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# Lens NEWSLETTER

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## LENS

LENS Newsletter is produced twice a year at ICARDA in cooperation with the University of Saskatchewan, Canada with the financial support of the International Development Research Centre (IDRC), Ottawa, Canada. LENS, the newsletter of the Lentil Experimental News Service, is a forum for communicating lentil research results. Short research articles provide rapid information exchange, and comprehensive reviews are invited regularly on specific areas of lentil research. The newsletter also includes book reviews, key abstracts on lentils, and recent lentil references. The Lentil Experimental News Service provides information on lentil research free of charge through a question and answer service, photocopies, and searches of a lentil document collection.

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**COVER PHOTO:** Germplasm collection in Ethiopia by Mr. Asfaw Telaye and Mr. Geletu Bejiga from a lentil stack

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**PESTS and DISEASES**



## LENTIL INFORMATION

# RESEARCH ARTICLES

## Breeding and Genetics

### Exploration and collection of natural genetic variability of lentil in Punjab - Pakistan

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**Abstract**

**The decrease in area and production of lentil resulted in a severe threat of genetic erosion. The plant collection expedition, which was planned for two weeks, travelled over 4000 km and collected 82 lentil samples in 11 districts of Punjab, spread over an altitude ranging from 190 to 350 m. There was considerable variation in plant height, pod size, seed size, seed coat colour, and pigmentation. There is still a need to collect lentils on priority basis from other areas of Punjab and areas of Sind and Baluchistan.**

**Introduction**

Lentil has been cultivated in Pakistan for centuries. At present, it is cultivated on 55.000 ha with a production of 25.000 tonnes with an annual decrease of 7-8% per annum (Table 1) (Anonymous 1985). Out of four provinces of Pakistan, 70% of the cultivated area is in Punjab. Yields are relatively low, yet lentil stands out as one of the most nutritive pulses with 25% protein and it constitutes an important meat substitute in many village communities. Traditional varieties, land races, and primitive cultivars are still used in cultivation. The indigenous forms have considerable

**Table 1.** Area and production of lentils in the four provinces of Pakistan (Anonymous 1985).

| | Provinces | | | | |
|---|---|---|---|---|---|
| | **Punjab** | **Sind** | **N.W.F.P.** | **Baluchistan** | **Pakistan** |
| | | | **Area in '000' hectares** | | |
| 1965-70 Average | 58.8 | 8.3 | 3.9 | 0.1 | 71.1 |
| 1970-75 Average | 62.7 | 8.4 | 3.6 | - | 74.8 |
| 1975-80 Average | 70.0 | 13.3 | 3.5 | - | 86.8 |
| 1980/81 | 57.6 | 12.3 | 2.8 | - | 72.7 |
| 1981/82 | 53.5 | 17.8 | 2.7 | - | 74.0 |
| 1982/83 | 60.7 | 18.5 | 3.1 | - | 82.3 |
| 1983/84 | 35.5 | 9.6 | 3.6 | 0.1 | 48.8 |
| | | | **Production in '000' tonnes** | | |
| 1965-70 Average | 20.2 | 3.1 | 0.9 | - | 24.2 |
| 1970-75 Average | 21.0 | 3.8 | 1.4 | - | 26.2 |
| 1975-80 Average | 26.1 | 5.9 | 1.6 | - | 33.6 |
| 1980 | 22.8 | 5.4 | 1.3 | - | 29.5 |
| 1981 | 22.1 | 8.0 | 1.3 | - | 31.4 |
| 1982/83 | 20.1 | 8.3 | 1.5 | - | 29.9 |
| 1983/84 | 15.5 | 4.4 | 1.8 | - | 21.7 |

genetic variation. Barulina (1930) suggested the eastern border of south western Asia as a possible center of origin of the cultivated lentil based on the fact that the region between Afghanistan, India, and Turkestan (the Himalaya - Hindu Kush Junction) showed the highest proportion of endemic varieties of cultivated species. All kinds of rare forms like *sub-spontaneae* were concentrated there, showing great morphological and physiological variation.

### *Organization and objectives*

To explore areas in the Punjab provinces, the lentil collection expedition was organized by the Plant Genetic Resources Laboratory in collaboration with the National Coordinating Research Program of Food Legumes and Pulses of the National Agricultural Research Centre, Islamabad. The major objective of the mission was to collect the natural genetic variability of lentil for conservation and utilization. The improved and genetically uniform cultivars, released by the Agriculture Department, are replacing the indigenous land races and primitive cultivars and causing a threat to valuable *Lens* genetic resources in the Punjab province. Thus, collection and conservation of lentil germplasm was imperative.

### *Exploration area*

The collecting mission travelled during two weeks over 4000 km and explored the districts of Gujrat, Sialkot, Lahore, Kasur, Sheikhupura, Gujranwala, Sahiwal, Multan, Muzaffargarh, Faisalabad, and Attock in the Punjab province (Fig. 1). The mission was in field just in time for lentil collection when the crop was mature. Course grid sampling was used to cover a maximum area in the target region. Collection techniques as described by Hawkes (1980) were used during the expedition. Observations in the area of exploration revealed that edaphic conditions such as soil type, topography, and climate varied from one district to another.

### *Samples collected*

The mission collected 82 lentil samples from 58 sites of Punjab province spread over an altitude ranging from 190 to 350 m (Table 2). Other crops of interest such as *Lathyrus*, *Pisum*, chickpea, and barley were also collected.

Random population samples were collected at each site. Most of the collections were made from farmers' fields, grain markets, village shops, and farm stores. Passport collection data were recorded in accordance with the IBPGR standard format.

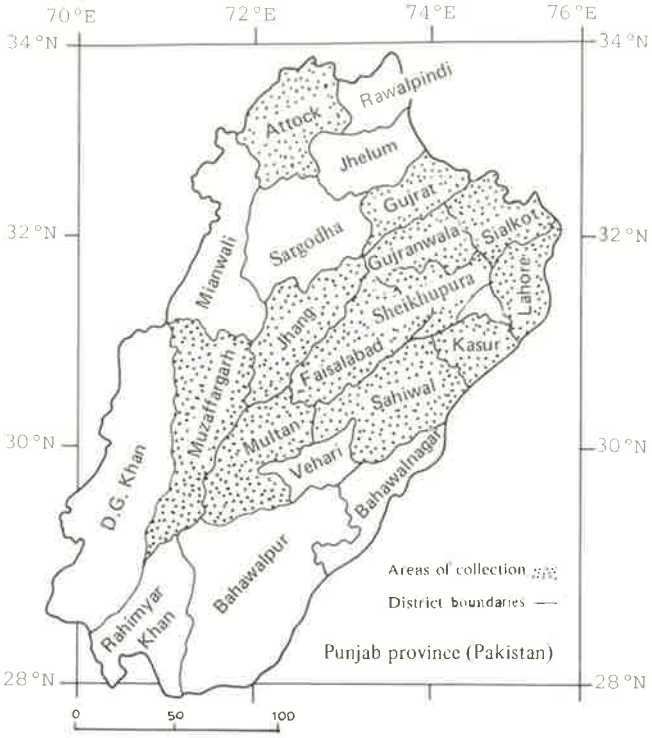


Fig. 1. Exploration areas for lentil collecting expedition in April, 1983.

**Table 2.** Lentil germplasm collection from Punjab-Pakistan 1983.

| District | Altitude range (m) | Number of sites | Number of samples |
|---|---|---|---|
| Gujrat | 330-350 | 2 | 2 |
| Sailkot | 290-340 | 14 | 17 |
| Gujranwala | 300-310 | 4 | 5 |
| Sheikhupura | 280-300 | 3 | 3 |
| Kasur | 300-310 | 2 | 2 |
| Lahore | 270-290 | 7 | 8 |
| Sahiwal | 230-270 | 7 | 16 |
| Multan | 190-230 | 6 | 9 |
| Muzaffargarh | 190-210 | 11 | 17 |
| Jhang | 290-300 | 1 | 2 |
| Faisalabad | 290-300 | 1 | 1 |
| Total | | 58 | 82 |

The collected lentil samples has a considerable variation in pod and seed coat colour and pigmentation in addition to plant height and number of branches/plant. The morphological and physiological variability can be attributed to the edaphic and ecological conditions.

Insect pests and diseases were also recorded in the field during collection. *Heliothis armigera*, Bruchid beetles, and *Sclerotinia sclerotiorum*, and *Rhizoctonia solani* were the common insects and diseases in most of the area, while *Ascochyta lentis* was observed only in Sialkot district.

### *Genetic erosion*

The indigenous lentil cultigen was under severe threat of genetic erosion in the areas of exploration due to several factors. The major factor was the inclination of farmers to grow crops other than lentil, which have higher return per unit area. At several sites, the farmers were growing lentil on small areas - a few meters square-field, just to meet the family's need. Under these circumstances, the area under lentil cultivation will shrink further in future resulting in complete disappearance of land races and primitive cultivars.

## Conclusion

The current mission explored a vast area in the province of Punjab to collect maximum natural genetic variability. The entire collection of lentil (*Lens culinaris*) belongs to subspecies *microsperma*. Morphological and physiological variation can be attributed to varied ecological, edaphic, and climatic conditions. The land races and primitive cultivars are under threat of genetic erosion and the area under lentil cultivation will further shrink in future resulting in complete disappearance of valuable germplasm. It is, therefore, imperative to explore the other areas in Punjab and the entire Sind and Baluchistan provinces.

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# Three interesting mutants in lentil


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## Abstract

**This paper describes the quantitative characters and yield components of the three of the mutants (compact, dwarf, and staggering) isolated in a previous study by the authors in 1983.**


## Introduction

A study was made on the effect of separate and simultaneous application of gamma rays and NMU on dry and dormant lentil (*Lens culinaris* Med.) seeds var T-36 and a number of macromutations were isolated (Dixit and Dubey 1983a and b). This paper presents a detailed description of three of these mutants. The data on yield and other quantitative characters of the three mutants and the parent variety are summarized in Table 1. Characteristic features of the three mutants are described in this paper (Table 1).

### *1. Compact*

The compact mutant is characterized by compact branches which give it a more compact shape (Fig. 1) as compared to the control (Fig. 2). This mutant has a significantly reduced plant height and leaf size. The number of primary branches was equal to the parent strain, but it had an increased number of secondary and tertiary branches. The compact mutant showed a highly significant increase in leaf number, pod number, seed number, test weight, and grain yield. Such a plant was detected in $M_2$ family under the 10 kR gamma ray treatment and was found to be true breeding through the $M_6$ generation. This type of mutant has various advantages over the existing plant type and may prove useful for commercial purposes because of the increased yield potential.

The globe mutant, recorded by Gupta *et al.* (1983), had a reduced seed yield as well as test weight, while the compact mutant, described here, has an increased yield potential. The accession number A.M. 10 was allotted to this mutant.

**Table 1.** Yield and yield components in induced mutants and control var T-36.

| Character | Control | Mutant A.M. 10 (Compact) | A.M. 16 (Dwarf) | A.M. 40 (Staggering) | C.D. at 5% (1%) |
|---|---|---|---|---|---|
| Plant height (cm) | 28.1 + 0.26 | 16.4** + 1.05 | 8.1** + 0.75 | 29.0** + 1.16 | 0.64 (0.85) |
| Number of branches/ plant | 3.6 + 0.11 | 3.6 + 0.20 | 4.0** + 0.15 | 2.4** + 0.12 | 0.12 (0.16) |
| Number of leaves/ plant | 466.8 + 6.49 | 929.2** + 60.7 | 485.5 + 17.78 | 402.8* + 43.06 | 62.22 (83.31) |
| Number of pods/ plant | 265.2 + 19.24 | 337.8* + 58.9 | 25.75** + 2.46 | 186.6* + 22.30 | 17.67 (23.46) |
| Number of seeds/pod | 1.44 + 0.05 | 1.6** + 0.16 | 1.3** + 0.22 | 1.76** + 0.73 | 0.01 (0.05) |
| Internode length (cm) | 2.1 + 0.11 | 2.9** + 0.13 | 0.8** + 0.06 | 1.1** + 0.06 | 0.29 (0.42) |
| Length of leaf (cm) | 2.81 + 0.04 | 2.26* + 0.09 | 0.85** + 00.12 | 0.64** + 0.16 | 0.37 (0.83) |
| Length of leaflets (cm) | 1.1 + 0.003 | 0.76** + 0.02 | 0.472** + 0.11 | 0.52** + 0.03 | 0.137 (0.293) |
| Width of leaflet (cm) | 0.22 + 0.003 | 0.25* + 0.01 | 0.16** + 0.00 | 0.203 + 0.022 | 0.026 (0.049) |
| Length of flower (cm) | 0.4 + 0.04 | 0.38 + 0.01 | 0.43** + 0.031 | 0.49** + 0.01 | 0.021 (0.038) |
| Grain yield/plant (gm) | 5.6 + 0.43 | 9.1** + 0.69 | 0.5** + 0.049 | 3.9** + 0.54 | 0.40 (0.52) |
| Test weight (gm) | 2.8 + 0.04 | 3.24** + 0.05 | 2.82 + 0.18 | 3.82** + 0.26 | 0.056 (0.075) |
| Time to flowering (days) | 80.2 + 0.53 | 80.2 + 0.53 | 70.0** + 0.29 | 60.4** + 0.22 | 0.31 (0.42) |

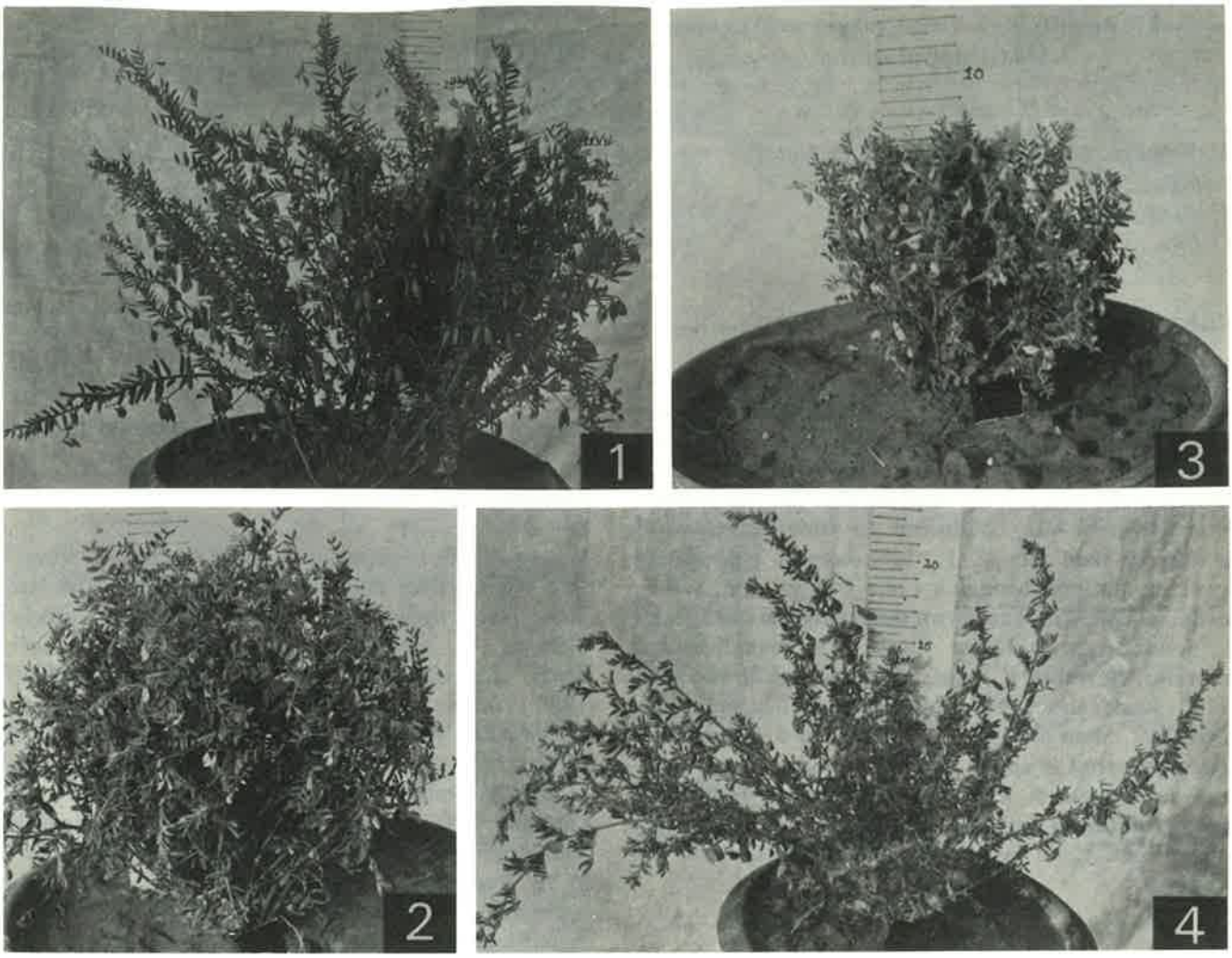
* = Significant at 5% level of probability and ** = Significant at 1% level of probability.

### 2. *Dwarf*

The plant height was 28 cm in the parent T-36 and 8-12 cm in the mutant plants (Fig. 3). The dwarf mutant also had a significant reduction in leaf size, pod number, and seed number. The grain yield also decreased due to reduction in pod formation, but it flowered earlier than the control. Our dwarf mutant has unsynchronized maturity with bold seeds, while the dwarf mutant, recorded by Sharma and Sharma (1977), had shrivelled and poor developed seeds. Only two dwarf plants were detected by us in the $M_2$ population under the 10 kR and 15 kR gamma ray treatments, respectively. The dwarf character was uniformly maintained in all the $M_3$ families and the succeeding generations through $M_6$ generation. The accession number A.M. 16 was alloted to this mutant in our stock.

