozygosity, and to the deleterious effects the inbreeding has on most cross-pollinated species.

# PROBLEMS OF SEED PRODUCTION IN FORAGE CROPS

In very few forage crops the variety is either a clone (for example cynodon dactylon), or a hybrid (maize and sorghum); the large majority of forage crops are prevalently cross-pollinated being either the insects or the wind, and therefore a variety is a population of different, highly heterozygous genotypes assembled by the breeder in a delicate equilibrium.

This equilibruim between different genotypes is very important because it is associated with the particular make-up of each variety, and therefore must be maintained during the life-time of that variety.

Before dealing with the genetic and the agronomic problems of seed production in cross-pollinated forage crops, it is important to mention that forage crops are bred and grown to maximize the production of leaves in contrast with other crops (cereals, pulses, oil plants, ect..) in which seed production is, biologically speaking, synonymous of grain production.

## 1) Genetic problems of seed production

The main problems to maintain varieties of cross-pollinated species, which are genetically speaking in equilbrium are:

a) isolation
b) generation of multiplication
c) seed production outside the area of adaptation.

These problems are all related to the need of a variety to be distinct, uniform, and stable. This need is dictated by law in a large number of countries where, unless these requirments are met, the certified seed of a variety can not be marketed. However, even if a country does not have a seed law, these requirements must be met in the interest of the farmers. It is often said that too many regulations in the matter of seed production and marketing are slowing down agricultural progresss, and in particular the introduction of new varieties, but it is at least suspicious that this comment often comes from seed companies or private plant breeders. It is true that in the absence of any law, carefully tailored to specific situations, any fraud becomes possible, especially with cross-pollinated crops where the identification of a variety is, for biological reasons, particularly difficult.

a) Isolation

Isolation is necessary to avoid outcrossing with foreign pollen and consequent changes in the genetic properties of a variety. In the production of breeder's seed mechanical isolation with mesh or special types of pollen-proof glasshouses can be used but seed production is often limited and not economical.

Isolation of wind-pollinated forage crops also can be obtained by growing relatively small plots placed within another crop as a physical barrier to foreign pollen. Also heavy cloth bags have been used as an efficient way of isolation between varieties of the same species. When wind is the main agent of pollination, a knowledge of prevailing wind direction is essential in the layout of plots in which different varieties of the same species are sown for seed production. Because of the economic limitations in using physical isolation, spatial

isolation is more commonly used, and minimum distances are required at different stages of seed multiplication.

The degree of outcrossing which would actually occur in a seed crop is influenced by the protective effect of pollen released by the variety itself. Griffiths (1953), working with perennial ryegrass (Lolium perenne), found that intervening plants of the same variety had a marked buffer action and were more effective in reducing contaimination than spatial isolation, as shown in table 1.

Table 1- Percentage of contamination in Non Red-Base Perennial Ryegrass Plants at Varying Isolation Distances

| Distance from Contaminante (m) | % contamination First row | Sixth row | Six rows |
|---|---|---|---|
| 7.5 | 41.63 | 17.86 | 27.15 |
| 15.0 | 12.09 | 4.79 | 7.21 |
| 30.0 | 5.60 | 1.65 | 3.73 |
| 60.0 | 1.81 | 0.56 | 0.89 |
| 120.0 | 0.81 | 0.59 | 0.52 |

In addition the size of a seed field is an important factor affecting contamination, and increasing the size of seed field reduces the effect of intervarietal outcrossing. In either or insect-pollinated crops, the smaller the seed field is in relation to the contaminant the greater the chance of crossing. Thus the isolation requirements for the production of different classes of certified seed of cross pollinated legumes vary with field size as shown in table 2.

Table 2: Minimum Isolation Requirements for the Production of Alfalfa, Birdsfoot Trefoil, and Red and White Clover Seed

| Seed class | Field of Less than 5 acres | Field of 5 acres or more |
|---|---|---|
| Foundation | 400 m | 400 m |
| Registered | 200 m | 100 m |
| Certified | 100 m | 50 m |

In the production of certified seed on farmers' fields, isolation is still very important but is more difficult to obtain. As a matter of fact a farmer who accepts to grow a crop for seed production under contract, can see his efforts and hopes vanish if the neighbour will plants the same crop. In some countries, i.e France and U.K., a law dictates that in specific areas the choice of the crop must be controlled by the local authorities.

b) Number of generations of multiplication

The number of generations of multiplication must be kept at a minimum in order to avoid or reduce the amount of genetic changes. As a matter of fact, during the generations of multiplication, the population is a affected by differences in climate which may change the genetic frequencies over a number of generations. The genetic properties of a population also change because different plants produce different seed yields:

for example, in forage grasses, a "leafy" type produces less seed than a "stemmy" type. With many generations, a leafy variety can switch slowly towards a stemmy variety.

In the case of synthetic varieties which are based on a number of selected, mother plants, vegetative propagation of mother plants is used to obtain the Breeder (or Prebasic) seed. The amount of this seed is usually limited and it is maintained for long term storage in moisture-proof containers at 0 °C. When the moisture content of the seed is around 8%, these conditions will permit a high germinability for up to 10 years. Since this is the average life-span of a variety, longer conservation time is not usually required. This first generation seed is used over a period of years to produce the Basic seed, and then with two more generations, the certified seed.

In this example the number of generations is kept at three which is possible only with a very large scale vegetative propagation of mother plants. When the demand for a variety increases, higher seed yields are obtained by increasing the area for the production of breeder's seed and not by adding one or more generations of multiplication.

c) Seed production outside the area of adaptation

Strictly speaking, this topic refers to seed multiplication of new varieties in areas different from those for which the variety was developed. However this topic overlaps with the import action of varieties developed in a different country and some of the aspects of introducing varieties will be briefly discussed.

There are many examples showing that rapid progress in agriculture has resulted from transferring varieties developed

in one area to another area.

The importance of seed from different countries may have different consequences depending upon the species and the country of origin. It has been shown that for some species the movement of certified seed from one country to another may lead to:

a) disease problems often unknown in the country of origin;
b) increase in variability between individuals to such an extent that a population is now no longer uniform enough to be called still variety. This is particularly true of some cross-pollinated crops, such as perennial forage crops, in which uniformity is strictly associated with adaptation. The same poulation, which is "relatively" uniform in its area of adaptation, may become highly variable when grown under different climatic conditions.
c) reduced persistence of perennial species due to lack of adaptation;
d) a form of genetic erosion: the introduction of no adapted material directly to the farmers will create a genetic flow with the adapted populations, the consequence of which being that future germplasm collections will no longer sample native material.

These dangers can be avoided only with the creation of a testing system which will apply to new varieties as well as to any imported variety.

Those countries where climatic conditions do not allow seed production, may breed their own varieties and produce certified seed outside the area of adaptation of the new variety, even in foreign countries where climatic conditions are more favourable. The procedures for growing

certified seed outside a variety's region of adaptation protect varietal purity by limiting the number of generations of increase and the number of seed crops that can be harvested from a field.

It has been shown that when seed of grass and legume varieties is produced in different environments, selective pressures may cause genetic shifts of such magnitude as to affect varietal performance. The amount of genetic shift depends on unlimited generations of increase, management practices, and regions of seed production differing climatically from the area where a variety was developed. Variations in plant height and percentage of winter injury in different seed lots of the alfalfa variety Tanger have been related to locations of seed production (Smith and Grober, 1950, Smith, 1958). Seed lots produced in Southern U.S.A. showed a definite trend towards higher percentage of taller plants and more winter injury. Similar findings have been reported for the alfalfa varieties Narragansett and Vernal when seed was produced at different latitudes (Smith, 1958). The percentage of tall plants was significantly higher when seed was grown in Mexico under short days. On the other hand, seed lots grown in Aalska and Canada produced fewer tall plants but an increasing number of shorter ones, having a rosette growth habit. Laude et al (1958) found that the twenty-one parental clones of the ladino clover variety Pilgrim exhibit a wide range in earliness and persistence of flowering, and that this variability was greatest at shorter day lengths. Under such conditions the clones would contribute disproportionately to this synthetic variety.

Management practices also can alter the genetic complex of an open-pollinated grass or legume variety during seed production. Steppler and Raymond (1954) observed changes in the proportions of plant types in the variety Lasalle of red clover when seed was harvested from a seedling-year stand. There was a significant increase in the number of early-flowering types and a corresponding decrease in the proportion of late-flowering or nonflowering plants.

For perennial species which can produce seed for more years, the seed should be harvested only in the first year after sowing: in subsequent years differential survival may sensibly affect the genetic contribution of individual plants.

Although certified seed can be successfully produced outside the area of adaptation, genetic stability and varietal performance can be maintained best when seed is produced in the environment where the variety was developed, and therefore basic seed should always be produced.

## 2) Agronomic problems of seed production

As previously mentioned, the main characteristic of forage crops is that they have been mainly selected for the irability to produce a large of dry matter yield. In that they differ substantially from crops like cereals and pulses where selection for grain yield is, in fact, selection for seed yield.

The main consequence is that agronomic practices for seed production in a given forage crop, often differ greatly from those usePd for the same crop when grown for forage production. For

example, row planting has been shown to increase seed production over dense planting in many forage crops.

Economically speaking, a seed crop of a forage species can be more profitable than forage yield. Agronomic practices like irrigation and the large use of fertilizer, which may not be justified when a given species is grown for forage production, are commonly used to increase seed production.

Forage grasses and legumes are grown for seed under a great variety of climatic and soil conditions, and each species has specific requirements in terms of agronomic practices. Therefore only very broad indication can be given on planting, growing and harvesting a seed crop.

a) Date of seeding. When grasses and legumes are sown for seed production, the dates of seeding are those that have been found generally to give the best forage stands.
b) Rate of seeding. Harlan et al (1956) found that in grasses, as a general rule, twenty-five viable seeds per foot are adequate, and one established plant per foot gives enough stand to produce maximum yields. Most legume crops have lower optimum seeding rates when grown for seed than for forage.
c) Soil versus row planting. Row planting is widely recognized as superior to solid planting to maximize seed production in many forage crops. Row planting has several advantages; smaller amount of stock seed are required per hectare; weed control and roguing are simplified; and many species produce seed at a higher level for a longer time.
d) Fertilization. Favourable levels of fertility are essential for consistently successful seed production of grasses and legumes.

Moderate to heavy applications of nitrogen are required for the economical production of grass seed. Legume crops, whether grown for seed or forage, have the same general nutrition requirements. Supplemental treatments of minor elements, such as boron, manganese are often required to keep the plant in the best growth condition for seed production.

e) Pollination, in the case of insect-pollinated forage crops like alfalfa, is a key-factor for a successful seed production. All factors which result in an abundance of actively pollinating insects, will also result in an abundant seed production. In the alfalfa seed production area of the United States, the use of as many as eight-ten colonies per hectare during full bloom has been practical.

f) Harvesting is one of the most critical steps in forage crops seed production. Although in some species, seed viability is attained 7-13 days after anthesis, at this time the seed has a high moisture content and a low thousand seed weight. If harvested at this stage, respiration of seed during storage may produce sufficient heat to reduce viability. On the other hand, as harvesting is delayed, losses due to seed shattering increases, and some species can be as high as 70%. Early lodging also contributes to reducing seed yield. Recently the application of chemicals to prevent lodging in some forage grasses, has resulted in an increase of seed yield up to 50%. This is mainly because the crop was able to divert a greater proportion of its total dry matter yield into the production of seed.

Since 1950 the use of desiccants as preharvest sprays has considerably aided seed growers to overcome some harvesting hazards. These sprays cause the foliage to wilt and dry out rapidly enough to permit harvesting before the pods or heads have dried sufficiently to shatter the seeds.

Seed losses due to shattering may be prevented by selection for high seed retention capacity. Although genotypes with the ability to retain seed have been identified in some species, this problem has so far received too little attention.

g) Postharvest treatments such as burning, clipping, or grazing affect seed yield of forage grasses. Burning the stubble and straw has given excellent control of several foliar, inflorescence, and seed-borne diseases. In some species summer burning stimulated the number of fertile tillers and greatly increased seed yields. Clipping and grazing the aftermath are practices commonly employed after harvest of grass seed crops although they often have a negative effect on seed yield.

h) Weed control is essential for the growth of strong healthy plants. In a seed crop established weeds not only compete with the sown crop for moisture, nutrients, and light but may lead to the rejection of a seed lot because of the presence of weed seed. Many weed seeds are physically similar to crop seeds, and their removal is difficult, if not impossible. Thus, efficient weed control starts with the selection of fields relatively free of weeds, and continues until the crop is harvested and processed for marketing.

# MEDICAGO SEED PRODCUTION

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## Introduction

An increase in world food supply is one of the most pressing needs of our time. A few countries of the world have food surpluses but the majority have shortage. World population is increasing at such a dramatic rate that the amount of food available per person will certainly drop accompanied by a concomitant increase in world tension economically, politically and socially. Crop production is dependent on a number of factors such as soil, topography, rainfall, irrigation water, temperature, length of growing season and type of farming. Not least in importance among the many factors involved in crop production is the kind and quality of seed which is planted. Seed quality is influenced by crop sequence, type and frequency of cultivation, climate, time of harvesting, genetic constitution of the seed, variety of seed planted, storage and treatment of the seed.

## Seed Production

The multiplication of foundation seed from the plant breeder's laboratory to commercial sale requires careful supervision. Usually the breeder will release seed to government experimental, or selected commercial farms, where 'mother seed' will be produced and then released more widely for commercial seed production.

## Seed Production Techniques

Seed production of medics can be optimised by firstly choosing the most suitable fields and secondly, by correct management.

### 1. Choice of Field

Fields containing various or objectionable weeds must, naturally, be avoided. Likewise fields containing other weeds should be avoided if possible, despite the fact that present day herbicides can conquer most weeds in medic crops. These, however, cost money and if they can be minimized, obviously production costs are lowered. Preference should be given to level fields free as possible from stumps and stones. Poorly structured sandy soils and heavy cracking clays should also if possible be avoided because of lower harvesting recovery on these types.

### 2. Soil Preparation and Sowing Methods

The cultivation of soil must be shallow. Fields must be managed to have as low a weed population as possible before sowing Medicago.

The seedbed required for a small seedbed species requires greater attention to fineness of tilth and consolidation than for the larger cereal and legume grains. There are relationships between soil particle size and seed size in germination rapidity and resistance to drought after germination due to seed-soil contact.

How this is achieved, i.e. a firm base with 1-2 cm. of finely worked soil on top is not important. However, the use of suitable scarifiers provides a rapid and economic method; more passes with harrows are required than is customary in this region.

Consolidated, flat seedbeds are required so that depth of seeding can be regulated. Very flat seedbeds are also required where seed production is contemplated.

It would be prudent to sow Medicago onto a properly prepared seedbed after the first major rain. This permits control of the weed population which could be substantially reduced. However, one cannot sow too late or production would be lost.

In much of North Africa, it has been customary to apply phosphate in advance of sowing, before the final working, and then applying the seed in another pass. This practice is inefficient both in terms of labour time and fertilizer inefficiency. Fertilizer must be placed in close proximity to Medicago seeds.

Seeding rates should be in the vicinity of 10-12 kg/ha. The use of high seeding rates may be required in some situations for competition with weedy species or to provide more winter forage. In colder areas 15-20 kg/ha might prove to be more profitable. If the seedbed is poor or the weed population high the higher seeding rate can be justified.

The weight of 1000 seeds is:

- 2.087 gr. -Harbinger (Medicago littoralis)
- 3.663 gr. -Jemalong (Medicago truncatula)
-17.616 gr. -Snail (Medicago scutellata)

Depth of seeding

For Harbinger and Jemalong, the optimum depth of seeding is 1.5 cm. There are too many losses with surface seeding and with deep seeding. For Snail, the optimum varies between 1 and 4 cm. due to its larger seed size.

In the absence of combined fertilizer and seed drills, it is suggested that an ideal method of sowing is by mixing the seed and superphosphate and applying this mixture through a fertilizer dropper. However, care should be taken not to leave seed and fertilizer mixed for long periods of time. This operation (on a well prepared seedbed) would then be followed by a passage of harrows or a roller, but not a smooth roller, $P_2O_5$ at the rate of about 40 to 45 kg/ha is recommended.

The "crosskill" roller has been shown usefull because it creates an irregularly indented surface which reduces erosion, trapping water and thus obtaining greater infiltration. Of course, it also breaks down the remaining large soil clods.

3. Grazing

Except in excessively dry seasons (when seed production is generally impractical), crops benefit from grazing. Ideally grazing should be done with sheep and not be closer than 5 cm. It should normally be stopped as soon as the crop begins to flower. In exceptionally good seasons, especially if the crop regenrated with early rains, late grazing is beneficial.

## 4. Weed Control

High yields can be otained in surprisingly dry seasons if all the soil moisture is available for the medic crop and optimum yields can only be achieved in any year provided weed control is excellent. Excellent weed control in medic crops is virtual weed eradication. The first step to weed control is to have adequately close rotation. After several years of good medic, experience has shown that a one year crop-one year medic is best. Under this system all weeds, particularly grassy weeds, are usually effectively suppressed. If this is not the case it is necessary to utilize herbicides until the weeds are under control.

## 5. Rolling

Rolling of crops to make a firm level soil surface is recommended because it will result in easier harvesting and better seed recovery. This is best done when soils are moist at any time from the fifth trifoliate leaf until commencement of flowering.

## 6. Burning

Burning of crops to remove top growth prior to harvest is not recommended on medic crops because this always results in some loss of germination and seed storage life and may completely destroy viability.

7. Soil PH

Medicago species are well adapted to neutral to alkaline soils. The PH affects the growth of medics through the influence on Rhizobia that are compatible with Medicago. The Rhizobia fix atmospheric nitrogen which becomes available to the plants.

8. Cover Crops

It is possible that cover crops (light seeding of oats or barley with the Medicago) may be useful in creating a more favourable micro-climate in the colder areas in the region.

9. Nodulation

Nodulation of the Medicago should not be a problem in the Middle East countries due to the presence of many local ecotypes, indicating the presence of Rhizobia bacteria. Localized problems could exist.

10. Harvesting

Today almost all medic seeds are harvested using a Harwood Bagshaw suction type machine. These suction machines with dryland crops reap about half a hectare per hour. Many grower operators find that 100 hectares per year per machine is as much as they can handle while the best operators may achieve 200 hectares per machine per season. It is still however, a slow tedious operation and currently the greatest single factor limiting expansion of further medic seed producion.

Several improved home constructed machines have been built which are more rapid and produce a better quality seed sample. The major difference with the new machines is that they involve pre-cleaning of the gathered burr material before it goes into the seed thresher.

Definitions:

1. Purity of seed: - Generally implies freedom from such impurities as weed seeds, foreign or inert matter, and crop seeds other than the kind being tested.

2. What is seed?: - An individual seed refers to a sexually produced reproductive organ of a higher plant. Botanically, a seed is a ripened ovule which, in general, is the result of fusion between the egg nucleus of the embryo sac with a micro-nucleus (microgamete) from the pollen grain of the same species. Following the fusion the zygote develops into a seed embryo with its several parts. In many higher plants 2 endosperm nuclei of the embryo sac also fuse with a second microgamete producing, finally, an endosperm which also develops as part of the seed.

   A normal seed always includes an embryo which contains a plumule (the primary stem bud), one or more cotyledons, a prominent or greatly reduced hypocotyl with a radicle at its lower end, sometimes an endosperm (depending upon genus or family), a seed coat, and a hilum.

3. Seed viability: - Viability refers to the ability of seeds, when placed under favourable conditions, to germinate and produce plants.

4. Seed longevity: - The length of life of seeds when mixed with field soil and exposed to natural conditions.

5. Seed dormancy: - Dormancy in seeds is a condition that prevents resumption of growth by a viable embryo when placed under conditions that promote germination of non dormant seeds of the same species. Dormancy is caused by unripe and undeveloped embryos, or by an impermeable membrane surrounding the embryo which restricts intake of water and exchange of gases. If properly treated, dormant seeds will germinate.

6. Impermeable seeds: - Is a term applied to a seed whose coat is so sealed as to prevent the entrance of water to the embryo. Such a seed cannot germinate until the seed coat is treated in some way to make it permeable to water. Impermeable seeds are common in the legume families and are generally referred to as hard seeds. Such seeds are usually viable. Many botanists consider impermeability as one form of dormancy.

Possibly the most important factor influencing Medicago seed production is that of seedcoat impermeability to water (hardseedeness). The degree of hardseedeness is influenced by genotype and environmental factors. Slow maturation enhances the deposition of impermeable substances while moistures stress interrupts it.

Hardseededness is broken down in the field by diurnal temperature fluctuations, causing contraction and expansion of the seed, finally laeding to rupture of the seedcoat. Soil surface temperatures at 50 - 60 $C^{o}$ by day and 10-15 $^{o}C$ by night favour the breakdown process. Other factors such as the effect of frost and chemical action after incorporation into the soil will also be involved. The rate of hard seed breakdown is important in the

regneration reliability. It has been suggested that an ideal cultivar should have about 20 - 30% breakdown by mid-October (in north Africa) but not much before this.

Rapidity of water uptake by the seeds is also an important factor. After one year a well adapted cultivar could produce seed yield on the soil of up to 1000 kg/ha, depending on management and seasonal conditions. During the following season, in the course of seedbed preparation for the cereal crop this seed (in pods) will be incorporated into the soil. It is essential, therefore, that soil workings should not be too deep (less than 10 cm). If buried too deep, the seedlings will never emerge; maximum hypocotyl length is related to seed size.

7. Weed Seeds: - Plants that are harmful to man or animals, poisonous, or that interfere with crop production are classed as weeds. Seeds of such plants when present in crop seed are classed as weed seeds.

8. Seed - borne organisms: - Many crop diseases are caused by microscopic organisms, and frequently a specific causal agent is carried by seed. Such organisms are referred to as seed-borne, often they can be detected by laboratory tests.

## Seed quality control and testing

Most governments have regulations governing the quality of agricultural seed offered for sale. This is a wise precaution, as noxious and worthless weeds can be introduced and seed-borne diseases disseminated in uncontrolled seed. The quality of the seed is controlled by seed-testing officers who generally operate under

international rules for seed-testing . A seed test is the detailed examination of a representative sample from which it is possible to estimate and report certain properties of the particular line of seed, including:

1. percentage by weight of pure seed.
2. the nature and respective percentages by weight of variousimpurities which are present.
3. The percentage of pure seeds which germinate with normal roots and shoots, and the percentages of hard seeds and fresh, ungerminated seed present at the final germination count.

Samples are collected at random at an intensity according to the bulk to be tested, mixed, and then reduced by accurate techniques to obtain a representative sample for testing.

In queensland, Austalia, the germination methods and standards for some lagume seeds are shown in table 1.

Table 1: Germination Methods and standards for some Legumes.

| Kind of seed | Percentage Germinable seed | | Percentage allowable by Weight | | | | Dormancy Treatment | Germination | First count | Final count |
|---|---|---|---|---|---|---|---|---|---|---|
| | Minimum of Germinable seeds | Maximum of hard seeds | Pure seed minimum | Weed seed maximum | Other Crop seed maximum | Inert matter maximum | | | | |
| Medicago Littoralis (harbinger medic) | 75 | 20 | 96.0 | 0.5 | 2.0 | 2.0 | | 20 °C | 4 days | 14 days |
| Medicago Lupulina (black medic) | 75 | 20 | 98.0 | 0.5 | 0.5 | 1.5 | Prechill fresh seed | 20°C | 4 " | 10 " |
| Medicago orbicularis | 50 | 20 | 95.0 | 0.5 | 0.5 | 4.5 | | 20°C | 4 " | 10 " |
| Medicago polymorpha (burn medic) | 75 | 20 | 95.0 | 0.5 | | 4.5 | | 20°C | 4 " | 14 " |
| Medicago sativa (alfalfa) | 80 | 30 | 98.0 | 0.5 | 0.5 | 1.5 | Prechill fresh seed | 20°C | 4 " | 10 " |
| Trifolum subterranean (subterranean clover) | 80 | 10 | 97.3 | 0.2 | 0.5 | 2.2 | Fresh seed, test at | 20°C 15°C | 4 " | 14 " |
| Vicia sativa (common vetch) | 60 | 10 | 98.8 | 0.2 | - | 1.2 | light seed, difuse light | 20°C,cover | 5 " | 10 " |

The acid used to break dormancy is commercial sulphuric acid of the specific gravity of 1.8

# SEED SAMPLING

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## Introduction

"The object of seed sampling is to obtain a sample of a size suitable for tests, in which the same constituents are present as in the seed lot and in the same proportion".

The quantity of seed tested in the laboratory is minute compared with the size of the seed lot which it is intended to represent (e.g. when 1 gram is analysed and the lot weighs 10,000 kg, the ratio is 1:10,000,000). To obtain uniform and accurate results in seed testing it is essential that the samples be taken and prepared with care and in accordance with the methods prescribed in the Rules. No matter how accurately the laboratory work is done, the results can only show the quality of the sample submitted for analysis, consequently, every effort must be made to ensure that the sample sent to the seed testing station accurately represents the composition of the seed lot. Likewise, in reducing the sample in the laboratory, every effort must be made to obtain a working sample that is representative of the sample submitted.

Thus, the rules are not only the guideline for seed testers, but as far as sampling is concerned, also for seed inspectors and other authorized persons who do the sampling in the warehouses.

It is essential that these rules be followed by the samplers because only in that case the seed testing station, if authorized by ISTA to do that, can issue international orange or green certificates. If sampling is done by unofficial persons only a blue certificate can be issued, which is of much less value.

## Certificates

Apart from all sorts of national certificates that exist, three international ISTA certificates are of supreme importance for the seed trade:

1. The Orange Seed Lot Certificate. This can be issued when sampling has been done according to the Rules by an official body approved by the seed testing station. And also the sampling and testing should be carried out in the same country where the seed lot is located.
2. The Green Seed Lot Certificate requires the same things as the Orange but in this case the testing is carried out by an authorized station in another country to where the lot is situated (and where sampling was done). Note: in both cases the testing station of the country where the seed lot is located shall be responsible for sampling, sealing, labelling and testing the sample and for the issue of the certificate.
3. The Blue Seed Sample Certificate only refers to the sample. This certificate is used when the sampling has occurred unonfficially and the seed testing station therefore is not certain of it representing the seed lot. The certificate only refers to the quality of the sample received and the sampling and sealing agency as well as the mark and seal of the lot are omitted. Details on the ISTA certificates can be found in chapter 2 of the Rules.

## Definitions

Lot - a lot is a specified quantity of seed, physically identifiable, in respect of which an International Analysis Certificate may be issied.

Primary sample- a primary sample is a small portion taken from one point in the lot.

Composite sample- a composite sample is formed by combining and mixing all the primary samples taken from the lot.

