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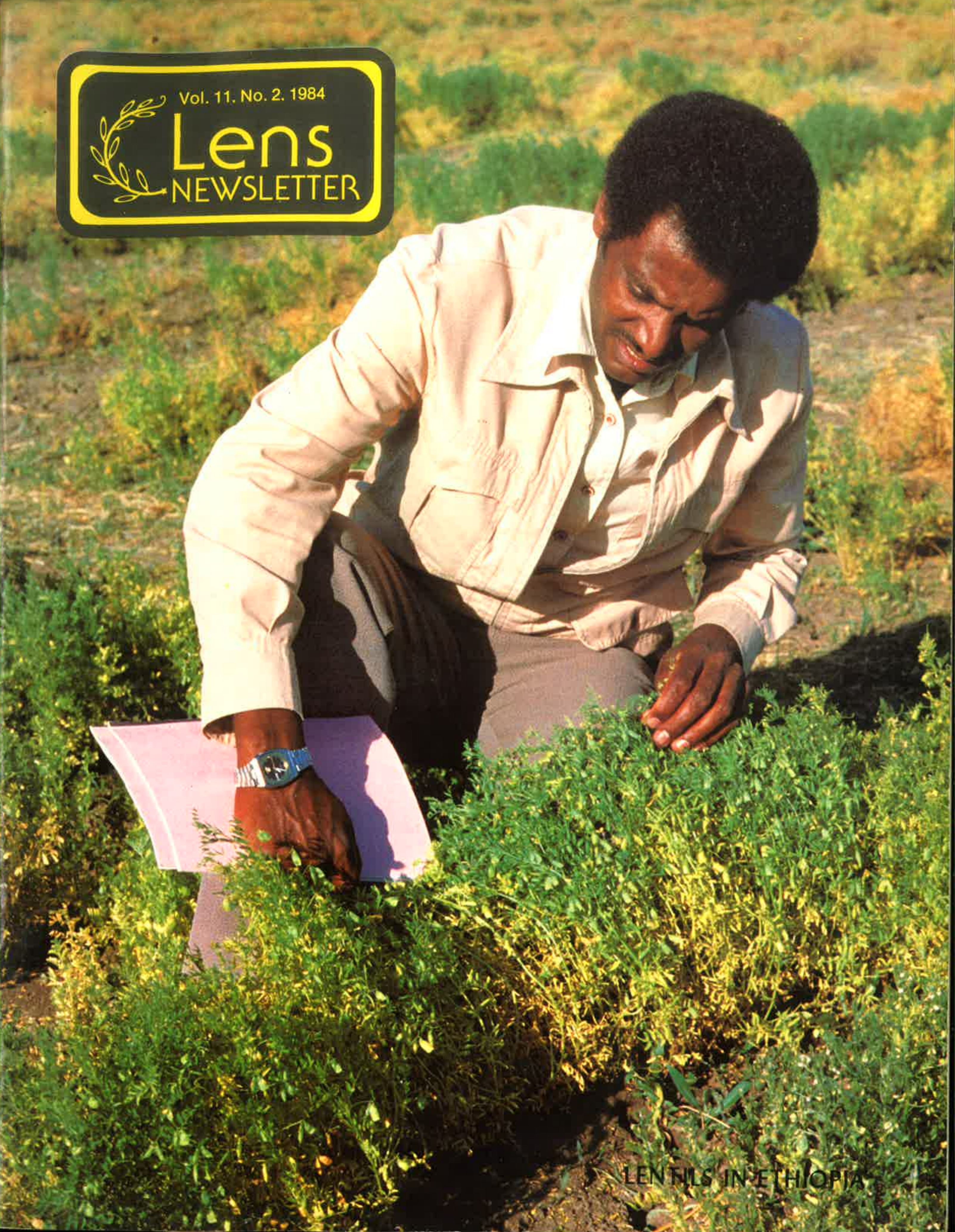
Lens NEWSLETTER



LENTILS IN ETHIOPIA

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LENS

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COVER PHOTO: Ethiopian lentil breeder Geletu Bejaga examines a lentil cultivar from ICARDA, NEL (ILL) 358, at Debrezeit University Farm in Ethiopia. The new cultivar, which is rust-resistant and yields 30-50% higher than the local cultivar, is being considered for release in Ethiopia.

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NEWSLETTER

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REVIEW ARTICLE

Lentils in Ethiopia

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Introduction

Lentil ranks fourth among the traditional pulse crops in Ethiopia. It is widely used in the Ethiopian diet in different forms. Food legume seeds, the major source of plant protein, provide an estimated 8% of the total calories for the population, and the domestic requirement for pulses is expected to increase 2.5 - 3% each year (Emmanuel *et al.* 1978). Therefore, lentil production, together with the production of other pulses, must be increased. In comparison with faba beans, peas, and chickpeas, lentil has certain advantages (Lal *et al.* 1976): it tolerates drought and can be grown without irrigation, and it requires the fewest plant protection measures.

Distribution and production

Ethiopia was the second largest lentil producer in the world up to around 1975, surpassed only by India, but it now ranks eighth (FAO 1982). According to FAO statistics for 1978-81, over 57% of lentil production in Africa comes from Ethiopia, but there has been a decline in both area and production (Table 1), requiring the attention of all concerned with lentil improvement.

Table 1. *Area, yield, and production of lentils in Ethiopia.*

Year	Area (1000 ha)	Yield (kg/ha)	Production (1000 metric tons)
1969 - 71	101	460	46
1973	172	430	74
1974	116	430	50
1975	142	430	61
1976	67	660	41
1977	36	223	38
1978	59	557	33
1979	59	460	27
1980	58	470	27
1981	59	455	27

Source: FAO Production Yearbooks.

Lentil was previously the second most important pulse crop of Ethiopia, surpassed only by chickpea (Westphal 1974), but it now ranks fourth after faba bean, chickpea, and field pea (FAO 1982).

Lentil is grown in different regions of Ethiopia but mainly in the northern and central highlands. It is cultivated largely in the central parts of the Ethiopian highlands: Shoa, Gojam, South West Wollo, South Begemdir and Eastern Wollega (Westphal 1974), at an altitude of 1800-3000 m above sea level, receiving 950-1500 mm average annual rainfall. Because of lentil's intolerance to extreme heat and cold, it is limited to higher elevations in tropical countries such as Ethiopia and Mexico (Summerfield 1981). Soils of major lentil growing areas include alfisols, vertisols and inceptisols (Westphal 1974). Of the two groups of lentils grown in the world, *microsperma*, the older type, is the major group cultivated in Ethiopia (Webb and Hawtin 1981).

Lentils are one of the major pulses cultivated in the Yerer and Kereyu highlands of Shoa where pulses and cereals rank first (Westphal 1974). Lentils are also cultivated in Begmider and Simen throughout temperate areas (Woyna Daga) up to 2700 m. In the Dabat region, they are grown in a rotation as a second (relay) crop usually after barley is harvested in September.

Lentil is raised under rainfed conditions, mostly as a pure stand. It is sometimes grown as a mixed crop with flax and both are hand-pulled at harvest and separated.

Post Harvest Processing and Uses

Lentil forms an integral part of the daily diet in Ethiopia. Lentil, cereals, and other highland pulses are the main protein sources. Lentil is considered a luxury food and is produced as a cash crop since it commands higher prices than other pulses and most cereals.

Either decorticated and split seed (kik) or whole seed is used to prepare "wot", a soup eaten with injer (bread made of powdered tef or wheat). Snacks are made by salting the boiled seed (nufro) and the roasted seed (kolo), and by mixing the roasted seed with sunflower seed. Sometimes the boiled seed is pressed and then mixed with green chili to prepare a special wot (azifa). The straw, pod walls, and other residues from threshing are used for animals. Sometimes the straw is burned as firewood.

Lentil is also one of the leading pulse crops in the Ethiopian export market. It increased rapidly among pulse exports up to 1975 (Table 2), when it comprised about 37% of exported pulses. Sri Lanka was the major market for lentils although considerable quantities were sold to Egypt, Sudan, Mauritius, and the United Kingdom (Min. of Agric., Planning and Programming Dept. 1972). The fact that Ethiopian lentils, which have small black seeds, have a limited export market compared to lentil seeds usually exported by European countries (Oil and Pulse Crops Export Corporation, personal communication) shows the need to grow green lentils in Ethiopia.