### 3. *Staggering*

This mutant was characterized by closely arranged longer branches which spread parallel to the ground for most of their length and finally turned upwards (Fig. 4). There was a significant reduction in branch number, leaf and leaflet size, pod number, internode length, and grain yield in the staggering mutant. But it was taller with larger flowers and bolder seeds in comparison with the parent strain. This mutant flowered about 20 days earlier than the control. Staggering mutant was induced in only one treatment i.e. 15 kR + NMU and was found to breed true in all the $M_3$ families and subsequent generations raised through $M_6$. The accession number A.M. 40 was alloted to this mutant in our stock.




Figs. 1, 2, 3, and 4. Three interesting mutants induced in lentil (*Lens culinaris* Med.).

The staggering mutant, observed in the present study, was quite different from the mutant recorded by Sharma and Sharma (1977), because their staggering mutant had a drastic reduction in leaf number. It also had only few normal leaves in the basal region of the plant at the end of the vegetative growth period. Thus, the mutants became virtually bare toward the end and there was no seed set. However, our staggering mutants showed highly significant increase in seed set. The compact mutant out of the three mutants described here may prove to be useful for direct cultivation because of its increased yield potential, while the dwarf and the staggering mutants are also of immense value from breeder's view point as they carry factors for earliness and other desirable traits e.g. bolder seeds and increased number of seeds/pod. These mutants are also of great academic value for genetic studies.

## Acknowledgement

We are grateful to Council of Scientific and Industrial Research, New Delhi for the grant of a Senior Research Fellowship to Miss Pratibha Dixit.

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# Screening for seed size in bulk segregating lentil populations

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## Abstract

**When crosses are made between parents differing in seed size in the development of large-seeded cultivars, the survival of large-seeded segregants is threatened in the bulk breeding method by their selective disadvantage due to a low seed number per unit weight. An experiment was conducted to study the effects of sieving the seed of 27 $F_2$ bulk-harvest segregating lentil populations through a 4 mm ⌀ sieve on $F_3$ and $F_4$ seeds and plants. The mean differences in the $F_3$ and $F_4$ generations between large and small-seeded fractions, sieved at $F_2$ generation, were 0.77 and 0.92 g/100 seeds, showing a large response to selection for seed size. Seed sieving is a simple and inexpensive technique that is useful in bulk breeding to concentrate large-seeded segregants in crosses both with parents differing greatly in seed size and with large-seeded genotypes as the desired objective of the program.**

## Introduction

The cultivated lentil (*Lens culinaris* Med.) is divided into two subspecies (*macrosperma* and *microsperma*) with a seed size less than 4.5 g/100 seeds (Barulina 1930). The area of cultivation and variability of *microsperma* is greater than that of the *macrosperma* group, which is cultivated around the Mediterranean basin and in North and South America. In view of the genetic divergence between the subspecies, the introgression of exotic genes from *microsperma* into locally adapted *macrosperma* cultivars may improve yields. Crosses with parents of different seed size are often made in the development of large-seeded cultivars. In the bulk breeding method, the survival of the larger-seeded segregants is threatened by their selective disadvantage due to a low seed number per unit weight. In soybean (*Glycine max*) and bean (*Phaseolus vulgaris*), the utilization of small-seeded cultivars for the improvement of large-seeded types requires special care and the breeder must obtain an adequate frequency of large-seeded segregants in a population without reducing excessively the genetic contribution of the small-seeded parent (Hamblin 1977; Bravo *et al.* 1981).

A program to reduce the loss of large-seeded lentils in bulk segregating populations was initiated by sieving seeds of $F_2$ (bulk-harvested) populations with a 4 mm ⌀ size. Both the low and high seed size fractions were taken through the $F_3$ and $F_4$ generations by the bulk method. A study was made on the influence of seed sieving on $F_3$ and $F_4$ seed size and $F_4$ plants.

## Materials and Methods

Segregating bulk populations were developed from 27 (two-way) crosses made in 1982 at ICARDA's Tel Hadya farm, North Syria (37°N, 37°E) among 16 selections differing in seed size ranging from 2.8 to 7.1 g/100 seeds. The selections were ILL 468 (ex-Chile); ILL 1880 (Turkey); ILL 2129, 4400, 4401, 5542, and 5610 (Syria); ILL 4349 (Canada); ILL 4605 (Argentina); ILL 4957 (USA); ILL 5527 (Hungary); ILL 5551 (Mexico); ILL 5572 (Iran); and ILL 5582, 5583, and 5588 (Jordan). The $F_1$ generation was grown at Shaubak in southern Jordan in 1982. The $F_2$ generation was sown at Tel Hadya in November 1983. The $F_2$ seeds (bulk-harvested) of each cross were sieved with a 4 mm ⌀ round-hole screen to obtain two seed size populations: large-seeded > 4 mm ⌀ (L), and small seeded < 4 mm ⌀ (S). Both L and S populations of each cross were grown as $F_3$ generation in the summer of 1983 in Shaubak, then harvested as bulk populations. Those $F_3$ seeds were then divided into two samples.

The first sample from $F_3$ seeds was used to study the variation in $F_3$ seed size. The L and S populations were measured for 100-seed weight. They were then screened in four round-hole sieves (3.5, 4, 4.5, and 5 mm ⌀) to give five fractions. The total seed weight (g) and 100-seed weight (g) of each fraction was then measured.

The second sample was sown at Tel Hadya in 1984 to produce $F_4$ plants. The two populations from each cross were sown in adjacent plots of 16 rows, 4 m long, and 37.5 cm apart with an intra-row distance of 4 cm (100 plants/$m^2$). Fertilizer at a rate of 50 kg $P_2O_5$/ha was added to the soil prior to planting. The characters: time to 50% flowering (days), plant height (cm) of 3 plants/plot, lowest pod height (cm) of 3 plants/plot,

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**Table 1.** Means, ranges, and standard errors (S.E.) of differences for characters of large (L) and small (S)-seeded fractions of the progeny of 27 $F_2$ sieved segregating populations.

| | L | Range of L | S | Range of S | S.E. |
|---|---|---|---|---|---|
| 100-seed weight (g) of $F_3$ | 4.4 | 3.0 - 5.7 | 3.6 | 2.6 - 4.8 | 0.12** |
| Time to flowering (d) of $F_4$ | 113.2 | 97 - 120 | 113.6 | 97 - 118 | 0.29 |
| Plant height (cm) of $F_4$ | 33.8 | 30 - 39 | 32.6 | 27 - 37.8 | 0.36** |
| Lowest pod height (cm) of $F_4$ | 21.9 | 19 - 29 | 21.3 | 18 - 26 | 0.43 |
| Number of seeds/pod of $F_4$ | 1.3 | 1.1 - 1.7 | 1.3 | 1.1 - 1.7 | 0.12 |
| 100-seed weight (g) of $F_4$ | 4.6 | 3.2 - 6.0 | 3.7 | 2.8 - 5.0 | 0.15** |

** $P < 0.01$

number of seeds/pod of 30 pods, and 100-seed weight (g) were measured.

In the statistical analysis, the paired t-test was used to examine the difference between the mean of L and S seeded populations for the characters measured in the $F_3$ and $F_4$ generations.

**Results and Discussion**

The populations formed by sieving $F_2$ seed significantly differed in seed size in the $F_3$ generation. The mean of $F_3$ 100-seed weight of L populations was 4.34 g (Table 1), whereas the 100-seed weight of the S populations was 3.57 g over 27 crosses, thus giving an average effect of sieving on seed size of 0.77 g.

The mean of 100-seed weight in $F_4$ of L and S populations were 4.57 g and 3.65 g, respectively. The difference between these values was highly significant giving an average effect on seed size of 0.92 g.

The response in the $F_3$ and $F_4$ generations to selection for seed size was due to the high heritability of seed size in lentil (Sakar 1983, Singh and Singh 1969). Seed sieving is a simple and inexpensive technique to concentrate larger-seeded segregants in bulk populations. As such, sieving is useful in the bulk breeding method for those lentil crosses which are expected to show a wide segregation for seed size, and where large-seeded genotypes are the desired objective of the breeding program. However, the value of the introgression of *microsperma* genes into *macrosperma* remains to be assessed.

Looking at the $F_3$ seed fraction in each population, the effects of sieving are illustrated by two representative crosses. In the cross, ILL 5551 x ILL 5582, the parents considerably differed in seed weight (2 g/100 seeds), whereas in the cross (ILL 2129 x ILL 5583) the difference was only 0.3 g/100 seeds. As a percentage of seed yield of both crosses the distribution of the seed size in both L and S of $F_3$ populations illustrates the shift in average seed weight from sieving at the $F_2$ generation (Figure 1). However, both crosses contained some large seeds in the S populations, and also some small seeds in the L populations. This is partly due to the effects of segregation for seed size and partly due to the variation within a single plant for seed weight and other environmental effects. Further sieving at later

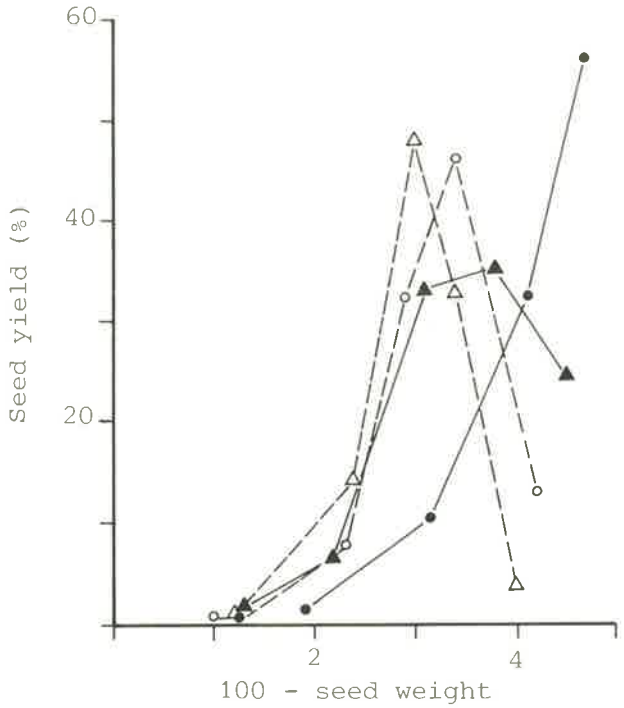


Fig. 1. Distribution of seed size (g) in both L ( o ) and S ( ▲ ) $F_3$ populations as a percentage of seed yield in crosses ILL 5551 x 5582 (——) and ILL 2129 x 5583 (- - -).

generations would assist the concentration of larger-seeded segregants.

The effects of seed sieving on time to flowering, plant height, and lowest pod height of $F_4$ plants and number of seeds/pod, and 100-seed weight of $F_4$ seeds are shown in Table 1. The L populations were significantly taller than their respective S populations and this indicated the positive correlation between seed size and plant height as found by Singh and Singh (1969). There were no significant effects of seed sieving on time to flowering, lowest pod height, and the number of seeds/pod.


### Acknowledgement

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## Genetics of seeding vigour and hard seed in lentil


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### Abstract

**Genetic studies on four traits were made on 100 freshly harvested lentil genotypes in the laboratory. A wide range of germination percentage was recorded. Sufficient amount of genetic variability exist in the material. High heritability estimates coupled with expected genetic advance as percentage of mean was recorded for all the characters. Germination percentage had negative correlation with hard seeds.**


### Introduction

An internal condition of the chemistry or stage of development prevents the germination of viable seed, although suitable growing temperature and moisture are provided. A state of dormancy is a resting state that must be broken by time, or a special condition, before seed will germinate at suitable temperature and moisture levels. Lentil seeds contain some dormant seeds at harvest. They create a problem in germination when tested in laboratory or planted in field. An artificial method to soften the hard seeds damages sometimes the germinability and vigour. On the other hand, an impermeable seed coat provides the best protection to seeds in storage as the vital process in such seeds is reduced to the lowest possible level (Porter 1949). Information on the presence of hard seeds in lentil is insufficient.

### Materials and Methods

The experiment comprised 100 lentil genotypes, freshly harvested. One-hundred seeds from each genotype were kept in petri dishes, sterilized in an autoclave, with two replications. The germination percentage was computed on the basis of the number of normal seedlings (ISTA 1976). The seeds which did not imbibe water during germination were reported as hard seeds or dormant seeds, and the seeds which imbibed water were treated as water soaked seeds. All the observations were recorded on the 8th day after sowing the seed.

Coefficient of variation, heritability, genetic advance, and coefficient of correlation were calculated as per the methods suggested by Burton (1952), Allard (1960), Johnson *et al.* (1955), and Miller *et al.* (1958), respectively.

**Table 1.** Genetic parameters.

| | Germination (%) | Water-soaked seeds (%) | Hard-seeds (%) | 100-seed weight (g) |
|---|---|---|---|---|
| Mean | 23.0 | 20.6 | 56.5 | 2.62 |
| Minimum | 0.0 | 0.0 | 5.0 | 1.06 |
| Maximum | 65.0 | 65.0 | 100.0 | 3.98 |
| Phenotypic variance | 218.3 | 151.3 | 372.1 | 2.92 |
| Genotypic variance | 176.6 | 118.7 | 331.0 | 2.90 |
| Error variance | 41.7 | 32.6 | 41.1 | 0.01 |
| Phenotypic coefficient of variation (%) | 64.8 | 59.7 | 34.2 | 75.47 |
| Genotypic coefficient of variation | 57.90 | 52.87 | 32.21 | 75.32 |
| Heritability ($h^2$) | 80.9 | 78.4 | 89.0 | 99.60 |
| Genetic advance (GA) | 24.6 | 19.9 | 35.4 | 3.50 |
| GA as % of mean | 107.3 | 96.5 | 62.6 | 154.73 |

## Results and Discussion

A wide range of germination percentage was recorded (Table 1). The highest germination was 65.0% and the lowest 0.0%, while Sami and Gupta (1980) recorded the highest germination (35.5%) and the lowest (18.5%) in the study carried out on six promising lentil varieties. The mean squares due to genotypes were highly significant for all the traits. Since the magnitude of absolute variation depends upon the unit in which a particular character was measured, coefficient of variation was worked out in order to compare the extent of variation among different characters. The genotypic coefficient of variation was high for all the characters (Table 1). This indicated that a sufficient amount of genetic variability exists in the material. In general, high heritability was recorded for all the characters (Table 1). The highest heritability was recorded for 100-seed weight followed by hard seeds. On the basis of heritability estimates, the expected genetic advance was computed. The magnitude of genetic advance is influenced by the unit of measurement, so genetic advance as percentage of mean is presented. In general, high genetic advance as percentage of mean was recorded for all the characters. The highest genetic advance as percentage of mean was recorded for 100-seed weight followed by germination percentage. High heritability estimates coupled with high expected genetic advance as percentage of mean were recorded for all the characters. Correlation coefficients are given in Table 2. The data indicated that phenotypic correlations were higher than environmental correlations and the genotypic correlations were the highest in general. Hard seeds have a negative correlation with germination percentage and water soaked seeds.

**Table 2.** Correlation coefficients of various characters.

| | | Water-soaked seeds | Hard-seeds | 100-seed weight (g) |
|---|---|---|---|---|
| Germination (%) | G | 0.176 | -0.815 | 0.190 |
| | P | 0.028 | -0.772** | 0.189 |
| | E | -0.556 | -0.559 | 0.661 |
| Water-soaked seeds (%) | G | | -0.681 | 0.092 |
| | P | | -0.631** | 0.082 |
| | E | | -0.451 | 0.020 |
| Hard-seeds (%) | G | | | -0.226 |
| | P | | | -0.171 |
| | E | | | 0.197 |

G, P, E are genetic, phenotypic, and environmental coefficients of correlation, respectively.
** $P < 0.01$.

Hence, it is concluded from this study that selection for high germination will reduce the number of hard seeds and also give a better plant stand.

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# Performance of exotic lentil germplasm in Bangladesh

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## Abstract

**Coefficient of variation, obtained from 200 lentil lines originating from seven countries, was very low for time to maturity (days) (3.94%), time to flowering (days) (9.65%), and plant height (10.92%); but high for seed yield/plant (48.69%) and 1000-seed weight (29.03%). Correlation coefficient between seed yield/plant and plant height was high and positive. Seed yield/plant had negative association with time to flowering (days) and seed size.**

## Introduction

Lentil is the second most important grain legume crop in Bangladesh in respect of area and production. But, it ranks first in terms of preference. It occupies about 73279 hectares producing 44000 (metric tons) of grain which contributes about 24% to the total production of pulses in the country. In comparison to other pulses, lentil yield is stable to some extent. Bangladesh stands first in productivity per unit area among the south Asian countries and ranks 13 among the top lentil producing countries of the world (Anonymous 1984). Lentil production is decreasing gradually. It went down by 9% during the last decade (Anonymous 1985) due to several reasons. The mean lentil productivity is about 640 kg/ha which compares unfavourably with that of wheat (1912 kg/ha) and rice (1200 kg/ha), and therefore, the farmers shift toward these crops, paying last priority to lentil production and allocating marginal land to lentil.

Like other lentil producing countries of the world, considerable genetic erosion of this crop also occured in Bangladesh. To improve the yield potential, the introduction of exotic lentil germplasm is urgently needed. This paper summarizes the results of the evaluation of exotic germplasm in Bangladesh.