Submitted sample- the submitted sample is the sample submitted to the testing station: it comprises the composite sample reduced as necssary (the composite sample is usually much larger than required for the various tests and in that case it must be reduced).

Working sample- the working sample is a reduced sample taken from the submitted sample in the laboratory, on which one of the quality tests is made.

## Principles and procedures for sampling the lot.

Before sampling of a lot is carried out the sampler should be satisfied that the lot shows no evidence of heterogeneity. In cases of doubt, heterogeneity can be determined by the heterogeneity test described in Rules 2.4.2.A. of annexe to chapter 2. In all other cases sampling should be refused.

The size of the lot shall also not exceed certain limits (column 2 of Table 2A, subject to a tolerance of 5%). This means that in agricultural seeds the lot shall not exceed 10,000 kg, for the large seeded species 20,000 kg. or, One exception has recently been made for maize where 40,000 kg is allowed.

A third requirement for sampling is that the lot shall be in bags or other containers, sealed (or capable of being sealed) and labelled or marked for identification by a single lot designation. This is because an International Seed Lot certificate may not be issued in respect of loose seed or seed in containers which cannot be sealed.

At the time of sampling, all containers must be labelled or marked to show a lot identification corresponding to the lot identification of the certificate. The containers shall be sealed, or seen to be sealed, by the sampler.

When sampling, various instruments are allowed. One of the most commonly used instruments is the stick or sleeve - type trier which consists of a hollow brass tube inside a closely fitting outer shell or sleeve which has a solid pointed end. The tube and sleeve have open slots in their walls so that when the tube is turned until the slots in the tube and sleeve are in line, seeds can flow into the cavity of the tube, and when the tube is given a half turn the openings are closed. The tubes vary in length and diameter, being designed for different kinds of seed and various sizes of containers, and are made with or without partitions. In sampling cereal seed in bags the following size of trier has been found suitable: 762 mm trier with outside diameter of 25.4 mm and six slots.

Bin samplers are constructed in the same way but are much larger, ranging up to 1600 mm (1,6m) in length and 38 mm in diameter

with six or nine slots.

The trier may be used horizontally or vertically. However, when used vertically the trier must have partitions dividing the instrument into a number of compartments. Otherwise, the seed will drop into the sampler from the upper layers when the trier is opened, leading to an over-representation of seed from these layers. When using a stick sampler vertically a certain drag of the seeds from the top towards the bottom is unavoidable. This drag is reduced if the trier is made as smooth and with as few ribs as possible.

Using it either vertically or horizontally, one should insert the trier diagonally into the bag or container. (For seed in bulk, vertical insertion is more practicable). The trier is thrust into the bag in closed position, then opened and turned a couple of times or gently agitated to allow it to fill completely. Thereafter it is closed again, withdrawn and emptied into a suitable pan a pipe cut lengthusise, or into a piece of waxed paper or similar material. Care should be exercised in closing the trier so that the seeds are not damaged.

The stick trier, up to a certain diameter, may be used through sack walls of coarsely woven jute or other similar material. When the trier is removed the point should be run across the hole a couple of times in opposite directions to pull the threads together and close the hole. Closed paper bags may also be sampled by puncturing the bag and afterwards sealing the hole with a special adhesive patch.

Another type of trier is the Nobbe trier. It is a pointed tube, long enough to reach the center of the bag, with an oval hole near the pointed end. For cereals the distance from opening to handle should be around 350 mm and the internal diameter of the tube should

be about 14 mm. It is only suitable for sampling bags. The trier should be inserted gently into the bag, pointing upwards at an angle of about $30^{o}$ to the horizontal, with the hole facing downwards until it reaches the centre of the bag. Then it is revolved through $18)^{o}$, bringing the hole face upwards, and is withdrawn with decreasing speed so that the quantity of seed obtained from successive locations increases progressively from centre to side of the bag. Alternatively, a trier long enough to penetrate to the further side of the bag should be withdrawn at a relatilvely constant speed. While the trier is being withdrawn it should be gently agitated so that an even flow of seed is maintained. The more polished the inner surface of the trier is, the more freely the seed will flow.

The sampling should be varied from top, middle and bottom of the bags. To sample the bottom of standing bags they may be raised off the floor and placed on top of other bags.

In certain cases and for certain species, especially chaffy, non-free flowing species (mainly grasses), hand sampling is sometimes the most satisfactory method. It is difficult by this method to sample deeper than about 400 mm. This will mean that it is impossible to obtain samples from the lower layer in bags and bins. In such cases the sampler may take special precautions such as requesting that some bags be emptied or partly emptied to facilitate sampling, and then be refilled. When sampling is done by hand great care should be taken to keep the fingers tightly closed about the seeds so none may escape.

For seed lots in bags (or other containers of similar capacity) that are uniform in size, the following sampling intensity shall be regarded as the minimum requirement.

Up to 5 containers: sample each container and always take at least 5 primary samples.

6 - 30 containers: Sample at least 1 in every 3 containers, but never less than 5.

31 or more : sample at least 1 in every 5 containers, but never less than 10.

For sampling intensity for seed in bulk, in containers of different or very small sizes, or from streams of seed entering containers refer to rule 2.6.2. and 2.6.2 A. (Rules and annexe to Rules).

If the primary samples appear uniform they shall be combined and mixed to form the composite sample. From that the submitted sample is obtained by one of the laboratory methods referred to below, using larger equipment if necessary. If it is difficult to mix and reduce the sample properly under warehouse conditions, the entire composite sample shall be forwarded to the seed testing station for reduction. If the composite sample is of appropriate size it may be regarded as the submitted sample without reduction. Each submitted sample shall be marked in a way that establishes the connection between lot and sample. Samples shall be packed so as to prevent damage during transit; if for germination tests, samples shall not be packed in moisture- proof containers; and if for determination of moisture content, shall be packed separately in moisture-proof containers; from which as much air as possible has been excluded.

Samples shall be dispatched by the sampler to the seed testing station without delay and shall never be left in the hands of the owner, applicant, or other persons not authorised by the sampling agency or by the seed testing station.

## Principles and procedures for sampling in the laboratory

As has already been said the care taken by the warehouse sampler should not be spoilt by innacurate work in the laboratory. Several methods and apparatus are at our disposal to reduce the submitted sample to the size of a working sample (for minimum weights of working smaple see column 4 of table 2A of the Rules, and for some cereals see table below).

## Weight of working samples for the more important cereals

| Latin name | Common name | Weight of working sample (g) |
|---|---|---|
| *Avena sativa* | Oats | 120 |
| *Hordeium vulgare* | Barley | 120 |
| *Oryza sativa* | Rice, or paddy | 40 |
| *Pennisetum typhoides* | Pearl millet | 15 |
| *Secale cereale* | Rye | 120 |
| *Sorghum bicolor* | Sorghum | 90 |
| *X Triticosecale* | Triticale | 120 |
| *Triticum aestivum* | Breadwheat | 120 |
| *Triticum durum* | Durum wheat | 120 |
| *Zea mays* | Maize, or corn | 900 |

One of following method can be used to prepare the working sample, method 5 being a combination of 1 and 4 and is advised when a large number of different species, especially small seeded species, is to be tested.

1. Mechanical divider method.

   Three machines are at our disposal for this method:

   a. the conical divider (Boerner type)
   b. the soil divider (Riffle type)
   c. the centrifugal divider (Gamet type)

   All machines divide a given quantity of seed into two approximately equal portions. The sample can be mixed by passing it through the divider, recombining the two parts and passing the whole sample through for a second time, and similarly, a third time if necessary. The sample is reduced by passing the seed through repeatedly and removing one half on each occasion. This process of successive halving is continued until a working sample of approximately, but not less than, the required size is obtained.

2. Modified halving method.

   The apparatus comprises a tray into which fits a grid of equal-sized cubical cells, open at the top and every alternate one having no bottom. After preliminary mixing, the seed is poured evenly over the grid. When the grid is lifted, approximately half the sample remains on the tray. This can be repeated until a working sample of approximately, but not less than, the required size is obtained.

3. Random cups method

   In this method 6-8 small cups are placed at random on a tray. After preliminary mixing, the seed is poured uniformly over the tray and the seed that falls into the cups is taken as a working sample. This means that for a particular group of similar species a certain size of cup is needed. At least 6 cups should be taken, but if the minimum weight is not yet attained the seventh and/or eighth cup can be added. (More details can be

found in Rule 2.7.2.A. ii).

4. Spoon method.
   This method is only permitted for small-seeded species. Seed-mixtures should not be sampled in this way. A tray, a spatula and a spoon with a straight front edge are required. After preliminary mixing, the seed is poured evenly over the tray; the tray must not be shaken thereafter. With the spoon in one hand and the spatula in the other, and using both, remove small portions of seed are removed from not less than 5 random places. Sufficient portions of seed are taken to constitute the working sample. With this method one never gets too few seeds and never far too much, the latter having the disadvantage of taking excessive analyzing time.

5. The combined method of divider and spoon.
   This method is extensively described in Project Seed Laboratory 2000-5000 on pages 23-25. We can limit ourselves here to the remark that it combines the benefits of two methods: rapid reduction in size of the mechanical divider (any of the three types) and the accuracy of the spoon method. Once this method is established in a laboratory it proves very efficient, especially when a large variety of species has to be investigated.

Duplicate analysis

To improve the accuracy and at the same time to check upon the analysis, it is advisable to take two independant working samples each of half the prescribed weight, and have them analysed by two different analysts. When the two results are within the tolerance limits given in column 3 of table 3A of the Rules, one may be confident over the result. In this way some or other analyst does

not regard the analysis in a light-hearted manner and at the same time the analysis can have the satisfaction of constant proof of their doing a good job.

# AN INTRODUCTION TO MOISTURE DETERMINATION OF SEEDS

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## 1. The moisture determination of seeds

The moisture content of seeds is one of the important factors influencing the period of time seeds will maintain their viability . High moisture content at harvest can increase the liability of the seed to threshing damage and later, in storage, viability decreases more rapidly at high moisture content because of mould growth, heating damage, aging and increased insect damage. Therefore it is of great value to know the moisture content of the seed directly after harvest and when necessary also after artificial drying. In the seed trade a certain moisture percentage is allowed, depending upon the kind of seed. The object of a moisture analysis is to find out the moisture content of a seed lot at the time it was sampled. The sample must be handled in such a way that its initial moisture content is retained. Therefore it should be packed in a moisture proof container (metal or plastic) and must be submitted to the station without delay and analysed directly upon arrival. During the determination, exposure of the seed to the laboratory atmosphere shall be reduced to the absolute minimum. For species which do not require grinding not more than 2 minutes may elapse from the time the

sample is removed from the container or the plastic package in which it was received until the working sample is enclosed in the drying container.

## 2. Method for determining moisture in seed

a. The air-oven method. This is the most common standard method used. The principal of this method is the elimination of water from the seed by drying under precisely prescribed and controlled conditions. The moisture content is expressed as a percentage of the original weight. For detailed specifications see ISTA Rules Chapter 9.

b. Quick methods. A variety of brands and types of moisture meters are available. The quick test methods should be calibrated or checked against the standard air-oven method. Because of the uncertainties involved in the use of most quick moisture testing methods, ISTA has specified only basic moisture testing methods in its rules for air-oven and toluene distillation method s.

### 2.1. Description of the air-oven method

The following equipment is necessary:

1. Containers of non-corrosive metal, thickness approximately 0.5 mm, with sides rounded at the base, flat bottom and level edges and a loose fitting cover. Both the container and its cover should be indicated by the same number to identify each sample after the drying period. The dimensions are: height 3 cm, diameter base 6 cm. The effective surface must enable the working sample to be distributed so as to give not more than 0.3 $g/cm^2$.

2. An elctrical oven with adequate ventilation and a thermostatic or electronic control for constant temperature.

3. A balance which weighs accurately in grams to 3 decimal places.

4. A grinding mill which must meet the following requirements:

   a) It should be constructed of a material that can not absorb moisture,
   wood is not suitable.

   b) It should be constructed in such a way that both seeds to be ground and the resulting ground material are protected as much as possible from the atmosphere of the room while grinding.

   c) It should grind evenly, and should not be operated at such a high speed that the ground material is heated. Air currents that might cause loss of moisture must be reduced to a minimum.

   d) The fineness of grinding should be adjustable, thorough cleaning should be easy.

5. A set of 3 sieves in a closed container containing sieves of mesh 0.5, 1.0 and 4.0 mm in diameter.

6. A desiccator with a suitable desiccant, e.g. silicagel. The desiccator should have a thick metal or porcelain plate to accelerate cooling of the containers and seed. The desiccator bottom compartment contains the silicagel (preferably coloured with cobalt chloride as an indicator; as soon as the dark blue colour becomes pale pink, the desiccant should be reactivated by heating it at 200 $^{o}$C in the oven).

7. A brush and a steelbrush to clean the mill after grinding.

8. A few trays made of metal, with holes of about 5 mm. These trays are used for easy removing of the containers with seed in and out of the oven. They are provided with holes to promote the air circulation in the oven.

9. A pair of crucible tongs and a cloth to take the hot containers, which are placed on the trays, out of the oven.

The moisture analysis is carried out on independently drawn duplicate working samples, weighed with an accuracy of 1 mg. With the exception of cereals (2 hours) and maize (4 hours) most species are dried for 1 hour at 130 °C. Seeds containing oil however, are dried for 17 hours at 103 °C. (see for detailed specifications ISTA Rules Chapter 9).

Each empty container is weighed including its cover. The submitted sample is throughly mixed with a small spoon and two 5.000 g portions are weighed directly into the containers. The seed should be evenly distributed over the surface of the container. After the weighing the containers are placed on top of their covers on the tray, in the oven, which has already been heated to the prescribed drying temperature. At the end of the drying period the containers are closed with their covers (using tongs and a cloth), and are allowed to cool for 30-45 minutes in a desiccator and then weighed again. The moisture content (M) is calculated to 1 decimal place by means of the formula.

$$M = M_2 - M_3 X \frac{100}{M_2 - M_1}$$

$M_1$ = weight of empty container with its cover

$M_2$ = weight of container with its cover and seeds before drying

$M_3$ = weight of container with its cover and seed after drying

The duplicate result of the determination may not differ by more than 0.2%. Otherwise the analysis should be repeated in duplicate.

2.1.1. Grinding and Pre-drying

Some seed species must be ground before the actual moisture content is determined (e.g. cotton, rice, maize, cereals, sorghum, peas and beans). For cereal and cotton seeds fine grinding is necessary; at least 50% of the ground material shall pass through a wire sieve with meshes of 0.5 mm and not more than 10% shall remain on a sieve with 1.0 mm meshes. For leguminous seeds course grinding is necessary; at least 50% of the ground material shall pass through a wire sieve with meshes of 4.0 mm. Grinding mill should be adjusted to obtain particles of the required dimensions. Grind a quantity of the sample larger than that required for the test ( 20 g.). If the species is one for which grinding is necessary and the moisture content is more than 17% (or 10% and 13% in the case of soybean and rice respectively) predrying before grinding is necessary.. Therefore two 50.0g portions are weighed and placed on two open trays at 130 $^{o}$C for 5-10 minutes. In the case of very moist seed, about 25.0% moisture content, the seeds are spread in two open trays and dried at 70 $^{o}$C. For 2-5 hours, depending on the initial water content. Thereafter the trays are left open in the laboratory for at least two hours. Then each of the duplicate quantities is weighed

separately and a portion is ground (e.g. 20 g.).

The ground material is then subjected to a moisture test using the oven method as prescribed above.

The moisture content (M) is calculated according to the following formula

$$M = S_1 + S_2 - \frac{S_1 \times S_2}{100}$$

$S_1$ = percentage of moisture lost by pre-drying (stage 1)

$S_2$ = percentage of moisture lost by the oven method (stage 2)

The reported moisture content of the pre-dried sample is the average result of the pre-dried duplicate determination, rounded off to the nearest 0.1%.

## 2.2. Description of the quick methods

Various equipment has been designed to shorten the time for moisture determination. These quick methods may be classified by the following different principles used:

1. Apparatus where the seed is weighed by a built-in balance, they are heated directly by an infra-red lamp.
2. Electric moisture meters, where the moisture of the seed is determined by their conductivity.
3. Electronic humidity measuring instruments, where the relative

humidity of seed is measured, which is in equilibrium with a certain moisture percentage.

In the first case, when seeds are heated by an infra-red lamp, heating of the material to higher temperature is required than for the air oven method. Most of these apparatus have a balance which measures continuously the loss of weight of the sample while being heated. The moisture percentage is usually read off from a direct reading scale. No calculations have to be made. The test can be finished in 10-15 minutes, depending on the kind of seed.

Electric moisture meters are also frequently used for a quick test. These meters do have a great advantage over all other methods in speed of use. The test can be completed in one minute. These meters are based on measurements of either the conductivity or the dielectric properties of the seeds.

For reliable use of both quick methods each meter must be calibrated for each species,. The calibration should be carried out against the standard air-oven method and the moisture determinations should be executed under standardised conditions. In general the reading of the meters is less precise than the results determined with the air-oven method, there may be as much as 1-2% difference. Consequently, calibrated meters are only suitable for approximate determinations of the moisture content, they can give the user an idea of the moisture percentage.

The following remarks concerning the relationship between relative humidity and seed moisture content were quoted from O.L. Justice and L.N. Bass (1978). The moisture percentages of seeds in equilibrium with a specific relative humidity vary with crop species. At any temperature air will hold a given amount of water in the form

of a vapor. When the air contains all the moisture it will hold it is said to be saturated, which is equivalent to the dewpoint or 100% relative humidity, warm air can hold more water than cool air. Thus, if the amount of water in the air is held constant and the temperature is increased, the relative humidity will be decreased. Conversely, if the temperature of the air is lowered, the relative humidty will be increased. Data from Hubberd et al (1957) quoted by Roberts (1973) show that a decrease in temperature from 35 $^{o}$ to 25 $^{o}$C increases the moisture content wheat by almost 1 percent at 20 percent relative humidity and by about 1.5 percent at 75 percent relative humidity.

Under all storage conditions the moisture content of seed will come to equilibrium with the surrounding air if given enough time. In fact, equilibrium is reached between the seeds and the air in the interstitial spaces among the seeds. It has been reached when the net movement of moisture from air to seed, or from seed to air is zero.

The relative humidity of the air is measured with an electronic humidity measuring instrument, which is provided with a temperature control as well.

The apparatus should be delivered with different probes for measurements in big and small seed lots packed in bags or seed containers. This can be done without sampling the seed. The result should be calibrated against a moisture test executed according to the air oven method.

The equilibrium moisture content of several crop seeds at different relative humidities at approximately 25 $^{o}$C is given in the table below.

| | Moisture content at indicated relative humidity (percent) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 10 | 20 | 30 | 45 | 60 | 75 | 80 |
| Bean, lima | 4.6 | 6.6 | 7.7 | 9.2 | 11.0 | 13.8 | 15.0 |
| Bean, snap | 3.0 | 4.8 | 6.8 | 9.4 | 12.0 | 15.0 | 16.0 |
| Beet, garden | 2.1 | 4.0 | 5.8 | 7.6 | 9.4 | 11.2 | 15.0 |
| Broad bean | 4.2 | 5.8 | 7.2 | 9.3 | 11.1 | 14.5 | 17.2 |
| Cabbage | 3.2 | 4.6 | 5.4 | 6.4 | 7.6 | 9.6 | 10.0 |
| Cabbage, Chinese | 2.4 | 3.4 | 4.6 | 6.3 | 7.8 | 9.4 | ---- |
| Carrot | 4.5 | 5.9 | 6.8 | 7.9 | 9.2 | 11.6 | 12.5 |
| Celery | 5.8 | 7.0 | 7.8 | 9.0 | 10.4 | 12.4 | 13.5 |
| Corn, sweet | 3.8 | 5.8 | 7.0 | 9.0 | 10.6 | 12.8 | 14.0 |
| Cucumber | 2.6 | 4.3 | 5.6 | 7.1 | 8.4 | 10.1 | 10.2 |
| Eggplant | 3.1 | 4.9 | 6.3 | 8.0 | 9.8 | 11.9 | --- |
| Lettuce | 2.8 | 4.2 | 5.1 | 5.9 | 7.1 | 9.6 | 10.0 |
| Mustrd, leaf | 1.8 | 3.2 | 4.6 | 6.3 | 7.8 | 9.4 | ---- |
| Okra | 3.8 | 7.2 | 8.3 | 10.0 | 11.2 | 13.1 | 14.5 |
| Onion | 4.6 | 6.8 | 8.0 | 9.5 | 11.2 | 13.4 | 13.6 |
| Onion, Welsh | 3.4 | 5.1 | 6.9 | 9.4 | 11.8 | 14.0 | --- |
| Parsnip | 5.0 | 6.1 | 7.0 | 8.2 | 9.5 | 11.2 | --- |
| Pea | 5.4 | 7.3 | 8.6 | 10.1 | 11.9 | 15.0 | 15.5 |
| Pepper | 2.8 | 4.5 | 6.0 | 7.8 | 9.2 | 11.0 | 12.0 |
| Radish | 2.6 | 3.8 | 5.1 | 6.8 | 8.3 | 10.2 | --- |
| Spinach | 4.6 | 6.5 | 7.8 | 9.5 | 11.1 | 13.2 | 14.5 |
| Squash, winter | 3.0 | 4.3 | 5.6 | 7.4 | 9.0 | 10.8 | --- |
| Tomato | 3.2 | 5.0 | 6.3 | 7.8 | 9.2 | 11.1 | 12.0 |
| Turnip | 2.6 | 4.0 | 5.1 | 6.3 | 7.4 | 9.0 | 10.0 |
| Watermelon | 3.0 | 4.8 | 6.1 | 7.6 | 8.8 | 10.4 | 11.0 |

Literature cited:

International Rules for Seeed Testing ,Rules 1976. Seed science and technology; 4,3-49 (1976)

Justice O.L. and L.N. Bass, 1978. Principles and Practices of Seed Storage, Agriculture Handbook 506, U.S. Dept. of Agriculture.

# AN INTRODUCTION TO PURITY ANALYSIS

## (WITH EMPHASIS ON CEREAL AND PULSE SEED)

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## 1. Introduction

When you buy seed, you expect to receive good seed and not a mixture of analytically pure seed with a high percentage of chaff, straw, sand, weed seeds, etc.

In practice it is not possible to remove all these admixtures completely with the use of cleaning machines: some will always remain, and the purity analysis is the test to determine exactly how much, even if the percentage is very low.

To protect the buyer, many countries have their own seed laws: among other things these laws presecribe the minimum quality standards seed lots have to meet. In Europe, the EEC (Common Market) also has such standards.

The seed testing stations of many countries are associated with the ISTA, which makes the "International Rules for Seed Testing". These ISTA Rules prescribe how to test seed, not what standards the lots have to meet.

## 2. The aim of the purity test (Rule 3.1)

The object of the purity test is defined as follows:

a. to determine the composition by weight of the sample being tested and by inference the composition of the seed lot.
   - in other words: the composition of the sample is ascertained and the results are expressed as weight percentages. When the sample has been drawn from the lot in a representative way, these results also apply to the lot.

b. to determine the identity of the various species of seeds and inert matter particles constituting the sample.
   which means that all seeds and other particles not only have to be separated from the good crop seed and determined by weight as prescribed in a., but also that all have to be given, if possible, a scientific name.

## 3. Activities preceding the actual purity test/Rule 2.6.m6-2.7.2)

a. Size of the submitted sample.
   The sample sent to the seed testing station either by a company, private person or sampling agency, the so-called submitted sample, is much too large for a single purity test. The minimum size of the submitted sample is specified per species in column 3 of table 2A of the Annexes of the Rules.

For instance, Capsicum seed has to be submitted in amounts of 150 gr. or more, whereas the purity test only requires 15 grams . There are several reasons for this discrepancy:

1. sampling accuracy in the warehouse does not allow smaller quantities..

2. the sample must be enough for all tests (except a moisture test, for which a separate sample is required), e.g. a test for seed health, a cytological test (chromosome counts), a test for cultivar determination ect.,
3. sometimes the seed testing station has to re-test becasue the first test (which is preferably done in duplicate) gives results out of tolerance. Re-tests can also be done on requests;
4. often a "number count test for other species" has to be done in addition to the purity test. This is a determination according to number (not weight) of seeds from other species in an amount of seed that is ten times the size of the sample required for the purity test;
5. the sub-sample for the purity test can not easily be extracted from smaller amounts.

b. Preparing the working sample

A working sample is a sub-sample taken from the submitted sample in a special way in order to be as representative of the seed lot as is the submitted sample.

The rules allow several techniques, the procedure followed at the Dutch station combines a quick (sub) sampling with a high accuracy (for other techniques refer to 2.7.2.A of the Annexes).

The procedure is a combination of mechanical division (with the soil divider or riffle-type divider) and the spoon method.

In order to obtain the correct size of the working sample which is based on the weight of 2500 seeds), the sample is poured into the hopper of the soil divider, which halves the

mass. One half is again poured into the hopper, resulting in another halving.

After several of these halvings one stops when one has about, but not less than 10 times the amount of seed. This is poured carefully and evenly into a shallow tray. Using a (straight-edged) spoon in one hand and a spatula in the other, one now removes small portions of seed from not less than five (preferably not less than 10) random places on the tray. Sufficient portions are taken to constitute a working sample of approximately, but not less than, the required size. It is forbidden to take any surplus from the working sample, one either has to test the larger samples (this is time consuming) or start all over again with the preparation of a new sample.

4. Definitions of the three components

In the purity test the particles are arranged in three groups; these will be defined below.

Since 1976 the international certificate mentions only three components instead of four: the components "other crop seed" and "weed seed" have been combined into one fraction, called "other seeds" This is for practical reasons: what is a weed in one country may be a crop in another. Because the names of all the species are mentioned on the certificate anyhow, the receiving country can see whether the lot contains seeds from any species they define as weed.

At many stations, however, national certificates still have four components, and all analyses are performed in this

way. For international certificates, these two percentages have to be combined.

The descriptions of the three components as given in the RUles (for vegetable seeds) are given below.

a. Pure seed

The pure seed shall refer to the species stated by the sender, or found to predominate in the test, and shall include all botancial varieties and cultivars of that species. The following structures (even if immature, undersized, shrivelled, diseased or germinated, provided they can definitely be identified as of that species) shall be regarded as pure seed:

(a) intact seeds (i.e. seeds in the botanical sense)
(b) achenes and similar fruits, schizocarps and mericarps with or without perianth and regardless of whether they contain a true seed, unless it is readily apparent that no true seed is present (refers to Compositae, Umbelliferae, etc.).
(c) Pieces of seeds, achenes, mericarps and caryopses, resulting from breakage, that are more than one-half their original size. However, seeds of the Leguminosae, Cruciferae with the seed coats entirely removed shall be regarded as inert matter.
(d) Florets and caryopses of Gramineae as follows:

(i) Florets and one-flowered spikelets with an obvious caryopsis containing endosperm. A sterile floret attached to a fertile floret in Avena, Panicum, Setaria and Sorghum is not removed but left attached

and included in the pure seed fraction. In other genera this sterile floret shall be detached and placed in the inert matter fraction.