Ethiopia also ranks first in the world for the proportion of its lentil crop exported. In 1977, it exported 63% of its production (32500 tons) compared to Argentina (60%), Syria (42%), USA (36%) and Turkey (32%) (Nygaard and Hawtin 1981). Although there is great external market demand, domestic prices are also very attractive. The price of split seed never drops below US$ 1.0/kg, while it sometimes goes up to US$ 2.00/kg. The price for whole seed is usually about US$ 0.75/kg. This shows clearly that lentil has potential as a cash crop for Ethiopian farmers and also as a good foreign exchange earner for the country. Improving lentil production will ensure more adequate protein for the basic diet, in which it is the major pulse, as well as provide the farmer with a cash income, because there is both an unsaturated local urban market and a good potential for export of any excess. Increased yields could also help to maintain prices the urban poor can afford.

Research

Research work by Addis Ababa University's Debre Zeit Agricultural Experiment Station started in 1972 on chickpeas, lentils, faba beans, and field peas, but the station later began to coordinate the national research program on lentils and chickpeas. Researchers recruited by Addis Ababa University to coordinate the national research program received training at the International Center for Agricultural Research in the Dry Areas (ICARDA).

The research program has gained in momentum, and nationally coordinated lentil improvement is being carried out on a broader scale. The national and prenational yield trials are conducted at the Institute of Agricultural Research stations and Agricultural Development Department sites in different agro-climatic regions. Collaboration with and assistance from ICARDA have resulted in some achievements.

Breeding

Germplasm

Ethiopia has a highly variable agro-climate which influences the extent of genetic diversity. Intensive local collection has not yet been undertaken. Initially, over 300 accessions were collected, most of which were market samples. The Ethiopian Plant Genetic Resource Center (PGRC/E) has not done much collection because of the low priority given to the crop. At present, about 369 accessions are available at ICARDA and over 200 different accessions at PGRC/E.

Table 2. *Quantity of pulses exported from Ethiopia, 1965-75 (1000 metric tons).*

Year	Chickpeas	Faba beans	Haricot beans	Lentils	Field peas	Total
1965	9.5	17.8	19.7	5.8	2.3	55.1
1966	10.9	22.4	19.5	14.9	1.5	69.2
1967	10.7	24.7	17.9	15.0	0.9	69.2
1968	13.9	18.5	19.3	22.0	1.0	74.7
1969	8.0	27.4	16.7	24.5	2.0	78.6
1970	2.2	15.6	17.1	15.8	0.4	51.5
1971	6.3	16.6	22.6	18.0	0.2	63.7
1972	10.7	19.0	25.7	21.9	0.5	77.8
1973	8.1	29.7	79.1	22.1	2.4	141.5
1974	8.2	26.0	46.0	30.0	10.5	120.7
1975	1.0	22.2	41.5	37.3		102.0

There is great potential for improving lentil. Its considerable indigenous genetic variability, if properly exploited, could contribute to the world's germplasm resources. The recent expansion of state-owned mechanized farms in the highland areas of Ethiopia, however, with emphasis on cereal production, as well as the current climatic change (drought), are causing genetic erosion. There is an urgent need to save this valuable genetic material.

Breeding and Selection

The cultivars used by farmers are genetic mixtures. The lentil varieties released from Debre Zeit are either derived from selection within the heterogeneous populations sampled during collection, or are selected from introductions, but are not the result of hybridization. Initial screening is made at Debre Zeit Agricultural Experiment Station. Genotypes with good yield potential and tolerance/resistance to diseases and insect pests are tested at additional locations before testing in pre-national and national yield trials. All the Ethiopian accessions and several accessions introduced from FAO, ICARDA, and other national programs have been evaluated for different agronomic characteristics and resistance to diseases.

A small crossing program has also been started to combine the merits of some genotypes. Many F_2 and F_3 segregating populations are received from ICARDA every year for selection under Ethiopian conditions. Recently, a joint breeding program was started by ICARDA and the Ethiopian national program to develop lines resistant to root rot, wilt, and rust diseases, which are the major limits on lentil production in Ethiopia. Crossing has already been undertaken at ICARDA and selection from F_2 populations will be made in Ethiopia. It is hoped that this collaborative effort will eventually improve the country's lentil production.

National Variety Trials and Varietal Development

The genotypes selected at Debre Zeit Agricultural Experiment Station are included in the national and pre-national yield trials conducted at many research stations and substations representing different agro-climatic regions. This is to select for wide adaptability or zonespecific adaptation and to evaluate the response to different diseases, insects, and other adverse environmental factors.

Over the years, several genotypes were identified for various desirable characters, such as Variety R-186 and EL-142 which were released for different agro-climatic zones. Variety R-186 (Mexican) is very late in maturity and was released for highland areas above 1900 m altitude, which has abundant rainfall during the growing season. EL-142 (Ethiopian lentil) is early maturing and was released for lowland areas receiving little rainfall. Many Ethiopian lentils are early maturing and do well in the lowland areas. Ethiopian lentils were also found to be in the early maturing group at ICARDA (Solh and Erskine 1981), and hence may be useful in other dry areas. Variety R-186 is almost out of production because it is not resistant to frost in October/ November. Variety NEL-358* (Mexican), recently registered for release, will replace R-186 in the highland areas of Ethiopia. Variety NEL-355 (Mexican) performs similarly to NEL-358. Varieties NEL-357 and NEL-256 also performed well in highland areas. In overall performance, Variety NEL-358 gave over 50% more yield than the local check varieties in the highland areas (Table 3). In most cases, it is not harvested in the lowland areas

Table 3. *Yield (kg/ha) of variety NEL-358 compared to other lentil selections grown in national yield trials at some highland region sites (1981-1983).*

	1981				1982				1983			
	Akaki	Kulumsa	Robe	Mean	Akaki	Kulumsa	Robe	Mean	Akaki	Kulumsa	Robe	Mean
NEL-358**	1930	4239	2547	2905	2610	2970	2780	2786	2444	2345	2256	2348
NEL-355	2200	3226	2875	2767	2300	2770	3040	2703	3045	2182	1325	2184
NEL-357	2000	3267	2375	2547	2340	2670	3010	2673	2303	2379	1318	2000
NEL-256	2160	3812	2797	2923	1970	2750	2700	2473	2206	1810	1387	1801
EL-142	1240	1437	2172	1616	2130	2160	2310	2200	1626	1516	1409	1517
R-186	1210	2934	1281	1808	2530	3830	1910	2756	2482	1998	412	1630
R-184	1070	3131	1250	1817	2380	2940	–	2660*	2328	1356	–	1842
R-59	1290	3893	1547	2243	2130	2670	2220	2340	1559	1604	303	1155
R-252	1020	3289	1703	2004	2060	2330	–	2195*	1870	1246	–	1558
Local check	200	539	1609	782	1800	2280	2900	2326	335	1557	784	630

* Mean of two locations.

** NEL-358 performed the best across 7 locations in 1981, 20 locations in 1982, and 6 locations in 1983.

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*Editor's note: NEL accession number = ILL acc. number in ICARDA germplasm collection.

because the soil moisture is exhausted before seed filling. No variety has been identified to replace EL-142 for lowland areas; hence, ICARDA has undertaken the crossing work to incorporate rust resistance into it. Generally, efforts must be made to develop cultivars resistant and/or tolerant to high and low temperatures to expand lentil growing to a wider area. Cold-tolerant accessions were identified by ICARDA from Indian or Pakistani lines but not from Ethiopia (ICARDA 1980/81). These lines should be introduced and tested in the highlands of Shoa, Arsi, and Bale.

Agronomy (Crop Management)

Recognizing that improved crop management techniques could allow large increases in yield, studies on better cultural practices were recently intensified. Information has been gathered on sowing dates and seeding rates at some locations.

Sowing Date

Lentil is planted in late June to early July on soils with low fertility and water holding capacity, while it is planted in September on heavy black clay soils. These latter soils allow double cropping in many parts of the country where lentil is planted as the second crop after cereals – a common practice in the highland areas around Gondar, particularly in Dabat region.

The results of the sowing date trials at Debre Zeit (1900 m), Akaki (2080 m), Chefe Donsa (2450 m), and Ejere (2050 m) showed the advantage of early planting (late June to mid-July) with the onset of rainfall, in comparison with the sowing date used by farmers (September). The overall yield with early planting is over 60% more than that obtained with the farmers' sowing date. Data obtained at Debre Zeit in 1978-83 revealed an increase of over 90% in grain yield with early planting. A further increase can be achieved if varieties with resistance to both soil-borne diseases and rust are developed. These studies showed that as planting date is delayed, the number of plants dying from soil-borne diseases decreases, which was also reported by Saxena (1981).

Seeding Rate

Low seeding rates, used traditionally by Ethiopian farmers, often result in poor plant populations, which are sometimes as low as 20-100 plants/m^2. But this varies from region to region depending on the planting date, soil type, and fertility.

Some trials are underway to identify the optimum seeding rates for row vs. broadcast sowing. The results obtained showed that 45-50 kg/ha is sufficient for row seeding while about 60-75 kg/ha is optimum for broadcasting. The optimum rate will be established soon for different soils and agro-climatic regions in Ethiopia.