## Materials and Methods

Two hundred early-maturing germplasm lines from seven lentil producing countries, received from the International Center for Agricultural Research in the Dry Areas (ICARDA), were evaluated in a germplasm nursery in the 1984/85 cropping season (Table 1). On 8 Nov 1984, the lines were sown after every 10 test entries in non-replicated single row plot of 4 m long with lentil-5 as local check at the Regional Agricultural Research Station, Ishurdi, Pabna. Spacing was 25 cm between rows and 2 cm between plants in a row. No fertilizer was applied. For uniform germination, only one post-sowing irrigation was applied. There was no rainfall during the cropping season. Observations on time to 50% flowering (days), time to maturity (days), plant height, seed yield/plant, and 1000-seed weight were recorded from 20 randomly selected plants from each entry. The characters were used for variability and correlation study.

**Table 1.** Origin and characteristics of the entries.

| Origin | Number of entries |
|---|---|
| India | 118 |
| Ethiopia | 42 |
| Egypt | 28 |
| Pakistan | 6 |
| Yemen | 4 |
| Turkey | 1 |
| USSR | 1 |
| Total | 200 |

## Results and Discussion

Data on the variability observed in the materials are presented in Table 2. Time to flowering (days) varied from 53 to 85 days with a mean of 74.7 days. Similarly, time to maturity (days) also showed low variability with 3.4% coefficient of variation. Plant height ranged from 34 to 54.2 cm with a mean of 40.5 cm. The results in Table 2 reveal the minimum variability for seed yield/plant (48.7%) and 1000-seed weight (29.0%). The range of variability for seed yield/plant might be useful to select higher yield lines. There was a large variation in seed size among the entries. The 1000-seed weight which ranged from 13 to 38 g offers some scope of selection for bold-seeded types which can be used in the Lentil Improvement Program.

**Table 2.** Mean, range, and coefficient variations of different characters in lentil.

| Character | Mean | Range | Coefficient variation (%) |
|---|---|---|---|
| Time to flowering (days) | 74.7 | 53 - 85 | 9.7 |
| Time to maturity (days) | 122.00 | 103 - 140 | 3.9 |
| Plant height (cm) | 44.5 | 34.2 - 54.2 | 10.9 |
| Seed yield/ plant (g) | 0.96 | 0.10 - 1.93 | 48.7 |
| 1000-seed weight (g) | 22.8 | 13.0 - 38.0 | 29.0 |

**Table 3.** Correlations among various yield components in lentil.

| Character | Time to 50% flowering (days) | Time to maturity (days) | Plant height (cm) | Seed yield/ plant (g) |
|---|---|---|---|---|
| Time to maturity (days) | 0.22** | | | |
| Plant height (cm) | 0.07 | 0.25** | | |
| Seed yield/plant (g) | -0.18* | -0.37** | 0.23** | |
| 1000-seed weight (g) | -0.37** | 0.02 | -0.21** | -0.29** |

** $P < 0.01$; * $P < 0.05 > 0.01$.

Correlation coefficients among the characters were estimated (Table 3). Seed yield/plant had strong positive correlation with plant height. This indicates that the taller plants may have more pod bearing nodes and, hence, higher seed yield. But, seed yield had negative association with seed size, time to flowering (days), and time to maturity (days). On the other hand, seed size showed negative correlation with time to flowering (days), plant height, and seed yield. Similar associations between seed yield and plant height were also reported by Singh *et al.* (1970), Dixit (1974), Singh (1977), Tikka *et al.* (1977), and Rahman and Doza (1982). Negative correlation between seed size and seed yield was reported by Singh (1977) and Rahman and Doza (1982). It may be inferred from the correlation study that the selection based on taller plant type with smaller seed size is effective for high seed yield.

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# Studies on variability for seed size, permeability of seed coat to water, and germination in lentil

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## Abstract

**Fifty seven accessions of lentil germplasm, collected from different parts of Madhya Pradesh, India were studied for seed size, permeability of seed coat to water, and germination at the Main Pulse Research Centre, Jawaharlal Nehru Agricultural University Campus, R. A. K. College of Agriculture, Sehore, Madhya Pradesh, India. There was a wide range of variability for seed size (1.4 - 3.4 g/100 seeds), seed permeability (5.0 - 55.8%), as well as for germination (44.2 - 89.4%). A strong, negative, and highly significant correlation (-0.95) was observed between seed impermeability and germination. Seed size was positively correlated with seed impermeability (0.75) and germination (0.77). The highest percentage of seed impermeability (55.8%) was obtained by JSL-1030. The entry JSL-941 exhibited maximum germination (89.4%).**

## Introduction

Lentil ranks third in importance after chickpea and *Lathyrus* among *rabi* pulse crops of Madhya Pradesh, India.

It is grown on an area of 315.5 thousand hectares, scattered over diverse agroclimatic regions, with an annual production of 138.9 (metric tons). The mean state productivity is 440 kg/ha. One reason for the low productivity is the poor plant population per unit area under rainfed conditions which account for almost 90% of the total lentil area. The other constraints which limit the increase of lentil production are the preference of the farmers for bold-seeded lentils (more than 3.0 g/100 seeds), insufficient moisture at sowing time, poor vegetative growth because of the absence of rain or the low average rainfall in winter, and the susceptibility to wilt and rust of bold-seeded cultivars.

The seed germination of legumes is adversely affected by the impermeability of seed coat to water (Green *et al.* 1966; Mondragon and Potts 1974; Shahi and Pandey 1982). Seed coat impermeability is a sort of seed dormancy mechanism which prevents the movement of water through seed coats and consequently the seeds do not germinate, even when placed under favourable conditions for seed germination. Impermeable seeds are reported to maintain seed viability longer by a reduction in their physiological activity to the possible lowest level. Similar information on seed impermeability and germination in lentils from rainfed situations is scanty and meagre. Hence, the present investigation was undertaken to study the variability in lentil germplasm, selected randomly for the above cited traits.

## Materials and Methods

Fifty-seven lentil accessions, selected randomly from the germplasm collection maintained at the centre, were studied at the Main Pulse Research Centre of Jawaharlal Nehru Agricultural University Campus - Rafi Ahmed Kidwai College of Agriculture in the 1984/85 season for seed germination and impermeability to water.

Four hundred seeds were taken from each of 57 accessions for germination test by blotter method (ISTA 1976). The seeds which did not imbibe water and remained hard, when placed for germination, were treated as impermeable. The germinated seeds were counted. The mean, range, and standard error for seed size, germination, and impermeability were worked out. Simple correlation between different characters were also calculated.

## Results and Discussion

The mean, range, and S. Em. for seed size, seed germination, and impermeability are given in Table 1.

The above data show that there was a considerable variation for the three traits in the material studied. Hence, the selection for lentil lines with higher germination and lower seed impermeability is possible. Sami (1982) also reported 18.5 - 35.5% dormant seeds in six lentil varieties. The frequency distribution graph for seed impermeability and germination (Fig. 1) shows that 36 lines out of 57 had seed impermeability ranging from 15.0 to 35.0%. Forty lines exhibited 65-85% germination. Only five lines showed germination between 85 and 100%.

**Table 1.** Mean, standard error, and range for three traits in lentil.

| No. | Character | Range | Mean | S.Em |
|---|---|---|---|---|
| 1. | Seed size (100 seed-weight in g) | 1.4 - 3.6 | 2.4 | 0.68 |
| 2. | Seed imper-meability (%) | 5.0 - 55.0 | 26.4 | 11.65 |
| 3. | Germination (%) | 44.2 - 89.4 | 72.9 | 11.74 |

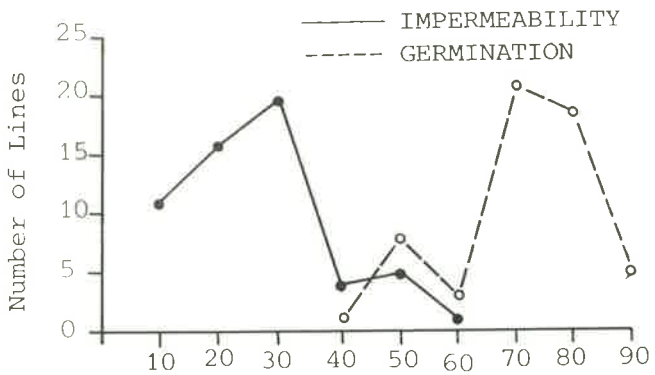


Fig. 1. Impermeability and germination in lentil.

Simple correlations worked out between different characters are given in Table 2.

A strong and negative correlation (-0.95) between seed impermeability and germination indicated that there is a good scope for selection of lines with higher seed germination and low seed impermeability. Seed size was positively correlated with seed impermeability (0.75) and germination (0.77). Shahi and Pandey (1982), however, reported negative correlation between seed size and impermeability in soybean.

**Table 2.** Correlation coefficients between seed size, seed impermeability, and germination in lentil.

| No. | Character | Seed impermeability | Germination |
|---|---|---|---|
| 1. | Seed size | 0.75** | 0.77** |
| 2. | Seed impermeability | - | -0.95** |

** Significant at 1% level.

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# Effect of Rhizobium inoculation on growth and crude protein/nitrogen contents of lentil in relation to soil salinity

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**Abstract**

**The effect of different salinity levels under non-inoculated and inoculated conditions was measured on lentil (*Lens culinaris* Medic.) (CV 9-6) for yield and nitrogen accumulation at different growth stages in sand culture. Inoculation with *Rhizobium leguminosarum* increased the plant vigour under salt stress and gave better dry matter yield. Total N (mg/plant) decreased with increasing salinity levels at flowering and maturity stages, both under non-inoculated as well as inoculated conditions. Inoculated plants contained considerably more nitrogen at all the salinity levels as compared to corresponding non-inoculated plants.**

## Introduction

Lentils (*Lens culinaris*) are one of the most important pulse crops grown in many parts of the world including Pakistan. They are comparatively more sensitive to salt stress as compared to other crops like wheat and barley. However, the crop is also important in rotations because of its ability to fix 83-114 kg/ha nitrogen in association with rhizobial bacteria (Nutman 1976). There are contradictory statements in literature about metabolism of nitrogen under saline conditions. Prisco and O'leary (1973) reported an increase in protein contents due to salinity. On the other hand, Helal *et al.* (1975), Helal and Mengel (1979), and Kahane and Poljakoff-Mayber (1968) found that the incorporation of labelled nitrogen into the plant was impaired by salt stress. Kahane and Poljakoff-Mayber (1968) further reported that NaCl was more harmful for the incorporation of labelled amino acids as compared to $Na_2SO_4$. Application of nitrogenous fertilizers are usually helpful in overcoming the harmful effects of salinity. But in legumes, nitrogen may depress the symbiotic nitrogen fixation (Eaglesham *et al.* 1983). Hence, the adaptability of grain legumes to saline environments may be affected positively by the establishment of symbiotic nitrogen fixation (Balasubramanian and Sinha 1976). Kisha *et al.* (1980) reported reduced N-fixation in faba beans, particularly with additional nitrogen fertilizers with increasing concentration of sodium chloride.

The objective of this study was to investigate the effect of different salt concentrations on yield, nitrogen contents, and crude protein contents of lentil.

## Materials and Methods

The experiment was carried out in sand culture using modified Leonard's bottle jar assemblies (Vincent 1970). Twenty lentil seeds (CV 9-6) were sown in three replicates using five salinity levels i.e. control (1.5), 3.0, 6.0, 9.0, and 12.0 ds/m. In another set of these treatments, peat-based effective rhizobium strain (*Rhizobium leguminosarum*) received from NIFTAL project, Hawaii was used to inoculate the seeds before sowing. NaCl and $CaCl_2$ (1:1 ratio) were used to create different salinity levels by adding them to half strength of Hoagland nutrient solution and Arnon (1950). Nutrient solution was made N deficient five weeks after germination. The solutions were changed on alternate days. Mean temperatures (min. and max.) ranged between 17 and 29° and 4 and 16°C, respectively during the course of this study, while the mean relative humidity ranged between 42 and 84 in the morning and 34 and 70 in the evening.

Plants were sampled 36 (seedling stage), 90 (flowering stage), and finally 144 days (maturity stage) after sowing date. The plant material was dried at 60°C for 24 hrs, weighed, and powdered in a micro-mill for total nitrogen analysis (McKenzie and Wallace 1954).

## Results and Discussion

The germination of lentil seeds decreased with increasing salinity level and was more adversely

Table 1. Dry matter yield of lentil at different salinity levels.

| Salinity levels ds/m at 25°C | Dry weight mg plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Non-inoculated | | | | Inoculated | | | |
| | Seedling stage | Flowering stage | Pod filling stage | Maturity stage | Seedling stage | Flowering stage | Pod Filling stage | Maturity stage |
| Control | 19.8 ± 2.2 | 126.7 ± 2.0 | 694 ± 80 | 735 ± 68 | 18.8 ± 1.4 | 129.2 ± 6.8 | 738 ± 76 | 867 ± 51 |
| 1.5 | | | | | | | | |
| 3.0 | 18.8 ± 1.1 | 104.1 ± 8.0 | 448 ± 75 | 652 ± 56 | 18.0 ± 2.3 | 111.4 ± 11.0 | 722 ± 81 | 803 ± 32 |
| 6.0 | 16.7 ± 0.8 | 70.3 ± 6.0 | 340 ± 60 | 358 ± 44 | 16.7 ± 0.8 | 84.5 ± 4.0 | 616 ± 72 | 668 ± 31 |
| 9.0 | 16.8 ± 1.7 | - | - | - | 16.6 ± 0.7 | - | - | - |

affected at 12.0 ds/m. Plants survived only for three weeks at 12.0 ds/m. Plants also died eight weeks after germination at 9.0 ds/m. The yield and nitrogen data have only been given up to 9.0 ds/m at seedling stage and up to 6.0 ds/m at flowering and maturity stages.

*Dry matter yield*

The results of dry matter yield are presented in Table 1. The increasing salinity levels had significant effect on dry matter production under non-inoculated as well as inoculated conditions. At seedling stage, there was a 15.1 and 11.7% reduction in dry matter at 9.0 ds/m as compared to control under non-inoculated and inoculated conditions, respectively. At later growth stages, depression in dry matter yield was tremendous due to stunted growth at higher salinity levels (Mass *et al.* 1977). At flowering stage, this decrease was 44.5% as compared to control (non-inoculated) and 34.6% (inoculated) at 6.0 ds/m. Similarly, the decrease in yield was 51.3 and 22.9%, respectively at maturity stage at 6.0 ds/m under non-inoculated and inoculated conditions. Yield data at the three stages clearly showed that yield depression was considerably less under inoculated conditions. This further shows the effectiveness of the rhizobial strain under salt stress.

*Nitrogen content at seedling stage*

Nitrogen contents at seedling stage are presented in Table 2. Increasing salinity levels increased the nitrogen percentage as well as crude protein (Prisco and O'leary 1973). The increase in nitrogen contents and crude protein was about 17.5% at 9.0 ds/m under non-inoculated conditions as compared to control. However, there was no effect on total N (mg/plant) due to stunted growth at higher salinity levels. Under inoculated conditions, an increase of 23.7% in nitrogen contents and crude protein was noted at 9.0 ds/m as compared to control. There was a slight increase in total N (mg/plant) which is negligible and might be due to slightly lower yield depression in this case.

**Table 2.** Nitrogen contents at seedling stage at different salinity levels.

| Salinity levels ds/m at 25°C | Nitrogen contents | | | | | |
|---|---|---|---|---|---|---|
| | Non-inoculated | | | Inoculated | | |
| | Dry weight (%) | mg/plant | C.P. (%) | Dry weight (%) | mg/plant | C.P. (%) |
| Control | | | | | | |
| 1.5 | 1.26 ± 0.07 | 0.24 | 7.91 ± 0.44 | 1.39 ± 0.11 | 0.26 | 8.69 ± 0.71 |
| 3.0 | 1.32 ± 0.02 | 0.24 | 8.25 ± 0.18 | 1.55 ± 0.15 | 0.27 | 9.71 ± 0.91 |
| 6.0 | 1.47 ± 0.07 | 0.24 | 9.20 ± 0.44 | 1.70 ± 0.05 | 0.27 | 10.64 ± 0.34 |
| 9.0 | 1.48 ± 0.09± | 0.24 | 9.25 ± 0.55 | 1.72 ± 0.08 | 0.27 | 10.75 ± 0.51 |

C.P. (Crude Protein) = N% x 6.25.