(ii) Free caryopses and pieces of caryopsis, resulting from breakage, that are more than one-half their original size.

b. Other seeds

Other seeds shall include seeds and seedlike structures of any plant species other than that of pure seed. With respect to classification as other seeds or inert matter, the distinguishing characteristics set out for pure seed shall also be applicable to other seeds except in the case of Cuscuta spp. (see c(a)2).

c. Inert matter

Inert matter shall include seeds, seedlike structures and other matter as follows.

(a) Seeds and seedlike structures

1. Pieces of broken or damaged seeds, achenes, mericarps one-half the original size or less, seeds of Leguminosae, Cruciferae with the seed coats entirely removed and structures defined in a (b) in which it is readily apparent that no true seed is present.
2. Seeds of Cuscuta species which are fragile (frequently enlarged) or ashen grey to creamy white in colour in section.

(b) Other matter

Soil, sand, stones, stems, leaves, pieces of bark, flowers, nematode galls, fungus bodies (such as ergot, other sclerotia and bunt balls) and all other matter not seeds.

5. Pure Seed Definitions of the major cereal and pulse crops

Only the structures that are described in the pure seed definition (PSD) are classed as pure seed. All other structures among the seeds or attached to the seed have to be classed either as other seed or as inert matter, depending on the nature of that structure.

The PSD's have been numbered for the purpose of simplicity:

| | |
|---|---|
| 1 Arachis | 1 Phaseolus |
| 2 Avena | 1 Pisum |
| 1 Cicer | 6 Secale |
| 1 Dolichos | 7 Sorghum |
| 1 Glycine | 1 Trifolium |
| 3 Hordeum | 6 XTriticosecale |
| 1 Lens | 6 Triticum |
| 1 Medicago | 1 Vicia |
| 4 Oryza | 1 Vigna |
| 5 Pennisetum | 6 Zea |

1- Seed, provided a portion of the testa is attached.
 - Piece of seed more than one-half the original size, provided a portion of the testa is attached.
2- Floret, with lemma and palea enclosing a caryopsis, plus attached sterile floret.
 - Floret, with lemma and palea enclosing a caryopsis.

 - Caryopsis.
 - Piece of caryopsis more than one-half the original size.
3- Floret, with lemma and palea enclosing a caryopsis (excluding an awn longer than the floret).
 - Piece of floret containing a caryopsis more than one-half the original size.
 - Caryopsis.
 - Piece of caryopsis more than one-half the original size.
4- Spikelet, with glumes, lemma and palea enclosing a caryopsis an (excluding an awn longer than the spilelet).
 - Floret with lemma and palea enclosing a caryopsis (excluding an awn longer than the floret)
 - Caryopsis.
 - Piece of caryopsis more than one-half the original size.
5- Floret, with lemma and palea enclosing a caryopsis.
 - Caryopsis.
 - Piece of caryopsis more than one-half the original size.
6- Caryopsis
 - Piece of caryopsis more than one-half the original size.
7- Fertile spikelet, with attached pedicel of sterile spikelet and rachis segment; fertile spikelet with glumes, lemma and palea enclosing a caryopsis, plus attached sterile lemma.
 - Spikelet, with glumes, lemma and palea enclosing a caryopsis, plus attached sterile lemma.
 - Caryopsis

- Piece of caryopsis more than one-half the original size.

6. Working procedure of the purity test (Rule 3.5)

a. Working sample

The purity analysis shall be made on a working sample taken from the submitted sample in accordance with Rule 2.7. and as explained in chapter 3.b.

The size of the working sample shall be:

either: not less than the weight indicated in column 4 of Table 2A of the Rules.

or: (in case the species is not mentioned): a weight estimated to contain at least 2500 seeds, subject to a minimum of 0.5 g and a maximum of 1000 g.

The analysis may be made on one working sample of this weight, each independently drawn.

b. Separation

The working sample (or sub-sample) after weighing, shall be separated into its component parts as defined in 4 caryopsis more than one-half the origi be shaken into a

- Seeds enclosed in fruits other than those indicated in 4.a. (b) shall be separated and the detached empty fruit classed as inert matter.
- For Beta vulgaris, except genetic monogerm cultivars, a special procedure is obligatory (see P.S.D. 5)
- After separation, each component part and any species of seed or kind of other matter of which a percentage is to be reported, shall be weighed in grams to the minimum number of decimal places necessary to calculate the percentage to one decimal place:

| When the number of grams of the working sample is: | Weigh the working sample and its components to the following number of decimal places: | Examples: |
|---|---|---|
| less than 1 | 4 | 0.8036 |
| 1 to 9.999 | 3 | 8.036 |
| 10 to 999.9 | 2 | 80.36 |
| 100 to 999.9 | 1 | 803.6 |
| 1000 or more | 0 | 8036 |



c. Tolerances

- If a duplicate analysis is made of two half-samples, the difference between the two must not exceed the tolerance between duplicate analyses given in column 3 of Table 3A of the RUles. If the difference is in excess of the tolerance, further pairs have to be analysed. For the correct procedure see Rule 3.6. and 3.6.A.
- When two or more purity analyses of whole working samples are made, the results must be within the tolerance given in column 4 of Table 3A. This column can also be used to compare results between different stations that have tested the same seed lot.

d. Reporting results

The results of a purity test shall be given to one decimal place and the percentage of all components must total 100.

Components of less than 0.05% shall be reported as trace. Components of 0.05% to 0.1% are reported as 0.1%

The Latin name of the species of pure seed, the Latin name of each species of other seed and the kind of inert matter must be reported.

7. Aids for simplifying the test or for improving its accuracy

a. Optical aids

- a magnifying glass of 3-5 times magnification is very useful.
- a binocular microscope may be needed for the small-seeded species or when one wants to determine presence of species that are hard to distinguish from the crop seed.

b. Balances

At least two balances are needed:

- one enabling 0.1 mg to be read accurately (capacity 160 - 200 g) an analytical balance.
- one allowing 10 mg to be read accurately (capacity about 1000 g) a precision balance.
- The precision balance can also be used for moisture determination.

c. Sieves

- a set of small hand-sieves with different perforations can be very useful. for dividng the working sample into two or more portions that are more homogeneous. This facilitates the test in two ways: it will be more accurate and will take less time to analyse.
- for Beta the prescribed sieve must be used.

d. Various other equipment

- spoons, spatulas, forceps, scalpel needles, shallow trays, funnels, watch glasses, etc. are always needed for a normal purity analysis.
- small metal containers are preferable to paper bags to receive the working sample and its components.

8. Special tests

There are several other tests, not belonging to the actual purity test, that can be done by the purity department.

a. number count test for other species (Rule 4)

In international trade this test is mainly used to

determine the presence of seeds of noxious or undesirable species. For this purpose the quantity of seed examined in a purity test is not sufficient and usually has to be increased tenfold (Table 2A, column 5).

In this test one only looks for species mentioned by the sender or in any seed law: the sample is not separated into the purity components, The number of seeds of each species sought is counted. To decide whether two determinations, made in the same station or in differnet stations, are significantly different, use Table 4A of the Rules.

b. 1000-seed weight (Rule 10). The 1000-seed weight is determined by a so-called weight determination. However, Rule 10 is rather complicated and less reliable than the following method.

A useful method is to count the number of seeds of the pure seed fraction of each half working sample (after the purity test is completed). If the difference between the two results does not exceed 2% one can accept the average and calculate the weight per 1000 seeds.

c. verification of species or cultivar (Rule 8)

This test has many applications and is performed by different techniques. The test has to be done by an exceptionally skilled analyst. Interested readers can refer to Rule 8.

d. Cytological test

In sugar beets and some grasses the degree of ploidy is a quality aspect of major importance. In sugar beets, for instance, the triploid seeds are preferred because they give better crops than diploid or tetraploid seeds.

However, the seed lots are always a mixture of all threee types and the extent of this heterogeneity is determined by this test.

The chromosomes are counted in cells from squashed and stained roottips or primary leaves collected from seedling.

For Beta the submitted sample must be fractioned by sieves to obtain a representative working sample. The chromosomes of 4 X 50 seeds are counted. This is not prescribed in the Rules; it requires special training too.

9. Pelleted seed (Annexes, Appendix A)

The Annexes of the Rules only give provisional rules for the testing of pelleted seeds.

The working procedure is the same as with normal seeds, but the fractions to be prepared are:
Pure pellets - unpelleted seed - inert matter.

See 3.2 of Appendix A of the Rules for the definitions of these fractions. After weighing, 100 pellets from the pure pellet fraction are taken and placed in a small container with water. After a few minutes the contents of the container are poured into a fine-mesh sieve which catches the particles that were in the pellets. The number of seeds of each species is counted, the kind of inert matter is specified (full details in 3.4 of Appendix A).

# PHENOL COLOUR REACTION FOR VARIETAL IDENTIFICATION OF WHEAT SEEDS

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Varietal identification is one of the important aspects of a good seed production program.

Pieper (1922) had shown that phenol tests could be used to identify wheat cultivars. Since then several workers have standardized this test. Some of these are published by Esbo in German (1945), Korpinen (1964) and walls (1965). The use of phenol colour reaction is one of the recommended tests for identification of wheat cultivars (International Seed Testing Association, 1976).

The phenol test is a very simple method for classifying the wheat the cultivars into different colour groups. The seed coat is the site of biochemical reactions giving black (++++), dark brown or mars brown (+++), brown or snuff brown (++), light brown or deep olive (+) and negative (-).

The biochemical studies on phenol colour reaction have shown that it involves the enzyme tyrosinase using phenol as a substrate (Esbo, 1945). Many times more than one cultivar falls into a particular colour group thus making it difficult to identify a

particular variety. However if the observation is taken frequently during the development of the colour on the seed coat it will be possible to further resolve the varieties into different groups as indicated above.

## EXPERIMIENTAL

Soak different cultivars of wheat in water overnight preferably at 20°C. Take a petri-dish (about 15 cm. dia.) and line it with 2 sheets of filter paper. Saturate the filter paper with about 4 ml of 1 % aqueous solution of phenol. Transfer the seeds on to the filter paper, cover the dish and put them at 30°C for about 4 hrs. Note the colour reaction.

## Observation

| Cultilvars | Black | Dark Brown | Brown | Light Brown | Negative |
|---|---|---|---|---|---|
| | (+++) | (+++) | (++) | (+) | (-) |

## References


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# AN INTRODUCTION TO GERMINATION TESTING

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## Germination Testing (based on ISTA-rules)

### 1. Introduction

The ultimate aim of the germination test is to furnish reliable information with respect to the field planting value of the seed and to provide results which can be used to compare the quality of different seed lots.

To this end the germination test must produce uniform and reproducible results within and between seed testing laboratories.

Testing under field conditions is normally unsatisfactory as the results cannot be repeated with reliability. Therefore laboratory germination methods have been envolved in which all or most of the external conditions can be controlled to give the most regular, rapid and complete germination for the majority of the samples of a particular kind of seed.

In seed laboratory practice, germination is defined as the emergence and development from the seed embryo of those essential structures which for the kind of seed in question are indicative of the ability to produce a normal plant under favourable conditions in soil.

So the conditions for laboratory germination must not only be specific enough to initiate growth in the seed, but also be favourable for development, in a limited period of time, into a stage whereby all essential structures can be evaluated to enable the separation of abnormal seedlings from normal ones.

Extensive comparative investigations have shown that abnormal seedlings have no practical value in an agricultural sense.

Germination is expressed as the percentage of the pure seed of the kind of seed under consideration which produces normal seedlings.

Provided the seeds tested were not dormant the result of a germination test preformed in this way, as a rule proves to be positively correlated with the emergence under practical sowing conditions. However not in a sense of forecasting the precise emergence but in the sense of indicating that under the same set of conditions a seed lot of relative high quality will emerge better than a seed lot lower in quality.

The International Seed Testing Association (I.S.T.A) has developed germination methods and directions for seedling evaluation for international use, which in general are followed in different countries as well.

## 2. General directions

The pure seed shall be well mixed and 400 seeds are counted at random into replicates of 100, 50 or 25 seeds. The seeds are spaced uniformly on the moist substratum and separated sufficiently in order to facilitate easy seedling evaluation and to prevent the seedlings from coming into contact with another before they are counted and removed. This is to prevent spreading of possible infections as far as possible.

After pretreatment to break dormancy the seeds are brought under optimal germination temperatures. Fungicide treatment is not used in the normal germination test, although it may be undertaken upon request.

The first count is made at the time that the majority of the seedlings have reached the stage of development in which proper evaluation is possible.

In the germiantion test the seedlings are completely dependent, for their growth, on the reserve nutrition stored in the seed, they have to be evaluated before running out of the reserve nutrition otherwise they will rot away.

The normal seedlings are removed and recorded. Seeds which are obviously dead and decayed and decayed seedlings are removed and recorded in order to prevent contamination. The same procedure is repeated at the intermediate counts and at the final count: also the number of possible hard and/or fresh ungerminated seeds is recorded. If, at the end of a test, some seeds have just started to germinate prolongation of the test is possible.

When the results of the replicates of a test are within the maximum tolerated range, the average of the normal seedlings represents the percentage germination.

## 3. Procedure

### 3.1 Preparing the replicates for testing

The replicates of the working sample (pure seed fraction) are either counted by mechanical devices, such as vacuum-counters, counting boards or by hand.

The seeds are spread on the vacuum head of which the plate is perforated with holes (e.g 100 or 50) on to which the seed is sucked when the vacuum is drawn. Vacuum-counters should have interchangeable heads of various sizes, diameter of the holes and number of holes. To avoid segregation the whole surface of the head must be evenly filled with seeds and then the vacuum is drawn. The excess seed is discarded by inverting the counterhead and a correction is made whenever a hole is found with none or more than one seed. A vacuum counter shall never be placed on a seed sample with its face downward so that lighter seeds will be selected. Smooth, non hairy and round to elliptical seeds may be counted by vacuum.

### 3.1.2. Counting board

The counting board consists of two plates above each other. Both plates are perforated by a number of holes (e.g. 50 or 100). The lower plate serves as a false bottom, which can be slid forward

and backward so that in a certain position the holes in both plates correspond and the seeds fall in place upon the substratum.

To avoid segregation the diameter of the holes should be such that even the largest seed of a sample fits in the holes.

In general counting boards are used for large seeds such as peas, beans and maize. Both vacuum head and counting board are approximately the size of the substratum on or in which the seeds are placed.

### 3.1.3 Hand counting

The pure seed is poured upon the working table, mixed well and divided, with the aid of a spatula, into so many equal parts as replicates are needed (e.g. 4 X 100, 8 X 50). Each part is well mixed again and the replicates are counted at random.

## 4. Preparing the substratum

Different substrata are used in the germination test: paper (1), sand (2), and in some cases soil (3), depending on the germination facilities in the laboratory, the dimensions of the seed and the requirements for light.

The substrata should be non toxic, be relativily free of molds, other micro-organisms and their spores and provide adequate aeration and moisture for the germinating seeds. At all times the substratum must contain sufficient moisture to meet the requirements for

germination, but the moisture must not be excessive. The initial quantity of water to be added to the substratum will depend on its nature and dimension. To reduce the need for addition of water after planting the relative humidity of the air surrounding the seeds should be kept as close as possible to saturation to prevent loss by evaporation.

## 4.1. Paper

The kind of paper may be filter, blotter or towels and can be used as follows: a) seeds are planted on top of paper (T.P. method) or b) seeds are planted between paper (B.P. method) either in envelopes, rolls or so-called pleated paper.

This pleated paper-method seems to be a very good substratum for the germination of pelleted seeds and seeds very susceptible for surplus moistening. As the test is carried out in closed boxes the moisture content can be regulated.

## 4.2. Sand

The sand should be free from both fine and large particles. It should mainly pass through a sieve having holes of 0,8 mm diameter and be retained on a sieve having holes of 0.05 mm diameter. When necessary the sand must be washed and sterilized to kill micro-organisms and foreign seeds. The amount of water to be added to the sand will depend on the characteristics and the size of the seed to be tested. It should never be so wet that optimal aeration is prevented. For seeds like maize, peas and beans, the sand should be moistened to approximately 60% of its waterholding capacity.

Preparation of the sand-bed could be done as follows: the germination-pan is filled with a levelled layer of moist sand (preferable with the aid of a metal scraper) and loosened with forceps or a metal rake. The seeds are planted and covered to a depth of 1-2 cm. The sand-cover is again loosened and levelled (care should be taken that the seeds are not touched). The surplus sand is removed with a scraper, in such way that the sand is not pressed.

## 4.3. Soil

Soil or an artificial compost are commonly used instead of sand to test samples which produce seedlings with phytotoxic symptoms, when germinated in sand or paper.

These seedlings may become normal in case the toxic substances are absorbed by the humus-complex of the soil.

Also to confirm the evaluation of seedlings in doubtful cases the soil test is used. The use of soil instead of sand for routine germination tests is not recommended as soil is more difficult to standardize and therefore liable to cause greater variation between test results.

To moisten, the soil water should be added until the consistency of the soil is such that the ball formed by squeezing it in the palm of the hand is easily broken when pressed between two fingers (1.S.T.A. -rule).

The water used to moisten the substratum should be reasonably free from acid, alkali, organic or other impurities (drinking water).

Detailed specifications for paper, sand, soil and water are given in the annexes of the I.S.T.A.-rules 1976, under 5.4.A

## 5. Temperature

The temperature is one of the most critical factors in the laboratory gremination. Different seeds require different temperature-ranges for germination.

Below or above that range, germination is prevented. In the range of temperature there is usually an optimal temperature at which the highest germination in the shortest time is obtained.
The conditions under which the seed is grown have some influence.
Some seeds require constant temperatures and others require alternating temperatures.

Usually when alternating temperatures are required the lower temperature is maintained for 16 hours and the higher temperature for 8 hours.

A sharp change-over lasting 1 hour or less may be necessary for seeds which are dormant. Care should be taken that the temperature is as uniform as possible throughout the germination period and throughout the germination apparatus. The temperature variation should not be more than $\pm$ 1 $^{o}$C in each 24-hour period.

## 6. Light

The influence of light in germination is a difficult matter. Some seeds only germinate in the dark, others are indifferent in their reaction. It is known that many seeds require light when they are dormant.

Free from the germination-promotive effect, light during the test is strongly advised to enable the essential structures of the seedlings to be evaluated with greater certainty and also to reduce the possibility of attack by micro-organisms.

In the germination test the light may be daylight or from an artificial source. Care should be taken that heating from the light source does not influence the temperature and humidity.

As the emission in the red spectrum plays an important positive role in breaking dormancy while that in the far red does not or may even induce dormancy, cool white fluerenscent tubes are recommended with a low emission in the far red and a high emission in the red region. The light is usually given for 8 hours in every 24 hours; in case of alternating temperatures the light is given during the high temperature period.
The light intensity should be approximately 750-1250 lux.

The type of substratum, the temperature and the requirement for light vary for the different species and will depend largely on the facilities available to the seed testing station.

## 7. Dormancy

Many viable seeds do not germinate under conditions which are normally regarded as favourable to germination. Such seeds are called dormant. The effect of light (a) and alternating temperature (b) were already mentioned. Some other treatments that may be used to induce germination are:

c) Dry storage of the seeds for several weeks or months before germination.

d) Predrying; the seeds are heated at a temperature not exceeding 40°C (mostly 35°C), with free air circulation for a period up to 7 days before being placed under the required conditions.

e) Prechilling; the seeds are placed in contact with the moist substratum and kept at a low temperature (5-10°) for an initial period before they are removed to the required germination temperature. Usually the period is not longer than 1-7 days, but tree seeds require a longer period.

f) Potassium nitrate; at the beginning of the test the substratum may be moistened with a 0.2% solution of KNO3 (2 grams/liter of water). Water is used for moistening thereafter.

g) Prewashing; Natural inhibiting substances which are soluble in water may be removed by soaking and washing in water before the beginning of the test. The temperature of the water is usually kept at 20-25°C.

h) Modification of the seedcoat and other structures; Clipping, piercing and scratching the seeds (e.g. some leguminoseae), removing the pulp from seeds (e.g. New-Zealand-Spinach) are accepted methods to initiate germination, but must be done very carefully in order to avoid injury to the resultant seedlings.

i) Gibberellic Acid ($GA_3$); it is known that some hormones and

regulators, such as gibberellic acid, kinetine and ethylene break dormany in several kinds of seeds.

Since 1976 the I.S.T.A. allows the use of $GA_3$ for breaking dormancy of Avena sativa, Hordeum vulgare, Secale sereale and Triticum aestivum. The substrate is then moistened with 500 ppm solution of $GA_3$ (500 mg/liter of water).

## 8. Evaluation.

See I.S.T.A. Handbook for Seedling evaluation.

## 9. Duration of the test

In general different seeds require different lengths of test-periods, although the type of substrate, the temperature and illumination have great influence. The duration of the test is determined by the time given for the final count. The chilling period to break dormancy is not included in the test period when reporting results. Dependent on the length of the test period several counts may be necessary as, in general, the seeds do not germinate all at once. But, the number of intermediate counts should be kept to a minimum to reduce the risk of damaging seedlings which have not yet sufficiently developed. More counts than are normally necessary may be performed when a sample contains seeds infected by fungi or bacteria. In official seed testing a test may be prolonged for an additional period of 7 days and a test may be terminated prior to the prescribed period when the analyst is satisfied that the maximum germination of the sample has been obtained.

## 10. Recording and calculation of the test results.

At the first count the number of normal seedlings is recorded (preferably on a special preprinted form).

Seeds which are obviously dead and decayed and also decayed seedlings are counted and removed from the test. The same procedure is repeated at eventual intermediate counts. At the final count also the number of hard seeds and fresh ungerminated seeds is recorded. The different categories must total up to the number of seeds the replicate started with. No assumption shall be made about the "missing".

At any count the number of unremoved seeds and seedlings should be counted and recorded in order to limit the risk of possible administrative failures. When the results of the replicates of a test are withing the allowed tolerance the average represents the percentage germination calculated to the nearest whole number (Normal seedlings).

If the results are out of tolerance or when there is evidence that the results may be unreliable because of wrong test conditions, errors in seedling evaluation, spread of fungi or bacteria, phytotoxicity, dormancy or because of inaccuracies in counting or recording the results, a second test should be made.

If the result of a second test is compatible with the result of the first test (within the tolerated range) the average of both test results represents the percentage germination. If the difference between first and second test result exceeds the tolerance at least one more test should be made.

## 11. Germination apparatus

Nowadays different modern germination equipment is available to meet the following requirements:

a) Possibility of any constant or alternating temperature between $10^{o}$C and $35^{o}$C.
b) Temperature-tolerance not exceeding $\pm$ 1 $^{o}$C.
c) A sharp change-over in temperature lasting less than 1 hour between $10^{o}$C and $30^{o}$C.
d) Humidity of the air very close to saturation.
e) Illumination facilities providing the required light intensity not interfering with the temperature and moisture conditions.
f) Automatically controlled and regulated.
g) Rather easy to repair or equiped with interchangeable units.
h) Easy to clean.

The most common germinators are:

a) The Jacobson or Copenhagen table. This apparatus consists of a plate upon which the filterpapers with seeds are placed. The beds are kept moist by means of a wick which extends from the seedbed through slides or holes in the germination plate into the underlying waterbath.

To prevent drying out the seedbed is covered with a well fitted belljar provided with a small hole allowing for ventilation without undue evaporation. The temperature is conditioned either indirectly by heating and cooling the water in the waterbath or directly, by controlling the germination plate and is usually automatically regulated and controlled. The entire unit is placed under artificial light or natural daylight.

b) Germination cabinets, either for constant or for alternating temperatures and may be with or without light facilities. They may be so-called dry cabinets, where germination must take place in closed boxes or wet cabinets in which seed can be germinated on open beds without drying out.
Temperature and light are usually automatically regulated and controlled.

c) Walk-in chambers or germination rooms, either for constant temperature only or for both constant and alternating temperatures. They may be wet or dry rooms, with or without light facilities. Instead of shelves the room germinator can be furnished with trolleys to facilitate easy transport.
The easiest and cheapest way is to arrange for constant temperatures and dry conditions.

Germination must then take place in closed boxes or pans with (transparent) covers to prevent drying out. The temperature can be controlled by an air conditioner. If alternating temperatures are required it can be arranged by moving the seedbeds (on trolleys) from one room (the one temperature component) to another room (the other temperature component).

Apart from financial possibilities, the choice of apparatus depends on the number and kind of samples tested in a laboratory. As an example, laboratories normally testing a large number of cereals in sand, usually in need for a prechilling period, should use germination rooms.

One room for prechilling ($10^{o}$C) and one room for germination (preferable with light) at $20^{o}$C.

EXAMPLE OF HOW TO FILL IN THE GERMINATION FORM

| method | days | % | number of days | normal seedlings | hard seeds | fresh ungerm. seeds | abnormal seedlings × | |
|---|---|---|---|---|---|---|---|---|
| TPL 20-30 | 5 | 71 | 14 | 82 | | | 5 | |

counting days (planting): 1/5 | | 6/5 | 11/5 | 15/5 | first cnt.

× including .. % broken seedlings

apparatus number: 24702

species: Brassica oleracea

4 (tray 3)

| date | number of days | 1 N | 1 H | 1 F | 1 A A-B | 1 A B | 1 Re Ro | 1 Re O | 2 N | 2 H | 2 F | 2 A A-B | 2 A B | 2 Re Ro | 2 Re O | 3 N | 3 H | 3 F | 3 A A-B | 3 A B | 3 Re Ro | 3 Re O | 4 N | 4 H | 4 F | 4 A A-B | 4 A B | 4 Re Ro | 4 Re O | initials of analyst | calculation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/5 | 5 | 70 | | | | | 2 | 28 | 68 | | | | | 4 | 28 | 71 -1 | | | | | 3 | 25 | 75 | | | | | 1 | 24 | | 71 |
| 11/5 | 10 | 10 | | | | | 1 | 17 | 12 | | | | | 0 | 16 | 7 | | | | | 2 | 16 | 8 -1 | | | | | 2 | 13 | | |
| 15/5 | 14 | 0 | | | 5 | | 12 | 0 | 1 | | | 7 | | 7 | 1 | 2 | | | 5 | | 9 | 0 | 1 | | | 4 | | 8 | 0 | | 82 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 80 | | 5 | | 15 | | 81 | | | 7 | | 11 | 1 | 80 -1 | | | 5 | | | | 84 -1 | | | 4 | | 11 | | | |
| | | | 80 | | 5 | | 15 | | 81 | | | 7 | | | | 81 | | | 5 | | | | 85 | | | 4 | | 11 | | | |

| | | | |
|---|---|---|---|
| normal | | N | 82 % |
| hard | | H | — % |
| fresh | | F | — % |
| A | A-B | | 5 % |
| | B | | — % |
| Re | Ro | | 13 % |
| | O | | 0 % |
| total | | | 100 % |

## References


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Germination testing of Wheat, Barley, Chickpea and Lentil.