Soil fertility and fertilizer

Lentil is raised on different soils in Ethiopia, ranging from light sandy to heavy clay soils. The use of fertilizer is not common for food legume crops, including lentils, so the crop depends mainly on nutrients available in the soil and nitrogen fixed during growing season.

Recently, trials were carried out on the heavy black clay soils of Akaki, Debre Zeit and Chefe Donsa to investigate the response of lentil to different rates of P and N. The results have shown highly significant grain yield response to applied phosphorus, while application of increasing rates of nitrogen fertilizer decreased grain yield at Chefe Donsa. The deficiency of zinc in the early stage of crop growth has been reported on heavy clay soils in India (Saxena and Singh 1977), which can be rectified by applying 10-15 kg zinc sulphate/hectare. This situation has never been observed under Ethiopian conditions, but needs consideration.

Weed Control

Lentil competes poorly with many weed species, because of its weak stem and slow growth. Results of trials on loss assessment at Debre Zeit showed over 90% yield loss from weeds. A 30-60 day period after planting was critical for weed competition. Efforts are underway to identify the best weeding period and herbicides.

Plant Pathology

Diseases that affect lentils in Ethiopia include *Ascochyta lini, Rhizoctonia solani, Sclerotium rolfsii, Fusarium oxysporum*, stunt virus, *Uromyces fabae*, and powdery mildew (Mengistu 1978). Ten years of study show that root rot, wilt and rust are the most economically important diseases of Ethiopian lentils. Ascochyta leaf blight, also recorded on some susceptible genotypes, is a potentially dangerous disease unless control methods are devised. Some genotypes tolerant to rust were identified, such as NEL-355 and NEL-358. More studies on lentil pathology are needed.

Entomology

A survey of the most common insects affecting lentils is underway. Heavy populations of pea aphid (*Acyrthosiphon pisum*) are frequently observed on lentils. An assessment of the economic significance of this insect has begun. In addition, lentil varieties are being screened against pea aphids. Pod borer could also be an important insect as symptoms have been observed in some plots, but the extent of its damage is unknown.

Harvesting

Ethiopian farmers usually harvest lentils before they are completely dry and start to shatter, either by hand pulling or cutting with a sickle. The plants are then left in small heaps (nedo) in the field or immediately transported to the threshing area (awidima: ground cemented with animal dung) and left to dry for some time before threshing. They are usually threshed by driving animals (usually oxen) over the crop, but sometimes by using sticks to beat the crop. Since the traditional harvesting method is labor-intensive, the crop is being replaced by cereals that are easily harvested by combine. The problems of lentil harvesting, as well as the lack of improved varieties resistant to soil-borne diseases and rust, are responsible for the reduced lentil area and production. If growing is mechanized, lentil could be grown on state farms in rotation with cereals—a possibility that should be investigated.

Future Prospects and Research Priorities

Lentils grown in different parts of Ethiopia have considerable genetic variability. However, since drought in the northern part of the country is causing genetic erosion of this valuable germplasm, its collection is urgently needed.

Lentil yield should be increased, not only to ensure more adequate protein in the basic diet, but also to provide the farmer with cash income. Future research priorities will therefore be to:

1) increase lentil germplasm collection in collaboration with the Ethiopian Plant Genetic Resource Center.
2) develop varieties resistant to root rot, wilt, and rust (major limiting factors of production).
3) strengthen the national breeding program to develop high-yielding varieties for
    a) highland areas (sufficient rainfall)
    b) lowland areas (little rainfall).
4) develop high yielding varieties of large-seeded green lentils to enable the country to compete well in the international market and to earn foreign exchange.
5) identify proper management practices (seeding rate, sowing date, fertilizer, etc.) for different agro-climatic regions.
6) identify proper machines to mechanize crop harvest.
7) identify efficient herbicides.
8) train researchers in all disciplines.
9) work closely with ICARDA to enable the national program to achieve the above mentioned objectives.

Generally, there are excellent prospects to improve lentil, but the effectiveness of the national lentil program in overcoming the constraints depends on the strong support of the Addis Ababa University, the Institute of Agricultural Research, and all others concerned with lentil improvement.

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RESEARCH ARTICLES

Breeding and Genetics

Documentation, characterization, and preliminary evaluation of lentil (*Lens culinaris*) germplasm in Pakistan

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Abstract

Information on 55 accessions of lentil germplasm collected from Sind and Punjab is summarized in this paper. The germplasm was evaluated for time to 50% flowering, time to maturity, plant height, pods/plant, yield, and incidence of diseases such as rust and lentil blight (*Ascochyta lentis*). All accessions were *microsperma*. Accessions PAK 40393 and PAK 40379 were almost free from diseases and could be effectively used in breeding programs.

Introduction

Lentils are a high protein (24-25%) food crop widely grown in the Near East and sub-tropical Asian countries. Although it ranks third in area of cultivation (73,000 hectares) and production (30,000 metric tons) among pulse crops grown in Pakistan, it gives the lowest average yield of 407 kg/ha (FAO 1981).

In Pakistan as in other parts of the world, considerable genetic erosion of cultivated lentil will soon occur due to the introduction of improved cultivars and other cash crops. However, some heterozygosity, like that found in barley (Jain and Allard 1960), could be present in lentil land races in spite of the low level of natural cross-pollination (Wilson and Law 1972).

Any strategy for the exploitation of a crop must include the collection and maintenance of land races and their relatives (Solh and Erskine 1981). This paper summarizes lentil germplasm evaluation in Pakistan for researchers involved in breeding and improvement of this crop.

Materials and Methods

Lentil germplasm was collected from Punjab and Sind, the major lentil producing provinces in Pakistan, on an expedition organized jointly by the Plant Genetic Resources and Food Legume Programmes of the Pakistan Agricultural Research Council from 2 to 20 Apr 1982. Fifty-five accessions of lentil germplasm were collected from various altitudes (sea level to 250 m), using sampling techniques described by Hashmi *et al.* (1981). Collections were made at 37 sites, including fields, markets, farm stores, and threshing floors.

Lentil germplasm was sown on 5 Nov 1982 for preliminary evaluation at the National Agricultural Research Centre, Islamabad. The inter- and intrarow spacing was 30 cm and 2 cm, respectively. Each plot was a single 5 m long row. Fertilizer was applied at a rate of 50 kg P_2O_5/ha. No irrigation was given. However, 610 mm of rainfall was recorded during the growing season. Germplasm was evaluated for seven characters: time to 50% flowering (days), time to 90% maturity (days), incidence of rust, and lentil blight incidence (recorded on a line basis); and plant height (cm), number of pods/plant, and seed yield (recorded on five plants selected randomly from each row).

Results and Discussion

Data on the variability observed in the characters recorded are presented in Tables 1 and 2. No variation was observed in the seed group, since all accessions collected were small seeded (*microsperma* type). Time to flowering varied from 117-150 days with a mean of 124.3 days. Time to maturity varied from 130-165 days with a mean of 151.3 days. The observed range of variability in these characters is enough to make useful selections for earliness. Plant height, measured from ground level to the plant tip, ranged from 29-45.6 cm, offering broad scope for selection of desirable height levels. Pods/plant were another parameter which could be exploited in a lentil breeding program.

The natural incidence of the diseases was high enough to screen the germplasm for resistance to rust (*Uromyces fabae*) and lentil blight (*Ascochyta lentis*). Visual scores were given for the intensity of these diseases in the row (Table 2). Accessions PAK-40393 and PAK-40379 were

Table 1. *Summary of evaluation data of 55 accessions for five agronomic characters.*

Character	Mean	Minimum	Maximum	Coefficient of variation (%)
Time to 50% flower (days)	124.3	117	150	13.8
Time to 90% maturity (days)	151.3	130	165	4.2
Mean plant height (cm)	35.6	29.0	45.6	13.6
Mean number of pods/plant	58.7	22.0	154.8	47.3
Mean seed yield/plant (g)	1.48	0.48	3.96	45.2

Table 2. *Summary of disease data.*

Intensity of diseases	Scores	Number of lines affected by rust	No. of lines affected by Ascochyta blight
Resistant	1	0	14
Moderately resistant	3	2	33
Average reaction	5	25	8
Moderately susceptible	7	22	0
Highly susceptible	9	6	0
	Total	55	55

virtually free from both diseases under natural infection and could be used as sources of resistance in lentil breeding programs.

The mean yield/plant ranged from 0.48-3.96 g, although yield was generally very low due to high incidence of diseases. The present study reveals sufficient variability in lentil germplasm to allow selection for the characters studied. Variability for these traits in lentil germplasm was also reported by Tiwari and Singh (1980) and Agrawal *et al.* (1976). Seed as well as passport and evaluation data on individual accessions are available on request from the Pulses Program at NARC and Plant Genetic Resources Unit of PARC at NARC, Islamabad.