**Table 3.** Nitrogen contents at flowering stage at different salinity levels.

| Salinity levels ds/m at 25°C | Nitrogen contents | | | | | |
|---|---|---|---|---|---|---|
| | Non-inoculated | | | Inoculated | | |
| | Dry weight (%) | mg/plant | C.P. (%) | Dry weight (%) | mg/plant | C.P. (%) |
| Control | | | | | | |
| 1.5 | 1.75 ± 0.11 | 2.21 | 10.93 ± 0.71 | 2.14 ± 0.03 | 2.76 | 13.41 ± 0.54 |
| 3.0 | 1.61 ± 0.11 | 1.67 | 10.06 ± 0.71 | 2.03 ± 0.15 | 2.26 | 12.68 ± 0.94 |
| 6.0 | 1.61 ± 0.09 | 1.13 | 10.06 ± 0.62 | 2.17 ± 0.09 | 1.83 | 13.56 ± 0.62 |
| 9.0 | - | - | - | - | - | - |

C.P. (Crude Protein) = N% x 6.25

**Table 4.** Nitrogen contents at maturity at different salinity levels.

| Salinity levels ds/m 25°C | Nitrogen and dry weight | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Non-inoculated | | | | | Inoculated | | | | |
| | Shoot | | Seed (%) | | | Shoot | | Seed | | |
| | N (%) | C.P. | N (%) | C.P. | Total N (mg/plant) | N (%) | C.P. | N (%) | C.P. | Total N (mg/plant) |
| Control | | | | | | | | | | |
| 1.5 | 1.0 | 6.25 | 3.0 | 18.75 | 13.1 | 1.4 | 8.75 | 4.0 | 25.0 | 21.5 |
| 3.0 | 1.1 | 6.87 | 2.5 | 15.62 | 8.4 | 1.6 | 10.00 | 3.1 | 19.37 | 15.8 |
| 6.0 | 1.4 | 8.75 | 2.8 | 17.50 | 5.6 | 1.7 | 10.63 | 3.0 | 18.75 | 13.0 |
| 9.0 | - | - | - | - | - | - | - | - | - | - |

C.P. (Crude Protein) = N% x 6.25

***Nitrogen content at flowering stage***

The percentage of nitrogen contents and crude protein was 22.3, 40.3, and 34.7% more in inoculated plant material as compared to non-inoculated at control, 3.0, and 6.0 ds/m salinity levels, respectively (Table 3). This clearly shows that plants suffered less under inoculated conditions due to better nodulation (data presented else where) and nitrogen fixation at elevated salinity levels. The percentage of nitrogen content was comparatively less under non-inoculated conditions. Impaired N metabolism at higher salinity levels was noted under non-inoculated conditions where percentage N was 80% less at 6.0 ds/m as compared to control. Under inoculated conditions, there was no depression in percent nitrogen and crude protein. Total nitrogen (mg/plant) was 24.8, 35.3, and 61.2% more under inoculated conditions as compared to non-inoculated conditions at control, 3.0, and 6.0 ds/m, respectively. It was also noted that total nitrogen/plant decreased with increasing salinity levels under non-inoculated as well as inoculated conditions. At 6.0 ds/m, this decrease was 48.8% in non-inoculated treatments and 33.7% in inoculated treatments which indicates better plant performance under *Rhizobium* inoculation.

***Nitrogen content at maturity stage***

Data regarding nitrogen and crude protein percentage in shoot and seed along with total nitrogen/plant are presented in Table 4. There was an increase in nitrogen content and crude protein of shoot with increasing salinity levels under non-inoculated as well as inoculated conditions. However, N and crude protein in seeds decreased with increasing salinity levels. Increase in nitrogen and crude protein of shoot at 6.0 ds/m compared to the control was 40% and 21.4% under non-inoculated and inoculated conditions,

respectively. It was also noted that nitrogen and crude protein percentage of seeds were comparatively better under inoculated conditions and in both cases it decreased with increasing salinity levels (Khondaker 1984). This suggests that nitrogen transformation to seed from shoot was inhibited due to disturbed metabolism at increasing salinity levels. Total nitrogen (mg/plant) was 64.1, 88.1, and 132.1% more under inoculated conditions than non-inoculated conditions at control, 3.0 and 6.0 ds/m, respectively. In non-inoculated plants, total nitrogen/plant decreased from 13.1 mg in control to 5.6 mg in 6.0 ds/m (57.2% decrease). Under inoculated conditions, the decrease was 21.5 - 13.0, respectively (39.5% decrease). Obviously, this was due to poor growth of plants at higher salinity levels (Balasubramanian and Sinha 1976).


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# Sowing dates for lentil in Salta, Argentina


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## Abstract

**Two trials were conducted during the 1984 and 1985 growing seasons to find out the optimum planting dates in Lerma Valley, Salta and to measure the effects of deviation from the conventional date of the end of June for evaluating plant characters. The cultivar "Precoze", which has good adaptability, was sown on eight planting dates with a 10-day difference between each beginning on 7 May in autumn. Seed yield, plant height, number of branches/plant, and height of lowest pods significantly varied due to different dates of planting. Delay of sowing reduced the number of days from seeding to time to maturity (days). Time to flowering (days) significantly varied with the thermal regime. The frost (-9°C) affected the yield on the 1st and 2nd sowing dates in 1984. Disease interaction was lacking. The optimum planting dates for lentils were between 15 and 30 May in Lerma Valleys, Salta.**


## Introduction

No data are available about the optimum sowing time of lentil in the ecological regions, where irrigation can be used for crop development, although sowing between 15 Apr and 30 May is recommended by SEAG (1983). The

sowing dates are between 15 June and the early days of July and crop harvest is by the end of October in the productive region south of Santa Fe, where land is rainfed. For the semi-arid areas of temperate valleys where there is a risk of early and late frosts, it is estimated that the sowing dates could begin from the first fortnight of May and be completed in the same month, or the first days of June (Riba 1979).

In the regions where winters are very cold, the optimum sowing date is in early spring. Where winters are mild, the optimum date is mid-autumn and the beginning of winter in warmer rainfed areas. In areas where the days are longer and the temperatures increase toward the flowering stage, when sowing is delayed, both the growing period and the reproductive growth period are reduced (Saxena 1981). In those years with late frosts, the reproductive growth period of the early sowing is affected and consequently the advantage of this is not achieved (Murinda and Saxena 1983). Plants can tolerate temperatures ranging from -2°C to -4°C during the vegetative stage. More severe frost during the night destroys the apical growth although axillary buds below the soil can initiate a regrowth, but these frosts affect flowering and early pod development. Frosts of -6°C at seed maturity produce stains on the seed coat and damage on those immature plant parts already damaged by the frosts (Muehlbauer and Slinkard 1983).

Murinda and Saxena (1983) found that ILL 4605 Argentina is less sensitive than other genotypes to longer days and higher temperatures in the period from planting date to time to flowering. Manara and Manara (1983) found that the average maximum daily temperature and the inadequate number of sunlight hours are limiting factors of yield for certain genotypes.

Kumar *et al.* (1983) and Dixit and Dubey (1984) found that lentil yields are positively correlated with plant height and the number of secondary branches. The partition analysis of the correlation coefficient revealed that the number of pods/plant, number of secondary branches/plant, plant height, and 100-seed weight have a direct positive effect on yields. Dixit and Dubey (1984) mentioned that yields are strongly and positively correlated with number of pods/plant, plant height, and number of branches/plant in order of importance. Krarup (1984) mentions that high yields/plant were associated positively with number of branches/plant and number of pods/plant in contrast with 100-seed weight and number of grains/pod that were manifested as stable agronomic characters.

The objective of the experiments was to determine the optimum sowing dates for lentil. In addition, we studied the variation in different agronomic characters caused by different environmental conditions and the associations between these traits.

## Materials and Methods

Experiments were carried out during the 1984 and 1985 growing seasons in Salta, Argentina, in the Lerma Valley region at 24°54'S 65°29'W and 1250 m above sea level. The soil type was alluvial with a silty-loam texture, of medium to low fertility and pH around 7. The cultivar Precoze, which has shown wide adaptability and which is the most widely grown cultivar in the production area, was used. The cultivar was grown in a randomized complete block design with four replications, using irrigation. Sowing started on 7 May and continued for a total of eight dates spaced at ten-day intervals.

Sowing was on ridges spaced 0.70 m apart with two rows/ridge at a rate of 50 seeds/m and a depth of 4 cm with an estimated density of 140 pl/$m^2$. Benomyl and Trisem chemicals were used for seed treatment. Each treatment received three irrigations: one before sowing, one before flowering stage, and one when the grain began forming. The net guarded area of the plot harvested was 5.6 $m^2$.

In each treatment, information was collected on seed yield/ha, yield/plant (g), plant height (cm), height of first pod (cm), number of branches/plant, and 100-seed weight (g). Observations were based on an average of 15 plants/row.

The relationships between phenological development, the principal climatic elements, and the incidence of diseases on different planting dates were studied.

The statistical analysis of the data was done using the analysis of variance and Tukey Test comparing the averages.

Simple correlations were used to know the degree of association among different parameters. Path coefficient analysis, cited by Li (1964), was used to discriminate the direct and indirect effects. Multiple regression was used to establish the most appropriate model to explain the effect of climate on yield. The phenotypic coefficient of variation (C.f.v.) was calculated assuming no genetic variance.

**Table 1.** Average over both seasons of characters for eight sowing dates.

| Character | Sowing dates 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Yield (kg/ha) | 978 | 991 | 875 | 656 | 571 | 450 | 393 | 326 |
| | A | A | A | B | BC | C | D | D |
| CV: 9.7 | | | | | | | | |
| Yield/plant | 0.91 | 0.83 | 0.71 | 0.58 | 0.47 | 0.49 | 0.34 | 0.29 |
| (g) | A | AB | BC | CD | DE | DE | EF | F |
| CV: 9.81 | | | | | | | | |
| Number of branches/ | 2.88 | 2.67 | 2.49 | 2.35 | 2.38 | 1.89 | 1.93 | 1.91 |
| plant | A | AB | AB | BC | B | D | CD | D |
| CV: 6.51 | | | | | | | | |
| Plant Height | 24.3 | 21.9 | 20.24 | 19.26 | 18.01 | 15.89 | 15.15 | 15.22 |
| (cm) | A | AB | BC | C | CD | DE | E | E |
| CV: 4.57 | | | | | | | | |
| Height to lowest | 11.06 | 11.68 | 11.4 | 10.2 | 10.32 | 8.94 | 9.04 | 8.49 |
| pods (cm) | AB | A | A | AB | AB | AB | AB | B |
| CV: 9.45 | | | | | | | | |
| Seed weight | 4.5 | 4.6 | 4.5 | 4.6 | 4.5 | 4.7 | 4.5 | 4.4 |
| (g) | a | a | a | a | a | a | a | a |
| CV: 3.4 | | | | | | | | |

CV: Coefficient of variation of the trial (%).

Means accompanied by the same letter were not significantly different at $P \leq 0.01$ (capital letters).

Means accompanied by the same letter were not significantly different at $P \leq 0.05$ (small letters).

## Results and Discussion

The analyses of variance showed that yield (kg/ha), yield/plant (g), branches/plant, and plant height (cm) significantly varied at 1% level of probability over the different dates. The first three sowing dates produced the highest yields, with yields falling off considerably with later sowing. A similar variation was seen for plant height and number of branches. The 100-seed weight remained constant.

The most favourable sowing dates were 7 and 17 May averaged over both seasons (Table 1). But there were radical differences between the seasons in yield (Fig. 1) but less differences for other characters (Fig. 2). The variation in yield was caused by the effect of late frost on the early planting dates when plants were in the reproductive stage of growth. The frost came on 25 August with an intensity of -9°C and 10 hr of duration. It affected flower-buds, flowers and grains and jeopardized yields from the first two sowing dates and reduced them in the third and fourth (Fig. 3). From long-term climate data it is inferred that the most appropriate sowing date could be between 15 and 30 May for early cultivars like "Precoze" considering the

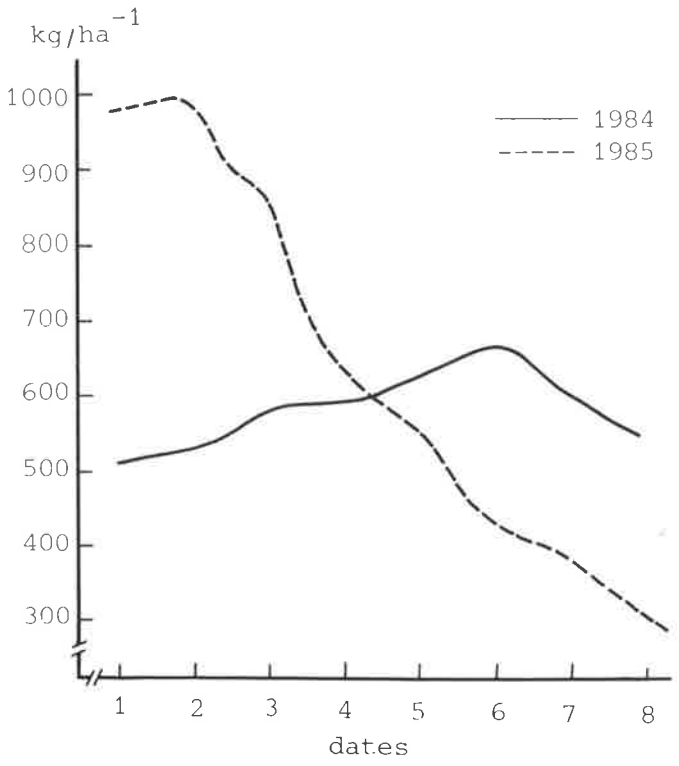


Fig. 1. Variation of yield (kg/ha$^{-1}$) among different dates of planting.

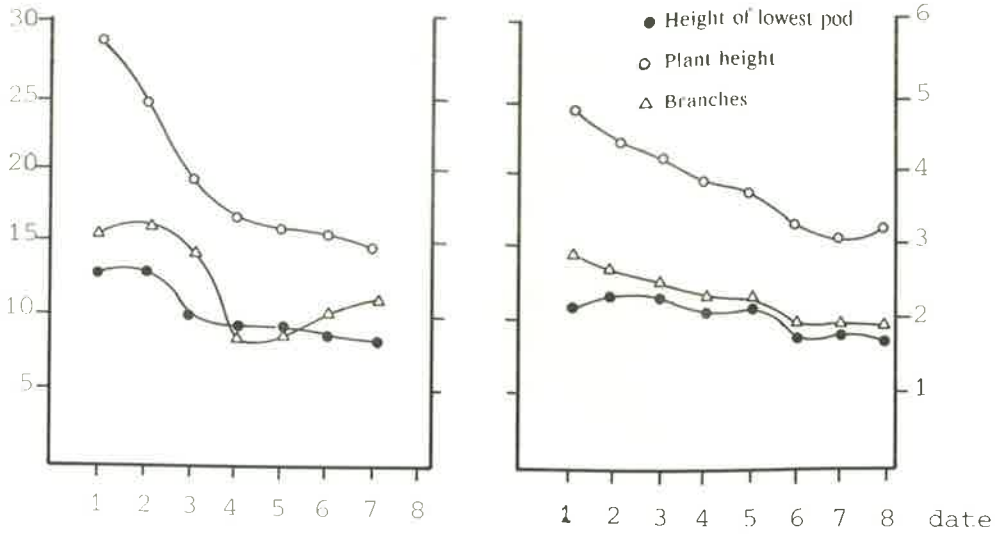


Fig. 2. Variation of plant height (cm), height of lowest pod (cm), and branches/plant among different dates of planting.

probable dates (1 Sep +/-20) for the occurrence of the last frost in the Lerma Valley (Burgos 1963).

The phenotypic coefficients of variation indicated the highest variation among characters for yield/plant followed by plant height and branches/plant (Table 2). The correlations, indicating strong positive associations between yield/plant, plant height, height to the first pod, and branches/plant; while 100-seed weight was independent (Table 3). Plant height had a strong direct effect (0.90) on seed yield; height to the first pod showed a very low direct effect (0.03), but an indirect effect by the way of plant height (0.49) and via the number of branches/plant (0.15). Number of branches/plant had a low direct effect (0.03), but an indirect effect through plant height (0.72), being negligible via the first pod (0.10). In this system, plant height was considered the principal contributor to the variation of yield, number of branches/plant, and height to first pod followed by their substantial indirect effects through the plant height in a growth pattern of the Precoze type.

Phenological development showed a strong interaction with sowing date. The highest yield and the most favourable sowing date for the crop coincided with 140 day crop cycle. Considering both growing seasons, the length of the crop cycle from sowing to maturity was

**Table 2.** Average and phenotypic coefficient of variation (%) for different characters.

| Character | Average | Phenotypic coefficient of variation |
|---|---|---|
| Yield/plant (g) | 0.57 | 41 |
| Seed weight (g) | 4.56 | 3 |
| Number of branches/ plant | 2.30 | 16 |
| Plant height (cm) | 18.8 | 17 |
| Height to lowest pod (cm) | 10.1 | 14 |
| Time to flowering (days) | 67 | 10 |
| Time from flowering to maturity (days) | 54 | 16 |

**Table 3.** Phenotypic correlations among the characters.

| Character | Plant height (cm) | Height to lowest pod (cm) | Seed weight (g) | Yield/ plant (g) |
|---|---|---|---|---|
| Number of branches/ plant | $0.92^{A}$ | $0.67^{A}$ | -0.05 | $0.86^{A}$ |
| Plant height | | $0.74^{A}$ | -0.03 | $0.93^{A}$ |
| Height to lowest pod | | | -0.06 | $0.67^{A}$ |
| Seed weight | | | | 0.10 |

$P \leq 0.01$ with capital letters.