## 1. Planting the seeds

Many details on media and apparatus to be used can be found in the ISTA Rules and Annexes, especially in the paragraphs 5.4.A, 5.5.A. and 5.6.A. Table 5A gives the following prescriptions for the species under consideration:

| Species | Substrate | Temperature $0^{o}C$ | Light | First count (days) | Final count (days) | Additional remarks |
|---|---|---|---|---|---|---|
| 1. Hordeum vulgare | S;BP | 20 | - | 4 | 7 | Prechill; after-ripening; $KNO_3$; $GA_3$; test at $15^{o}C$; diffuse light |
| 2. Triticum aestivum | S;BP | 20 | - | 4 | 7 | as for Hordeum |
| Triticum Durum | | | | | | for durum |
| 3. Cicer arietinum | S;BP | 20;20-30 | - | 5 | 8 | 6 |
| 4. Lens culinaris | BP | 20 | - | 5 | 10 | Prechill |

BP= between paper; S=sand; $GA_3$= gibberellic acid

The following is an extract from the ISTA Handbook for Seedling Evaluation

## 2. Evaluation of wheat and barley (as well as rye and oats)

The mature grain consists of a caryopsis, which may be naked (e.g. Triticum) or remain enclosed within the lemma and palea in the harvested unit (e.g Hordeum). The embryo is situated at one end of the caryopsis. The scutellum remains in direct contact with the endosperm, which forms the main food reserves. The embryonic axis consists at its lower end of the radicle and a specific number of initials of seminal roots. The radicle is protected by a sheath, the coleorrhiza. The plumule at the upper end of the embryonic axis is also surrounded by a protective sheath, the coleoptile. (The part of the seedling axis between the attachment of the scutellum and the coleoptile)

At the start of germination the coleorrhiza breaks through the pericarp and the primary root pushes through the coleorrhiza followed almost simultaneously by the other semianl roots. The appearance of the seminal roots is followed by the elongation of the coleoptile with the first leaf developing inside, which later in the test emerges from the coleoptile near the tip. The mesocotyl may elongate considerably depending on the species tested and in response to test conditions.

Normal seedlings are those which have:

At least two seminal roots intact or with only slight defects: e.g. discoloured or necrotic spots
The mesocotyl (where developed) intact or with only slight defects:
The coleoptile intact or with only slight defects:
e.g - discoloured or necrotic spots

- loose twists
- split for one third or less from the tip

The leaf intact, emerging through the coleoptile near the tip (or at least reaching half-way up) or with only slight defects:

e.g. - discoloured or necrotic spots
- slightly damaged

Remarks:

Tests should not be evaluated before the first leaf has emerged from the coleoptile in most of the seedlings. Seedlings, which at the end of the first period have not reached this stage of development, are considered normal if otherwise normal, unless the leaf is extending less than half-way up the coleoptile.

Seedlings with a split coleoptile are considered normal when the split runs down from the tip to one third or less of the coleoptile length. If the split extends to more than one third of the length, or if the coleoptile is split at its base, the seedling must be classed abnormal. When the length of the split is assessed, care should be taken not to enlarge the split by handling the seedling.

A seedling with a coleoptile trapped by the glumes or the fruit coat is considered normal when development is otherwise normal, but abnormal if development is considerably retarded.

Seed samples of chemically treated cereals germinated on an artificial substrate (especially paper) often produce seedlings with phytotoxic symptoms, such as short and swollen coleoptiles and stubby seminal roots. If there is a number of such seedlings in a test, a retest in soil should be conducted. Soil may allow a more realistic

evaluation of the sample, since some of the chemical will be absorbed;therefore seedlings with phytotoxic symptoms will be fewer or even eliminated in soil. All seedlings left to show phytotoxic symptoms in soil are considered abnormal.

3. Evaluation of chickpea and lentil (as well as peas and vetches)

Dicotyledons with hypogeal germination

The shoot system consists of an elongated epicotyl and the terminal bud with developing primary leaves. The cotyledons usually remain inside the seed coat. The hypocotyl is not visible.

The root system consists of a primary root, usually with root hairs, and Secondary roots which are to be taken into account, if the primary root is defective.

The embryos of mature seeds in the genera of this group have two large fleshy cotyledons containing the food reserve. At the start of germination the primary root emerges through the testa, elongates rapidly and secondary roots soon develop. The hypocotyl is hardly discernible, but the epicotyl elongates considerably. In many genera of this group (e.g. Vicia and Pisum) the epicotyl carries 1-3 scale leaves below the primary foliage leaves and the terminal bud. The bud in the axil of each cotyledon normally remains dormant unless the terminal bud is seriously damaged.

Normal seedlings are those which have:

The primary root intact or with only slight defects:

e.g - discoloured or necrotic spots
- healed cracks or splits
- cracks and splits of limited depth

note: seedlings are also classed as normal in case the primary root is defective but a sufficient number of normal secondary roots have developed.

The cotyledons intact or with only slight defects:

e.g - less than 50% of the original tissue not functioning
- three cotyledons

The epicotyl intact or with only slight defects:

e.g - discoloured or necrotic spots
- healed cracks, splits or breaks
- cracks or splits of limited depth
- loose twists

The primary leaves intact or with only slight defects:

e.g - less than 50% of the area not functioning

The terminal bud intact

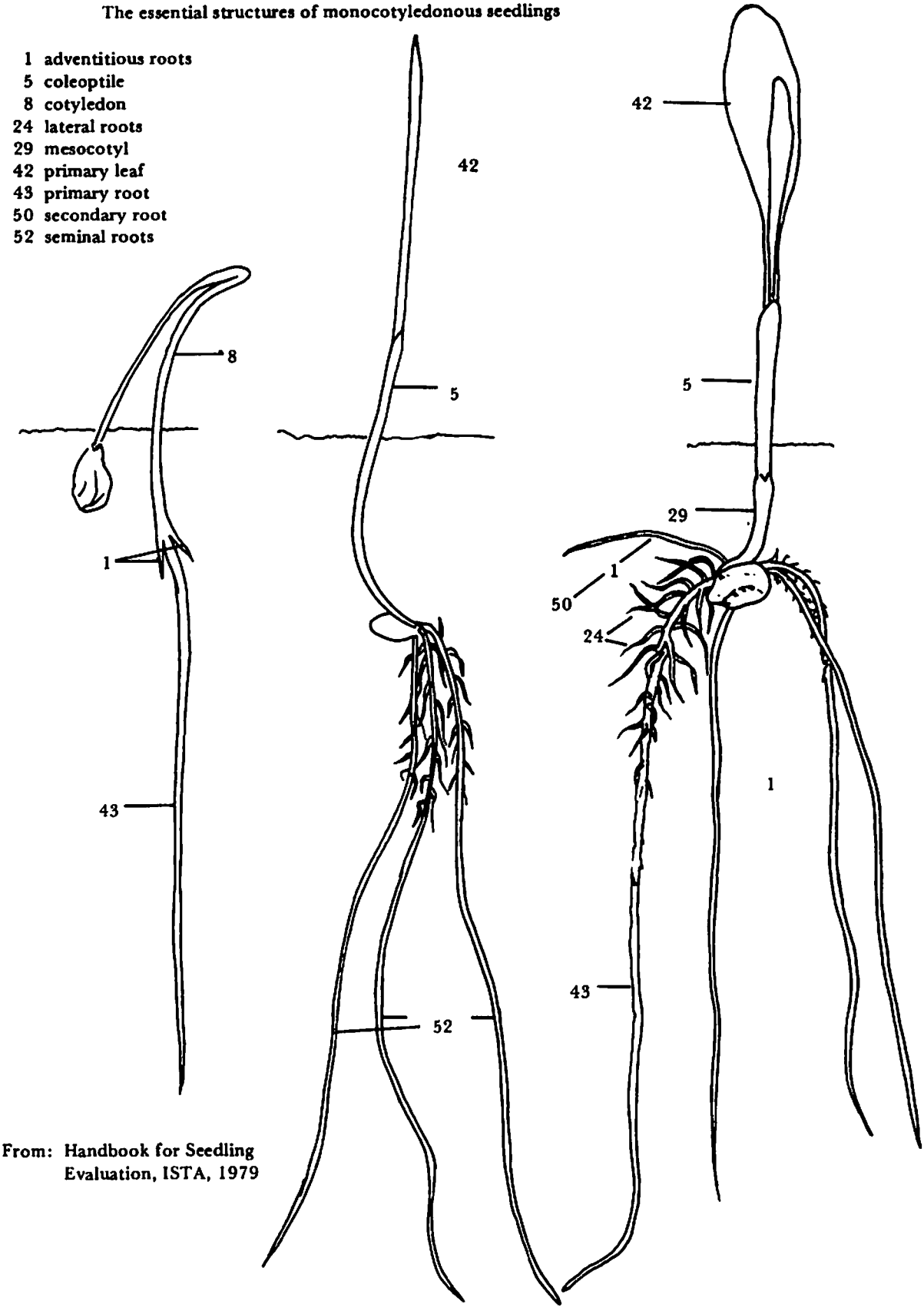
Remarks:

Attention should be paid to the point of attachment of the cotyledons for signs of decay or disease.

When the main shoot does not develop satisfactorily, the seedling is classed as abnormal, even if axillary shoots have developed.

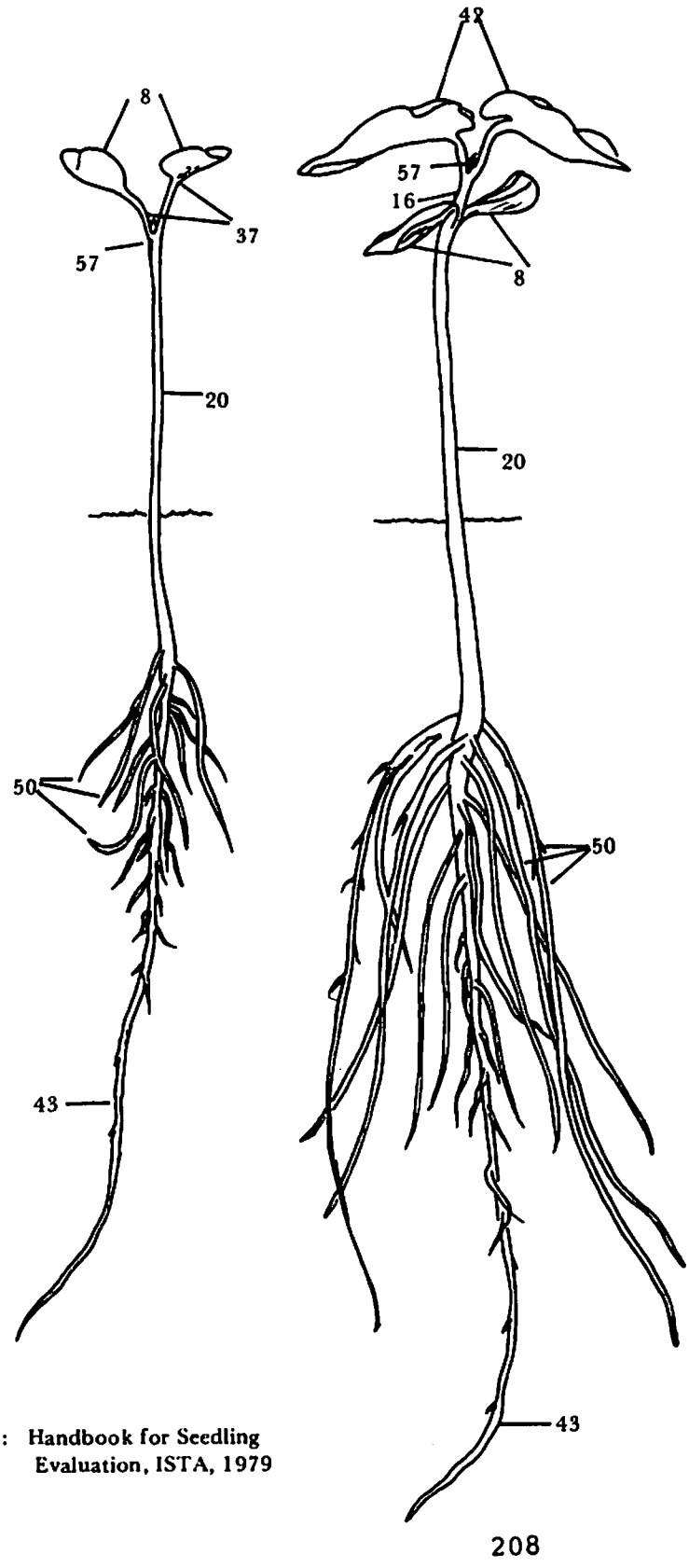
The essential structures of monocotyledonous seedlings

1 adventitious roots
5 coleoptile
8 cotyledon
24 lateral roots
29 mesocotyl
42 primary leaf
43 primary root
50 secondary root
52 seminal roots




From: Handbook for Seedling Evaluation, ISTA, 1979

The essential structures of dicotyledonous seedlings




8 cotyledons
16 epicotyl
20 hypocotyl
37 petiole
42 primary leaves
43 primary root
47 scale leaves
50 secondary roots
57 terminal bud

From: Handbook for Seedling Evaluation, ISTA, 1979

# TETRAZOLIUM TEST FOR SEED VIABILITY

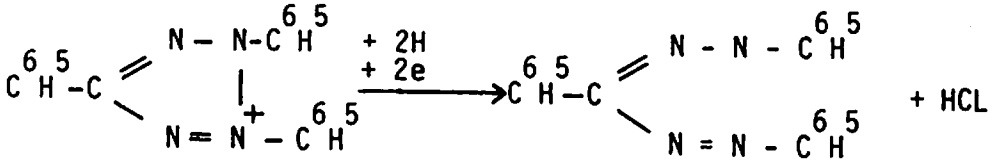
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Tetrazolium test was developed in Germany by Lakon in the 1940s, and introduced in to the U.S.A. after the World War II. The test has been developed to furnish a quick estimate of seed viability.

The living embryo or root-shoot axis of seeds converts absorbed colourless tetrazolium solution into a red colour substance called formazen. The reaction by which the colour develops is as follows:




2,3-5 triphenyil tetrazolium chloride

triphenyl formazan (Red in colour)

Method:

1. Wheat and chickpea seeds should be soaked in water overnight at room temperature.

2. The water-soaked seeds are then cut longitudinally (e.g. wheat, maize etc.) or laterally (e.g. small seeded grasses) to expose the embryo. Seed coats of dicots should be removed to facilitate the quick penetration of tetrazolium (e.g. Cicer).
3. After preparing the desired no. of seeds (e.g. say 100), they should be soaked either in 1.0% of teterazolium solution (TZ) of PH 6 to 7 and be kept preferably in darkness at about $30^{0}$C of 3-4 hrs. Temperature influences the reaction e.g. at $26^{0}$C staining will be twice as fast as at $20^{0}$C and at $32^{0}$C twice as fast as at $26^{0}$C. It is preferable not to conduct the test above $40^{0}$C. If the acidity of the TZ solution is much higher, the colour will not develop even on viable embryos. Solution with progressively lower PH values than 6 tends to be reflected first by weaker staining and later by failure to stain. On the other hand solutions with progressively higher PH values than optimum reflect progressively darker staining. Evaluation problems may be created at exceedingly high PH values.
4. When the colour has developed the TZ solution should be drained, the seed should be rinsed 2-3 times with water and evaluated. During evaluation, seeds should be immersed in water. If it is not possible to evaluate seeds the same day, the stained seeds may be kept in a refrigerator in water for 1-2 days. Staining patterns for Iriticum (wheat) are given in Figure 1 and of a typical dicot seed in figure 3. Many seeds are neither completely dead nor completely alive, therefore staining patterns should be correlated with the seedling descriptions. (Fig 2 and 4).

Accurate interpretation of the tetrazolium test is dependent upon:

1. Knowledge of seed and seedling structures.
2. Understanding the mechanism of the test and its limitations.

3. Combining interpretation of staining patterns with other visible aspects of seed quality.
4. Interest and Experience.

The analyst should be familiar with cell division areas in embryos. In grasses the location of these areas includes tips of radicle & seminal roots the base of plumules. If a dead area includes mesocotyl & seminal roots, the embryo cannot develop into a seedling. In wheat and rye the tips of coleorhizas are frequently injured & dead. In maize that has been shelled at high moisture, the upper & lower tips of scutellum frequently fail to stain. These symptoms do not necessarily prevent germination under favourable conditions, especially if seeds are properly treated with a suitable fungicide. Damage to legume seed frequently occurs in hypocotyls and points of attachment of cotyledons and hypocotyls. Injuries that involve growing points or that are located between or adjacent to essential structures, are more critical than injuries of similar magnitude but in more remote regions as in tips of cotyledons. Therefore, the above points may be considered when deciding whether seed is germinable or non-germinable.

Properly conducted TZ & germination test results are generally in close agreement. Differences in results are usually smaller with high quality seed than with low quality seed.

Discrepancies between tetrazolium test and germination test results may be due to several reasons, these are:

1. Sample differences
2. Improper germination testing
3. Improper TZ testing techniques
4. Dormant seed

5. Hard seed
6. Seed-borne organisms
7. Chemical injury: fumigation, injury and overtreatment with mercurial seed treatment may not be detected with the TZ test. The chemical damage that prevents normal germination may not inhibit the TZ staining process.

When the pigment within the seed coat or lemma prevents clear vision a few drops of the following clearing solutions can be used. Removal of pigmentation from the covering structure requires about 10-30 minutes.

Lactophenol Solution:

| | | | |
|---|---|---|---|
| 1. | 20 | Parts | Lactic acid |
| 2. | 20 | Parts | Phenol |
| 3. | 40 | Parts | Glycerin |
| 4. | 20 | Parts | Water |

Advantages of TZ

1. Quick estimate of viability can be obtained (within 12-20 hours).
2. When the seed is dormant or very slow in germinating a viability test is extremely useful.
3. Seeds are not damaged (in dicot only) in analysis, therefore they could be germinated.

Disadvantages of TZ

1. It is difficult to distinguish between normal and abnormal seedlings.
2. It does not differentiate between dormant and non-dormant seeds
3. Since the TZ test does not involve germination, micro-organisms harmful to germinating seedlings are not detected.

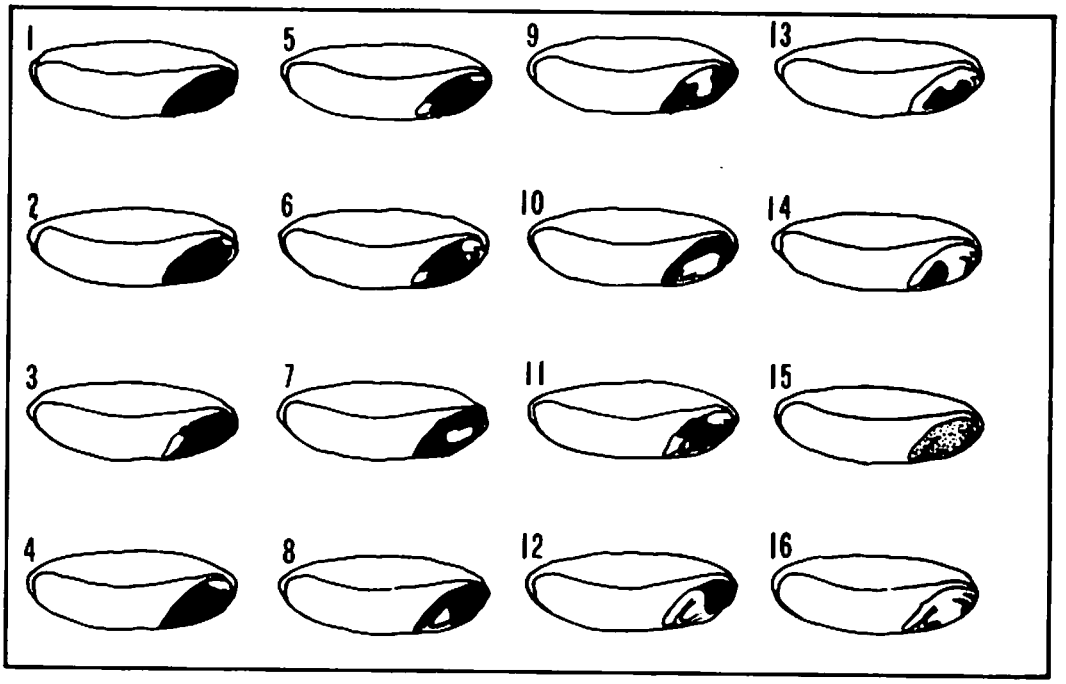



Fig 1. Wheat, Tetrazolium staining patterns for germinable and non-germinable seed (5)

Criteria for interpreting tetrazolium test results on wheat seed. Black areas indicate stained, living tissue; white represent unstained and dead tissue.

| | |
|---|---|
| No. 1. | GERMINABLE. Entire embryo stained bright red. |
| Nos. 2-5 | GERMINABLE. Extremities of scutellum unstained. |
| No. 6. | GERMINABLE. Extremities of scutellum, radicle tip, and coleorhiza unstained. . |
| No. 7. | NON-GERMINABLE. More than three-fourths of radicle unstained. |
| No. 8. | NON-GERMINABLE. Plumule unstained. |
| No. 9. | NON-GERMINABLE. Central portion of scutellum and scutellar node unstained. |
| No. 10. | NON-GERMINABLE. Embryonic axis unstained. |
| No. 11. | NON-GERMINABLE. Extremities of scutellum and plumule tip unstained. |
| No. 12. | NON-GERMINABLE. Entire upper half of embryo unstained. |
| No. 13. | NON-GERMINABLE. Scutellum unstained. |
| No. 14. | NON-GERMINABLE. Scutellum radicle, and coleorhiza unstained. |
| No. 15. | NON-GERMINABLE. Stain very faint pink. |
| No. 16. | NON-GERMINABLE. Entire embryo unstained . . |

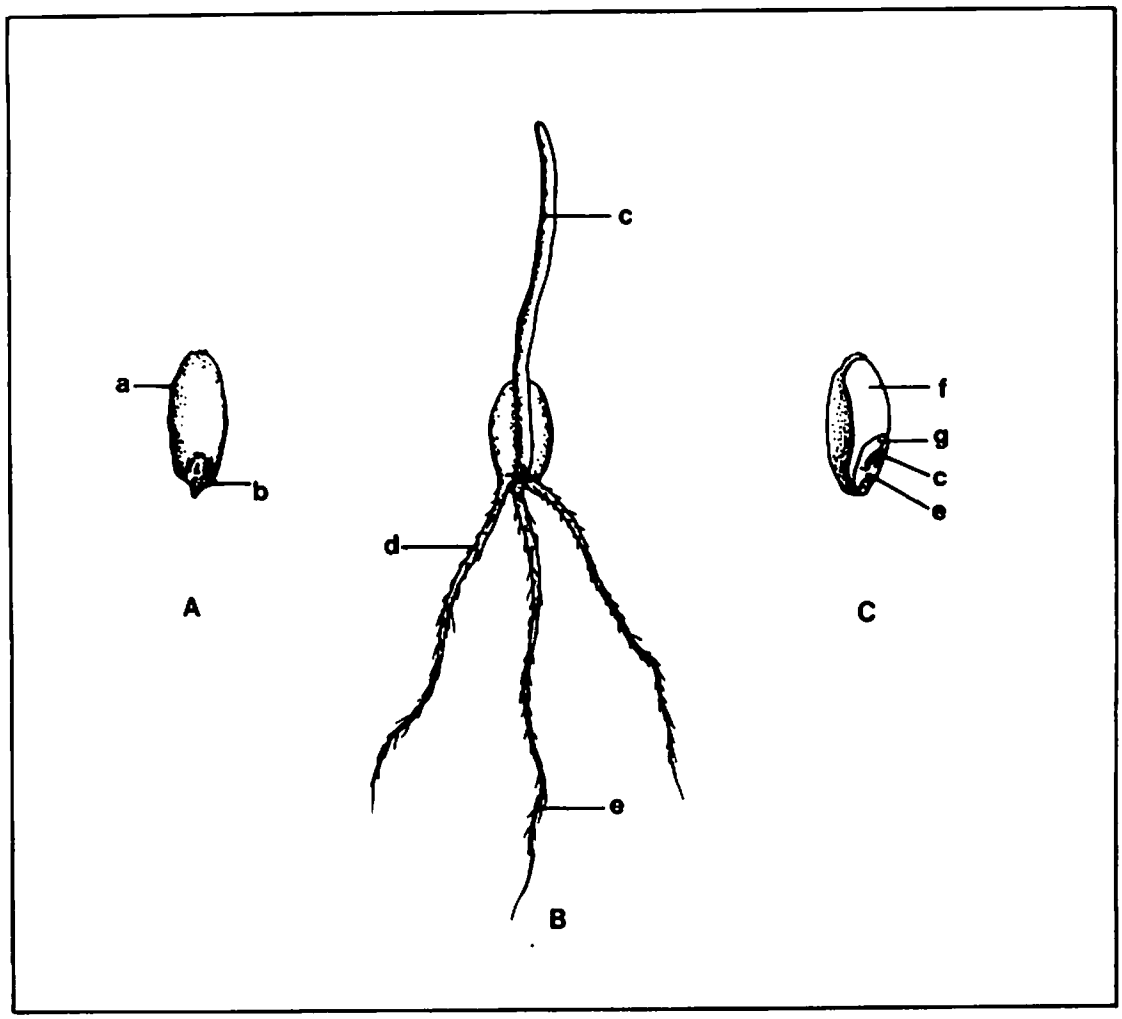



Fig 2. Wheat-Seed and seedling structure A. Intact seed; B. Seedling; C. Bisected seed. a, Pericarp; b, germ; c, plumule; d, secondary root; e, primary root (radicle; f, endosperm; g, scutellum, (5).