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Association among phenological characters in lentil (*Lens culinaris*)

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Abstract

The phenological characters of fruiting zone length, total number of nodes, number of fruiting nodes, number of branches/plant, and plant height were studied on 33 lines grown at Hissar, India in the 1982/83 season. All the characters showed significant genetic variation. The positive correlation between fruiting zone length and the number of fruiting nodes highlighted.

Introduction

Lentils are an important winter food legume crop grown under a wide range of agro-climatic conditions. Lentils are consumed in India primarily in the form of dal, which is made more commonly from *microsperma* than from *macrosperma* lentils. Scant information is available, however, on some lentil phenological characters such as fruiting zone, total number of nodes and fruiting nodes, and their association. Such information is important in indirect selection, and also in identifying desirable parents for hybridization.

Materials and Methods

Thirty-three elite lines, selected from crosses, were evaluated during the 1982/1983 season for plant height (cm), fruiting zone length (distance in cm between highest and lowest fruiting nodes), total number of nodes, number of fruiting nodes, and the number of branches/plant. The lines were planted in sandy loam soil at Hissar (29° 10'N, 75° 46'E) on Nov 19. The experiment was replicated four times in a randomized complete block design. The plants were spaced 5 cm apart in 4 m long paired rows separated by 25 cm.

Data were recorded on 10 plants selected randomly from each plot. Phenotypic correlations were computed for all possible pairs of characters using standard formulae.

The elite lines differed significantly in all the characters studied. The overall mean and range among the entries and standard error for the five characters are shown in Table 1.

Of the characters studied, plant height had the maximum range. Line LH73 was the tallest, whereas LH1 was the shortest. LH93 had the longest fruiting zone, while LH82-9 had the shortest fruiting zone with a plant height of 33 cm. LH143 had the highest total number of nodes (24.7) as well as number of fruiting nodes (16.0), whereas LH82-9 had the lowest number of total nodes (16.7) and fruiting nodes (9.3). LH82-1 produced the greatest number of branches (21.3) and LH261 produced the fewest (8.0). The tallest line, LH73– with a total plant height of 49.6 cm – had a fruiting zone of 18 cm. Only 12.6 out of a total of 24.3 nodes were productive, which shows that a large plant does not necessarily imply great productivity.

Table 1. *Mean, standard error (S.E.), and range for five lentil characters.*

Character	Mean	S.E.	Range
Plant height (cm)	39.6	0.79	32.5 - 49.6
Fruiting zone length (cm)	22.5	0.65	16.0 - 30.5
Total number of nodes	20.7	0.33	16.6 24.6
Number of fruiting nodes	12.6	0.29	9.3 - 16.0
Number of branches/ plant	12.9	0.63	6.3 - 21.3

On the other hand, lines LH1 and LH93 had a large fruiting zone (26.5 and 30.5 cm, respectively) in relation to their total height (32.5 and 41.0 cm). Of the lines studied, LH93 showed the greatest promise based on fruiting zone and the highest proportion of fertile nodes.

Table 2 shows that plant height had a significant positive correlation with both fruiting zone length and the total number of nodes. Fruiting zone length was positively associated with the total number of nodes and significantly correlated with number of fruiting nodes. The total number of nodes was significantly correlated with the number of fruiting nodes.

Based on correlations among phenological characters, this study indicates that it is possible to select a plant type with both a long fruiting zone and more fruiting nodes. This may, in turn, result in an increased harvest index and, hence, seed yield.

Table 2. *Phenotypic correlations among five characters.*

	Fruiting zone length	Total number of nodes	Number of fruiting nodes	Number of branches/plant
Plant height	0.461**	0.360*	0.252	0.033
Fruiting zone length		0.327	0.491**	–0.098
Total number of nodes			0.693**	–0.161
Number of fruiting nodes				–0.185

* $P < 0.05 > 0.01$ ** $P < 0.01$

Cytological instability of colchiploids in *Lens culinaris*

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Abstract

Six colchiploid *Lens culinaris* plants were cytologically examined. Two plants were pure tetraploids; the other four were mixoploids with many diploid pollen mother cells (PMCs) and tetraploid PMCs within the anthers of the same flower bud. In a mixoploid, PMCs with 29 and 27 chromosomes were found in addition to tetraploid ones. In most of the PMCs, irregular behavior of chromosomes during different stages of meiosis and occurrence of diploid PMCs (depolyploidization) suggested that such colchiploid lentils were cytologically unstable.

Introduction

Polyploidy is an effective and distinct cytogenetic process which affects the evolution of higher plants. In 30-35% of flowering plants and many ferns, the somatic chromosome numbers are multiples of basic diploid numbers. But in Papilionaceae, both aneuploidy and euploidy have no significant role in the evolution and differentiation of species. Superiority of polyploids over diploids in both yield and resistance was established by many workers in several crops and ornamental plants. Most efforts to induce polyploidy in lentil have failed. Tawar and Tiwari (1981) and Sharma *et al.* (1983) have recently developed colchitetraploids, but since they are in early generations, they are not recommended for cultivation.

This study is of the cytology of six lentil colchiploids induced by Sharma *et al.* (1983).

Materials and Methods

The cytological study was carried out in six lentil colchiploids grown at ICAR Pulse Directorate, Kanpur. The seeds of colchiploid lentils were supplied by Professor P.K. Gupta, Head of Genetics and Plant Breeding, Faculty of Agriculture, Meerut University.

Young flower buds fixed in 1:3 acetoalchohol, were squashed in 1% acetocarmine. Fresh smears were examined for cytological details. Suitable pollen mother cells were photographed from temporary preparations on 35 mm film with an Olympus PM-6 microphotographic camera.

Cytological observations and discussion

A cytological study in colchiploid plants revealed that two plants were tetraploids, while the other four were mixoploids showing the occurrence of a number of diploid PMCs in addition to tetraploid ones within the anthers of the same flower bud (Figs. 1, 2, 5, and 6). In one of the mixoploids, PMCs with 29 and 27 chromosomes were found in addition to tetraploid ones.

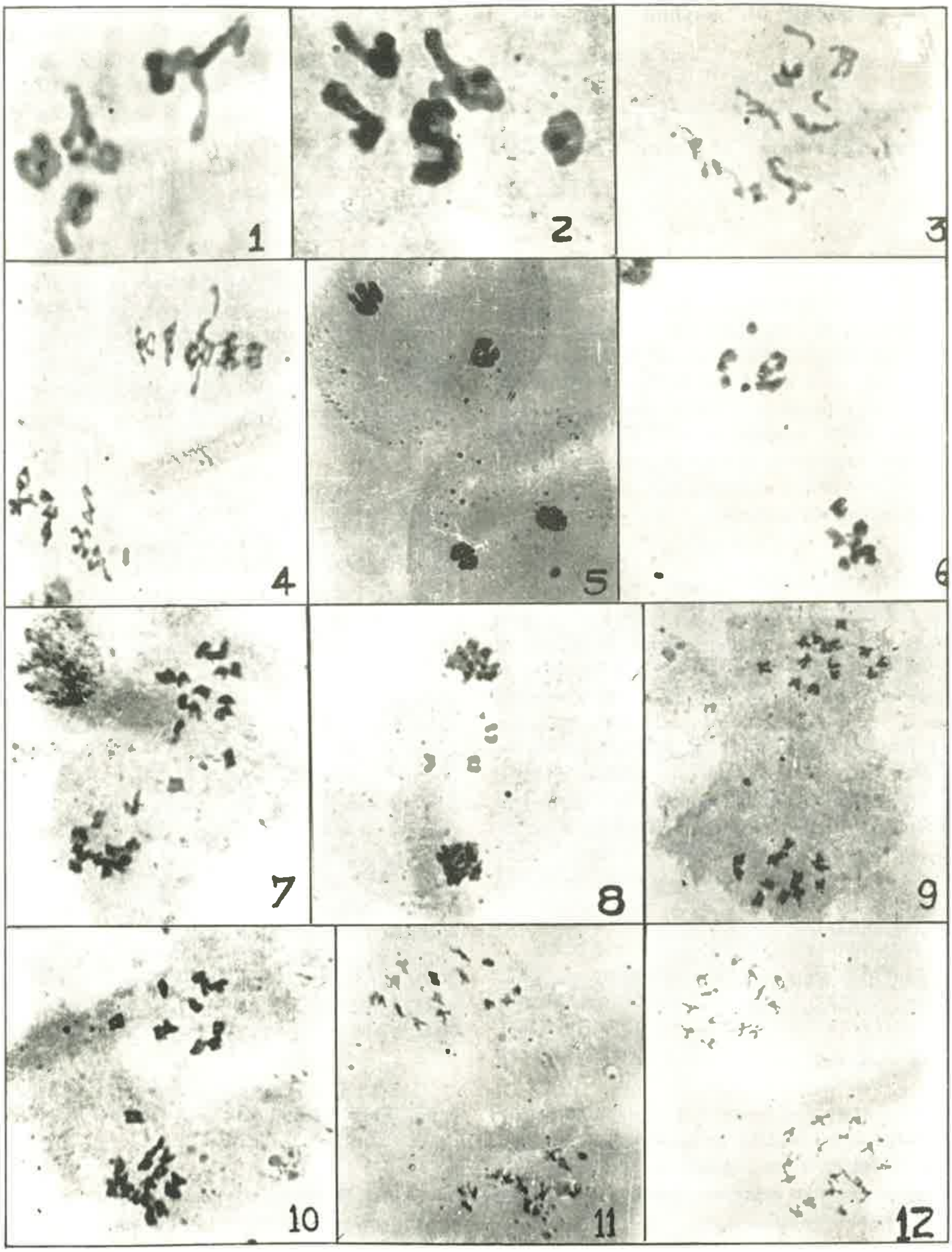
The behavior of chromosomes in tetraploid PMCs of both tetraploids and mixoploids was abnormal. Chromosomal associations at prophase I and metaphase I clearly indicated the general features found in auto-tetraploids. In addition, bivalents, tetravalents, and univalents were found in variable numbers in many PMCs.