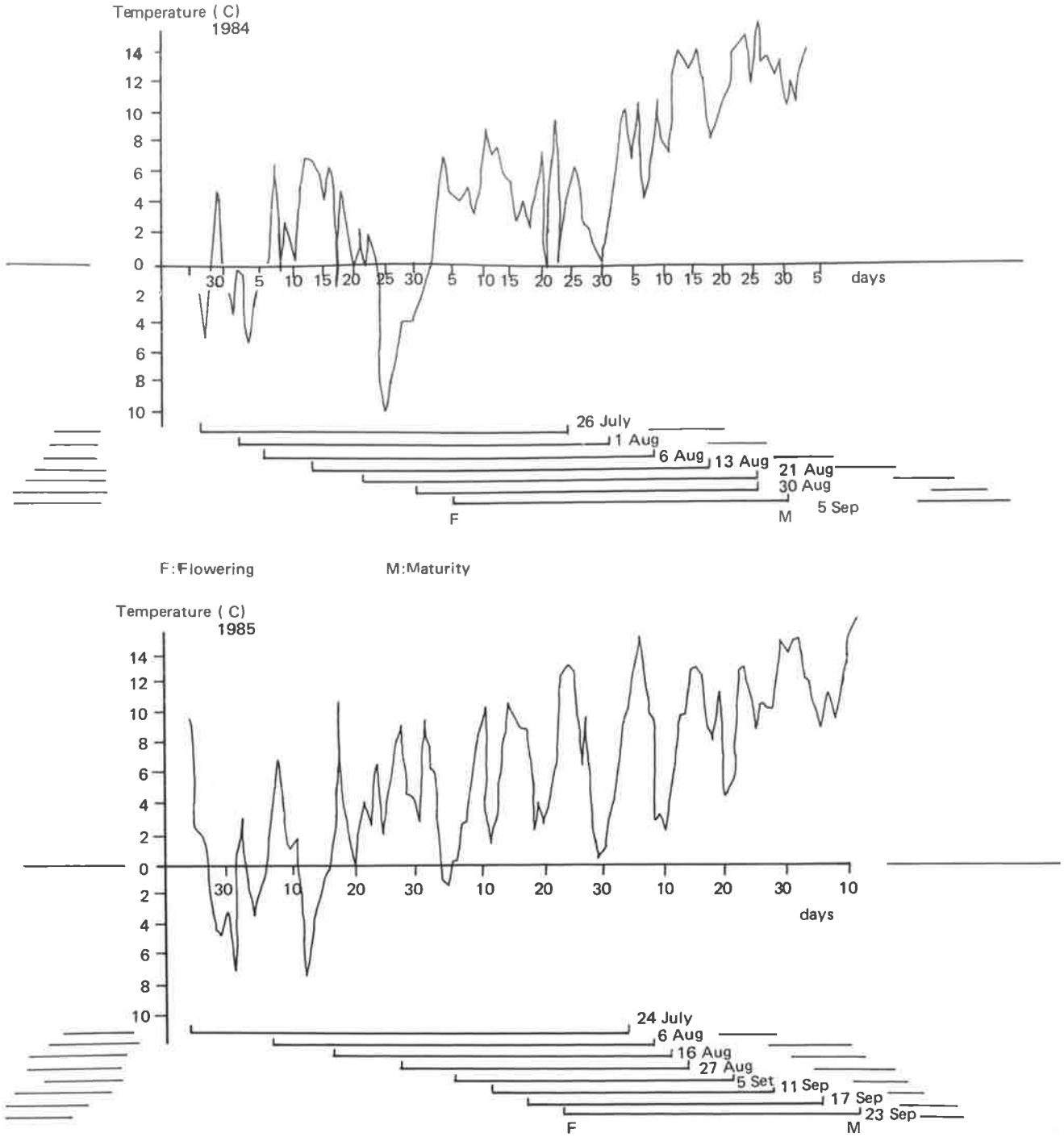


Fig. 3. Frost incidence over reproductive period of different sowing dates.

relatively stable showing coefficients of variation of 7% in 1984 and 9% in 1985. However, there was considerable variation between the seasons in time to flowering, and in the length of the reproductive period (Figs. 4 and 5).

The time to flowering in lentil is affected by temperature and photoperiod. Differences between the years can only be ascribed to temperature, because the photoperiods over years are constant. Within years the time to flowering decreased as the temperature in-

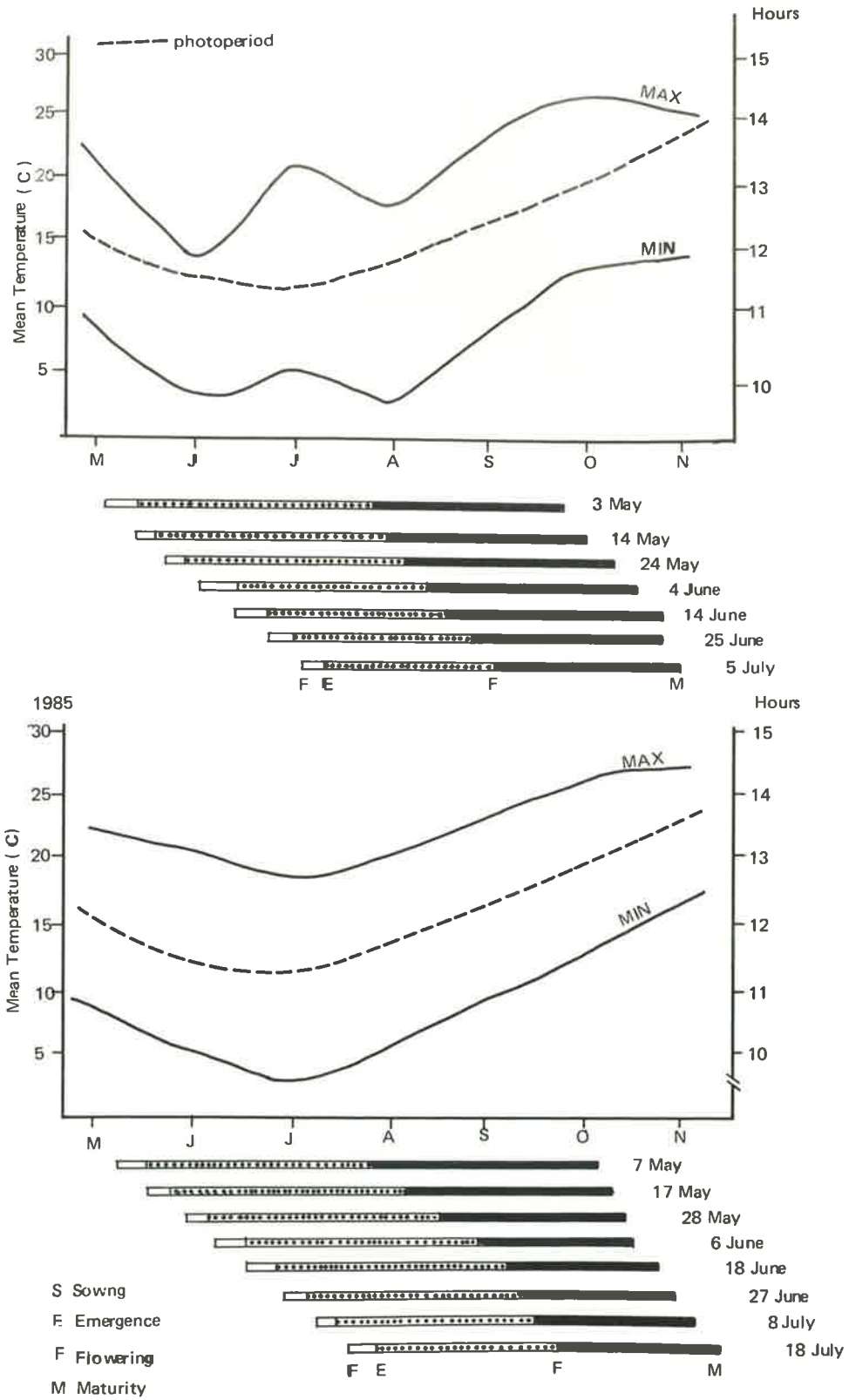


Fig. 4. Phenological development of lentil, at Salta under different sowing dates, in relation to the main climate.

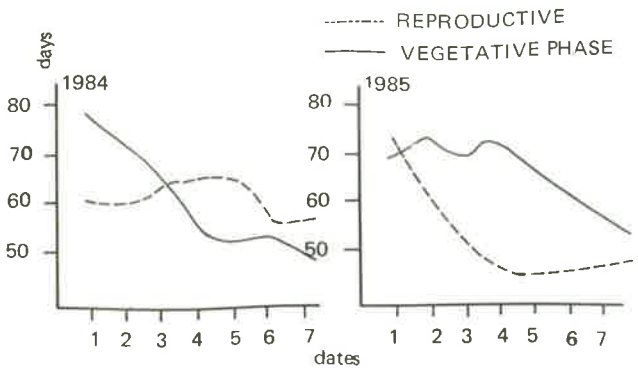


Fig. 5. Vegetative and reproductive phase: interaction both within different sowing dates.

creased with delayed sowing. Conversely, as temperatures increased, the reproductive phase was reduced. Within years it should be mentioned that it is not possible to separate completely the effects of temperature and photoperiod.

Time to emergence was less variable than the other phenological characters being dependent on soil humidity. Low temperatures slightly retarded the time to emergence, which was nearly 100% overall.

Correlations were made between yield and phenological characters, on the one hand, and the principal climatic variables, on the other hand, to explain the variation in plant response. For time to flowering, it was confirmed that high temperatures and long photoperiods reduce the length of the vegetative period. The same response was found for time from flowering to maturity. The correlations found in the yields e.g. time to flowering (days) and time to flowering to time to maturity with the principal climatic elements revealed that the vegetative and reproductive periods and the yield were strongly associated with the parameters considered. Both stages are either shortened or extended with the increase or decrease of the minimum average temperature and the average maximum, respectively. The relation was inverse. There was consequently a positive direct relation between number of hours and the temperature less or equal to $O^{o}C$ ($\leq 0^{o}C$). The yield showed a strong positive correlation with the duration of both stages, which indicates that the yields corresponded to each other with longer vegetative and reproductive periods and not only with one stage in particular. The correlation between the number of hours and the temperatures $\leq 0^{o}C$ had an effect on yield during the two years and all the correlations were positive and significant except one found between yield and hours $\leq 0^{o}C$ during time to maturity in 1984. This correlation was negative (-0.44) clearly indicating that this was associated to yield within the limits of tolerance of the cultivar at temperatures below zero when the frost is very intense and temperature is less than $-5^{o}C$ in maturity stage, yields diminish due to the irreversible damages caused in the formation and maturity of the grains (Tables 1 and 5).

The relationship between climate and yield was most clearly shown by the multiple regression of the different climatic variables on yield.

The most important climatic variables in the variation of the yields were the minimum temperature from germination to time to flowering (FLOW) and the maximum temperature from time to flowering to time maturity (MAT), thus resulting in the following equation:

**Table 4.** Range of variability of daily average of climatic elements in growth stages.

| Climatic element | Vegetative period | | Reproductive period | |
|---|---|---|---|---|
| | 1984 | 1985 | 1984 | 1985 |
| Mean max. temperature ($^{o}C$) | 17.8 - 19.3 | 18.9 - 21.0 | 20.6 - 25.6 | 21.1 - 25.5 |
| Mean min. temperature ($^{o}C$) | 0.5 - 1.7 | 0.5 - 3.6 | 2.1 - 7.8 | 3.9 - 9.9 |
| Photoperiod (hrs) | 11.4 - 11.9 | 11.4 - 12.2 | 12.2 - 13.1 | 12.3 - 13.5 |
| Hours with temperature $\leq 0^{o}C$ | 1 - 25 | 5 - 46 | 0 - 17 | 0 - 6 |

Source: Agrometeorological station INTA, Cerrillos, Salta, Republic of Argentina.

**Table 5.** Correlation between yield, time to flowering, and time to flower-maturity climatics elements.

| Parameter | Time to flowering | Time to flowering-Time to maturity | Yield |
|---|---|---|---|
| Mean max. temperature emergence - flowering | -0.46** | | -0.10 |
| Mean max. temperature flow - mat. | | -0.89** | -0.90** |
| Mean min. temperature emergence - flowering | -0.88** | | -0.63** |
| Mean min. temperature flow - mat. | | -0.77** | -0.94** |
| Hours with temperature $\leq 0^{o}C$ emergence - flowering | 0.93** | | 0.77** |
| Hours with temperature $\leq 0^{o}C$ flow - mat. | | 0.92** | 0.73** |
| Photoperiod emergence - flowering | -0.91** | | -0.92** |
| Photoperiod flowering - Mat. | | -0.77** | -0.94** |
| Time to flowering | | 0.35* | 0.80** |
| Time to flowering - Time to maturity | | | 0.75** |

* $P \leq 0.05$
** $P \leq 0.01$

YIELD = 4284-76.73 MIN. T. FLOW. -145.19 MAX. T. MAD. with a determination coefficient $R^2$ = 88%. This indicates that 1°C increase in the minimum average temperature during time to flowering (days) and in the maximum average during the time from flowering to maturity produced reductions in yields for 76.7 and 145.2 kg/ha, respectively. Eighty-eight percent of the variation in yield could be explained by the variation in these climatic elements.

The incidence of diseases was low. Only few isolated plants were manifested with symptoms of wilt in the first four sowing dates.

## Conclusions

No limiting factors were found for the crop under irrigation.

The optimum sowing date in Salta, Argentina could be between 15-30 May in autumn.

Plant height was the most important yield component followed by number of branches/plant.

The Precoze cultivar showed good tolerance to frost. Frosts of -9°C in the vegetative period and -5°C in the reproductive period did not affect the yield.

Low minimum temperatures in the vegetative period and low maximum temperatures in the reproductive period were favourable for yield expression.


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## Response of lentil to phosphorus and zinc application

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### Abstract

**A study was made on the response of lentil cv ILL 4400 to the application of phosphorus and zinc in a pot culture, using a low fertility Calcic Xerosol top soil (2.54 ppm available P and 1.50 ppm available Zn) from Breda in northern Syria. Phosphorus application at a rate of 100 kg triple superphosphate (48 kg $P_2O_5$/ha) resulted in significant increase (P = 0.05) in plant height, number of nodes, root dry weight, and P concentration of shoot. The shoot dry weight increase was significant at a rate of P = 0.1. Zinc application had no significant effect on growth. The interaction between zinc and phosphorus application was also not significant.**

### Introduction

Plant response to the application of fertilizer nutrients depends on the available nutrient status of the soil (Ali *et al.* 1981; Singh and Marok 1981). Soils in the West Asia and North Africa region, where lentils are commonly grown, have been often found to be low in available phosphorus. The problem of phosphorus deficiency can be further accentuated if the moisture supply is sub-optimal, as is often the case in lentil growing areas (Matar 1976). Lentils are also known to be highly sensitive to zinc deficiency (Saxena and Singh 1977; Shukursha 1976), but there is little information on the response of lentil to application of zinc in the dry areas of West Asia and North Africa. High levels of available soil phosphorus have been found to reduce the availability of zinc in several field crops, hence an optimum balance between the phosphorus and zinc level in the soil is necessary. This pot-culture study examined the effect of phosphorus and zinc application, singly and in combination, on the growth, dry matter yield, and phosphate concentration of lentil on a Calcic Xerosol low in available phosphorus.

### Materials and Methods

The experiment was conducted in a green house using pot-culture. The treatments comprised three levels of P (0.24 and 48 kg $P_2O_5$/ha) and two levels of Zn (0 and 5 kg Zn/ha) and were tested in a randomized block design with five replications. Eight kg of Calcic Xerosol top soil from Breda in north Syria was used per pot. The soil, which was low in available phosphorus (2.54 ppm P) and sufficient in available zinc (1.50 ppm available Zn), had 8.5 pH and an electrical conductivity of 0.28 ms/cm. The required quantity of P and Zn, through triple-superphosphate and zinc sulphate, respectively, was mixed well in the top 2/3 soil as per the treatment. A uniform dose of 30 kg N/ha and 0.1 kg a.i./ha of carbofuron granules were also applied to all pots. Ten seeds of lentil cv ILL 4400, inoculated with an appropriate strain of *Rhizobium leguminosarum*, were sown in each pot on 15 Apr 1985. After emergence, only 6 pl/pot were retained.

Pots were irrigated regularly with demineralized water to maintain optimum moisture supply. Growth measurements (plant height, number of branches, and number of nodes/plant) were made at 30 and 50 days after sowing. The plants were harvested 50 days after sowing and dry matter accumulation in root and shoot was recorded. The shoot material was analyzed for total P concentration.

### Results and Discussion

Dry matter accumulation in root and shoot increased with increasing rate of P application, the effect being more conspicuous in the case of root dry weight (Table 1). Zinc application increased dry weight, but the effect was statistically insignificant. Various growth attributes, studied at 30 and 50 days after sowing,

**Table 1.** Effect of P and Zn application on the growth, dry matter accumulation, and shoot P concentration in lentil cv ILL 4400.

| Treatment | Plant height (cm) | | Number of branches/ plant | | Number of nodes/ plant | | Dry weight (g)/ plant 50 DAS | | P % in shoot |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 50 DAS | 30 DAS | 50 DAS | 30 DAS | 50 DAS | Shoot | Root | 50 DAS |
| **P level** (kg $P_2O_5$/ha | | | | | | | | | |
| 0 | 9.8 | 9.7 | 2.3 | 2.4 | 13.8 | 14.8 | 0.093 | 0.116 | 0.056 |
| 24 | 10.5 | 11.7 | 2.3 | 2.4 | 13.4 | 15.3 | 0.163 | 0.132 | 0.080 |
| 48 | 11.4 | 13.8 | 2.3 | 2.5 | 14.8 | 18.8 | 0.164 | 0.228 | 0.096 |
| S.Em ± | 0.23 | 0.46 | 0.10 | 0.10 | 0.47 | 0.75 | 0.022 | 0.026 | 0.003 |
| **Zn level** (kg Zn/ha | | | | | | | | | |
| 0 | 10.40 | 11.32 | 2.3 | 13.8 | 15.8 | 0.117 | 0.142 | 0.077 | |
| 5 | 10.74 | 12.14 | 2.4 | 2.5 | 14.1 | 17.2 | 0.163 | 0.174 | 0.078 |
| S.Em ± | 0.19 | 0.37 | 0.08 | 0.08 | 0.39 | 0.61 | 0.018 | 0.021 | 0.003 |

DAS = Days after sowing.

showed the same trends in response to P and Zn application as was the case with the dry matter. The magnitude of increase in plant height from 30th to 50th day after sowing showed an increase with increasing rate of phosphorus on this soil. These results are in confirmation with those of Ali *et al.* (1981) and Saxena and Wassimi (1980).