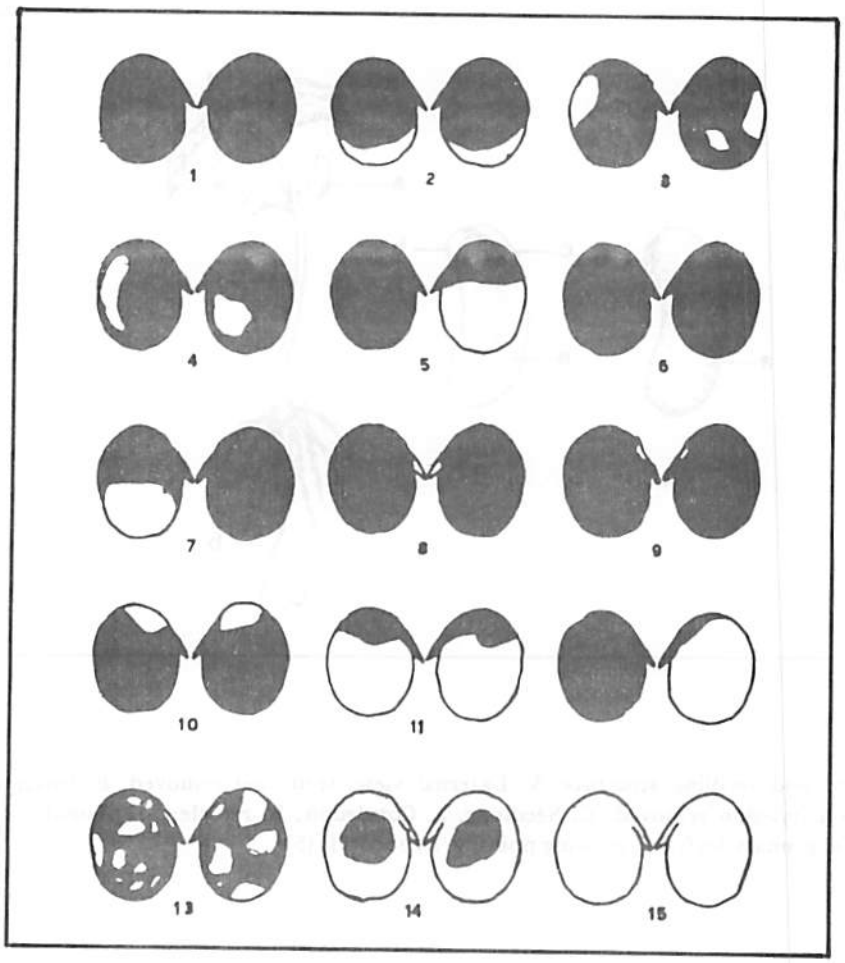



Fig 3. Tetrazolium staining patterns and non-germinable seeds

Criteria for interpreting tetrazolium test results of hairy vetch seeds. Illustrations are paired and depict both sides of seed. Black areas indicate stained, living tissue; white areas represent unstained and dead tissue.

| | |
|---|---|
| No 1. | GERMINABLE. Seed completely stained. |
| Nos 2-5. | GERMINABLE. Non-critical, unstained areas on cotyledons. |
| No 6. | GERMINABLE. Extreme tip of radicle unstained. |
| No 7. | GERMINABLE. Extreme tip of radicle unstained: one-half of one cotyledon unstained. |
| No 8. | NON-GERMINABLE. More than extreme tip of radicle unstained. |
| No 9.m | NON-GERMINABLE. Unstained area on upper portion of raducle. |
| No 10. | NON-GERMINABLE. Juncture of radicle and cotyledons unstained. |
| No 11. | NON-GERMINABLE. More than one-half of cotyledonary tissue unstained. |
| No 12. | NON-GERMINABLE. One cotyledon almost entirely unstained. |
| No 13. | NON-GERMINABLE. Extensive mottled areas of unstained tissue. |
| No 14. | NON-GERMINABLE. Only small central portion of cotyledons stained. |
| No 15. | NON-GERMINABLE. Seed completely unstained. |

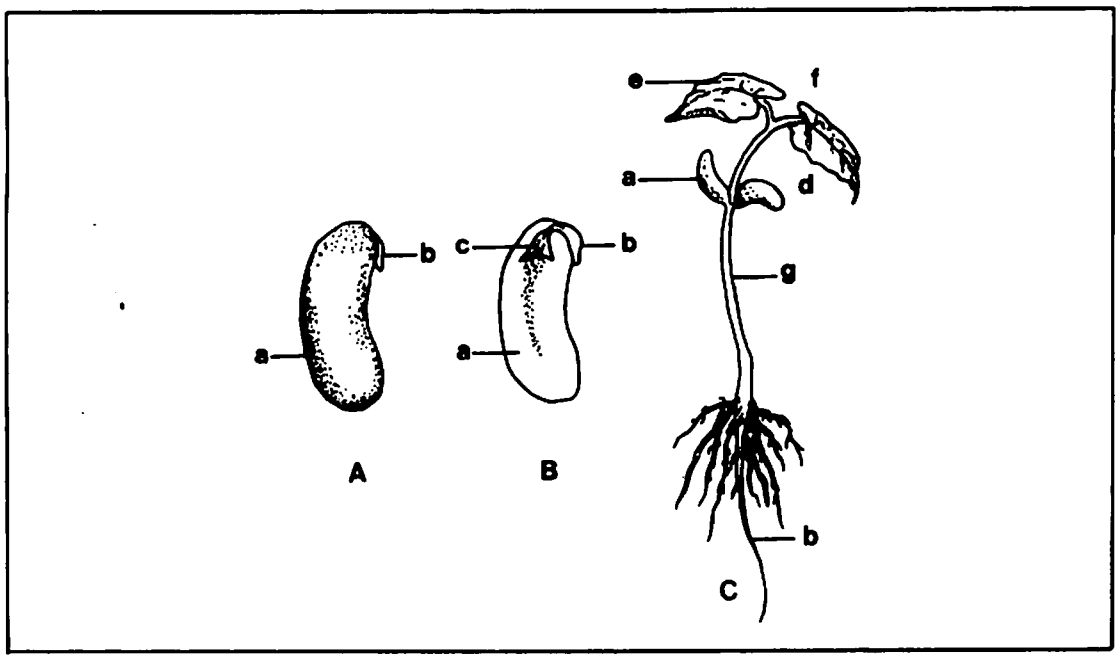



Fig 4. Beans-Seed and seedling structure A. External view, seed coat removed. B. Interior view, one cotyledon removed. C. Seedlong. a, Cotyledon; B, radicle; c, plumule; d, epicotyl; e, primary leaf; P f, growing point; g, hypocotyl. (5).

# CONCEPTS OF SEED VIGOUR AND ITS MEASUREMENT

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In seed evaluation germination is defined as "the emergence and development from the seed embryo of those essential structures which, for the kind of seed in question, are indicative of its ability to produce a normal plant under favourable conditions." Procedures for determining germination percentage have been perfected and standardised so that different laboratories obtain remarkably uniform results when testing seeds of the same lot. Conditions which are used for the standard germination test, however, are almost in direct contrast to conditions to which seeds are normally subjected in the field.

In the standard germination test, weak, deteriorated seeds may be capable of producing a normal seedling, because moisture and termperature during the test are optimum and the germination substrata are not loaded with microorganisms, herbicides, fertilizers, fungicides or systemic insecticides as were observed in soil. In many instances seed lots of apparent equal quality as indicated by the germination percentage will produce large differential responses in field emergence. Therefore, the determination of " the degree of aliveness" (vigour) of a seed is just as important as the determination of life itself. Such an anlysis is termed "Vigour".

The studies with maize, rice, jowar, cotton etc. at Mississippi State University have shown that low vigour seed cause the problems in stands of seed bearing plants, such as delayed and reduced

emergence; small plants with thin stems; fewer nodes and reduced leaf-area; reduced tillering; delayed panical exsertion and reduced panical length; delayed anthesis; increased barren plants; delayed maturity and decreased yield. However, low vigour is not necessarily related to low yield.

Many attempts have been made to define the term "vigour" as applied to seed. In the United States, the early concepts and definitions of vigour focused on differences in stand producing potential among seed lots of equivalent germination under sub-optimal (actually, near minimal) field conditions. Focusing on these aspects was natural, considering the success of the cold test for corn seed which was introduced in the early 1940's. The cold test assays the emergence of seed under simulated wet, cold seed bed conditions and, hence, evaluates the emergence potential of seed in such an environment as it might actually occur during the early planting season.

Isely (1957) made one of the first attempts to conceptualise and define seed vigour: Vigour is, "the sum of all attributes which favour stand establishment under unfavourable field conditions." Isley's concept has been shown in Fig 1. Delouche and Cardwell (1960) pointed out, however, that it is restrictive under unfavourable conditions. Therefore, logical assumptions deriving from the above definition were that (a) vigour had an influence only on stand establishment and (b) differences in vigour among seed lots were manifested only under conditions unfavourable for germination and emergence. Accordingly, they slightly but significantly revised isely's definition as follows: "Vigour is the sum of all seed attributes which favour rapid and uniform stand establishment in the field". Yet, this revised definition was also limiting, since it did not take into account vigour effects beyond stand establishment.

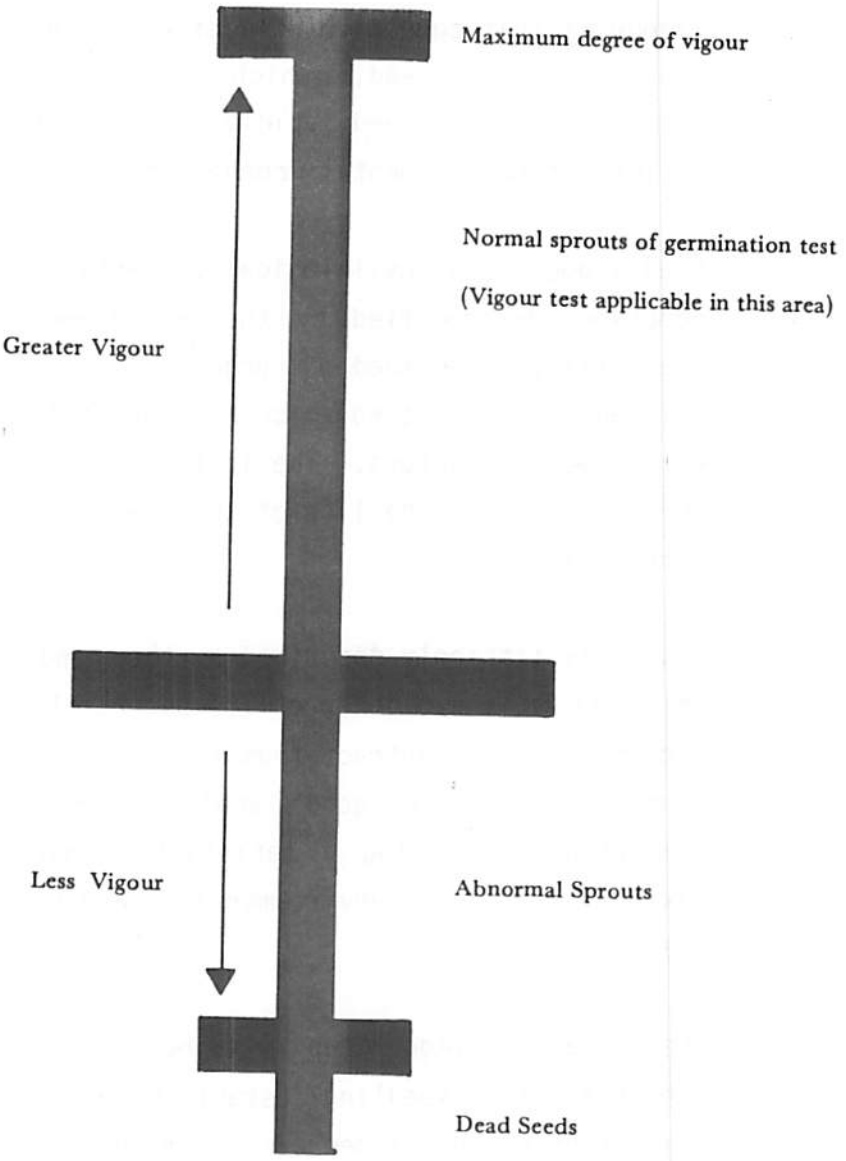



Fig 1. Schematic representation of relationship between Germination and Vigour (Revised from Isley, 1957)

In more recent years a variety of other definitions and concepts of seed vigour have been proposed.

> "Vigour is that condition of active good health and natural robustness in seed, which, upon planting, permits germination to proceed rapidly and completely under a wide variety of environmental conditions". Woodstock (1969).

> "Seed vigour is a physiological property determined by the genotype and modified by the environment, which governs the ability of a seed to produce a seedling rapidly in soil and the extent to which the seed tolerates a range of environmental factors. The influence of seed vigour may persist through the life of the plant and affect yield. " Perry (1972)

> "Vigour is fittingly described as the condition of a seed which is at the highest of its potential powers, when all factors that may detract from its quality are absent and those that make a 'good' seed are present in the right proportion, promising a satisfactory performance over a maximum range of environmental conditions. "Heydecker (1972)"

> "The concept of vigour can first be considered as a maximum potential for seedling establishment, and second as a quantum of potential decrease from that maximum until the seed is dead, i.e. has zero potential for establishment. The maximum is set by the genetic purity constitution of the plant and is normally attained by part of each population". Pollock and Roos (1972)"

While all of these "definitions" are interesting, informative and contribute toward a conceptualisation of vigour, they are equally unsatisfactory as "working definitions".

Recently the following new definitions were proposed (AOSA Vigour News Letter 1975).

> "Seed vigour is the sum total of all those properties in seed which, upon planting, result in rapid and uniform production of healthy seedlings under a wide range of environments including both favourable and stress conditions. "(Association of Official Seed Analysts, U.S.A.)

> "Seed vigour is the sum total of those properties of the seed which determine the potential level of performance and activity of a non-dormant seed or seedlot during germination and seedling emergence. "(International Seed Testing Association).

Vigour Tests:

> "A vigour test is a laboratory method to evaluate seed vigour "(AOSA)
> "A vigour test is a reproducible laboratory method which differentiates high vigour from low vigour seed "(ISTA)

Seeds which perform well are termed as "high vigour seed" while those which perform poorly are called "low vigour seed".

Some of the vigour tests available to measure seed quality are:

1. Growth rate test
2. Cool germination test
3. Cold test
4. Tetrazolium test
5. Accelerated ageing test
6. Brick gravel test
7. Paper piercing test
8. Free fatty acid test
9. GADA test
10. Exhaustion test
11. Respiration test
12. Glucose metabolism test
13. Adenosin triphosphate (ATP) test
14. Measurement of leachates

1. Growth Rate Test:

a) First Count: This test can be incorporated into the standard germination test. The number of normal seedlings removed when the preliminary count (First count) of the germination tests is made is an indication of the quality of the seed lot. The higher the percentage of normal seedlings removed at the preliminary count the better the quality of the seed lot.
If the first count is to be used to compare different lots of seed over a period of several months, all first counts must be made at the same time interval after planting.

b) Seed of Germination: If a more detailed test is desired, speed of germination may be used. This test can be incorporated into the standard germination test, but will require more time to evaluate than a regular, standard germination test. After the seeds have begun to germinate they must be checked daily at

approximately the same time each day. Normal seedlings are removed from the test when they reach a pre-determined size. This procedure is continued until all seeds that are capable of producing a normal seedling have germinated. An index is computed for each seed lot by dividing the number of normal seedlings removed each day by the day on which they were removed after planting. Thus quality indexes of lot A(15) and Lot B(20) are obtained in the following manner:

$$\text{Lot A: } \frac{\text{No. of seedling removed daily}}{\text{day after planting}} = \frac{0+0+0+8+10+24+28+24}{1\ 2\ 3\ 4\ 5\ 6\ 7\ 8}$$

$$= (0)+(0)+(0)+(2)+(2)+(4)+(4)+(3) = 15$$

$$\text{Lot B: } \frac{\text{No.of seedling removed daily}}{\text{day after planting}} = \frac{0+0+12+24+45+7}{1\ 2\ 3\ 4\ 5\ 6}$$

$$= (0)+(0)+(4)+(6)+(9)+(1) = 20$$

Lot B would be considered the better quality of the two lots since the higher index indicates better seed quality.

c) Root and/or Shoot Growth: Another growth rate test that may be easily employed is root length or shoot length or both.

This test involves the measuring of the length of root (or root and hypocotyl) or shoot at a specified number of days after planting in the germinator. When using this system of

comparison, the lot making the most growth is considered to have the highest quality. Only normal seedlings should be measured.

Root and/or shoot growth can be employed with grasses and grains. However, dicots will probably have to be limited to root or root and hypocotyl growth because of the slowness of epicotyl elongation in many dicot species.

The tests we have discussed thus far can be conducted in the laboratory with no additional equipment other than that required for standard germination tests.

In order to make valid comparisons of these tests both the conditions of the test and the conditions of germination must be very carefully controlled. If some replications become dry, for example, growth will be slower and the results of the test will be biased. If alternating temperatures are used, the time of day when the tests are used, the time of day when the tests are placed in the germinator will affect the result. For example, corn is germinated at an alternating temperature of $20^{o}C$ - $30^{o}C$ If tests are placed in the germinator at the beginning of the $30^{o}C$ cycle and are compared with tests placed in the germinator at the beginning of the $20^{o}C$ cycle, we would expect the test which was begun at $30^{o}C$ to make more total growth than the test which was begun at $20^{o}C$ when measurements are made the same number of hours after the beginning of the test. If laboratory growth tests are to be used it would be well to consider using a constant temperature to avoid this problem.

d) Speed of seedling Growth and Seedling Weights:
Total seedling growth in the greenhouse or field may be measured at a specified number of days after planting. The lot of seed producing the most growth per normal seedling is considered to be

the best quality. Seedlings may be cut and weighed, fresh or dry, for additional information. Seedlings producing the more weight are considered to come from the better quality seed.

2. Cool Germination Test:

This test may be conducted by using any type of germination equipment capable of maintaining a constant 19°C temperature and sufficient humidity to prevent drying of the substrata. Only one count is made on the sixth day for acid delinted cottonseed and on the seventh day for machine delinted cottonseed.

This type of test is limited to the effect of cool temperature on the germination of cottonseed and the growth rate of cotton seedlings.

This test differs from the Cold Test which is a pathological test in that it is a Cool Germination Test conducted at a constant temperature of 18°C

3. Cold Test:

The cold test is the oldest routinely used vigour test. It was developed for corn seed but is equally meaningful for cotton, sorghum and soyabean seed evaluations. However, there do need to be some further efforts on standardisation of procedures and interpretation. This test is more useful to estimate field performance of seed in low temperature soil conditions.

The test is performed by planting seed in non-sterilized soil which is obtained from a corn field. A cold test should contain at least four replicates of 50 seeds each. In general, the planting procedure involves placing a 3/4 inch thick layer of soil on the bottom of the plastic box. The soil is levelled and the seeds are distributed on it and pressed into it with a piece of wood cut to fit the box. Approximately the same amount of soil that was placed under the seeds is then placed over them and it is levelled and compacted. Enough water is added to bring the medium to 70% of its water holding capacity. This water should be adjusted to $10^{o}C$ prior to use. After the water has been added, the covers are placced on the plastic boxes and they are put into a refrigerator at $10^{o}C$. After seven days, the boxes are transferred to another chamber at $25^{o}C$. Seedling counts and/or measurements are made four days after transfer.

The results of cold tests are usually expressed as percentage germination, that is the percentage of seeds which produced seedlings that would be considered to be normal in a standard germination test. Additional information can be obtained from cold tests by making daily counts of emerged seedlings or by measuring the comparative heights of seedling.

4. Tetrazolium Test (TZ):

The TZ test is more and more widely used to rapidly determine the viability of seed lots. It is used less often to evaluate vigour. This is unfortunate because the TZ test provides more accurate and useful information on the physiological quality of seed than any other test. Admittedly, the information generated by the test is available, only to an experienced TZ analyst.

However, this is not a real constraint to expansion in use of the TZ test. Information from tests of all sorts also have little meaning to inexperienced persons.

The basis of the TZ vigour test involves the identification, location and appraisal of sound, weak and dead embryo tissues in reference to possible influence upon seed storage qualities, seed germination, and early seedling development under unfavourable conditions as well as favourable conditions. The degree of soundness of different areas of embryonic tissues is made recognizable by use of a colourless aqueous solution of a tetrazolium salt. The chemical, 2,3,5- triphenyl tetrazolium chloride is used as the indicator. Differences in colour, or lack of colour, along with observation of tissue turgidity or flaccidness permits recognition of sound, weak and dead tissues. Simultaneous observations of the presence, location and extent of fractures, missing embryo parts, insect cavities, abnormalities etc., provide supplemental information that is essential for embryo soundness evaluation.

Appraisal of embryo soundness of individual seeds is made largely on the basis of the presence, amount, depth, and or presence within, essential embryo structures. Comparative TZ, storage germination and seedling tests are helpful to analysts who are learning to recognize and establish a general relationship between embryo observations and performance of seed and resulting seedlings under favourable conditions.

The TZ vigour test permits the simultaneous establishment of different levels of soundness. The simplest and accepted classification is to divide viable seeds into (a) sound, and (b) unsound classes. Minor imperfections are to be included in the sound class.

5. Accelerated Aging Test:

This test was developed at the Seed Technology Laboratory, Mississippi State University, U.S.A., for different kinds of seed. This technique involves exposure of seed to $40^{o}C$ - $45^{o}C$ temperature and 100% relative humidity for 2 to 8 days followed by a regular germination test. Seedlots that maintain germination well even after accelerated ageing, also maintain germination well under normal storage conditions. On the other hand those lots severely reduced in germination after accelerated aging treatment decline rapidly in germination during storage.

The basic assumption of this test, therefore, is that the germination percentage of a seed lot after a period of accelerated aging is highly related to the vigour of the lot and hence to the lot's capacity to perform well under field conditions.

6. Brick Gravel Test:

The test was developed in Germany by Hiltner in 1911 to show pathogenic infection.

The brick gravel method basically involves the use of a rather porous type of brick gravel of 2-3 mm size. In small grain's vigour tests about 1- 1/5 inch layer of moist gravel is placed above the seed. This layer impedes the emergence of weak, partially diseased, cork-screw type seedlings and other seedlings with injured coleoptile tips. Minor difference exists in the testing procedures at the various laboratories, but the

principles are about the same. The interwedging of the brick gravel places a stress upon the emergence of elongating shoots. The seedlings that emerge through the layer of brick gravel are traditionally considered triebkrafty or strong. In 1955 the laboratories, at least in Germany, were requested to use the Ziegel gruswert, which to us means brick gravel value. This was done so as to separate the results from other types of vigour test.

## 7. Paper Piercing Test:

This method utilizes regular testing sand plus a specially selected type of paper disc through which seedlings penetrate in order to be considered strong.

The paper characteristics are as follows:
Basic weight 90 gm/mt$^2$, thickness.. 0.4 mm bulk.. 4, dry bursting strength .. 0.3 kg/cm$^2$, breaking length ...1000-5000 mm; filtering speed 500 ml/mi., wet bursting strength .. 150 mm; ash content ...0.1%, fibre composition - chemical wood pulp with high alpha percentage.

The paper used in Sweden is manufactured by the Grychsbo Papers bruck A B, Gryscksbo, Sweden.

The test as used for cereal crops involves placing seed on top of approximately 1/2 inch of moist sand, covering of seeds with a specially selected dry filter paper and then covering of paper with about 1 1/4 inch of moist sand. Tests are held at 20$^{o}$C for 8 days. A quality of paper was selected to provide results that were comparable to those from a test under favourable soil

conditions. The merits of the paper piercing test includes the use of the usual testing media, sand, plus a standardised piercing media, the paper disc. Sand is also a cleaner and more agreeable material than brick gravel. The test is suitable especially for small grains.

8. Free Fatty Acid Test:

The free fatty acid content of seed can be used to a limited extent as an index of germination and/or vigour. Generally, seeds with a low free fatty acid content are assumed to be of high quality. However, many examples could be cited where the FFA content of seed was less than 1%, but the germination was also less than 50%. However, if two cottonseed lots were equal in germination but differed in FFA content, one could generally assume the lower of the two lots in FFA to be the higher in vigour . However, it is unlikely FFA analysis will ever become a standardized method for evaluation of vigour.

Intra-lot analysis of FFA is probably a better indication of quality than inter-lot analysis. Without exception, a normal lot of cottonseed is heterogeneous in quality. This can easily be demonstrated by gravity grading a lot of cottonseed and comparing the quality of various seed fractions.

9. Gada Test:

Gultanic Acid Decarboxylase Activity (GADA) is a test that measures the acitivity of one specific enzyme rather than a

system of enzymes as does tetrazolium. The level of enzyme activity is determined by the amount of carbon dioxide ($CO_2$) given off and is positively correlated to seed quality i.e the more $CO_2$ given off the better the quality of the seed. Grabe (1965).

GADA appears to be better related to seed quality of corn and wheat rather than to quality of dicotyledonous species such as soyabeans, cotton etc.

The equipment needed for this test is relatively inexpensive. It consists of a water bath for controlling temperature, simple, easy to make manometers, a scale for measuring manometer fluid movement, small containers like 1/2 pint jars and a small grinder. Although the GADA test has given valuable results for corn and wheat, it has not been proved as valuable for all seeds.

10. Exhaustion Test:

This test was developed in 1960 by Germ for wheat, rye and barley and later it was used for peas and beans. Two sheets of paper towel, 15 cm x 37 cm, are placed exactly on top of each other and rolled up. This roll is then put into a cylindrical glass container (20 cm high, 5 cm in diameter) containing 30 ml water. When most of the water is absorbed by the paper, it is taken out, put on a glass plate and unrolled. Then 50 seeds are put on it, 5 cm below the upper edge of the paper and about 3 cm from the left edge of it in regular intervals of 1 cm, sprouting end up and root end down. Then the right edge of the paper is folded over 2 to 3 times and rolled into a loose roll taking care that

the seeds are not disturbed.

The rolled paper is then stood upright in the glass container mentioned above which is covered with a glass plate and placed in the dark at 10°C for 11-13 days and the seedlings are evaluated. Those seedlings that have a shoot and roots extending more than 2" above or below the placement, are considered vigorous.

11. Respiration Test:

Respiration has been shown to be closely correlated with seedling growth rate of Lima, bean, corn, wheat, soyabean and paddy especially during early hours of imbibition in water. In corn and paddy differences in respiration rate have been used to distinguish between high, medium end low vigour seeds. However, in the case of paddy intravarietal differences were attempted and obtained. During the process of respiration Oxygen is taken up by seeds and Carbondioxide is evolved. The ratio of the volume of Carbon dioxide evolved per unit time to the volume of Oxygen consumed per unit of time is called respiratory quotient

$$\left(R.Q. = \frac{Q\ CO_2}{Q\ O_2}\right)$$

and the respiratory quotients were found to be often more related to the vigour then Oxygen uptake alone. The rate of gas exchange is measured in a respirometer called the Wasburg respiremeter.

The measurement of respiration never achieved routine use in seed testing laboratories because of involvement of, perhaps,

expensive equipment.

12. Glucose Metabolism Test:

This test has been proposed by Abdul Baki (1969) for wheat and barley. The test is sophisticated, involves the use of 14-C (radioactive carbon) and very expensive equipment. Therefore, it did not recieve much acceptance by seed analysts.