These results contrast with the earlier reports of Sharma *et al.* (1983) who reported regular formation of 14 bivalents in the same colchiploids. In this study, only a small number of tetraploid cells were seen with 14 bivalents. Most of the polyvalents at diakinesis showed loose associations of chromosomes. The univalents arose mostly either as a result of failure in the formation of bivalents or due to desynapsis. Metaphase I was also disturbed, and in several PMCs the chromosomes were scattered away from the equator. Anaphase I in some tetraploid PMCs was regular with 14:14 distribution of chromosomes at the poles. However, a delayed separation of homologues of some bivalents was noticed in many PMCs at anaphase I. Two-six lagging chromosomes were also noticed in a large number of PMCs (Figs. 7 and 8), which resulted in unequal distribution of chromosomes to the poles. Sharma *et al.* (1983) reported normal anaphase I and II in most PMCs they examined, and did not notice any laggards. PMCs with 29 and 27 chromosomes in one mixoploid showed 16:13, 15:14, 16:11, and 14:13 chromosomes at the poles at late anaphase I (Figs 9-12).

Meiosis II was regular in most PMCs except in those with lagging chromosomes.

Pollen fertility, considerably affected by meiotic irregularities, ranged between 66-87% in different plants.

The diploid PMCs of mixoploids showed regular meiosis with regular formation of seven bivalents at diakinesis and equal distribution of chromosomes at the poles during anaphase I and II (Fig. 6).



Meiosis in colchi tetraploids of Lens culinaris. Figs 1 and 2. PMCs at diakinesis with seven bivalents. Figs. 3 and 4. Tetraploid PMCs showing the presence of univalents. Fig. 5. Two PMCs at anaphase I; one shows a lagging chromosome. Fig. 6. Normal anaphase I in a diploid PMC. Figs. 7 and 8. Two tetraploid PMCs showing lagging chromosomes. Fig. 9. 14: 13 distribution of chromosomes at anaphase I. Fig. 10. 16 : 11 distribution of chromosomes at the poles. Fig. 11. 15 : 14 chromosomes at anaphase I. Fig. 12. PMC with 29 chromosomes distributed 16 : 13 at the poles.

The low occurrence of aneuploids and polyploids in many genera of Papilionaceae needs further consideration. In *L. culinaris*, like many other species, an increase or decrease in the haploid chromosome number generally causes sterility and inviability of gametes. Malaviya and Shukla (1981, 1983a, 1983b) observed this in spontaneous polyploids of four lentil cultivars: L-3991, WYR-134, ILL-2177, and ILL-467. Tawar and Tiwari (1981) and Sharma *et al.* (1983) found increased seed and pod size in their materials, but colchiploid plants grown at Kanpur were found to be dwarf (10-15 cm in height) and sparsely branched. Seed set was also poor and seed size no better than in diploid lentils. However, the small sized seeds in colchiploids grown at Kanpur could be due to late sowing.

The occurrence of diploid and tetraploid PMCs in anthers of the same flower bud and disturbed meiosis indicates the process of depolyploidization, and most of the plants may become diploid after repeated growing of the seeds in successive generations. Rykova (1978) reported such a process of depolyploidization in tetraploid flax. He found that 17 out of 70 families of $4x$ flax with no diploids gave progenies with some diploid plants. He also found two tetraploid plants, both with low seed set, in the progeny of diploid plants derived from tetraploid flax. Thus, the possibility of total elimination of polyploids also cannot be ruled out, as predicted by Stebbins' (1971) "bottleneck hypothesis."

The depolyploidization in *L. culinaris* is in contrast to Stebbins' (1971) observation that the polyploid races are non-reversible.

Since only a single zygote cell with a fixed chromosome number undergoes morphogenesis and produces the embryo which later becomes a plant, the occurrence of PMCs at different ploidy levels within the anthers of the same flower bud in the same plant is of great significance. It may be that some sort of mitotic imbalances in the cells of the apical meristem cause mixoploidy. It is also possible that external conditions or endogenous substances disturb the mitotic process, causing the sporogenous tissue to become mixoploid in nature during anther development. Certain exogenous growth stimulants (D'Amato 1952) as well as certain unknown substances of endogenous origin (Lorz 1947) stimulate endomitosis, resulting in polysomaty in differentiated root tissue.

Irregular behavior of chromosomes during different stages of meiosis in a great majority of PMCs, and the occurrence of diploid PMCs (depolyploidization), strongly suggest that the colchiploids of lentil developed by Sharma *et al.* (1983) are cytologically unstable. Low seed set, pollen fertility, and poor development of fruits and seeds support this premise.

Acknowledgement

The authors thank Dr. S. Chandra, Director, ICAR Pulse Directorate, Kanpur for permitting them to conduct cytological observations on the colchiploid lentil plants growing at the center.

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Effects of chemical mutagens on the somatic chromosomes and mitosis in lentil (*Lens culinaris* Medic)

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Abstract

The effects of the mutagens ethylmethane sulphonate, nitrosomethyl urea, and diethyl sulphate at three concentrations each on somatic chromosomes and mitosis were studied on lentil variety T36. The anomalies observed at mitotic metaphase, anaphase, telophase and interphase are described. The percentage of cells showing abnormalities increased with mutagen dose, but was highest with NMU.

Introduction

Mitotic anomalies induced by mutagens are often regarded as an index of mutagen effectiveness. In lentil, the mitotic consequences of physical mutagens such as gamma rays, x-rays, and chemical mutagens were reported by Sinha and Godward (1968) and Jana *et al.* (1966, 1974). However, there is little information on treatment with the alkylating agents-ethylmethane sulphonate (EMS), nitrosomethyl urea (NMU), and diethyl sulphate (DES).

This paper reports the effects of seed soaking with varying doses of chemical mutagens NMU, EMS, and DES on somatic chromosomes and mitosis in lentil (*Lens culinaris* Medic) variety T36.

Materials and Methods

Dry seeds of lentil variety T36 were treated with three different concentrations of each mutagen for six hours (Table 1). The treated seeds, 50 in each treatment, were washed thoroughly and germinated in a sand culture in petri dishes. Fifty untreated seeds were soaked in water for six hours and germinated to serve as a control. Root tips from eight-day old seedlings were collected and fixed in 1:3 acetoalcohol for 24 hours at low temperature and then preserved in 70% alcohol. Prior to squash preparation, the root tips were hydrolyzed in 1N HCl for 10-12 minutes at 70°C. Root tip squashes in 1% aceto-orceine were used for studying mitosis.

Table 1. *Concentrations of mutagens.*

Dose	EMS (%)	NMU (%)	DES (%)
Low (L)	0.05	0.025	0.25
Medium (M)	0.125	0.05	0.5
High (H)	0.25	0.1	0.75

Results and Discussion

All three chemicals increased the cell size in the meristematic zone of the root tips, improved condensation, and increased separation of the chromosomes at metaphase (Fig. 1). The highest condensation of chromosomes was caused by the NMU treatment, followed by the EMS and DES treatments. These chemicals also brought about C-mitotic effect in the form of separation of two chromatids of a chromosome except at their centromeres.