The interaction between P and Zn application in affecting any of the characters was non-significant. Perhaps the range of the test levels of the two fertilizer nutrients was not large enough to permit any antagonism. Small improvement in different growth attributes with an application of 5 kg Zn/ha does point to the possibility that when the Zn content of 1.5 ppm is available in soil, a positive effect resulting from application of zinc sulphate can be expected. It may be worthwhile to test higher levels of both P and Zn to have a better understanding of the need for Zn application in these high pH soils.

It is interesting to note that the dry weight of shoot was less than the dry weight of roots. This was most probably due to large fluctuations in day and night temperatures in the green-house in April and May which resulted in premature leaf-drop in lentil plants. This may also explain why the positive effect of P application on the shoot dry matter was not that high. It will be desirable to consider this point in a future study on the soil fertility relationships in lentil.


## Acknowledgement

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# Herbicidal weed control in lentil

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## Abstract

**To control weeds in lentil, eight herbicides (1.0 kg Fluchloralin/ha pre-planting incorporated (ppi), 1.0 kg Isoproturon/ha pre-emergence (pre), 0.80 kg Terbutryn/ha pre, 1.0 kg Metoxuron/ha pre, 1.0 kg Oxadiazon/ha pre, 0.25 kg Fluazifop-butyl/ha post-emergence applied 20 days after sowing (DAS), 0.25 kg Haloxyfop methyl/ha, and 0.25 kg Oxyfluorfen/ha pre) were tested at Jawaharlal Nehru Krishi Vishwa, Vidyalaya, Jabalpur. The major weeds were *Phalaris minor* Retz., *Trifolium fragiferum* L., *Melilotus alba* Desr., *M. parviflora* Desf., *Medicago denticulata* Willd., *Rumex dentatus* L., *Cyperus rotundus* L., *Cynodon dactylon* Pers., *Digitaria adscendens* Henr., and *Paspalum distichum* L. Fluchloralin (1.0 kg/ha) controlled only the annual grassy weeds, while Haloxyfop methyl (0.25 kg/ha) and Fluazifop-butyl applied as post-emergent at 20 DAS controlled all the grassy weeds, but not dicots and sedges. Terbutryn (0.8 kg/ha), Oxadiazon (1.0 kg/ha), and Isoproturon (1.0 kg/ha pre-emergent) best controlled annual weeds of lentil, but Oxadiazon reduced the crop germination. The highest seed yield (1187 kg/ha) was obtained with Isoproturon (1.0 kg/ha) followed by (1134 kg/ha) with Terbutryn (0.80 kg/ha). Both of these treatments were at par to one hand weeding (1187 kg/ha).**

## Introduction

Lentil (*Lens culinaris* Medik.) is one of the major winter pulses grown in Madhya Pradesh, India. Its growth suffers from weed competition and about 60% yield is reduced (Saxena and Wassimi 1981) depending upon the type and density of weeds. Weeds are one of the major constraints for increasing lentil yield since due to a shortage of green forage during winter farmers pick the weeds at a late stage. Weeding at this stage does not only allow the removal of the nutrients, but it also causes mechanical injury to the crop. Hence, the use of herbicides is more efficient. Information on herbicidal weed control in lentil is sparse both in this state and in the rest of India. However, some research on herbicidal weed control was conducted elsewhere (Drew 1980; Slinkard 1980). Therefore, the present investigation was conducted to find selective and effective herbicides to control location-specific weeds in lentil.

## Materials and Methods

A field experiment was carried out on sandy-loam soil at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in a randomized block design with 10 treatments and four replicates. The treatments consisted of 1.0 kg Fluchloralin/ha pre-plant soil incorporated (ppi), 1.0 kg Isoproturon/ha pre-emergence (pre), 0.8 kg Terbutryn/ha pre, 1.0 kg Metoxuron/ha pre, 1.0 kg Oxadiazon/ha pre, 0.25 kg Oxyfluorfen/ha pre, 0.25 kg Fluazifop-butyl/ha post emergence (post) 20 DAS (days after sowing), and 0.25 kg Haloxyfop methyl/ha post 20 DAS. The herbicides were compared with hand weeding once at 30 DAS and a weedy check. The herbicides were applied in 700 l water/ha. The field was infested with *Phalaris minor* Refz., *Trifolium flagiferum* L., *Medicago denticulata* Willd., *Melilotus alba* Desf., *Chenopodium album* L., *Portulaca oleracea* L., *Rumex dentatus* L., *Cynodon dactylon* Pers., *Cyperus rotundus* L., *Paspalum distichum* L., and *Digitaria adscendens* Henr. *Phalaris minor* was dominant because the field was under irrigated wheat for about the last 10 years following rice-wheat rotation. The lentil crop was also grown as an irrigated crop in the *Rabi* (November - March season) after rice crop. The Fluchloralin was sprayed on a well prepared seedbed and mixed in the soil just before sowing. The pre-emergent application of the herbicide was done two days after sowing and irrigation for germination.

## Results and Discussion

### *Effects on weeds*

Effective weed control was noted due to pre-emergent application of Terbutryn (0.8 kg/ha), Oxadiazon (1.0 kg/ha), Oxyfluorfen (0.25 kg/ha), and Isoproturon (1.0 kg/ha). These herbicides controlled most of the annual grassy and broad leaf weeds (Table 1) and showed a high weed control efficiency (Table 2). Application of 1.0 kg Fluchloralin/ha (ppi) also controlled most of the grassy and broad-leaf weeds, but did not effectively control *M. denticulata*, *Melilotus* spp., and *T. fragiferum*. The post emergent application of 0.25 kg Fluazifop-butyl/ha and of 0.25 kg Haloxyfop methyl/ha controlled only grassy weeds *viz. C. dactylon*, *P. distichum*, and *P. minor*. Application of 1.0 kg Metoxuron/ha reduced weed population, but was not effective against *P. minor*.

**Table 1.** The number of plants/$m^2$ of weed species in each treatment.

| Treatment (kg/ha) | *Cynodon dactylon* | *Digitaria adscendens* | *Paspalum distichum* | *Phalaris minor* | *Cyperus rotundus* | *Chenopodium album* |
|---|---|---|---|---|---|---|
| Weed check | 0.5 | 41 | 2 | 312 | 7 | 36 |
| HW 1 30 DAS | 1 | 10 | - | 7 | 24 | - |
| Fluchloralin 1.0 ppi | 1 | 2 | 3 | 33 | 4 | 6 |
| Isoproturon 1.0 pre | 0.5 | 24 | 1 | 105 | 4 | 4 |
| Terbutryn 0.80 pre | 0 | 3 | 0.8 | 43 | 11 | 0.3 |
| Metoxuron 1.0 pre | 0 | 10 | 3 | 171 | 3 | 6 |
| Oxadiazon 1.0 pre | 0 | 7 | 0 | 51 | 6 | 0 |
| Fluazifop-butyl 0.25 post | 0.3 | 0 | 0 | 1 | 4 | 35 |
| Haloxyfop-methyl 0.25 post | 0 | 0 | 0 | 0 | 4 | 6 |
| Oxyfluorfen 0.25 pre | 0 | 5 | 0 | 85 | 6 | 2.5 |

**Table 2.** Effect of different treatments on weed population biomass and weed control efficiency in lentil.

| Treatment (kg/ha) | Weed population/ $m^2$ | Weed biomass (kg/ha) | WCE (%) |
|---|---|---|---|
| Weedy check | 439.3 | 2510 | - |
| HW 1 30 DAS | 116.8 | 365 | 85.4 |
| Fluchloralin 1.0 ppi | 173.5 | 2380 | 5.2 |
| Isoproturon 1.0 pre | 234.0 | 1525 | 39.2 |
| Terbutryn 0.8 pre | 67.9 | 1702 | 32.2 |
| Metoxuron 1.0 pre | 245.5 | 1932 | 23.0 |
| Oxadiazon 1.0 pre | 79.5 | 1830 | 30.0 |
| Fluazifop-butyl 0.25 post | 638.8 | 2110 | 15.9 |
| Haloxyfop-methyl 0.25 post | 576.5 | 2370 | 5.5 |
| Oxyfluorfen 0.25 pre | 150.2 | 1900 | 24.3 |

*Effects on crop*

Germination of the crop was not reduced significantly by any of the herbicides tested. However, the greatest reduction in population was noted in the plots treated with Oxadiazon and Oxyfluorfen (Table 3). The seedling emergence in the plots treated with Oxadiazon was delayed about a week as compared to other herbicidal treatments. Plant height did not vary significantly, but the number of branches and pods/plant significantly increased under the effective treatments as compared to control. The greatest reduction in the branches and pods/plant was noted under weedy check and Fluazifop-butyl, Haloxyfop methyl, Fluchloralin, and Metoxuron which had greater weed competition.

The highest seed yield (1187 kg/ha) was noted in the plots treated with Isoproturon which was at par to one hand weeding (1187 kg/ha) followed by plots treated with Terbutryn (1134 kg/ha), Oxyfluorfen (906 kg/ha), and Oxadiazon (799 kg/ha). The crop-shoot dry weight was also significantly higher in these treatments. The efficacy of Isoproturon and Terbutryn for controlling weeds and increasing seed yield was also reported in wheat by Pandey and Singh (1984) and in gram by Bisen and Tiwari (1983). The application of Fluchloralin, Fluazifop-butyl, and Haloxifop methyl did not increase seed yield and crop dry weight significantly as competition from dicotyledonous weeds was not checked by these herbicides. Seed yields in plots treated with these herbicides were at par to weedy check (134 kg/ha). Metoxuron only controlled dicot weeds at 1.0 kg/ha and consequently the lentil seed yield was 661

Table 1. Cont'd.

| *Indigofera* spp. | *Medicago denticulata* | *Melilotus alba* | *Portulaca oleracea* | *Rumex dentatus* | *Trifolium flagiferum* | *Spergula* spp. | Other |
|---|---|---|---|---|---|---|---|
| 69 | 16 | 61 | 32 | 1 | 67 | 5 | 8 |
| 16 | 4 | 7 | 3 | - | 16 | - | 27 |
| 3 | 15 | 50 | 2 | - | 42 | 1 | 12 |
| 37 | 8 | 19 | 6 | - | 17 | 1 | 6 |
| 0.5 | 0.3 | 1 | 2 | 0 | 2 | 0 | 5 |
| 8 | 9 | 23 | 2 | 0.3 | 12 | 0.3 | 7 |
| 0 | 2 | 3 | 0.3 | 0 | 3 | 0 | 7 |
| 28 | 12 | 74 | 1 | 0.5 | 58 | 0.5 | 5 |
| 24 | 5 | 57 | 0.5 | 0.3 | 49 | 2 | 9 |
| 3.5 | 4 | 18 | 0.5 | 0 | 22 | 0.3 | 9 |

kg/ha; the reduction below the control (1187 kg/ha) was due to competition from monocots. The weed index under control was 88.7%, Fluazifop-butyl (95%), Fluchloralin (85%), Haloxyfop methyl (81.8%), and Metoxuron (44.3%). The weed index was nil in plots treated with Isoproturon followed by terbutryn (44%). The greatest weed index in this crop was due to its short plant type and slow early growth, which allowed more vigorous

Table 3. Influence of chemical weed control on lentil and yield.

| Treatment (kg/ha) | Crop plant population ($m^{-1}$ row) | Plant height (cm) | Number of branches/ plant | Number of pods/ plant (kg/ha) | Crop dry weight | Seed yield (kg/ha) | Weed index (%) |
|---|---|---|---|---|---|---|---|
| Weedy check | 27.4 | 53.5 | 4.62 | 16.9 | 1071 | 134 | 88.7 |
| H.W. 1 30 DAS | 22.7 | 46.2 | 6.77 | 22.2 | 3660 | 1184 | - |
| Fluchloralin 1.0 ppi | 19.6 | 52.4 | 6.55 | 18.3 | 1334 | 178 | 85.0 |
| Isoproturon 1.0 pre emergence | 31.2 | 46.9 | 5.70 | 26.5 | 3928 | 1187 | - |
| Terbutryn 0.8 pre emergence | 25.2 | 47.2 | 7.60 | 22.5 | 3303 | 1134 | 4.4 |
| Metoxuron 1.0 pre emergence | 24.4 | 46.5 | 5.30 | 18.7 | 2267 | 661 | 44.3 |
| Oxadiazon 1.0 pre emergence | 15.0 | 44.4 | 6.12 | 26.0 | 2232 | 792 | 32.6 |
| Fluazifop butyl 0.25 post emergence 20 DAS | 21.8 | 51.8 | 6.67 | 15.3 | 660 | 58 | 95.1 |
| Haloxyfop methyl 0.25 post emergence 20 DAS | 27.5 | 51.3 | 5.65 | 20.6 | 1517 | 216 | 81.8 |
| Oxyfluorfen 0.25 pre | 19.0 | 50.2 | 8.15 | 30.4 | 2946 | 906 | 23.6 |
| SEm + | 3.17 | 4.8 | 0.73 | 2.4 | 217 | 204 | - |
| LSD P = 0.05 | 10.13 | NS | 2.34 | 7.2 | 696 | 652 | - |

**Table 4.** Economics of different weed control treatments in lentil.

| Treatment | Value of straw (Rs) | Value of seed (Rs) | Gross return (Rs) | Cost of treatment (Rs) | Profit or loss over control (%) |
|---|---|---|---|---|---|
| Weedy check | 234 | 536 | 770 | - | - |
| H.W. 1 30 DAS | 618 | 4748 | 5366 | 1400 | 3196 |
| Fluchloralin 1.0 ppi | 52 | 712 | 764 | 550 | 556 |
| Isoproturon 1.0 pre emergence | 685 | 4748 | 5433 | 418 | 4245 |
| Terbutryn 0.8 pre emergence | 542 | 4536 | 5078 | 300 | 4008 |
| Metoxuron 1.0 pre emergence | 401 | 2644 | 3045 | 212 | 2063 |
| Oxadiazon 1.0 pre emergence | 358 | 3196 | 3554 | 450 | 2334 |
| Fluazifop butyl 0.25 post 20 DAS | 150 | 232 | 382 | 150 | 538 |
| Haloxyfop methyl 0.25 post 20 DAS | 325 | 864 | 1189 | 150 | 269 |
| Oxyfluorfen 0.25 pre | 510 | 3624 | 4134 | 200 | 3164 |

Basis of calculations
Lentil seed Rs 4.00/kg
Lentil straw Rs 0.25/kg
Treatment cost
Hand weeding 100 labour/ha or Rs 14/day Basalin 48 E (Fluchloralin) Rs 250/L
Tolkan 50 WP (Isoproturon) Rs 184/kg
* Igran 80 WP (Terbutryn) Rs 250/kg
* Dosanex 80 WP (Metoxuron) Rs 150/kg
* Ronstar 25 EC (Oxadiazon) Rs 100/L
* Fusilade 25 EC (Fluazifop butyl) Rs 100/L
* Gallant 25 EC (Haloxyfop methyl) Rs 100/L
* Goal 25 EC (Oxyfluorfen) Rs 150/L
Spraying Charges Rs 50/ha
* Assumed cost.

growth of weeds and offered more competitive stresses. Saxena and Wassimi (1980) also reported about 60% reduction in yield due to weed competition. The present investigation concluded that the pre-emergent application of 1.0 kg Isoproturon/ha and 0.8 kg terbutryn/ha are the best agronomically and economically to control both monocotyledonous and dicotyledonous weeds (Table 4), while 0.25 kg Flauzifop-butyl/ha and 0.25 kg Haloxyfop methyl/ha, applied as post emergence at 20 DAS after sowing, are the best treatments to control only grassy weeds.

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# A modified technique for raising lentil seedlings

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**Abstract**

**Lentil seedlings, raised for transplanting to hydroponic tanks using the ragdoll technique, are etiolated and germinate unevenly. These problems are overcome by germinating seeds in vermiculite-filled plastic tubes or in styroblocks.**

The lentils are grown in the growth room by transplanting seedlings into hydroponic tanks. Until now, seedlings are prepared for transplanting using the ragdoll technique. After about eight days the lentil seedlings are ready for transplanting. It was found that this technique creates two problems. First, seedlings become etiolated causing epicotyls to become elongated and spindly. Secondly, germination and growth are uneven because the seeds toward the inside of the rolls receive less aeration.

The new technique eliminates both problems. The expandable plastic tubes about 10 cm long and 2 cm in diameter, the type used in forestry nurseries, are packed side by side in a plastic container. The tubes are filled with vermiculite which is then compressed to a depth of 2 cm from the top of the tube. Lentil seeds are placed individually in the tubes, covered with vermiculite, and watered enough to allow the vermiculite to become thoroughly wet. The entire container is then placed in the growth room and watered when necessary. Seedlings emerge within 6-7 days and are easily removed for transplanting to the hydroponic tanks. It was found that the seedlings, which emerged more quickly, were more vigorous and more uniform compared with the ragdoll technique. As a result, the time required to harvest seed from plants is reduced 7-10 days. This allows more flexibility in scheduling and easily permits three crops/year in the growth room.