13. Adenosin Triphosphate (ATP) Level:

This test was suggested in 1972 by Te May Ching and Danielsen Significant correlations were obtained between ATP content in imbibed seeds and seedling height and weight.

14. Measurement of Leachates:

With the ageing of seeds the permeability of the seed membrane increases. Thus many substances present in seeds e.g. sugars, free aminoacids, organic acids and various elements, leach out in the presence of water. The concentration of leachates is normally measured either by the electrical conductivity method or by chemical methods. Abdul Baki and Anderson (1970) reported that leaching in olderihe deteriorated seeds may be due more to available sugars than to changes in membrance structure and permeability. Agrawal (1977) while working on paddy emphasised that leaching of sugars should be related to the total soluble

sugars present in seeds. Temperature has been found to have a pronounced effect on leaching. With the increase in temperature from 10°C to 40°C, a 122% to 153% increase in leaching was observed in paddy seeds. Therefore, Agrawal (1977) emphasised that while performing the experiments on leaching temperature should be maintained carefully.

Leaching of sugars has not always been found to be related to vigour in crop seeds.

Concluding Remarks:

In the preceding paragraphs, many tests have been described for evaluating the vigour of seeds. None of the above tests are universal in the sense that not a single test has been proved to be successful for all kinds of seeds. At one stage the GADA test was very popular in the U.S.A., but for various reasons it has lost popularity. If a vigour test has to be used by a seed analyst in a Seed Testing Laboratory, it should be inexpensive, rapid, easy to perform and reproducible. Somehow, seed analysts the world over have been reluctant to use a method which is elaborate and involves the use of sophisticated equipment.

No single test will satisfy all requirements and a method or combination of methods should be chosen to suit the seed kind and environment into which it will be sown.

Of the various tests described, growth rate tests (First count, speed of germination, root and/or shoot growth), and the tetrazolium test may be used in the routine testing of various crop seeds in the Seed Testing Laboratories.

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# SOME SEED BORNE DISEASES OF WHEAT AND BARLEY

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## Wheat

### Tilletia caries and T. foetida (Bunt)

#### Symptoms

By emergence the ears look normal, but the symptoms become apparent when the ears get older. Infected ears have a loose, open appearance. The bunt balls are fatter than the healthy ones.

The pericarp of the infected grains remains intact. By rupture of these grains the dark teliospores appear and a strong unpleasant odour will be noticed.

#### Disease cycle

The fungus survives as teliopores on the kernel. Teliospores can oversummer two growing seasons in the soil, providing that the soil remains dry; in wet soil the telispores stay alive only a few weeks . Seedlings are only susceptible to the disease until the coleoptile splits (about 10 days at 12 $^{o}$C). The fungus grows with the plant and can reach the tissues just below the growing point. The mycelium infects the kernels. Mycelium cells are transformed into teliospores. By threshing spores are dispersed

over healthy kernels.

Control

- Resistant cultivars: In the past the resistance of some cultivars broke down.
- Clean seed through field inspection.
- Sowing date: By sowing early in the autumn the young seedling passes through the susceptible stage faster.
- Chemical control: Because the contamination of the seed remains on the outside, contact fungicides can be used. Organomercuro fungicides have been used in the past, but are now being replaced by more modern systemic one.

## Ustilago tritici (Loose smut)

Symptoms

Loose smut symptoms are obvious between heading and maturity. Initially, diseased heads are black and clearly visible among newly emerged, green, healthy heads. The infected heads emerge slightly earlier; later the whole head is transformed into a dry olive-black spore mass. The teliospores are withheld by a thin membrane after this breaks the spores are released and only the rachis of the kernel remains.

Disease cycle

The infection of the heads is only possible during a few days following fertilization of the flowers. As the diseased heads emerge earlier, the release of the spores is synchronised with the susceptible period of the plant. The teliospores germinate on the

flowers. Mycelium invades part of the embryo of the seed. Thus survival of the fungus is as mycelium inside the seed. This make chemical control complicated compared to Tilletia caries where the fungus remains on the outside. The infection of the young seedling occurs intracellularly out of the seed, the fungus follows the growth of the plant intercelluarly.

Control

- Resistant cultivars: The resistance can be based on different mechanisms. The adult plant may posses resistance to the infection of the flowers by the teliospores or the embryo may posses a resistance. Another possibility is a selection for closed flowering. The plant then has a good chance of disease escaping the disease.
- Field inspection.
- Seed certification: Presence of the fungus can be checked by microscope.
- Chemical control: Only systemic fungicides are effective.
- Heat treatments: This consists of soaking the seed first in 20 C water for 5 hours, draining it for 1 minute dipping it in 49 C water for about 1 minute then in 52 C water for exactly 11 minutes and immediately afterwards in cold water to cool. Because of the complication of this method and the high risk of damaging the seed, this method is not used any more.

Barley

Ustilago hordi (Covered smut)

Symptoms

Infected heads emerge at about the same time as normal healthy ones. The black teliospores are usually retained within the

persistent membranes of the grain.

Disease cycle

The teliospores survive on the grain under the hull. The infection cycle is more or less comparable with Tilletia caries on wheat:
The seedling is only susceptible until the first green leaves appear.
The mycelium advances intercellularly through the parenchyma until it penetrates the flowerprimordia.
Infection of healthy kernels usually occurs during the threshing.

Control

- Resistance breeding is possible.
- Chemical control can be done with contact fungicides though systemics are better.

Ustilago nuda (Loose smut)

Symptoms

The smutted head is surrounded by a very thin membrance which breaks down soon after head emergence.
The olive-brown teliospores are then released and the heads can be reduced to a nude rachis.

Disease cycle

Like Ustilago tritici on wheat: Survival as mycelium in the embryo. Infection of healthy plants occurs during flowering.

Control

Through resistant cultivars, heat treatment or chemical control by systemic fungicides.

Pyrenophora graminea (syn. Helminthosporium gramineum)
( Stripe disease )

Symptoms

First symptoms are long pale-green stripes that may extend the entire length of the leaf. They can appear on the first leaf but usually do not appear until the 4-5 leaf stage. Later the stripes turn greyish - yellow and leaves can split along the stripes. The affected plants are often only half the size of the normal ones, mostly they do not reach the stage of earing.

Disease cycle

The pathogen survives as mycelium inside the grain but outside the embryo. During the germination of the seed the fungus grows into the young plant and penetrates further up. On the killed tissues conidia develop that spread to the healthy flowers where they germinate, generally near the awn end of the glume giving rise to mycelium growth between glume and pericap. Humid conditions in the heading period favour the infection of the kernels.

Control

Resistance breeding is possible
Use of certified seed.
Hot water treatments or use of systemic fungicides.

# SEED-BORNE DISEASES OF LENTIL AND THEIR CONTROL

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Seed used for propagation and even nourishment should be healthy and disease-free. Diseased seed may have low germination capacity, give reduced vigour and may show some morphological changes. In addition, diseased seed may have toxic effects on man and animals.

Seeds in general are vehicles, sometimes without being diseased, for the distribution and dissemination of plant pathogens and new pathotypes.

Seed-borne pathogens are sometimes the cause of disease outbreaks,since small amounts of seed-borne inoculum can be of great epidemiological significance.

Pathogens that are transmitted by seed are bacteria, fungi, nematodes, and viruses. Also seeds of the flowering parasitic plant (Cuscuta spp.) can be transmitted with seed. Most of the pathogens transmitted by seed are fungi. Not transmitted by seed are MLO, RLO, and the phloem limited viruses.

## 1 Mode of Transmission:

There are three ways by which pathogens can be transmitted with the seed:

1. Seed Contaminants; such as inert materials (soil clods, plant debris, and or loose reproductive organs of the pathogens). Inert materials might act as carriers of the active or resting stages of organisms. Important pathogen organs which can be carried with seed are fruiting bodies, telio and uredospores, nematode galls, chlamydospores, and sclerotia.

2. Contamination of the Seed Surface; seed coat and/or pericarp by the different pathogen organs. Different kinds of spore, fruiting bodies, and microsclerotia are carried on seed surfaces. Even some viruses and bacteria can be transmitted in this way.

3. Seed Infection.
Infection may occur in embryo ( = embryal infection ), in endosperm and on seed coat ( = embryal infection). Most seed-borne viruses and all loose smut pathogens fall in this category of transmission. Pathogen organs found into infected seeds are: dormant mycelium, chlamydospores, fruiting bodies, virus particles, bacterial cells, nematode larvae, and microsclerotia.

## II Pathogen transmitted by seed

Table 1 lists the pathogens of some legumes and cereals that can be transmitted by seed. Species of the three bacteria genera, Corynebacterium, Pseudomoasand Xanthomonas are seed-borne and can be transmitted by seed.

At least eight viruses and a large number of fungus species are transmitted by legums seeds. Helminthosoporium spp. Rhynchosporium secales,Ustilago spp. and Tilletia spp. are the most important

diseases of cereals that are seed-borne.

## III Detection of Seed-Borne Pathogens

There are standard procedures and methods for seed health testing; these aim to intercept pathogens on the various crops by revealing these or their symptoms.

Selection of testing method depends on the host and the type of pathogens that may be carried in the seed. Among the methods used are the following:

1. Direct inspection is used for the examination of dry seed (steriomicroscope) to detect sclerotia, smut balls, and nematode galls.

2. Examination of a suspension from washed or soaked seeds is used to detect covered smuts (Teliospores), downy mildews (Oospores), and nematodes (Larvae).

3. The whole-embyro count method is mainly used to detect smuts .

4. The blotter method and the Agar-plate method are the most commonly used procedures for detecting seed-borne fungi, mainly F. imperfecti, and are considered as general tests.

## IV Seed decontamination and disinfection:

Seed treatment aims to reduce, eliminate, or eradicate pathogens transmitted with the seed, on the seed, or in the seed.

1. Thorough cleaning (sifting) of the seed eliminates a large number of contaminants mixed with seed and excludes serious plant pathogens.
2. The heat treatment is very effective in eradicating pathogens in infected seed (loose smuts; viruses), but rather risky if not properly controlled. Systemic fungicides have now replaced the hot water treatment to a large extent.
3. Seed treatment with fungicides is the most practiced measure all over the world and is efficient in controlling a broad range of seed-borne pathogens.

Numerous fungicides can be used for seed treatment. Inorganic mercury compounds are limited in use beauase of the slow build-up of soil residues, their phytotoxicity and toxicity.

A large number of seed-dressing compounds is available on the market. They are efficient in controlling seed-borne pathogens and they are safe in use. They should replace the mercury compounds.

## V Seed-borne diseases of lentil:

Several fungi have been found associated with lentil diseases externally (seed contamination), internally (seed infection) and as contaminant seed contamination. The fungi belong to the

following genera:

Alternaria
Botrytis
Aspergillus, Penicillium
Rhizoctonia solani
Fusarium oxysporum
Sclerotinia sclerotiorum
Sclerotium rolfsii
Ascochyta spp.
Peronospora lentil
Meloidogyne spp
Uromyces fabae

1. Diseases of seedling blight (damping-off) and root rot:

All are extremely destructive diseases. The disease results from the decay of the seedling stem shortly after germination. They attack the seedling in the pre-emergence stage; or results from seed decay before germination.

Several pathogens are involved in these diseases, they are soil inhabitant and some are seed-borne. An important seed-borne pathogen is F. oxysporum which is reponsible for early wilting and drying of seedlings. It is transmitted as seed contamination and seed infection.

S.rolfsii, the cause of collar rot, is a very serious pathogen involved in these diseases . The sclerotia of the pathgen remain in the soil or are mixed with the seed as contaminant seed contamination. However, the mycelium can be detected on the seed surface.

Measures of control are seed cleaning to eliminate the sclerotia and seed treatment. Chemicals used for seed treatment are Thiram and Brassicol.

## 2. Stem blight

A disease found in many countries. It affects the stem and blight symptoms are developed on lentil leaves.

The causal agent of this disease is S.sclerotiorum, it survives by means of its sclorotia in the soil. However, sclerotia of the fungus are mixed with the seed and can be carried from one place to another.

Thorough cleaning of the seed is the main measure of control.

## 3. Rust

Rust is the most important foliar disease. It is becoming limiting factor in lentil production in some countries.

Rust is caused by U. fabae. The infected inert matter mixed with the seed acts as a basic inoculum for the recurrence of the disease. Inert matter contains Uredia and Telia with uredospores and teliospores.

Thorough cleaning of the seed eliminates the seed-borne inoculum.

## 4. Downy mildew

The downy mildew of lentil, *P. lentis*, is becoming important in some lentil cultivation regions of the world. Survival structures are the oospores that can be transmitted by the seed as seed contamination. Seed cleaning and seed treatment with chemicals help to reduce/eliminate the inoculum.

## 5. Ascochtya leaf blight

It is a serious disease of lentil. *A. lentis* has been reported recently from several places. As other *Ascochyta* spp., *A. lentis* is seed-borne. Pycnidia are found on and under the seed coat.

Chemical seed treatment with systemic fungicide is effective in controlling the inoculum.

Seed treatment with suitable fungicides is essential. However the chemicals should have compatability with Rhizobium strains used. Thiram, Dithane M-45, Difolatan, Bavistin are not harmful at the usual dosage.

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Table 1. SEED-BORNE OF LEGUMES AND CEREALS*

Alfalfa, chickpea, faba beans, lentils, medics, vetches

| Bacteri | Viruses | Fungi | Nematodes |
|---|---|---|---|
| Corynebacterium sp. | Alfalfa MV | Ascochyta spp. | Criconemoides sp. |
| Pseudomonas fabae | BY MV | Botrytis spp. | Ditylenchus dispaci |
| Xanthomonas, spp | BB MMV | Cerospora zebrina | Helicotylenchus |
| | BBSV | Cladosporium spp | |
| | PSBMV | Erysiphe pisi | |
| | Pea Early Browining V | Fusarium spp | |
| | Pea mild Mosaid | Mycosphaerella pinodes | |
| | | Peronospora Viciae | |
| | | Phoma medicaginis | |
| | | Pleospora herbarium | |
| | | R. Solani | |
| | | Sclerotinia spp | |
| | | Septoria pisi | |
| | | Sclerotium rolfsii | |
| | | Stemphylium sarciniformae | |
| | | U. Vicia | |

Barley and Wheat

| | | | |
|---|---|---|---|
| Corynebacterium spp | Barley stripe MV | Alternaria spp | Anguina tritici |
| Pseudomonas spp | | C. purpurea | Criconemoides sp |
| Xanthomonas spp | | Cochiiobolus sativus | Haplolaimus spp |
| | | Dreshslera spp | Helicotylenchus sp |
| | | Fusarium sp | Protylenchus spp |
| | | Rhynchosporium secalis | Tylenchorhynchus spp |
| | | Septoria spp | |
| | | Sclerotinia spp | |
| | | Tilletia spp | |
| | | Urocystis agropyri | |
| | | Ustilago spp | |

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* Bos et at (1979): Anonymous (1980)

# SEED BORNE DISEASES OF CHICKPEA AND THEIR CONTROL

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The transfer of plant materials on a global scale involves a potential danger of the accidental transfer of diseases and pests with them resulting in their wide-spread distribution. The possible benefits of any collection and evaluation programmes are vitiated if pathogens and pests that are harmful to them are also introduced. The various plant genetic materials in addition to seed that are commonly transferred are roots, rhizomes, bulbs, corms, offshoots, cuttings, buds and Pollen. The plant health problems encountered in their transfer are pathological, nematological, entomological and phanerogamic parasitical. A knowledge of these problems of the crops, types of materials appropriate for the transfer of germplasm, methods of choosing, collecting, preparing and handling them is essential for the successful international transfer of plant genetic resources.

## Plant Quarantine Principles, Methodology and suggested approaches.

### Principles:

Plant quarantines, promulgated by a government or group of governments, restrict the entry of plants, plant products, soil cultures of living organisms, packing, materials and commodities, as well as their containers and means of conveyance. The aim is to protect agriculture and the environment from avoidable damage by hazardous organisms inadvertently introduced and spread by man into new areas. Plant quarantine is a control measure of diseases and pests by way of preventing infection for infestation or reducing it

and eradicating it through treatment or therapy.

Plant quarantine regulations have the following features in common:

1. Specify prohibitions.
2. Grant exceptions to prohibitions for scientific purposes.
3. Require import permits.
4. Require phytosanitary certificates and/or certificates of origin.
5. Stipulate inspection upon arrival.
6. Prescribe treatment upon arrival to eliminate a risk.
7. Prescribe quarantine, post entry quarantine, isolation or other safeguards.

Organisms move from one region to another along natural path ways or along those created by man. Quarantine prevent man from providing means for the spread of pathogens. Many plant quarantine officers and scientists subscribe to the hypothesis that all harmful organisms will eventually gain access to all regions of the world because quarantine can only delay their spread. The hypothesis remains untested, however. Thousands of hazardous organisms are still not distributed throughout the world even though man has been moving about for thousands of years. Nevertheless, agriculture can benefit even if some are only delayed until resistance is incorporated into our breeding lines.

Plant quarantine has two major roles to play in the collection, conservation and maintenance of germplasm collections. The first involves protection of agriculture from inadvertent introduction of pests and pathogens of quarantine significance. The second involves protection of gene collections themselves from the ravages of domestic and foreign pests and pathogens.

The legal basis for quarantine in plant introductions is found in legislation issued by national and state (or provincial) governments.
The standards or guidelines for promulgating these regulations are often suggested by international organisations or intergovernment agreements or conventions.

Organisms of quarantine significance may include any pest or pathogen that a government considers to pose a threat to the country's or region's agriculture and environment. Such organisms are usually exotic to that country or region but may also include exotic strains or races of domestic organisms. For larger countries the definition may also be extended to include foreign isolates of domestic organisms.

In promulgating the quarantine regulations, the pest and pathogen risk analysis is based on two general aspects (1) the benefits must exceed the risk and (2) the benefits must exceed the costs of enforcing the quarantine regulations.

## Methodology.

### A. Plant quarantine regulations

1. Regulating the size, age and type of plant material of high risk genera.
2. Regulating the entry of potentially high risk genera by prohibition, post entry quarantine, and restricted entry with permit.
3. Regulating alternate hosts.
4. Regulating secondary or reservior hosts.

5. Regulating by stipulating entry requirements.
6. Regulating packing materials.

B. Inspection and detection

1. Inspection and phytosanitary certificates.
2. Inspection methdology.
3. Inspecting for obscure pathogens.
4. Virus detection and identification.
5. Genetic disorder vs. virus like symptoms.
6. Inadvent selection of latent viruses.
7. Inspection of seeds.
8. inspection vs. incubation period and latency.

C. Treatments

1. Heat treatment or thermotherapy by hot water, hot air, or vapor heat. The basic principle is that plant material must be raised to a temperature that will kill the pest or pathogen without killing the plant or plant part.
2. Chemical treatments or chemotherapeutants as sprays, dips, slurries, dusts or fumigants.
3. Excision of diseased parts.
4. Heat therapy and meristem tip culture.

D. Utilising quarantine facilities or isolation

1. Quarantine stations/post-entry quarantine stations.
2. Geographic or climatic isolation.
3. Isolation on importer premises.

4. Third country or intermediate quarantine.
5. Consortium of plant quarantine stations.

Suggested approaches

The following suggestions are given to all parties involved in the exchange of germplasm in order to accelerate the flow of genetic stock with out increasing risk.

1. Plan ahead.
2. Avoid duplication .
3. Evaluate requirements.
4. Channel requests for germplasm through a single plant introduction office.
5. Reassess "population" requiremtns.

Testing:

Different methods of seed health testing, mainly applicable for detection of fungi, are presented in table 1. The tests could be of a generalised type which may reveal a wide range of pathogens or specialised to detect a definite species, pathogenic race or a strain. Most commonly used generalised tests for detection of fungi are the ordinary ("standard") blotter test and the agar plate test which reveal a wide range of fungi though largely restricted to fungi imperfectii. The other very versatile testing procedures are seedling symptom tests and growing-on tests. The specialised tests are those of serological used for detection and identification of different viruses or bacteria or their strains; phage-plaque tests

used for identification of strains of bacteria and idicator-plant tests used for identification of physiologic races of pathogens.

Screening:

The screening of plant material destined for transfer from one region to another is quarantine policy in practice. The disease potentials of pathogens must be weighed against the potentials of seed used in breeding or cultivation.

Seed Disinfection or Decontamination:

Seed treatment for eradication of seed-borne pathogens can be used as an acceptable precaution in quarantine only if careful consideration is given to the limitation of such procedures. In general agricultural practice seed-treatment may be acceptable even if only some reduction of inoculum is achieved. In quarantine, no residual inoculum must remain after treatment. The primary justification for seed - treatment as a quarantine precaution is its use as an additional safeguard to kill undetected trace amounts of inoculum in apparently healthy consignments. Another acceptable policy would be to treat seed which carry low amounts of inoculum in order to save paricularly valuable material. At any rate it could be unwise to accept for seed treatment consignments of seed that are badly infected or contaminated by organisms considered in strict quarantine as long as it has not been proved beyond all doubt that the treatment precludes any risk.

The following seed treats may be considered:

- Heat treatment including hot water treatment and aerated steam treatment.
- Organomercurials.
- Thiram, captan and systemic fungicides among which benonyl and carbaxin stand out.
- Insecticides including aldrin and dialdrin, and fumigation with methyl bromide.

Exclusion of infected tissues:

When only infected seeds of particularly valuable material or systemically infected plants developed from these seeds are available , pathogen free stocks may be obtained by meri - stem cultures.

Methods for Detection of Seed - Borne Viruses

1. Visual examination of seed for externally visible seed abnormalities associated with virus infection such as seed-coat mottling in soybeans due to soybean mosaic virus infection.
2. Growing on tests in which seedlings produced are examined for symptoms. This test, however, can not detect the viruses that are carried with no symptoms.
3. Infectivity tests employing indicator plants that specifically react to certain viruses irrespective of symptoms in the tested material. This , when used along with growing on tests, provides additional information.

4. Serological tests overcome the short-comings of the above tests and are direct, specific and rapid.
5. Electron microscope tests.

Control measures

1. Removal of infected seed.
2. Seed disinfection by seed cleaning, aging, chemical and heat treatments and irradiation (TMV on seed coats of tomato seeds was inactivated by treatment with 10% trisodium phosphate).
3. Seed certification.
4. Quarantine.

Seed - borne diseases of lentils:

The fungi that have been reported to be seed-borne in lentils include Altenaria alternate, Ascochyta Lentis, Botrytis Cineria, Fevia fulva, curvularia lunata, Helminthosporium sp., Aspergillus flavus, A. niger, A. ochracens, chaetomium spp., Macrophonina phaseolina, Thanatephorus cucrmeris, Rhizopus sp; , Corticium rolfsii, Fusarium moniliforme, F. semitectume, F. solani, F. oxysporum, penicillium spp:, phoma sp. and Stachybotrys sp. Among these, species of Fusarium, Rhizoctonia, Aspergillus, sclerotium and Botrytis are responsible for seed rot and seedling damage at the pre-and post emergence stages.

Seed-borne F. Oxysporum is responsible for the early wilting and drying of seedlings. Seed-borne F. roseum causes root-rot in U.S.A.

The sclerotia of S. sclerotiorum and plant parts infected with uromyces fabae and peronospora lentis get mixed with seed and help in the perpetuation and recurrence of disease.

Among the viruses infecting lentils pea mosaic is known to be seed-borne.

Seed - treatment with fungicides is essential to check seed-borne pathogens.

Seed treatment with Thiram + Brassicol or Thiram + Bavistin (1.) 2.5 g/kg seed, Benlate 0.3% by weight and 0.15% boric acid and KM No 4 reduced the incidence of wilt caused by F. Oxysporum. Seed treatment with Thiram + brassicol 1.1 at 2.5 g/kg has given promising results for collar rot caused by Corticium rolfsii. Brassicol at 2 g/kg seed has been reported to be effective for root rot pathogens. Seed treated with Captan, Thiram or phaltant 0.2% by weight has been reported to be effective for stem rot. Seed treatment with organomercurials has been recommended to eliminate seed-borne inoculum of rust caused by Uromyces fabae.

Seed-borne diseases of chickpea:

The fungi that were isolated from chickpea seeds were Alternaria sp.P, Ascochyta rabiei, Aspergillus spp., Botrytis cineria, curvularia sp. Fusarium spp; Fusarium Oxysporum, Penicillium spp; Phoma sorghina, Rhizoctonia bataticola and Rhizopus sp. Of these A. rabiei, Alternaria sp. B. cineria, and F. Oxysporum are only isolated from surface sterilized seeds: A rabici, B cineria and F. Oxysporum are internally seed-borne.

Seed treat with Benlate and Calixin-M mixture (1:1) (3 g/kg seed) or Calixin M (3 g/kg) was found to completely eliminate A. rabiei from infected seed. Seed treated with Benlate T (0.15%) (Benomyl 30% and Thiram 30%) eradicated Fusarium completely from seed and almost all other fungi mentioned above.

## Seed-health Testing Procedures, Summarized from Neergaard (1977)

### Method:

Direct inspection. Examination of the dry seed, with impurities, using a hand lens or, preferably, a stereoscopic microscope. Seeds may be submerged in water drops to release spores and facilitate detection.

### Application:

Sclerotia of fungi, smut ball, nematode galls, infected plant debris; e.g., Sclerotinia sclerotiorum, Botrytis cinerea, Claviceps purpurea. Seeds discolored or with lesions produced by fungi, bacteria, or viruses, e.g., Xanthomonas phaseoli, viruses such as soybean mosaic virus in leguminous seed.

Method:

Examination of suspension from washings of seed. An electrical mechanical shaker can be used to obtain standardized washings. Samples of the suspension are examined under compound microscrope.

Application:

Covered smut, e.g., Ustilago hordei and Tiletia spp. in cereals, oospores of certain downy mildews; quick orientation on the presence of other fungi that must be adequately detected by incubation procedures, e.g., Pyricularia oryzae, Drechslera oryzae, and Trichoconis padwickii in rice.

Method:

Whole embryo count method. Soaking grains overnight in 10% NaOH at 22°C. then washing with warm water through sieves of decreasing mesh size. Embryos finally cleared in lactophenol.

Application:

Loose smuts of barley, Ustilago nuda, and wheat, Ustilago tritici.

Method:

Motter Method.

Seed are incubated on water-moistened blotter, usually for 7 days at $20^{o}C$. Sporulation of fungi is stimulated by near-ultraviolet (NUV) irradiation, standard 12/12 hr light/dark cycle. Petri dishes are usually used as containers. To allow penetration of the NUV, plastic or pyrex glass containers should be used. Sometimes blotters are soaked in 0.1- 0.2% 2,4-D solution to counteract seed germination, thus aiding recording.