Anomalies induced at mitotic metaphase included failure of one or two chromosomes to orient themselves at the equatorial plate; star metaphase; and stickiness of chromosomes. At anaphase, formation of one, two or more chromatin bridges with or without chromosome fragments was frequently observed (Fig. 2). This suggests that frequent exchanges between chromosomes occurred in the treatments, the number of bridges/cell depending upon the number of chromosomes taking part in the exchange. However, as suggested by Conger (1965), all the exchanges induced between chromosomes may not form bridges at anaphase. Lagging chromosomes or chromosome fragments were also observed, which suggests the formation of acentric chromosomes during exchange and/or of chromosomal breaks. The anomaly observed at telophase was the formation of one or more micronuclei.

Interphase cells included in the tally of anomalous cells had giant nuclei or were binucleate. Giant interphase nuclei might be polyploid, while the binucleate condition might result from cytokinensis failure. Sometimes the two nuclei of a binucleate cell tended to undergo further divisions. In such cases, two metaphase plates showing star metaphase condition were observed within the same cell (Fig. 3). Sometimes, in addition to two metaphase plates, a micronucleus could be observed within a cell. Polyploid cells, showing double chromosome number at metaphase, were frequently induced by NMU and EMS (Fig. 4). The formation of polyploid cells suggests that the mutagens brought about the failure of the spindle mechanism.

The effect of varying concentrations of the three mutagens on the total percentage of dividing cells showing mitotic abnormalities is depicted in Fig. 5. As shown, the percentage of cells showing abnormalities increased for each mutagen with the increase of the mutagen dose. NMU induced the most anomalous cells at the high and medium dose levels, while EMS was the most effective mutagen at the low dose level. DES induced the fewest abnormal cells at all three doses.

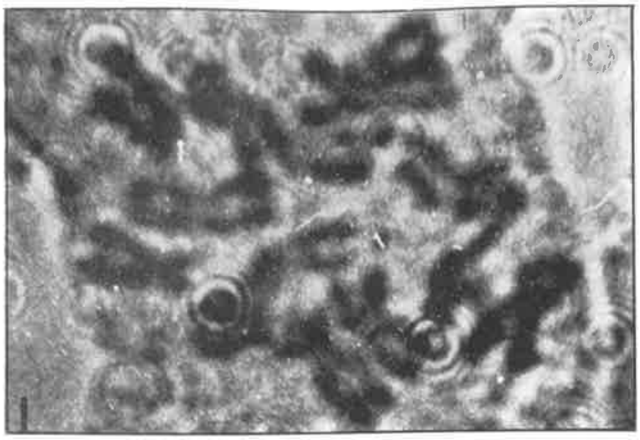

Fig. 1. *Well-spread metaphase plate showing C-mitotic effect (EMS treated).*

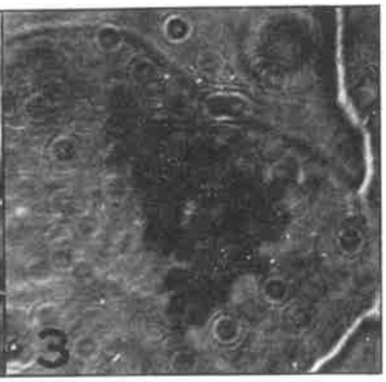

Fig. 2. *Chromatin bridge at anaphase (NMU treated).*

Fig. 3. *Cell with two star metaphases (EMS treated).*

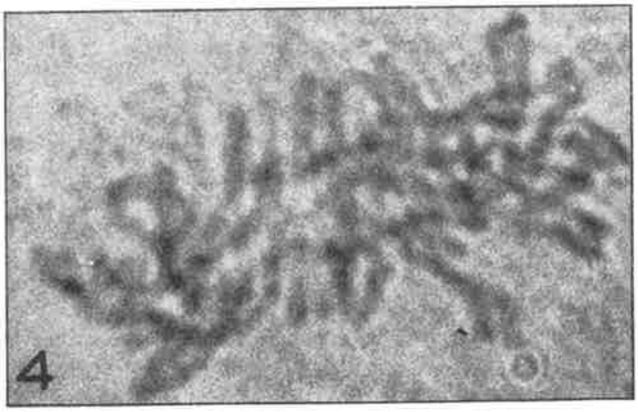

Fig. 4. *Polyploid cell (NMU treated).*

Figs. 1 - 4. *Mitosis in mutagen-treated Lens culinaris. All figures 1500 X.*

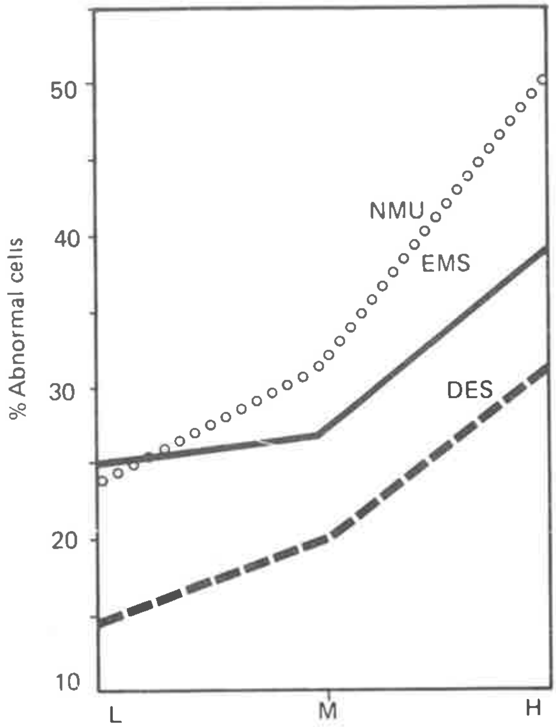

Fig. 5. *Effect of increasing concentrations of mutagens on percentage of abnormal cells (L = low; M = medium; H = high).*

Comparison of cells showing anomalies at different stages of mitosis, in terms of percentage of total abnormal cells induced by different chemicals, is presented in Fig. 6. The figure reveals that all three mutagens induced maximum anomalies in the interphase cells, at which stage 47-50% of cells in each treatment showed anomalies. The percentage of anomalous cells among the mutagen treatments ranged from 20 to 26% at metaphase or anaphase. EMS and DES induced more anomalous cells at metaphase than at anaphase, with the opposite under the NMU treatment. Also in the NMU treatment, 13% of abnormal cells were at telophase, when EMS and DES showed a very few anomalous cells.

A small percentage of cells showing anomalies at telophase may result from metaphasic anomalies such as star metaphase or stickiness, which can cause metaphasic arrest, while bridges at anaphase may break up by telophase. Therefore, only some lagging chromosomes, constituting substantial chromatin of the nucleus, formed micronuclei at telophase.

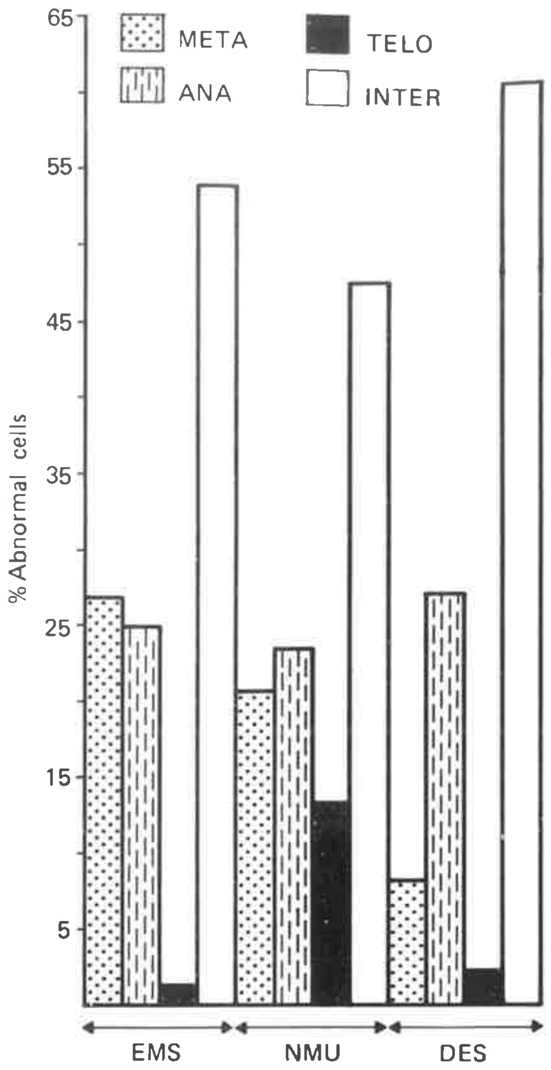

Fig. 6. *The effect of mutagens on percentage of abnormal cells at different cell division stages.*

Doses of all the three mutagens employed showed a linear relationship with the induced anomalies. Sinha and Godward (1968) also recorded such a linearity between doses of gamma rays and their effectiveness in inducing mitotic anomalies in lentil. Among the three mutagens used, NMU was most effective in inducing cytogenetic hazards in the form of mitotic abnormalities. The three mutagens as arranged in order of effectiveness are: NMU >EMS >DES.