Styroblocks were also used with equal success. These are 10 cm-thick styrofoam blocks with prefabricated holes which are filled with vermiculite as described above. This technique is also useful for screening seedlings for morphological and isozyme variation. Styroblocks and expandable tubes are available from forestry nursery supply companies.

# Physico-chemical characters and nutrient composition of lentils grown in Pakistan

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## Abstract

**Physical characters, cookability and nutritional quality of four improved lentil lines were determined. The hydration coefficient ranged from 175.0 to 189.7%. The cooking time of dry seed (23.0-26.4 min) significantly reduced (6.3-8.0 min) when the seeds were soaked overnight in water. Lentils contained an average of 24.1% protein, 4.3% fat, 55.0% carbohydrate, 4.7% crude fibre, 2.7% ash, 1.03% tannin, and 355 Kcal/100 g. The average contents of Ca, P, Fe, Zn, Mn, Cu, Ni, and phytate were 190.1, 282.9, 9.6, 6.1, 3.4, 2.3, 0.3, and 164.2 mg/100 g, respectively. The major amino acids were glutamic acid, proline, aspartic acid, leucine, lysine, and arginine. Methionine was present in relatively lower concentration.**

## Introduction

The food legumes are major sources of protein and other nutrients in the diets of the majority of population in developing countries. Their role, however, is limited by several factors including low protein digestibility, antinutritional factors, and flatulence and poor cooking qualities (Elias and Bressani 1974; Khan and Ghafoor 1978; Weder *et al.* 1985).

Legumes contain twice as much protein as cereal grains. This protein is a rich source of lysine although low in sulphur containing amino acids (Khan *et al.* 1978). The proteins of cereal grains and food legumes supplement each other nutritionally because each is comparatively rich in amino acids in which the other is deficient (Khan *et al.* 1976; Khan *et al.* 1977; Khan and Eggum 1978; Khan and Eggum 1979). The highest protein quality was obtained when 50% of the protein of the diet was derived from each of wheat and lentils (Khan *et al.* 1979).

In spite of their nutritional importance, plant breeders have given less attention to food legumes than cereal grains. Consequently, legume yields remain at a low yield level and legume production is either stagnant or dropping. The challenge to the legume breeders is to develop varieties which are both more productive and more nutritious. The present paper deals with the physico-chemical characters and nutrient composition of some improved lentil lines evolved in Pakistan.

## Materials and Methods

***Lentil samples:*** Four improved lentil (*Lens culinaris*) lines, grown at the National Agricultural Research Centre, Islamabad were used in the study.

***Physico-chemical measurements:*** Parameters including seed size (weight), hydration coefficient, and cooking time were studied. All tests were carried out in duplicate.

Seed size was recorded as the mean weight of 100 seeds. Hydration coefficient was calculated by measuring water uptake by 10 g of lentil soaked in 25 ml of distilled water for 8 hr at room temperature (Hulse *et al.* 1977). Cooking time of dry and soaked seed (soaked overnight in distilled water) was derived from a boiling and thumb pressing method according to Williams *et al.* (1983).

***Chemical analysis:*** Seeds were ground in cyclotec mill to pass a 1.0 mm ⌀ screen. Moisture content was determined by drying a 2 g sample of ground lentils at 130°C for 70 minutes, then cooling, and weighing. Protein (Nx5.7), fat, crude fibre, ash, and major elements were determined by the official methods (Horwitz W. 1980). Carbohydrate contents were calculated by difference. Gross energy value was calculated by multiplying protein, fat, and carbohydrate contents with factors of 4,9, and 4, respectively. Trace elements were determined by using atomic absorption spectrometer, model 4000 (Perkin-Elmer). Tannin content was estimated as described by Eggum and Christensen (1975). Phytate content was measured according to Haug and Lantzsch (1983). The amino acids were determined with Beckman 6300 amino acid analyzer (Khan *et al.* 1978).

Table 1. Seed yield and physico-chemical parameters of lentils.

| Line | Seed yield (kg/ha) | 100-seed weight (g) | Hydration coefficient (%) | Cooking time (min) Dry | Soaked |
|---|---|---|---|---|---|
| 18-10 | 550 | 1.9 | 184.6 | 26.4 | 6.3 |
| 9-6 | 750 | 1.9 | 178.3 | 24.3 | 7.5 |
| 18-12 | 550 | 2.0 | 189.7 | 24.5 | 8.0 |
| Vm-25 | 550 | 2.0 | 175.0 | 23.0 | 7.0 |
| Mean | 600 | 2.0 | 181.9 | 24.6 | 7.2 |
| S.E. +/- | 10.0 | 0.06 | 6.55 | 11.44 | 0.65 |
| C.V. | 16.67 | 3.08 | 3.60 | 5.85 | 8.97 |

S.E.: Standard error
C.V.: Coefficient of variation

## Results and Discussion

The yield and physico-chemical parameters of improved lentil lines are given in Table 1.

The overall mean for seed yield was 600 kg/ha. The lines yielded 550 kg/ha - 750 kg/ha. The average seed weight was 2.0 g/100 seeds. The hydration coefficient varied from 175.0 to 189.7%. Rapid water uptake is a desirable attribute of legume grain used for food. In the present study, the value for hydration coefficient was highest in line 18-12. Cooking time is one of the important parameters in evaluating the quality of legumes. The cooking process makes hard seed soft by improving the plasticity of the cell wall and gelatinization of the starch. The mean time for cooking of dry seeds was 24.6 min. Seeds of Vm-25 were the quickest to cook (23.0 min.), whereas seeds of line 18-10 took an average of 26.4 min. to cook. However, cooking time significantly reduced when seeds were soaked overnight in water. A range of 6.3-8.0 min in cooking time was observed. Seeds of line 18-10 with highest content of phytate (Table 2) has the shortest cooking time (6.3 min). There was no relationship between the hydration coefficient and cooking time of seeds in the present study. The cooking quality of lentil has been reported to be dependent on the seed coat, phytic acid and pectin contents of seed coat, Ca + Mg/P ratio, and amylose content (Bhatty 1984).

Chemical composition of improved lentil lines are given in Table 2.

The protein content (Nx5.7) ranged from 22.8% in line 18-10 to 25.0% in Vm-25. The overall mean was 24.1% giving a protein yield of 141 kg/ha. Bhatty *et al.* (1976) reported protein content of six lentil genotypes ranging from 27.7 - 31.3%. The protein content of world lentil collection has been reported to be 23.4 - 36.4% (Hawtin *et al.* 1977). The protein content of lentil is comparable with that of faba bean, higher than chickpea, and more than double that of

Table 2. Chemical composition (dry basis) of some improved lentil lines.

| Line | Protein (Nx5.7) (%) | Fat (%) | Carbohydrate (%) | Crude fibre (%) | Ash (%) | Energy (Kcal/100 g) | mg/100 g Ca | P | Fe | Zn | Mn | Cu | Ni | Phytate | Tannin (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-10 | 22.8 | 4.9 | 57.4 | 4.3 | 2.7 | 365 | 173.9 | 260.6 | 9.6 | 5.2 | 3.3 | 2.0 | 0.3 | 181.6 | 1.09 |
| 9-6 | 24.6 | 3.6 | 56.4 | 4.8 | 2.5 | 356 | 171.2 | 264.5 | 9.6 | 5.4 | 2.6 | 2.0 | 0.3 | 154.2 | 1.08 |
| 18-12 | 23.9 | 3.6 | 56.3 | 5.0 | 2.7 | 353 | 284.4 | 276.4 | 9.0 | 4.8 | 3.7 | 2.5 | 0.2 | 154.8 | 1.00 |
| Vm-25 | 25.0 | 4.9 | 50.0 | 4.8 | 2.7 | 344 | 130.9 | 330.6 | 10.1 | 8.9 | 3.9 | 2.6 | 0.3 | 166.8 | 0.98 |
| Mean | 24.1 | 4.3 | 55.0 | 4.7 | 2.7 | 355 | 190.1 | 282.9 | 9.6 | 6.1 | 3.4 | 2.3 | 0.3 | 164.2 | 1.03 |
| S.E. | 0.96 | 0.75 | 3.39 | 0.30 | 0.10 | 8.66 | 65.87 | 50.87 | 0.45 | 1.90 | 0.57 | 0.32 | 0.05 | 12.6 | 0.06 |
| C.V. | 3.99 | 17.65 | 6.14 | 6.35 | 3.77 | 2.44 | 34.49 | 18.85 | 0.70 | 11.28 | 16.89 | 14.06 | 18.18 | 7.68 | 5.78 |

S.E.: Standard error
C.V.: Coefficient of variation

wheat (Abu-Shakra and Tannous 1981). The fat content varied from 3.6 to 4.9%. The carbohydrate was highest (57.4%) in line 18-10 and lowest (50.0%) in Vm-25. The fibre content ranged from 4.3 to 5.0%. The ash content was uniform in all the lines. Calcium content was highest (284.4 mg/100 g) in line 18-12, whereas phosphorus was highest (330.6 mg/100 g) in Vm-25. The concentration of iron ranged from 9.0 to 10.1 mg/100 g. The highest content (8.9 mg/100 g) of zinc was found in Vm-25. The concentration of manganese, copper, and nickel ranged from 2.6 to 3.9, from 2.0 to 2.6, and from 0.2 to 0.3 mg/100 g, respectively. The phytate content ranged from 154.2 mg/100 g in line 9-6 to 181.0 mg/100 g in line 18-10. It is evident that lentil is rich in iron and other minerals. The levels of various mineral elements in lentil seed were found to be influenced by the availability of plant nutrients in the soil media during plant growth and seed development (Wassimi *et al.* 1978). The tannin content varied between 0.98 and 1.09%. The gross energy ranged from 344 Kcal/100 g in Vm-25 to 365 Kcal/100 g in genotype 18-10.

In addition to the level of protein in lentil seeds, the amino acid content of the protein is very important in its nutritional quality. The amino acid contents of four improved lentil lines are given in Table 3.

**Table 3.** Amino acid contents (mg/gN) of some improved lentil lines.

| | Line | | | |
|---|---|---|---|---|
| **Amino acid** | **18-10** | **9-6** | **18-12** | **Vm-25** |
| Aspartic acid | 665.6 | 426.5 | 588.8 | 471.6 |
| Threonin | 275.2 | 173.9 | 281.3 | 166.3 |
| Serine | 400.4 | 252.7 | 345.7 | 248.3 |
| Glutamic acid | 1298.6 | 822.9 | 858.2 | 820.1 |
| Proline | 445.4 | 289.8 | 445.8 | 371.3 |
| Glycine | 270.2 | 190.1 | 257.5 | 143.5 |
| Alanine | 167.6 | 134.4 | 176.4 | 109.4 |
| Valine | 315.3 | 224.8 | 302.8 | 211.9 |
| Methionine | 65.1 | 41.7 | 64.4 | 22.8 |
| Isoleucine | 267.7 | 199.4 | 257.5 | 193.6 |
| Leucine | 540.5 | 390.9 | 483.9 | 353.1 |
| Tyrosine | 185.2 | 115.9 | 219.3 | 104.8 |
| Phenylalanine | 357.8 | 238.8 | 338.5 | 293.9 |
| Lysine | 510.4 | 421.9 | 381.4 | 375.9 |
| Histidine | 167.6 | 148.4 | 176.4 | 129.9 |
| Arginine | 390.3 | 350.0 | 357.6 | 312.1 |

The lysine content ranged from 375.9 mg/gN in Vm-25 to 510.4 mg/gN in line 18-10. The concentration of methionine, the first limiting amino acid in legumes varied between 22.8 and 65.1 mg/gN. The major amino acids of lentil were glutamic acid, proline, aspartic acid, leucine, lysine, and arginine. Methionine was present in relatively lower concentration. The amino acid composition of these lines was similar to kidney beans, cowpeas, and chickpeas as reported by Tannous and Ullah (1969). The contents of lysine, leucine, isoleucine, and histidine of lentils in the present study were comparable with the essential amino acids of egg protein as reported by Sheffner (1967).

There is an urgent need to increase the yield, improve the quantity and quality of protein, and to eliminate antinutritional factors. Also the breeder should introduce varieties with larger seed size as the decortication loss has been related to seed size.

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## Detection of broad bean stain virus in lentil seed groups

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### Abstract

**Broad bean stain virus (BBSV) was easily detected in lentil seed groups each of 25 seeds by the enzyme-linked immuno-sorbent assay (ELISA). When seeds were dissected into axes, cotyledons, and seed coats BBSV detection was highest in cotyledons followed by the germinating axes and least in seed coats. Detection in ground intact seeds was less than in germinated seedlings. Testing lentil seed groups provided a practical mean in monitoring seed-borne BBSV in lentil seed lots.**

### Introduction

The seed-borne broad bean stain virus (BBSV) infects a number of leguminous crops including lentils (*Lens culinaris*) (Bos *et al.* 1986; Boswell and Gibbs 1983). No loss estimates have been reported for lentils infected with BBSV. Nevertheless, symptoms induced in response to infection are very mild and virus incidence is usually low, an indication that losses incurred by BBSV on lentils are most likely minimal. However, since BBSV is beetle-transmissible, infection can spread to susceptible crops such as pea (*Pisum sativum*) and faba bean (*Vicia faba*) in places where the insect vector is prevalent.

Testing for BBSV is, therefore, important in areas where susceptible economically important crops are grown. Because of the low seed infection rate, testing for BBSV in single seeds would be very time consuming and not economical. In this study we investigated the possibility of testing groups of lentil seeds for the presence of BBSV.

### Materials and Methods

A lentil seed lot (cv Syrian Local), which contained seed-borne BBSV, was used as the seed source for this study. Seeds for testing was randomly picked and each 25 were grouped together as one sample. Seeds were tested as (i) ground, (ii) intact seedlings, and (iii) dissected seedlings to axes, cotyledon, and seed coat. Seeds were sown in moistened sterile sand in germination boxes and incubated at 22-24°C for one week.

Testing for BBSV was carried out using the enzyme-linked immuno-sorbent assay (ELISA) following the procedure of Clark and Adams (1977) with one exception. The Standard extraction buffer was replaced by 0.2M phosphate buffer, pH 6.0. The antiserum used was produced in the virology laboratory of the Faculty of Agricultural and Food Sciences, American University of Beirut, Beirut against a purified BBSV isolate from faba bean (SV 173-85). ELISA values were taken by a Dynatech micro ELISA minireader (MR 590). In each ELISA plate, eight healthy samples were used to determine the negative threshold value. ELISA sample values higher than the healthy mean plus three standard deviations were considered positive.

**Table 1.** Detection of broad bean stain virus (BBSV) in ground intact seeds, intact seedlings, and dissected seedlings (developing shoot and root, cotyledons, and seed coat) of lentil seed groups when tested by ELISA.

| Sample | Number of groups* tested | Number of groups infected | Seed infection rate estimate |
|---|---|---|---|
| Dissected seedlings | | | |
| shoot and root | 39 | 36 | 9.8 |
| cotyledon | 39 | 37 | 11.2 |
| seed coat | 39 | 17 | 2.3 |
| Intact seedlings | 40 | 39 | 13.8 |
| Ground intact seeds | 40 | 31 | 5.8 |

* Each group was a mixture of 25 seeds.

## Results

The seed infection rate obtained for ground intact seeds was lower (5.8%) than that of intact germinated seedlings (13.8%) (Table 1). In dissected seedlings, both germinated axes (shoot + root) and cotyledons gave a higher infection rate than the seed coat. The reason for this is mainly due to the nature of the different tissues extracted. Samples were homogenized for 30 seconds in a Waring blendor using a microcontainer. This extraction time permitted more virus to be extracted from the germinating embryo than from the seed coat. Using a similar procedure for the detection of BBSV in faba bean seeds, virus was detected in the germinating embryo, but not at all from the seed coat (unpublished).

The seed infection rates in Table 1 were estimates calculated by the formula $p = [1 - (\frac{Y}{N})^{\frac{1}{n}}] \times 100$ where p = % of seed infection rate, Y = number of groups found healthy, N = total number of groups tested, and n = the number of seeds which constituted a group (Maury *et al.* 1985). In the experiments presented in Table 1, n = 25 and N was 39 or 40. The precision of the seed infection rate estimate is higher with low infection rates than with high infection rates. Precision could have been increased if preliminary tests were carried out to determine the optimal values of n and N that one should use (Maury *et al.* 1985). However, in this study our aim was not the precise comparison between seed infection rates of different samples, but rather to identify seed lots which contain the virus for the purpose of discarding them for use in seed multiplication.

## Conclusion

Groups of 25 lentil seeds could be easily tested for the detection of BBSV. Sensitivity of group testing was higher with germinated seedlings as compared to ground intact seeds. It is recommended then to use groups of germinated seedlings for the determination of BBSV infection rate in lentil seeds.

## Acknowledgements

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# LENTIL INFORMATION

## Key Lentil Abstracts

Champ, M., Brillouet, J. and Rouao, X. 1986. **Non-starchy polysaccharides of *Phaseolus vulgaris*, *Lens esculenta*, and *Cicer arietinum* seeds.** *Journal of Agricultural and Food Chemistry* 34(2): 326-329. Laboratoire de Biochimie et Technologie des Glucides, Institut National de la Recherche Agronomique, 44072 Nantes Cedex, France.