Application:

The method used most commonly for detecting a considerable range of Fungi Imperfecti, including different spp. of Acremonium, Acroconidiella, Alternaria, Ascochyta, Botrytis, Cercospora, Collectotrichum, Diplodia, Drechslera, Fusarium, Macrophomina, Myrothecium, Phoma, Phomopsis, Septoria, and others, and for practically all kinds of seed, including cereals, grasses, ornamentals ("flower seeds"), forest seeds, and vegetables.

Method:

Agar plate method

The seeds are placed in petri dishes on nutrient agar, in particular malt extract agar (MA), and potato-dextrose agar (PDA). Sore selective media are available for specific tests. Light treatment as for the blotter test. Incubation for 5-7 days. Experienced analysts

are capable of recording results by naked-eye examination, using colony characters as criteria.

Application:

The classical procedure for flax seed on MA (Ulster method) and used (on PDA) for detection of Septoria nodorum in wheat (Bronnimann's method, continuous daylight for 7 days), Ascochyta spp. on pea, and for other fungi and hosts. Although slow growing fungi cannot be adequately detected, the procedure is relatively sensitive for revealing minor amounts of incoculum.

Method:

Freezing method

A modified blotter method. After 1-2 days at 10-20 $^{o}$C, according to specification, incubation for some hours or for 1 day at -20 $^{o}$C, then at 20 $^{o}$C NUV light for 5-7 days.

Application:

Sometimes preferred for detecting certain fungi, e.g., Phoma lingam in cruciferous seeds, Septoria nodorum in wheat, Alternaria porri in onion.

Method:

Ordinary seedling symptom test. The seed is sown in autoclaved soil, sand, or similar material and placed under normal daylight conditions for observation of symptoms. A special procedure, the classical Hiltner test, offers standard conditions for detection of seedling pathogens.

Application:

Often used for detecting seedling symptoms which reveal pathogens rather than fungi to be identified. Useful for detecting nursery pathogens in forest seeds and detecting cereal seedling pathogens.

Method:

Water-agar seedling symptom test. The seeds are sown on water agar, in 16-mm test tubes, one seed per tube,or in microculture plastic plates or petri dishes. They are placed under daylight conditions, e.g., 12/12-hr cycle of artificial daylight and darkness. Seedlings are inspected for symptoms, healthy seedlings may be transplanted for further post-quarantine cultivation.

Application:

Can be used for many kinds of seed as an economical procedure which, in test tubes, secures separation of healthy and infected seedlings. Has been used for detecting Drechslera graminea, D. sorokiniana, and D. teres in barley, Septoria nodorum and D. sorokiniana in wheat; Didymella bryoniae in cucurbit; Macrophomina phaseaolina in sesame; and other pathogens and hosts.

Method:

Indicator test, inoculation methods. A standard technique for identification of viruses but also used for detection of trace amounts of pathogenic bacteria, e.g., by hypodermal injection of indicator plants with material by the pathogen under test.

Application:

Used for detection of Xanthomonas phaseoli and other bacteria in French bean, Xanthomonas campestris in crucifers, possible usable for detection of X. oryzae in rice, etc.

Method:

Phage-plaque method. Maceration of the seed to be tested followed by incubation for 24 hr to enable multiplication of

bacteria. Samples of this material transferred to sterile flasks, and a standrad suspension of phage particles is added. Samples of this mixture are plated immediately and after 6-12 hr on plates with the indicator bacterium. Presence of homologous bacteria is indicated by significant increase in number of phage particles in the second plating.

Application:

Used for detection of Pseudomonas phaseolicola and Xanthomonas phaeoli in French bean, Pseudomonas pisi in pea, Corynebacterium michiganeuse and Xanthomonas vesicatoria in tomato. Used for routine testing of Foundation Seed of French bean in Canada.

Method:

Serological methods. An antiserum must be provided and the tests may follow different procedures: the slide agglutination test, the tube precipitin test, the micro-precipitin test, the gel double diffusion test, the latex flocculation test, the immunofluorescence test.

Application:

Used for different seed-borne viruses, and may be used for any pathogen for detection of Pseudomonas phaseolicola.

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# LABORATORY EXERCISE IN SEED TREATMENTS

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Types of seed treatment procedures to control parasitic fungi, bacteria and, to some extent,nematodes are:

- mechanical methods
- physical methods
- chemical methods (see Table 1)

Nowadays the chemical methods play a major role. The basic principle in any chemical treatment is mixing seed and chemical in order to obtain an adequate coating and, for some treatments, adequate penetration. Chemicals can be applied as dust (about 2g per Kg seed) or slurry (about 5-10 ml per Kg seed). Disadvantages of dust treatment are as follows: (1) dustiness around the treater and consequently danger to operators of continual operation, (11) accurate metering is more difficult than in slurry treatment. Further development of slurry treatment is the mist treater. The fungicide solution is broken into small droplets with rapidly spinning discs. The dispersal of the small droplets ensures complete and uniform coverage of the seed.

## Equipment

1. Dust treater

Frequently standard models of cement mixers are used in treating seed.

For smaller samples, hand or power-rotated drums can be used (Fig 1). An appropriate amount of fungicide is added to the seed. Seeds and fugicides are kept in the drum, which is rotated for adequate mixing. Placing the container in a diagonal position provides further agitation in rotating. About 50 revolutions (turned slowly) are recommended.

2. Mist-O-Matic Treater

The adjustable counterweight ensures the same quantity of seed to be treated every time. Adjustments can be made between 250 and 600 g for each spraying. The two measuring cups hold 2.5 ml each. So 2.5 ml per treatment is the fixed factor and the amount of seed has to be adjusted according to the recommendations of the company (see Table 2).

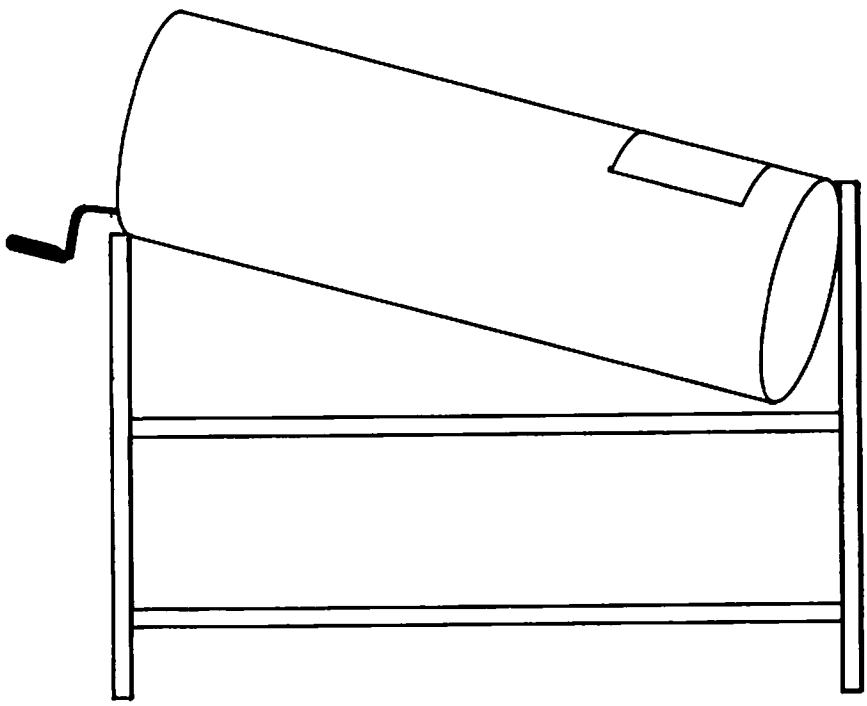


Fig. 1. Self-made dust-treater, rotating drum

Table 1. Some Non-Mercurial Seed Dressing Fungicides - Effectivity and Recommended Dosage
(Compiled from manufacturer's information)

| Trade Name/ Supplier | Active Ingredients | Effectivity | In | Recommended Dosage Per 100 Kg seed |
|---|---|---|---|---|
| Arbosan UT | 15% Methfuroxam | Tilletia caries,foetida | Wheat | |
| Giba Geigy | 2.5% Imazalil | Ustilago nuda, hordie | Wheat/Barley | 200 g |
| | 2.5% Thiabendazole | Helminthosporium teres | Barley | |
| | | H. gramineum | Barley | |
| | | Fusarium nivale | Rye | |
| Baytan F | 25% Triadimenol | Tilletia caries,foetida | Wheat | |
| Bayer | 3% Fuberidazole | Ustilago nuda | Wheat | 150 g |
| | | Fusarium nivale | Rye | |
| | | Urocystis occulta | Rye | |
| Baytan Universal | 25% Triadimenol | Tilletia caries,foetida | Wheat | |
| Bayer | 10% Imazalil | Ustilago nuda | Wheat | |
| | | Fusarium nivale | Rye | |
| | | Urocystis occulta | Rye | 150 g |
| | | H. gramineum | Barley | |
| | | Ustilago nuda | Barley | |

Cont. Table 1.

| Trade Name/ Supplier | Active Ingredients | Effectivity | In | Recommended Dosage Per 100 kg seed |
|---|---|---|---|---|
| Drawigran plus | 30% Fenfuram | Tilletia caries,foetida | Wheat | 300 g |
| Wacker | 15% Thiabendazole | Ustilago nuda | Wheat/Barley | 300 g |
| | 8% Quintozene | Ustilago hordei | Barley | 300 g |
| | 2% Imazalil | H. gramineum | Barley | 300 g |
| | | H. teres | Barley | 300 g |
| | | Fusarium nivale | Rye | 250 g |
| Dupont Benomyl | 50% Benomyl | Tilletia caries,foetida | Wheat | |
| Dupont | | Ustilago nuda | Wheat | 300 g |
| | | Fusarium nivale | Rye | |
| Panoctin Universal | 10% Fenfuram | Tilletia caries,foetida | Wheat | |
| Shell | 30% Guazatine | H. gramineum | Barley | 300 g |
| | 2% Imazalil | Fusarium nivale | Rye | |
| | | Ustilago nuda | Wheat/Barley | |
| Panoctin Universal | 10% Fenfuram | Tilletia caries,foetida | Wheat | |
| Feucht | 30% Guazatine | H. gramineum | Barley | |
| Shell | 2% Izmazalil | Fusarium nivale | Rye | 200 ml |
| | | Ustilago nuda | Wheat/Barley | |
| Panoctin plus | 30% Guazatine | Helminthosporium | Barley | 300 g |
| Shell | 2% Imazalil | gramineum | | |

Cont. Table 1.

| Trade Name/ Supplier | Active Ingredients | Effectivity | In | Recommended Dosage Per 100 Kg seed |
|---|---|---|---|---|
| Panoctin plus<br>Feucht<br>Shell | 30% Guazatine<br>2% Imazalil | Helminthosporium<br>gramineum | Barley | 200 ml |
| Rovral TS<br><br>Hoechst<br>Rhone-Poulenc | 35% Iprodione<br>17% Carbendazime | Tilletia caries<br>Fusarium nivale<br>Ustilago nuda<br>Helminthosporium spp. | Wheat<br>Rye<br>Wheat/Barley<br>Barley | 150 g<br>200-250 g<br>200-250 g<br>150 g |
| Trimidal<br>BASF | 10% Nuarimol | Ustilago nuda<br>f.sp. hordei | Barley | 200 g |
| Trimidal GT<br>BASF<br><br>1.5%Imazalil | 10% Nuarimol | Ustilago nuda<br>f. sp. hordei<br>H. gramineum | Barley<br><br>Barley | 200 g |
| Vitavax<br><br>Uniroyal | 75% Carboxin | Tilletia caries,foetida<br>Ustilago nuda<br>Ustilago nuda<br>H. gramineum | Wheat<br>Wheat<br>Barley<br>Barley | 300 g<br><br>250 g |
| Voronit Spezial<br>Bayer | 25% Quintozene<br>3% Fuberidazole | Tilletia caries,foetida<br>Fusarium nivale | Wheat<br>Rye | 200 g |

Table 2. Table for Adjustment of Counterweight of Mist-O-Matic

| Fungicide | Fungicide: water ratio in slurry | Fungicide in 2.5 ml slurry | Recommanded concentration g/kg | Amount of seed to be treated |
|---|---|---|---|---|
| Vitavax - Combi | 1:3 | 0.625 g | 2.5 | 250.0 g |
| Vitavax - Combi | 1:1 | 1.250 g | 2.5 | 500.0 g |
| Baytan - Universal | 1:3 | 0.625 g | 1.5 | 416.6 g |
| Baytan - Universal | 1:2 | 0.833 g | 1.5 | 555.0 g |
| Baytan - Universal | 1:4 | 0.500 g | 1.5 | 333.0 g |
| Arbosan - Special | 1:3 | 0.625 g | 2.0 | 312.5 g |
| Arbosan - Special | 1:4 | 0.500 g | 2.0 | 250.0 g |

# AN INTRODUCTION TO PROCESSING SEED MACHINERY,

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## Introduction

Seed cleaning, or in a wider sense, seed processing is one of the first steps that can be taken by any country to improve its seed. Although the investment seems high, the return will so easily be obtained and the improvements will be obvious. In comparison to other elements of a seed industry, seed processing plants are relatively easy to operate and manage. No large numbers of trained personnel are needed, and a system of payment for the cleaning job is easily administered

## The structure of a seed cleaning plant

Apart from an office and preferably also a small quality lab, the plant will consist of the following elements (see simplified diagram of a cereal cleaning plant):

### 1. Reception

Here the crude material is delivered, either in bags or bulk. When in bags these must be opened or placed on a dryer for bagged seeds.

2. Scalper

Before the raw material is dried it is economic to remove the largest trash first. This is done with a simple screen machine with large perforations in the screens in order to remove only the particles that are much larger than the seed.

3. Dryer

Then the seed is dried or not, depending on the moisture content

4. Debearder (Brushing machine, De-awner)

Through a storage bin where the seed stays until its turn to be cleaned, the seed can be run through a debearder or brushing machine. Oats and Barley are often treated with brushing machines to separate the seeds from each other and to remove the awns respectively. Rye and wheat can also be removed from their husks. In cereals this machine completes what the thresher has left undone. This machine is not needed in all cases.

5. Pre-cleaner

If no scalper is fitted a precleaner may be necessary to do more or less the same: removal of large impurities and in this way reduce the volume. At the same time it provides an even feeding in the next machine which is equally important.

6. Air-screen cleaner

Together with the next machine this machine is the heart of the seed cleaning plant. There the basic or fine cleaning is done. This machine combines separation of larger and smaller impurities

through closely chosen perforations in the screens, and one or more air-separations which removes the light impurities and empty or shrivelled seed.

7. Indented cylinder separator (or a disc separator).

   This machine is also an essential machine in that it separates shorter and/or longer impurities (shorter seeds of other species, broken seeds, soil particles or stalks).

8. Specific gravity separator

   In many plants nowadays this machine is also fitted. It gives an additional grading on specific gravity which the air has left undone: it is able to separate on smaller differences in specific gravity than the air-screen cleaner. In this way germination capacity can be further impoved through the removal of inferior grains, it can partly eliminate ergot affected seeds and can reduce the number of soil particles still further.

9. Treater (Dresser)

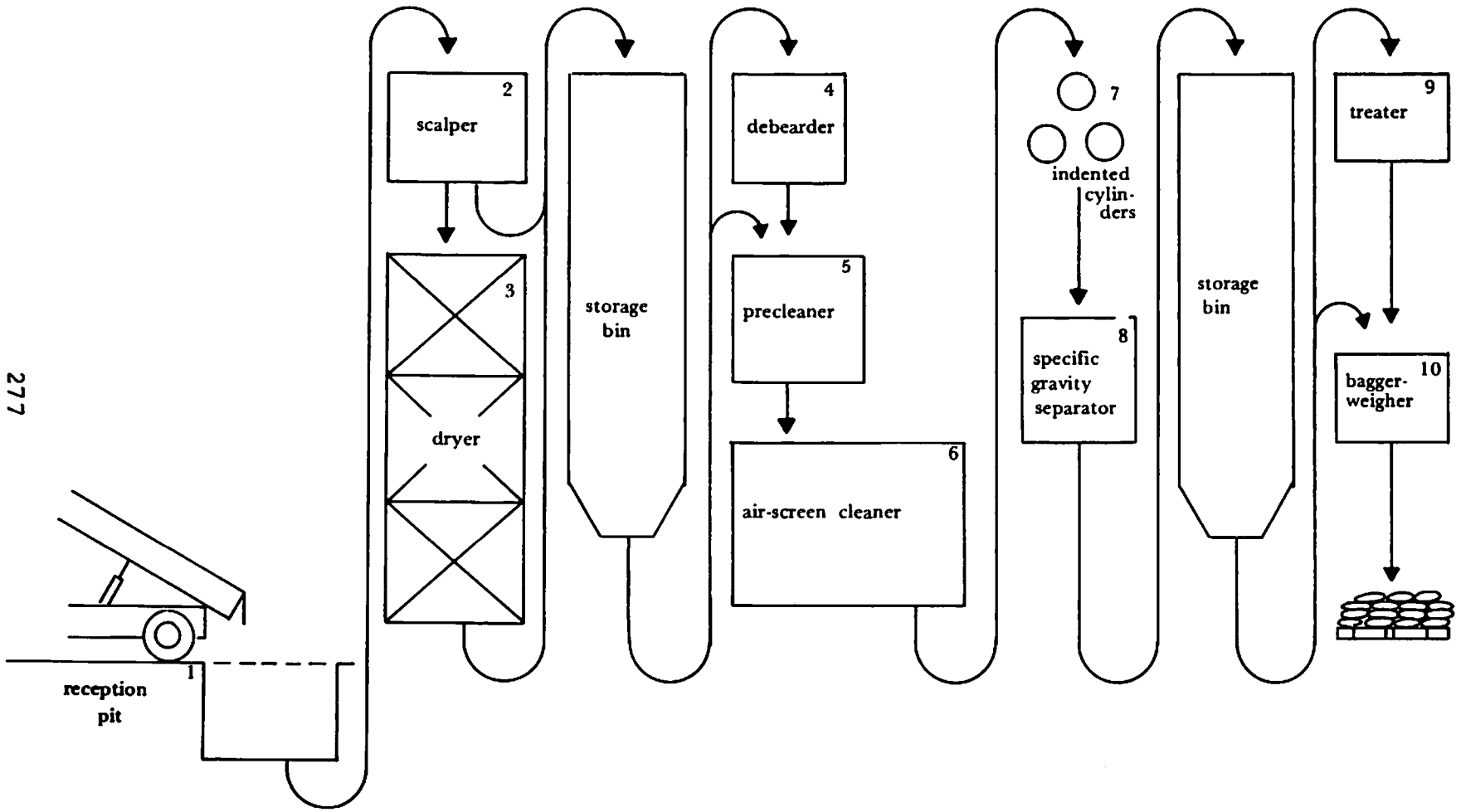
   After the previous machine the seed is stored in a storage silo, in order to wait for treatment, bagging and dispatch. If the seed needs treatment with fungicides and/or insecticides it is passed through a seed treater.

10. Bagger-weigher

    After treatment the seed can be bagged with an automatic weighing and bagging unit.

All vertical conveying is usually done by bucket or penumatic elevators. Horizontal transport is mostly done with belt conveyors. Many machines are not directly fed but the seed is coming from buffer bins (not in the diagram), this is to assure a constant flow of seed at the same rate throughout the plant and to avoid over-charging, especially of the air-screen cleaner, indented cylinders, treater and bagging unit which do not operate properly with excess seed.

SIMPLIFIED DIAGRAM OF A CEREAL SEED CLEANING PLANT



# AN INTRODUCTION TO SEED CLEANING

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## 1. Introduction

Seed cleaning is one of the most effective weapons against bad seed quality. With seed cleaning, if done with the right equipment and with the appropiate knowledge, one can increase purity, germination, decrease the content of other seeds,very often also decrease the number of diseased seeds, improve the visual aspect of the seed lot and its commercial and field planting value.

These are reasons enough to consider the establishment of well equipped seed cleaning plants in several localities in the country. Many manufacturers of seed cleaning equipment can install a whole plant and in addition to that train staff to operate the machines. This is called a turn-key project. Turn key projects in general are much more effective than projects where the installment and initial operation of the machinery is done by local authorities.

Seed cleaning of harvested seed is always, under all circumstances, necessary. The lot after harvest, although in some exceptional cases it may look pretty good, always contains empty seeds, shrivelled, immature and/or diseased seeds, remains of fruits,straw, chaff, soil particles, and very often also seeds of

other species (other crop seeds or weed seeds).
In another paper elsewhere (seed cleaning machinery - short introduction) the structure of a cereal cleaning plant is indicated.

In this paper we shall consider the various machines in more detail, with emphasis on the underlying separation principles.

## 2. The most important machines and their working principles

### 2.1 Air-screen cleaner

This is the most important machine, the "heart" of all cleaning plants. Its function is based on two separations: by screens and by aspiration (air).

#### 2.1.1 The machine

Most air-screen cleaners consist of a shaking screen-case, a box that contains the screens or sieves and in addition to that one or more fixed air channels. The best effect is obtained when the screen-case, or the two screen-cases, contain four or more screens in total (see Figure 1). The screens can be used as 2 sets of screens, to improve the capacity, or as 4 independant screens (with holes of 4 different dimensions) in order to obtain the maximum effect. Figure 2 gives three alternatives using 4 screens: with 4, 3 and 2 different screens respectively. The latter has the highest capacity, consisting in fact of two 2-screen machines. The first has the best possibilities to remove

almost every impurity.

### 2.1.2 The screens

Screens can be made of several materials. Most commonly used is iron sheet (zinc or stainless are also available). The sheet is perforated with either round, oblong or triangular holes.

Round holes. The diameter of the holes is the size indication: a sheet with holes of 1.0 mm diatmeter is called a 1.0 mm round (hole) screen (size can also be specified in inches).

Oblong holes. The width of the oblong holes or slots is the size indication: a sheet with holes 1.0 mm wide and 15 mm long is called a 1.0 mm slotted (or oblong) screen (size can also specified in iches).

Triagular holes. The length of the sides of the triangle (all sides are equal) is given units of 1/64 of an inch. A triangular screen no. 8 has triagular holes with sides of 8/64 inch.

Screens with triangular holes are seldomly used, mainly in Spinacia oleracea to remove the triangular seeds of Polygonum.

A part from sheet metal, mesh can also be used.
Mesh sieves are indicated with the number of openings per inch. No. 20 has 20 openings per inch.

The different perforations have different possibilities in separating seeds and admixtures. Seed lots cotain round (thin or thick) and oblong (thin or thick) particles. Round screens will

separate long from short when the seeds slide over the screens. The difference between long and short must be large (top screens always have round holes to remove long stalks from the rest). Furthermore, and more important, round holes separate on the width of the particles, or in the case of round particles on diameter (see Figure 3). This effect is especially strong when the seeds are not sliding over the screens but will jump. This can be induced by beating the screen (automatically).

Oblong holes separate on thickness of the particles (or in the case of round seeds on diameter).
The following diagram gives a summary of the functions of the round and oblong screens (with oblong seeds sliding over the screen).

| shape of particles | perforation | |
|---|---|---|
| | round | oblong |
| short and thick | ↓ | → |
| long and thick | → | → |
| short and thin | ↓ | ↓ |
| long and thin | → | ↓ |

↓ = pass through screen
→ = remain on screen

Mesh sieves are not very often used in agricultural crops. A disadvantage is their inaccurate screening: the holes usually differ in size. A great advantage is the large total suface of the openings (= effective screen area). Up to + 50% of the area consists of openings; this is much less in round, oblong and

triagular screens, depending on the arrangement of the holes. Mesh sieves are mainly used in small seeds (e.g. flower seeds).

### 2.1.3 The aspirator

Air-screen cleaners have a built-in aspirator which can separate light impurities (empty or party filled seeds, husks, glumes, etc.) from the seed. In the larger machines the aspirator is double (see Figure 1): a pre-suction channel that takes up light impurities before the seed reaches the screens, and an after-suction that will remove impurities from the seed that are still left after the seed has passed the screens. The pre-suction should not be adjusted too strongly: only impurities other than seed ought to be removed. It is meant to reduce the volume, thus making the screens more effective. The after-suction is to be set very carefully because with this treatment we intend to remove seeds, that is seeds that are empty or of low quality. (note: It is not meant to remove straw and stalk pieces, these ought to be removed with the screens. If these are present however, the air will take some of them out, but it is better to check the screens: the round hole screen can possibly be of a smaller size, or an oblong screen can perhaps be replaced by a round one).

There are also apsirators that are not combined with screens. These aspirators are often used as pre-cleaners for crops with heavy seeds that contain large amounts of light trash (e.g. peas and beans). After the aspirator the seed is then fed into the air-screen cleaner.

## 2.2. Indented cylinder (trieur)

While the screens of the air-screen cleaner mainly separates on the width and the thickness of the seed, the indented cylinder (or indented disk) separate on the length of the seed. And because there are always impurities (especially broken seeds, weed seeds) that are either longer or shorter than the crop seed, this machine is always needed in a seed cleaning line. In many crops the air-screen cleaner together with the cylinder will produce a good clean seed lot. In some cases, and especially when the standards are very high, additional machines are needed.

Note: With these two machines all important seed characteristics are utilized: width, thickness, length and specific gravity (air separation). There are machines that use one of these characteristics more extensively (e.g. long screen machine, vibratory screeners, cylinder screen machines, specific gravity separators). They are only economic in certain cases, and cannot be regarded as main cleaning machines. Some of them are treated in the following paragraphs.

Two ways of using the indented cylinder.

The indents (pockets), depending on their size, will lift particles up to a certain height. At that point the particle will drop out of the indent and fall downwards. The cylinders revolve at a certain fixed speed and therefore certain particles of a particular size will always drop out of the indents at a certain height when using the same cylinder. Others, which are longer will drop out earlier (lower), and when one puts a tray

between these points, a separation occurs. In this way one can make use of the machine in two different ways:

Round-grain application, where the shorter impurities are lifted and the longer crop seeds are left below.

Long-grain application, where the crop seed is lifted and the longer impurities are left below.

Both applications are depicted in Figure 4a and 4b respectively. Of course the sizes of the indents need to be larger in the long-grain application, when the crop is the same in both cases.

Also, the risk of losing good seed is larger with the long-grain application: all crop seeds have to be lifted, if not, they are discharged together with the long impurities. This results in a lower capacity (less volume can be cleaned with long-grain per time unit). Therefore to keep up with the capacity of the air-screen cleaner and the round-grain, we need two long-grain cylinders. Figure 5 indicates the flow of the seeds over this combination. The cylinders are usually mounted on top of each other.