Acknowledgements

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Path analysis in lentil (*Lens culinaris* Med.)

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Abstract

The relationship between seed yield and seven agronomic traits was studied by correlation and path analysis in 40 elite mutant lines in one season. There was a strong direct effect of the number of pods/plant on seed yield. Plant height and the number of branches were the next highest contributors toward seed yield.

Introduction

Yield is a complex character associated with many interrelated component characters. The interdependence of contributing factors often affects their direct relationship with yield, thus making correlation coefficients unreliable in selection indices. Path coefficient analysis separates the direct effects from the indirect effects through other related characters by partitioning the correlation coefficients. Recent findings on direct and indirect effects through path analysis of lentil have been contradictory in lentil (Singh *et al.* 1970; Nandan and Pandya 1980; Chauhan and Sinha 1982; Singh 1977; Tikka *et al.* 1977; Sarwar *et al.* 1982; Kumar *et al.* 1983).

This study was made to determine the association of seed yield with its components and some developmental traits, using path coefficient analysis.

Materials and Methods

Forty elite mutants were selected from mutants induced by separate and simultaneous applications of gamma rays and nitrosomethyl urea (Dixit and Dubey 1983 a; and 1983 b). M_3 populations were planted in a randomized row design with five replications. Observations were recorded for eight characters: plant height, number of branches/ plant, number of leaves/plant, time to maturity, number of pods/ plant, number of seeds/pod, 200-seed weight, and seed yield/plant. Phenotypic correlations between various traits were calculated in the usual manner and path coefficient analysis was carried out according to the method of Dewey and Lu (1959).

Results

Table 1 shows the correlation coefficients of seed yield with its components and estimates of the direct and indirect effects of path coefficients.

Pod number: Number of pods/plant had the greatest direct effect on seed yield (0.568). Its indirect effects were positive through plant height, branches, leaves, and seeds/ pod, but negative and low through 200-seed weight and maturity period. The strong direct effect of number of pods/plant was the main reason for the strong positive correlation (0.878) of this character with seed yield.

Plant height: The correlation between plant height and seed yield was positive (0.833), coming second to that of the pod number. Its direct effect was also positive and high (0.495). Plant height had negligible positive indirect effects on yield via most of the characters except for via pods/ plant, which was comparatively high (0.326). The indirect effect through time to maturity was negative and negligible.

Number of branches: Number of branches had a low but positive direct effect on seed yield (0.062). The indirect effects were positive through all the characters except for 200-seed weight, which showed a negative and negligible indirect effect. The correlation value was positive and significant (0.255). The main factor for positive correlation was the substantial positive indirect effect via pods/plant.

Plant height and number of branches were the next most positive direct contributors toward seed yield after number of pods, probably because of their large indirect positive effects via pods/plant. This clearly indicates that as the number of branches and plant height increase, the total number of pods/plant increases because of the greater number of potential pod bearing nodes.

Leaf number: The direct effect of number of leaves on yield was positive and low (0.003). The indirect effects were positive and comparatively high via pods/plant (0.286) and plant height (0.170), while they were negligible via other characteristics. Thus, the high positive correlation value between yield and leaf number (0.476) is mainly due to the indirect effects via pods/plant and plant height.

Table 1. *Path analysis showing the direct and indirect effects of seven characters on lentil yield.*

Characters	Indirect effects via							Correlation value with yield
	Plant height	Number of branches	Number of leaves	Time to maturity	Number of pods	Number of seeds/pod	200-seed weight	
Plant height	(0.495)	0.007	0.001	–0.013	0.327	0.012	0.004	0.833*
No. of branches	0.052	(0.062)	0.000	0.003	0.137	0.007	–0.007	0.255*
No. of leaves	0.170	0.004	(0.003)	0.007	0.286	0.005	0.000	0.476*
Time to maturity	0.103	–0.003	–0.000	(–0.062)	0.058	0.006	0.001	0.103
No. of pods	0.285	0.015	0.002	–0.006	(0.568)	0.016	–0.001	0.878*
No. of seeds/pod	0.143	0.008	0.000	–0.008	0.174	(0.052)	–0.001	0.369*
200-seed weight	0.051	–0.010	0.000	–0.002	–0.009	–0.001	(0.042)	0.071

Residual effect = 0.367; * = Significant at 5% level of probability.
Figures in parentheses are direct effects on yield.

Seed number: Number of seeds/pod had a positive direct effect on yield with a significant correlation value (0.369). The indirect effects were positive and high via plant height and pod number, but positive and low via branches and leaves. The indirect effects were negligible via 200-seed weight and time to maturity.

Seed weight: The correlation between 200-seed weight and yield was positive but insignificant (0.071). The direct effect of seed weight on seed yield was also positive and low (0.042). The indirect effects were negligible via branches, pods, seeds/pod and time to maturity, while the indirect effect of 200-seed weight was positive through plant height (0.05).

Time to maturity: Time to maturity had a negative direct effect on seed yield, while the correlation value was positive. This was mainly due to strong positive indirect effects through plant height and number of pods; however, its indirect effect was negligible through branches and leaves.

Discussion

Although most earlier reports record a large direct effect of pods/plant on lentil seed yield, information is still contradictory on the contributions of plant height and number of branches. Tikka *et al.* (1977), Sarwar *et al.* (1982), and Kumar *et al.* (1983) recorded a substantial direct effect of plant height, while Chauhan and Sinha (1982) reported a negative direct effect of plant height on seed yield. Similarly, a number of workers observed a large and positive direct effect of number of branches (Nandan and Pandya 1980; Chauhan and Sinha 1982; Kumar *et al.* 1983), while Singh (1977) reported a negative direct effect of this component on yield.

Seed weight showed a positive direct effect of low magnitude in this study, while earlier workers have observed a negative direct effect (Nandan and Pandya 1980; Chauhan and Sinha 1982). Similarly, the slight negative direct effect of maturity period on seed yield observed differs from the results of Chauhan and Sinha (1982), which showed a positive effect. Thus, more studies on a more variable set of genotypes are required to assess the true genetic relationship among lentil characters.

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Factor analysis in *Lens culinaris* Medik

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Abstract

Factor analysis was undertaken of data on 11 variables of 240 Indian germplasm accessions. 90% of variation was explained by four factors. Yield/plant was directly linked with pod numbers/plant and pod size. Pods/plant was linked with plant height and the number of branches. Time to flower and pod breadth negatively affected yield.

Introduction

Factor analysis is a statistical technique for reducing a large number of correlated variables to a few main factors. Factor analysis has been used in marketing research (Tewdt 1952; Shetty 1969) to extract factors affecting correlations. The technique was also utilized effectively by plant breeders (Walton 1972; Denis and Adams 1978; Tikka and Asawa 1981) to improve yield of crop plants by overcoming the limitations of correlation, path-coefficient, and regression analyses. As the factors are uncorrelated, it is possible to study them separately to reach valid conclusions. The objective of this study was to determine the relationship between a number of characters by extracting the minimum number of factors, and also to determine the yield components in lentil.

Materials and Methods

The data comprised average values of five plants of 240 lentil accessions grown at NBPGR Farms, New Delhi and studied for 11 characters (Kumar *et al.* 1983; Sapra *et al.* 1984). A number of factoring methods were tried with and without iterations, using different methods of rotation. However, Rao's canonical factoring method with iterations, using the Eqimax method of rotation, was chosen to interpret the observed phenomenon. Twenty-five iterations were used, which gave accuracy up to the second or third digit.

Results and Discussion

The variation in, and correlations between, the eleven characters were discussed earlier (Kumar *et al.* 1983). Percentages of variation explained by the four factors were 39.4, 30.9, 16.1, and 13.6, respectively. Thus, nearly 70% of the variation in the dependence structure was explained by the first two factors and the remaining 30% by the other two factors. The estimates of communality; i.e. the amount of a variable's variation accounted for by the common factors together, were very low for the variables of time to maturity (0.04), pod length (0.15), seeds/pod (0.04), and yield/plant (0.09); and comparatively low for 100-seed weight (0.33) (Table 1). In other words, the variation for these variables is mainly accounted for by specific factors.

Factor I, accounting for 39.4% of the variation, included the characters of vegetative importance; i.e., primary branches (0.72) and secondary branches (0.89). Factor II consisted of two negatively correlated variables i.e., time to flowering (0.84) and 100-seed weight (0.55). Factor III was made up of plant height (0.89) and pods/plant (0.55), whereas factor IV consisted only of pod breadth with a very high loading (0.93).