Nonstarchy polysaccharides of three legume seeds (kidney bean, lentil, and chickpea) have been isolated and analyzed. Trichloroacetic acid soluble materials represent respectively 7.1, 0.8, and 2.1% of kidney bean, lentil, and chickpea whole dry seeds. Arabinose is the major sugar of the three extracts. Their arabinose: galactose ratios are respectively 1:0.35, 1:0.77, and 1:0.57. Cotyledon cell walls were defatted and then treated with pronase and $\alpha$-amylase. Dry matter ranged from 7.5% in lentil to 13.7% in chickpea. Cell walls from kidney bean, lentil, and chickpea contained respectively 67, 73, and 42% pectic polysaccharides associated with 16, 12, and 10% cellulose. Arabinose was the major pectic sugar of the three walls. Hulls were mainly composed of cellulose (29-41%) associated with hemicellulosic and pectic polymers. They had low lignin contents (1.2-1.7%). Kidney bean hulls contained the greatest percentage of the (xylose + glucose) pair whereas chickpea exhibited the greatest amount of pectic polysaccharides.

Hornford, R.G. and Drew, B.N. 1986. **Yield reductions in field peas and lentils resulting from volunteer crop competition.** *Canadian Journal of Plant Science* 66(1): 206. Crop Development Centre, University of Saskatchewan, Saskatoon, Saskatchewan S7N OWO.

Wild oat (*Avena fatua*) and wild mustard (*Brassica kaber*) are two serious weeds of the northern prairies, both in relative abundance and competitive ability. Field experiments using domesticated species (*Avena sativa* and *Brassica hirta*) to stimulate the effect of the wild species were conducted to determine yield reductions in field pea (*Pisum sativum*) and lentil (*Lens culinaris*). Increasing infestation density of individual weed species and combinations resulted in reduction of seed yield for both field pea and lentil. Lentils were less competitive than field pea, but volunteer crop populations of 10 plants/$m^2$ significantly reduced yields of both lentil and field pea.

Kaiser, W.J. and Hannan, M. 1986. **Incidence of seedborne *Ascochyta lentis* in lentil germplasm.** *Phytopathology* 76(3): 355-360. Western Regional Plant Introduction Station, U.S. Department of Agriculture, Agricultural Research Service, Washington State University, Pullman 99164, USA.

A foliar blight of lentil (*Lens culinaris*) was observed in June 1981 in several plant introductions in cold-tolerance trials planted in the fall of 1980 at Pullman and Central Ferry, WA. *Ascochyta lentis* was the predominant fungus isolated from discolored, necrotic lesions on the foliage and seeds of diseased lentil. Isolates of *A. lentis* were pathogenic to the foliage of lentil, but not to the foliage of chickpea (*Cicer arietinum*) or pea (*Pisum sativum*). The fungus was isolated from 1.5 to 3.5% of the original introduced seed from three of five lentil PI accessions included in the 1980/1981 cold-tolerance trials. Infection by *A. lentis* of seeds, harvested from these trials (increase seeds), ranged from 0.5 to 68.5% and from 10 to 42.5% at Pullman and Central Ferry, respectively. Many seeds from heavily infected accessions were shriveled and discolored, and seed quality was adversely affected. Also, seed size was significantly correlated to the level of seedborne infection. A total of 17.060 original seeds from 284 accessions from 30 countries were screened for seedborne *A. lentis*. The fungus was isolated from 2.0% of the seeds which represented 16% of the accessions and 16 countries. Most severe infections were found on original seeds from Australia, India, Italy, Spain, and Turkey. Other fungi pathogenic to lentil that were also isolated, but less frequently than *A. lentis*, included: *Botrytis cinerea*, *Fusarium avenaceum*, *Macrophomina phaseolina*, *Phoma medicaginis* var. *pinodella*, and *Rhizoctonia solani*. Incidence of seedborne *A. lentis* from original

infected seeds (5.0-61.7%) in 20 exotic PI accessions to increase seeds grown in typical spring plantings at Pullman was 0-2.5%. *Ascochyta lentis* remained viable in original seeds of several accessions stored for more than 30 yr. The fungus survived over 3 year in naturally infected lentil pods and seeds at 4-6 C or in a shelter outdoors, and for 1.5 yr on the soil surface, but it lost viability within 29 wk at a soil depth of 16 cm.

Roberts, E.H., Summerfield, R.J., Muehlbauer, F.J. and Short, R.W. 1986. **Flowering in lentil (*Lens culinaris* Medic.): The duration of the photoperiodic inductive phase as a function of accumulated day length above the critical photoperiod.** *Annals of Botany* 58: 235-248. Plant Environment Laboratory, Department of Agriculture, University of Reading, Shinfield Grange, Cutbush Lane, Shinfield, Reading, Berks RG2 9AD, England.

The durations from emergence to the appearance of first flower buds and to first open flowers were recorded in three genotypes of lentil (*Lens culinaris* Medic.) when plants were transferred from short days (either 8 or 10 h) to long days (16 h), or *vice versa*, after various times from emergence. These results were compared with those of control treatments in which plants remained in either short or long days throughout. Four developmental phases were identified: pre-emergence, pre-inductive, inductive and post-inductive. The first two phases and the last are insensitive to photoperiod, but are probably sensitive to temperature. The duration of the inductive phase, which has to be completed before flowering can occur at the end of the post-inductive phase, can be predicted by assuming that its reciprocal is a linear function of both photoperiod and temperature. It follows that the critical photoperiod decreases with increase in temperature and that the duration of the inductive phase can be calculated from a summation of the amounts by which successive daylengths exceed the critical photoperiod until a value ('the photoperiodic sum') characteristic of the genotype is reached. The implications of these findings for predictive field models of time to flowering in lentils are discussed.

Schotzko, D.J. and O'Keeffe, L.E. 1986. **Comparison of sweepnet, D-Vac, and absolute sampling for *Lygus hesperus* (Heteroptera: Miridae) in lentils.** *Journal of Economic Entomology* 79(1): 224-228. Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, Idaho 83843, USA.

Sweepnet accuracy was compared with that of D-Vac and absolute sampling for determining adult and nymph *Lygus hesperus* Knight densities in lentils. Sweepnet population estimates were similar to those obtained with absolute and D-Vac sampling methods, although sweepnet sampling consistently gave a lower estimate of nymph numbers. The sampling period did not appear to affect sweepnet adult population estimates, while late-season afternoons were the preferred times for sampling nymphs. Therefore, when monitoring the pest status of *L. hesperus* in lentils, afternoon sampling provides more accurate population estimates than morning sampling. Original counts, area, and volume adjustments were used to evaluate sampling method effectiveness and the volume adjustment was found to be more accurate than area or original counts.

Schotzko, D.J. and O'Keeffe, L.E. 1986. **Evaluation of diel variation of sweepnet effectiveness in lentils for sampling *Lygus hesperus* (Heteroptera: Miridae).** *Journal of Economic Entomology* 79(2): 447-451. Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, Idaho 83843, USA.

Relative effects of the abiotic environment and time of sampling on population estimates of *Lygus hesperus* Knight in lentils were determined during two years. Sweepnet samples were taken randomly at two locations in two fields every hour for 72 consecutive hours. Light, temperature, relative humidity, and wind velocity were the abiotic factors studied. Number of *L. hesperus* adults collected by sweepnet in lentils and the abiotic factors monitored in 1983 or early season 1984 were not correlated. There is no predictable optimum time within a 24-h cycle for sweepnet sampling of adults early in the season. Optimum sampling time for lygus bug nymphs late in the season was late afternoon. Lygus bug nymphs collected by sweepnet were correlated with relative humidity, temperature, and light in both years.

Sharma, S.K. and Sharma, B. 1986. **Mutagen sensitivity and mutability in lentil.** *Theoretical and Applied Genetics* 71(6): 820-825. Division of Genetics, Indian Agricultural Research Institute, New Delhi 110012, India.

Seeds of two cultivars, each of '*macrosperma*' and '*microsperma*' varietal groups of lentil were mutagenised with gamma-rays and NMU to determine their mutagen sensitivity and mutability. The increasing

doses of gamma-rays and NMU decreased germination, root and shoot length, pollen fertility, and plant survival, but increased the occurrence of leaf spots. The root system was found to be more sensitive to both mutagens than the shoot. The '*macrosperma*' varietal group was more sensitive to both the mutagens than '*microsperma*' group. In 'microsperma' group, variety 'Pusa-1' was more sensitive to both the mutagens than 'L-259', while in the '*macrosperma*' group 'L-1491' showed more sensitivity to the mutagens than 'L-1492'. Radio-sensitivity corresponded positively with chemo-sensitivity in both varietal groups. There was a positive relationship between radio- and chemo-sensitivity of the genotypes and their mutability. The results also revealed the existence of a parallelism between radio-mutability and chemo-mutability. Due to saturation in the mutational events and vigour of both diplontic and haplontic selection in the biological material, the mutation frequency either decreased or remained constant at higher doses of the mutagens.

## TOP TWENTY

*Top twenty lentil producing countries with their annual area (A x 1000 ha) and production (P x 1000 tonnes), ranked on 1984 production.*

| | | 1966-70 | | 1971-75 | | 1976-80 | | 1983 | | 1984 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rank** | **Country** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** |
| 1 | Turkey | 102 | 100.2 | 113.4 | 105.6 | 193.2 | 205.6 | 650 | 650 | 620 | 570 |
| 2 | India | 792.8 | 364.8 | 851.1 | 404.8 | 908 | 401 | 995 | 489 | 978 | 531 |
| 3 | Bangladesh | 70.6 | 50.4 | 68 | 48.8 | 78 | 48.8 | 74 | 48 | 75 | 79 |
| 4 | Spain | 51.6 | 36.4 | 65.6 | 46.8 | 72.2 | 52 | 66 | 37 | 64 | 44 |
| 5 | Canada | - | - | - | - | - | - | 48 | 55 | 55 | 39 |
| 6 | Syria | 97.2 | 62.4 | 100.4 | 66.2 | 127 | 94.2 | 71 | 61 | 72 | 35 |
| 7 | Ethiopia | 171.6 | 104.4 | 157.6 | 80.8 | 61.6 | 36.8 | 55 | 42 | 50 | 32 |
| 8 | Iran | 61.2 | 39.8 | 47 | 32 | 40.4 | 27.6 | 79 | 38 | 70 | 30 |
| 9 | Pakistan | 71 | 24.4 | 74.6 | 26.2 | 87 | 33.4 | 82 | 30 | 80 | 29 |
| 10 | USA | 26.2 | 31.6 | 33.2 | 41.2 | 56.4 | 65.8 | 41 | 43 | 26 | 27 |
| 11 | Morocco | 25.2 | 13.6 | 37 | 21.6 | 40.4 | 19.8 | 79 | 32 | 65 | 25 |
| 12 | France | 10 | 12.6 | 8.4 | 11 | 10.8 | 14.6 | 10 | 16 | 10 | 20 |
| 13 | Chile | 11 | 6.2 | 18.6 | 11.6 | 37.6 | 23.2 | 23 | 14 | 24 | 16 |
| 14 | Mexico | 6.8 | 4.4 | 8 | 6.4 | 10.2 | 8.8 | 13 | 10 | 13 | 12 |
| 15 | USSR | 53.6 | 63.2 | 59.6 | 57 | 18 | 5 | 15 | 10 | 17 | 11 |
| 16 | Egypt | 24 | 34 | 27.6 | 51.2 | 15.4 | 18.8 | 6 | 7 | 8 | 11 |
| 17 | Jordan | 21.8 | 14.6 | 22 | 16.8 | 14.4 | 6 | 9 | 8 | 10 | 8 |
| 18 | Argentina | 20.4 | 12 | 11 | 8.6 | 28.6 | 25.2 | 7 | 7 | 8 | 7 |
| 19 | Colombia | - | - | 22 | 10 | 19.8 | 7.6 | 17 | 6 | 17 | 6 |
| 20 | Iraq | 9.8 | 6 | 6.6 | 4.2 | 8.4 | 7.4 | 5 | 4 | 5 | 4 |

**Editor's note:** The FAO Production Yearbooks are amended when new information becomes available.

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## LENS News Service

### FORTHCOMING CONFERENCES - 1987

**April**

**The Role of Legumes in Conservation Tillage Systems**
Athens, Georgia, Montana, USA, 27-29 Apr
Contact: American Society of Agronomy, 677 S. Segoe Rd., Madison, WI 53711, USA

**May**

**Annual Meeting of the Canadian Institute of Food Science and Technology**
Hamilton, Ontario, Canada, 17-20 May
Contact: Canadian Institute of Food Science and Technology, Suite 38, 46 Elgin Street, Ottawa, Ontario, K1P 5K6, Canada

**June**

**General Assembly of the International Pulse Trade and Industry Confederation**
Hotel Martinez, 73, La Croisette, Cannes, France, 11-13 June
Contact: Federation Nationale du Legume Sec, Bureau 273-Bourse de Commerce-F- 75040 Paris Cedex 01, France

**August**

**The Fourth Symposium on Parasitic Weeds**
Philips University, Marburg, Federal Republic of Germany, 2-7 Aug
Contact: Dr. H. Chr. Weber, Fachbereich Biologie, Lahnberge, Philips University, 3500 Marburg, Federal Republic of Germany

**September**

**International Symposium on New Crops for Food and Industry**
Southampton University, Southampton, UK, 22-25 Sep
Contact: Mr. N. Haq, Symposium Secretary, Department of Biology, Building 44, The University, Southampton, SO9 5NH, UK

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## اعلان الى العلماء والباحثين العرب الكرام

يسر المركز الدولي للبحوث الزراعية في المناطق الجافة ( ايكاردا ) ، اعلامكم بان مركز بحوث التنمية الدولية ( IDRC ) في أوتاوا ـ كندا قد وافق على تقديم دعم مالي لمشروع LENS مدته ثلاث سنوات اعتبارا من بداية عام 1987 ولغاية 1989 . ويحيطكم علما بان ادارج اللغة العربية ضمن النشرة الاخبارية للعدس"LENS "يشكل أحد أهم اهداف ذلك البرنامج .

وبمزيد من السرور تعلن اسرة تحرير " LENS " للباحثين العرب العاملين في مجال تحسين محصول العدس ، انها ستبدأ اصدار نشرتها العلمية باللغتين العربية والانكليزية بدءا من شهر آب/ اغسطس القادم . لذا فيرجى من الاخوة العلماء الراغبين في نشر بحوثهم باللغة العربية التفضل بارسالها الى العنوان التالي : مجلة " لنس" ، ايكاردا ـ قسم التوثيق ، ص.ب. 5466 حلب ـ سورية .

ملاحظة :

تتم كتابة البحث بلغة عربية واضحة ، وفق الترتيب التالي :

1 ) الملخص ويكتب باللغتين العربية والانكليزية .
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4 ) النتائج .
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6 ) المراجع .

## Contributors' Style Guide

**Policy**
The aim of LENS Newsletter is to publish quickly the results of recent research on lentils. Articles should normally be brief, confined to a single subject, good quality, and of primary interest to research, extension, and production workers, and administrators and policy makers.

**Style**
Articles should have an abstract (maximum 250 words) and whenever possible the following sections: introduction, materials and methods, and results and discussion. Authors should refer to recent issues of LENS for guidance on format. Articles will be edited to maintain uniform style but substantial editing will be referred to the author for his/her approval; occasionally, papers may be returned for revision.

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**Manuscript**
Articles should be typed double-spaced on one side of the page only. The original and two other legible copies should be submitted. The contributor should include his name and initials, title, program or department, institute, postal address, and telex number if available. Figures should be drawn in India ink; send original artwork, not photocopies. Define in footnotes or legends any unusual abbreviations or symbols used in a figure or table. Good quality black and white photographs are acceptable for publication. Photographs and figures should preferably be 8.5 cm or 17.4 cm wide.

Units of measurement are to be in the metric system; e.g. t/ha, kg, g, m, km, ml (= mililiter), $m^2$.

The numbers one to nine should be written as words except in combination with units of measure; all other numbers should be written as numerals; e.g., nine plants. 10 leaves, 9 g, ninth, 10th, 0700 hr.

**Examples of common expressions and abbreviations**
3 g; 18 mm; 300 $m^2$; 4 Mar 1983; 27%; 50 five-day old plants; 1.6 million; 23 u g; $5^oC$; 1980/81 season; 1980-82 seasons; Fig.; No.; FAO; USA. Fertilizers: 1 kg N or $P_2O_5$ or $K_2O$/ha.
Mon, Tues, Wed, Thurs, Fri, Sat, Sun; Jan, Feb, Mar, Apr, May, June, July, Aug, Sept, Oct, Nov, Dec. Versus = vs, least significant difference = LSD, standard error = SE +, coefficient(s) of variation = CV(s). Probability: Use asterisks to denote probability * = $P<0.05$; ** = $P<0.01$; *** = $P<0.001$.

**Botanical:** Include the authority name at the first mention of scientific names. Cultivar(s) = cv(s), variety = var(s), species = sp./spp., subspecies = subsp., subgenus = subg., forma = f., forma specialis = f. sp.

**References**
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*Books:* Webb, C. and Hawtin, G. (eds.). 1981. Lentils. ICARDA/CAB, CAB, Slough, England, 216 pp

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*Papers in Proceedings:* Hariri, G. 1979. Insect pests of chickpea and lentils in the countries of the Eastern Mediterranean: A review. Pages 120-123 *in* Food Legume Improvement and Development: Proceedings of a Workshop, University of Aleppo (Hawtin, G. and Chancellor, G.J., eds.), ICARDA/Aleppo University, May 1979, Aleppo, Syria. ICARDA/IDRC, Ottawa, Ontario, Canada.

**Submission of articles**
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