## 2.3. Specific gravity separator.

After the seed is totally clean it may be necessary to obtain an even higher quality of seed. This may be because the germination capacity is not yet above the minimum standard, or that one wants to have a very high germination capacity. It may also be that still some impurities remain that are impossible to

remove with the normal set of cleaning machines (e.g. particles of exactly the same dimensions. Then it is possible to pass the seed over the specific growth separator. In general one can say that seed of the higher density classes is of better quality. Soil clods with a much higher density than the seed, can be removed separately.

The principle is that seeds are fed onto the machine in a rather thick layer (3-5 seeds thick) (Figures 6 and 7). The shaking deck will push the seeds uphill (= in our figures from left to right). But because there is an even flow of air through the deck only the heavier seeds are in touch with the deck and are pushed uphill. The lighter seeds more or less float over the heavy seeds downhill. One can combine several outlets together, according to the purpose, to give the clean seed and collect one or two others as waist material. One can also use them separately as different classes of seed.

The machine needs careful setting, and operating this machines needs much experience, otherwise there will be no results whatsoever.

## 2.4. Special cleaning machines.

To this category belong machines with limited but special functions and therefore limited applications.

### 2.4.1. Belt grader (= band grader, = draper mill)

Mainly used in sugarbeet seed cleaning as a pre-cleaner before the air-screen cleaner: it will remove the bulk of sticks that are present between the seeds: the upward rolling cloth band will take the sticks upward, while the seeds are still round enough to roll downward against the direction of the band. In some small seeded flower seeds rubber bands are used.

### 2.4.2 Spiral separator.

Used after the main cleaning with air-screen cleaner and indented cylinders. In Brassica's it will remove the damaged or irregular seeds. It is also used in some round-seeded legumes. The damaged or irregular seeds will not roll as hard as intact round ones. When the seeds move downward on a spiral track the good seeds will get such a high speed that they leave the track over the edge, and will end up in a second collecting track.

### 2.4.3 Velvet rolls (= Dodder mill)

Rough seeds can be removed from a smooth crop seed in this machine, e.g. Cuscuta seeds out of clovers.

### 2.4.4. Colour separator.

This electronic machine is mainly used in vegetable seed cleaning (especially with peas). An electronic eye will see off-coloured seeds and will activate an air-jet to blow these from a vertical stream of seeds. The stream of seeds, however, consists of seeds dropping singly one after the other from an inlet into the good seed outlet. The blown-out seeds are collected separately. The capacity of the machine is low, but with many highly valued seed lots it pays to have one.

### 2.4.5. Magnetic separator.

Some seeds, because of their surface texture, will take up iron powder, while the crop seed does not. This is the case with Sinapis arvensis seeds present in brassica. The Sinapis will take the iron powder, after adding a very small quantity of water. A revolving electro-magnet can separate them from the unpowdered Brassica seeds.

### 2.4.6. Paddy table.

Paddy (rice in glumes) can be cleaned from naked cariopses with this machine. The machine works on the surface texture of the seeds, combined with the resilience of these. The machine is nowadays replaced by specific gravity separators.

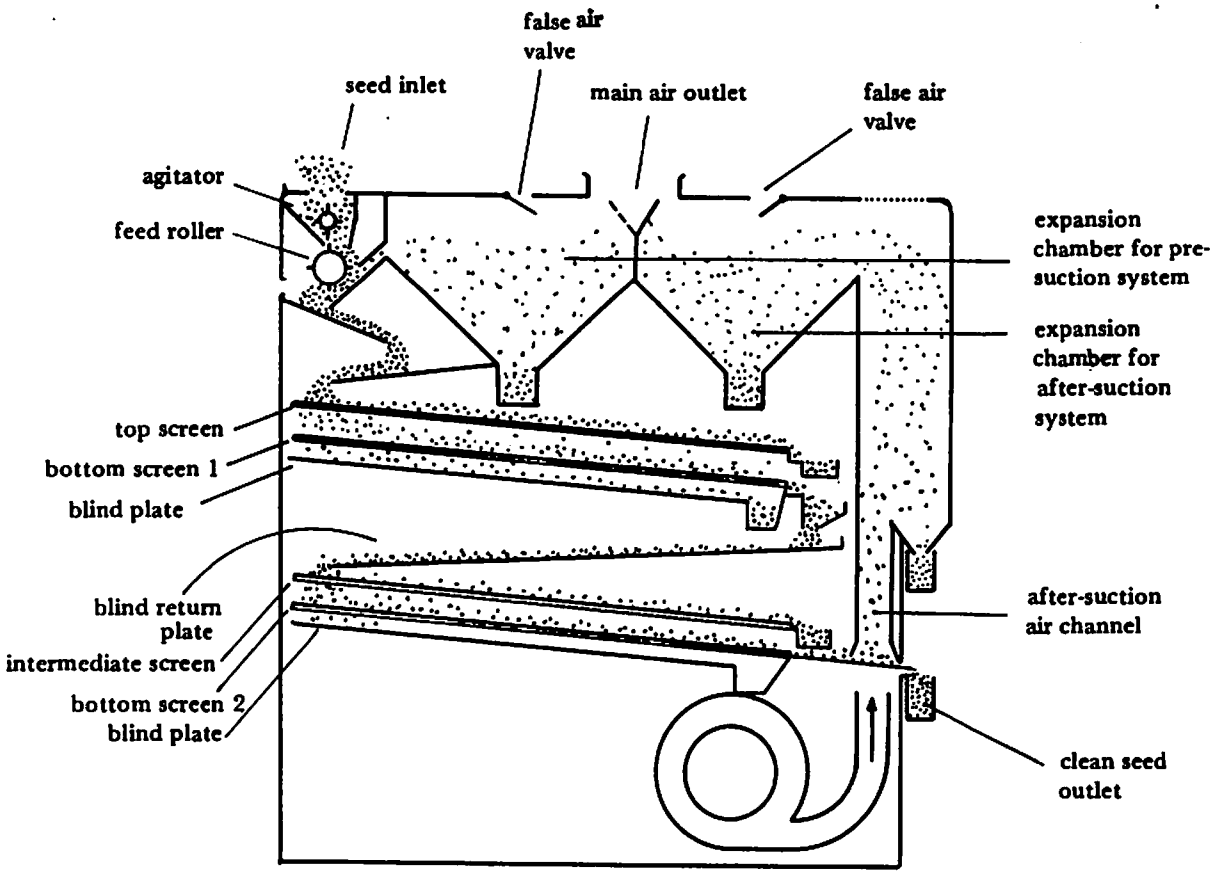
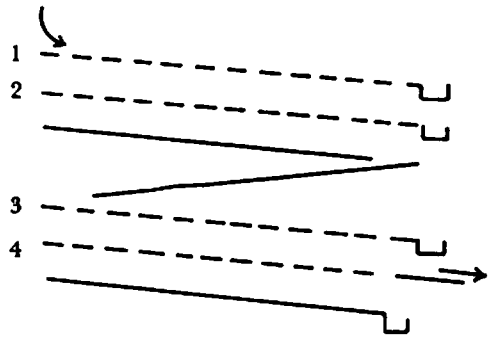
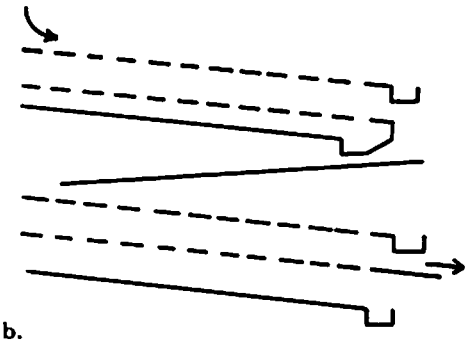


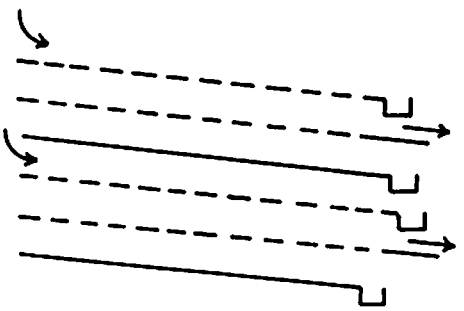

Figure 1. Sophisticated air-screen cleaner, with pre- and after-suction and four screens (two bottom screens, one intermediate and one top screen are used; see also Fig. 2b.)




a.
use of 4 different screens;
the good seed passes 3
screens (1, 2 & 3)
1 bottom screen (4)



b.
use of 3 different screens;
the good seed passes 2
screens (1 & 3)
2 bottom screens (2 & 4)



receptacles for rejects

feeding of uncleaned seeds

good (clean) seeds to aspirator

c.
use of 2 different screens;
the good seed passes 1
screen (1 or 3)
2 bottom screens (2 or 4)

Figure 2. Three ways of using a 4-screen cleaning machine

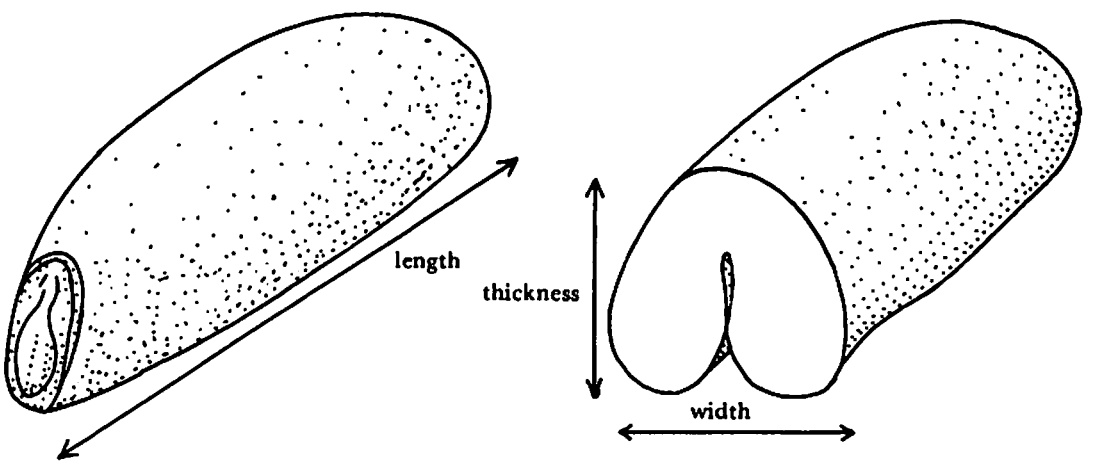



Figure 3. Dimensions of a cereal grain

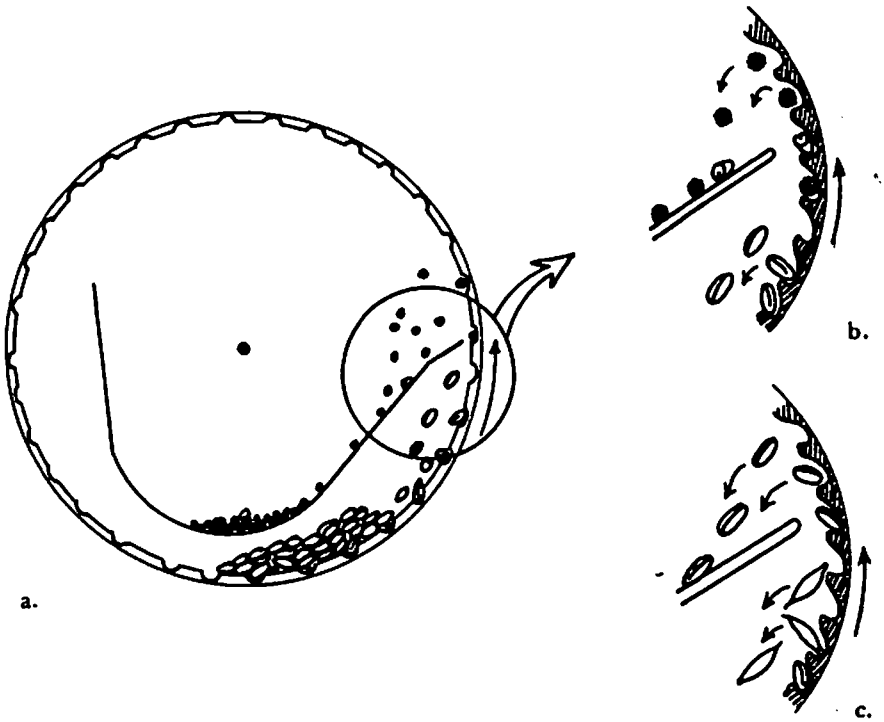



Figure 4. a. Working principle of indented cylinder;
b. round-grain application;
c. long-grain application

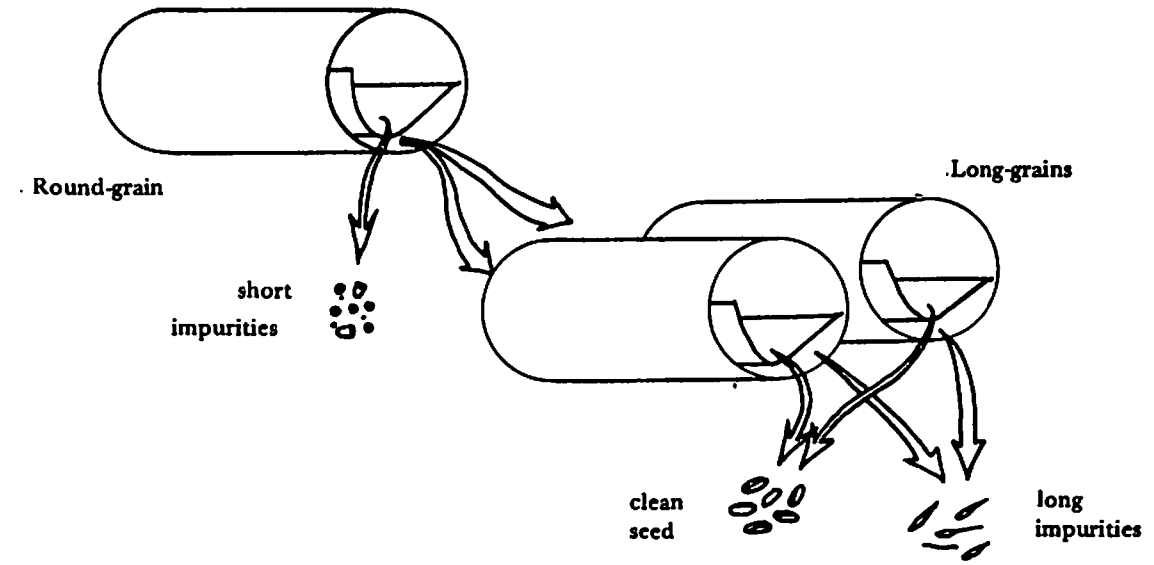
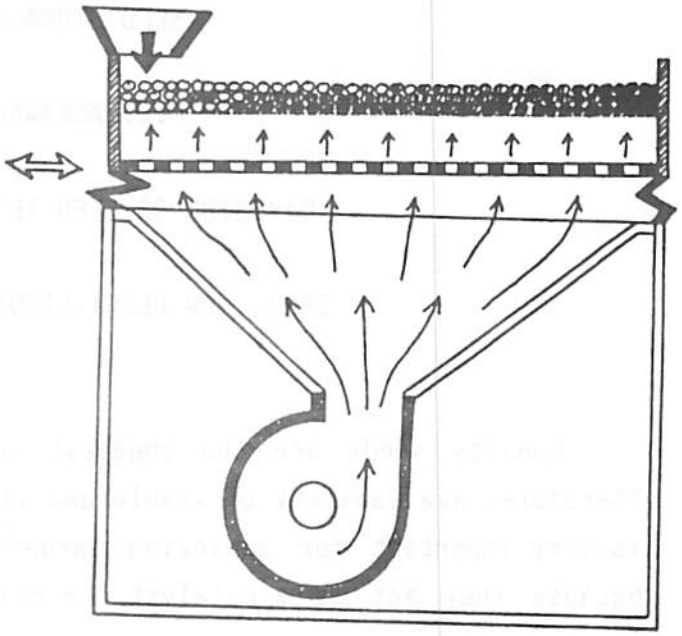



Figure 5. The flow of seeds over the standard combination of one round-grain with two long-grain cylinders.

Figure 6. Working principle of the specific gravity separator



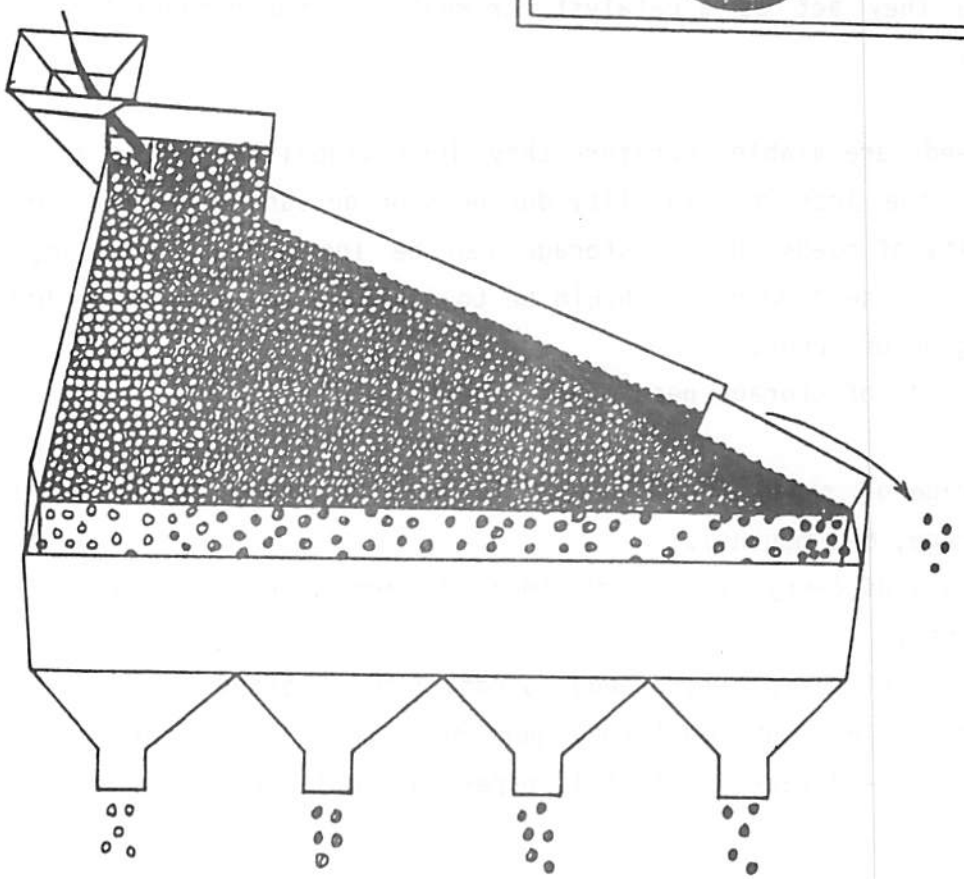



Figure 7. A specific gravity separator with triangular deck showing the several fractions: one light, two intermediate and one heavy fractions. The fifth side outlet is used when soil particles are present.

# SEED STORAGE

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Quality seeds are the cheapest input in modern agriculture. Therefore, availability of viable and vigorous seeds at planting time is very important for achieving targets of agricultural production because they act as a catalyst for realising the potential of other inputs.

Seeds are viable therefore they lose viability during storage. Neither the loss of viability during storage can be stopped nor the viability of seeds during storage can be increased. However, the purpose of seed storage should be to minimize the loss of viability and vigour of seeds.
Three kinds of storage need may be identified:

1. Storage of seeds from harvest to next planting (short duration storage, 6-8 months).
2. Storage of carry-over seeds (medium term storage, usually 12-14 months).
3. Storage of germplasm, breeder seeds, sample tested in seed testing laboratories for regulatory purposes etc. (long term storage, usually 5-20 years). In this paper, attention will be paid 1 & 2 only.

Seeds can be divided into 2 major groups with respect to their viability characteristics:

(1) Orthodox seeds: period of viabilty is increased with the decrease in seed moisture and storage temperature, e.g. seed of cereals, food legumes, forages etc.

In seeds belonging to the orthodox group considerable variation between species with respect to storability exists. These seeds can be roughly further divied into:

I. Good storer eg. Oryza sativa, Vigna radiata etc.
II. Intermadiate storer eg. Gossypium sp.,Sorghum, bicolor, Triticum, sp.
III. Poor storer eg. Glycine max, Arachis hypogea.

(2) Recalcitrant group: seeds belonging to this group can not be dried without harmful effects, they have a short viability period under ambient conditions eg. seeds of coffee, rubber, cocoa, oil palm etc.

Factors influencing loss of viability during storage:

1. Seed moisture or relative humidity of the atmosphere,
2. Storage temperature,
3. Physical conditions of the seed,
4. Inheritance,
5. Gas during storage,
6. Microflora and insects,
7. Fungicides.

Out of these, the first two factors are very important.

Relative humidity.

It is a measure of water vapour in the air relative to the amount that air can hold at saturation at a given temperature. With the increase in air temperature the water holding capacity of air also increases. If the absolute weight of moisture remains constant, RH decreases upon heating. If the air is heated, the water holding capacity of the air increases rapidly (Table 1). Thus, if air is cooled, the RH will rise or if it is heated the RH will drop.

Table 1. Moisture in Air at saturation (100%) at different temperatures.

| Temparature | g. of water vapour per kg of dry air |
|---|---|
| -5 | 2.48 |
| 0 | 3.78 |
| 10 | 7.63 |
| 20 | 14.70 |
| 30 | 27.18 |
| 40 | 48.79 |
| 50 | 86.11 |

Each kind of seed will attain a characteristic moisture content at a given RH at a particular temperature which is called equilibrium moisture content. (Table 2).

Table 2. Equilibrium seed moisture (%, wet basis) at various levels of relative humidity at 25°C.

| | PERCENTAGE RELATIVE HUMIDITY | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15 | 30 | 45 | 60 | 75 | 90 | 100 |
| 1. Wheat hard red winter | 6.4 | 8.5 | 10.5 | 12.5 | 14.6 | 20.1 | 25.0 |
| 2. Maize | 6.4 | 8.4 | 10.5 | 12.9 | 14.8 | 19.1 | 23.8 |
| 3. Groundnut | 2.5 | 4.0 | 5.5 | 7.0 | 10.0 | 13.0 | - |
| 4. Sunflower | - | 5.1 | 6.5 | 8.0 | - | 15.0 | - |
| 5. Lettuce | 4.0 | 5.0 | 5.9 | 7.0 | 9.0 | - | - |
| 6. Tomato | 6.0 | 7.0 | 8.0 | 9.0 | 11.0 | - | - |

Seeds of most species can be dried to 2-3% moisture without significant injury provided injury is not caused by another factor associated with seed drying-such as high temperature.

Temperature

In general, the higher the temperature the more rapid is the seed deterioration at a given level. Seed moisture and storage temparture interact in influencing the seed viability during storage. Low temperature is more effective than higher temperatures for storing seeds, but temperature above freezing, especially between $5^{o}C$ and freezing have been considered adequate. Maintenance of low temperature is expensive.

Heat from external sources penetrates slowly into the seed bulk. Diurnal temperature rarely affect seed below a few cms. from the surface. The metabolic heat produced exclusively by dry seed is about 1 x 10 [-7] cal sec [-1]cm [-3] and by damp seed/grain approximately 1.3 x 10[-5]cal sec cm[-3]. The amount of heat produced by fungi, insects & other oganisms invading th grain is considerably higher. In considering temperature for building better seed storage structures important points to remember are:

1. Mites do not develop below 5[o]C (41[o]F)nor insects below 15[o]C (60[o]F).
2. Most storage fungi do not develop below 0[o]C($32^{o}F$).
3. The effect of temperature on an organism is correlated with the amount of moisture presesnt because a rise in temperature corresponds with the decrease in the relative amount of moisture in the atmosphere. Harrington (1960) had given a rule of thumb. According to this rule:

1. For each 1% in seed moisture the life of the seed in halved. This rule applies when the seed moisture content is between about 5 and 14%.

2. For each 5[o]C increase in temperature the life of the seed is halved. This rule applies between 0[o]C and 50[o]C.

These two rules apply independently. Thus, seeds having 10% moisture and stored at 20[o]C will survive about as long as those with 8% moisture stored at 30[o]C.

Physical condition of the seed

Most mechanical injuries are not readily detected. Commonly used tests for mechanical injuries include observations of fractured seed coat or of seedling structures in growth tests. Symptoms of mechanical damage in standard growth tests are variable. They include 1) detached seed structure, 2) breaks within structures, 3) abnormally shaped structures, 4) scar tissues infections, 5) restricted growth, 6) unnatural shrinkage of cotyledons & 7) splits or otherwise abnormally developed hypocotyls and primary roots. Injured roots often appear dwarfed and twisted and the tips are often blunt and dull in appearance.

Microflora and insects

Storage fungi chiefly comprise several "group species" of the genus Aspergillus and Penicillium.

The storage fungi do not invade grains to any extent before harvest. The major effects of storage fungi upon seeds are:

1. Decrease in germinability,
2. Discoloured embryo or whole kernels or seeds,
3. Production of mycotoxins,
4. Heating,
5. Development of mustiness and caking,
6. Total decay.

The viability of seeds may be affected by the presence of insects in a number of ways:

1) If the insect becomes sufficiently abundant, it may render the storage environment harmful to the seed eg. by simultaneously raising the temperature, moisture content & the CO[2] content of the atmosphere and by depleting the oxygen.

2) The embryo may be damaged or killed by the feeding of adult or larvae or by oviposition.

3) Insects may introduce fungi that consume the seed or weaken or attack the seedling.

4) Insects may spin webs and construct cocoons that interfere sufficiently with the even flow of seed to make cleaning necessary & also cause loss of seed.

5) Control measures taken against the insects may kill some seeds.

Prevention and control of insect infestation in stores:

1) Good storage facilities.
2) Prevention of infestation by

A) Cooling,

B) Airtight storage.

3) Chemical methods of protection and control.

A) Fumigants: methyl bromide, hydrogen cyanide, phosphine, ethylene dichloride, carbon tetrachloride, carbon disulphide and naphthalene.
Phosphine is very popular-doses: 3-69/m[3] (i.e. 1 to 2 tab./m[3]), exposure period 5 days. Maximum 2-3 fumigation at 60 day intervals, after fumigation the store should be thoroughly aerated.

B) Contact insecticides e.g. DDT (1g DDT 10% dust/Kg of seed) Lindane, malathion etc.

Gas during storage

There is an interaction between seed moisture and various gases individually or in combination on the loss of viability during storage. An atmosphere of higher oxygen concentation than that of air hastens deterioration while an atmosphere of carbon-dioxide is reported to increase the storage life (seed moisture less than 6%). An atmosphere of nitrogen gas was found to delay the onset of deterioration, however, once the deterioration started, it proceeded as rapidly as in air.

Currently, different gases are not utilized commercially for storage, but research interests are increasing.

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