Yield/plant had a small loading, on factor I (0.19) and factor II (0.22), revealing the complex nature of the character. Length of pod was similar; since pods/plant had a moderately high loading (0.15), it is also a complex character to some extent. 100-seed weight was also complex.

In addition, factor analysis suggested that some pairs of the highly correlated characters were included in the same group. For example, secondary branches and pods/plant, with a significant correlation coefficient (0.44), were listed under different groups.

Table 1. *Eqimax rotated factor matrix.*

Character	Factor I	Factor II	Factor III	Factor IV	Communality
Time to flowering (days)	–0.24	0.84	0.23	0.08	0.82
Time to maturity (days)	0.12	0.14	–0.09	0.00	0.04
Plant height (cm)	0.04	–0.23	0.89	–0.03	0.84
Primary branches	0.72	–0.21	0.13	–0.19	0.62
Secondary branches	0.89	0.10	0.27	–0.06	0.88
Pods/plant	0.33	0.15	0.55	0.08	0.44
Pod length (cm)	–0.20	0.01	0.02	0.32	0.14
Pod breadth (cm)	0.13	–0.18	–0.11	0.93	0.93
Seeds/pod	0.12	0.05	0.12	0.09	0.04
Yield/plant (gm)	0.05	–0.08	0.19	–0.22	0.09
100-seed weight (gm)	–0.06	–0.55	0.13	0.07	0.32

It is evident from the factor analysis that yield/plant is directly linked with pods/plant and pod size. Pods/plant, in turn, is linked with secondary and primary branches and also with plant height. Time to flowering had a positive loading, and 100-seed weight had a negative loading on factor II. This indicates that the first character exerted negative pressure on seed size and thus negatively affected yield. Pod breadth also adversely affected yield.

This study, resulting in four main factors, has established the complex nature of some characters and has sorted out the components of lentil yield. Some of these findings have been supported by Tikka *et al.* (1981).

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A triploid plant in lentil (*Lens culinaris* Med.)

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Abstract

A triploid plant was obtained by crossing two translocation heterozygotes, one with a ring of six chromosomes and the other with a ring of four chromosomes. The frequency of trivalents was fairly high at 2.4/cell at metaphase I, suggesting the autotriploid nature of the triploid.

Introduction

Intensive studies were carried out for five years in the laboratory at Meerut University, Department of Agricultural Botany, on cytogenetics of lentils (*Lens culinaris* Med.) to obtain a complete set of simple primary trisomics and a translocation tester set. Progress made in this direction has been reported (Gupta and Singh 1981 a, 1981 b, 1982).

We have produced, maintained, and studied autotetraploids (Gupta and Singh 1982; Sharma *et al.* 1983). During the last three years, these autotetraploids were crossed with normal diploids to produce triploids for the production of primary trisomics. The reciprocal crosses between autotetraploids and diploids failed, however. At the same time , in the hybrid progeny of crosses made between interchange heterozygotes to produce multiple translocations, a triploid plant was obtained and utilized for the study of meiotic behavior reported here.

Materials and Methods

Seeds of 10 selected translocation heterozygotes showing one quadrivalent were irradiated with a 300 Gy dose of gamma rays. Plants with multiple translocations were screened through meiosis of sterile plants showing a high level of pollen sterility. The triploid plant was obtained from a cross between two translocation heterozygotes, one with a ring of six chromosomes and the other with a ring of four (the latter the male parent). Standard cytological techniques were followed for the study of meiosis. Photomicrography was used and data were recorded on meiotic configuration at metaphase-I.

Results and Discussion

Table 1 shows the results of meiotic analysis of the triploid plant at metaphase-I. As seen, a quadrivalent with a mean frequency of 0.10/cell was found, which could be attributed to the presence of interchange heterozygosity involving a small segment. The frequency of trivalents is fairly high (Figs. 1-4), suggesting the autotriploid nature of the plant. The frequency of trivalents in this triploid ($x = 7$; $2n = 21$) is comparable to the mean trivalents/cell (1.9-3.3) in the triploids of *Cynodon dactylon* ($x = 9$; ($2n = 27$) studied earlier (Gupta and Srivastava 1970). The triploid plant was used as a female parent in crosses with diploids. Meristems of this triploid are also being used for tissue culture to raise additional triploid plants for use in crosses with diploids.

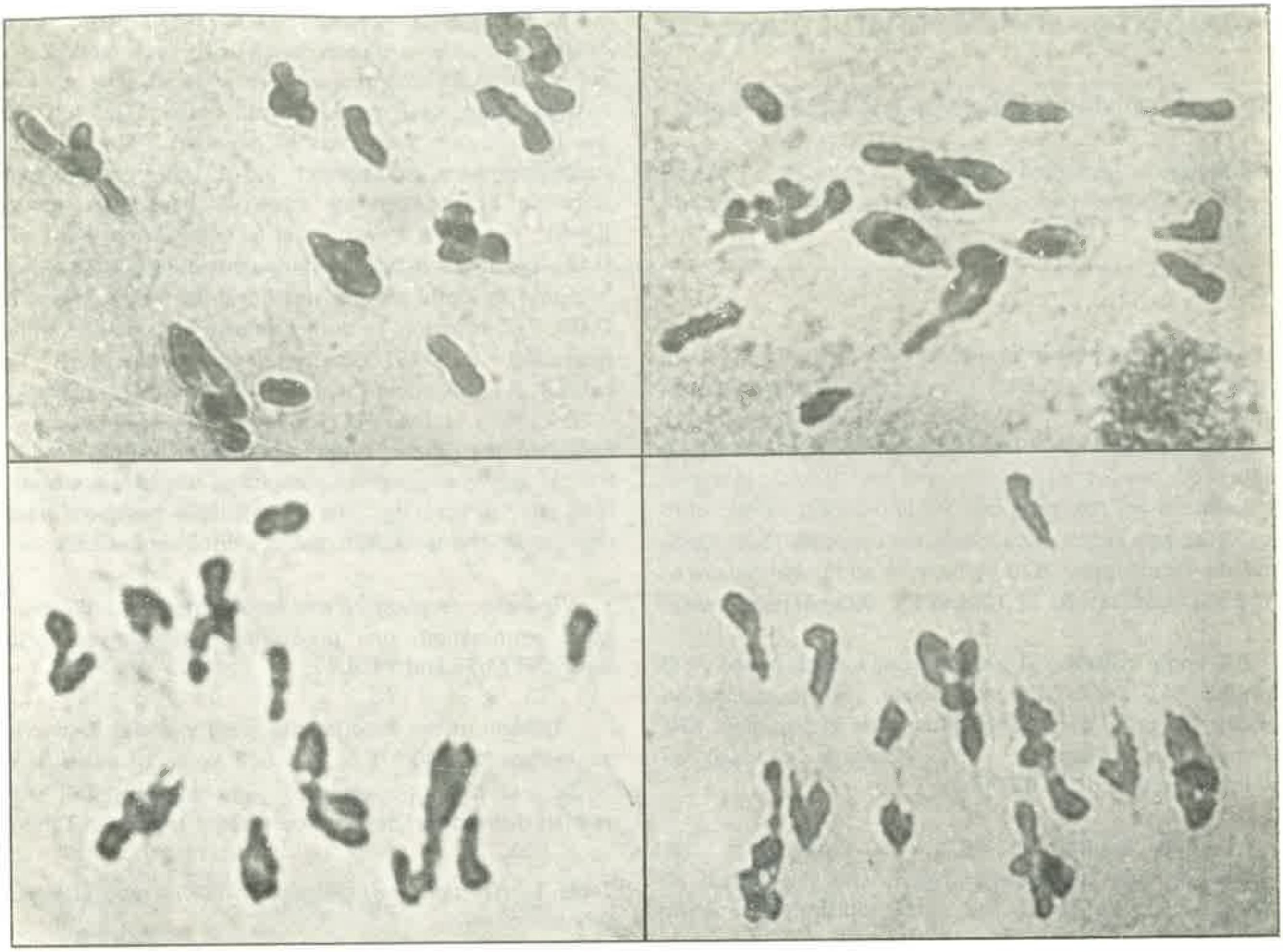

Fig. 1 - 4. *Chromosome associations (MI) in triploid lentil*

Fig. 1. $2^{III} + 5^{II} + 5^{I}$ **Fig. 2.** $2^{III} + 6^{II} + 3^{I}$ **Fig. 3.** $1^{IV} + 3^{III} + 2^{II} + 4^{I}$ **Fig. 4.** $1^{IV} + 1^{III} + 6^{II} + 2^{I}$

Table 1. *Chromosome associations in triploid lentil (Lens culinaris Med.).*

Ploidy level	Chromosome association				Pollen fertility %
	I	II	III	IV	
Diploid					
(2*n* = 14)	—	7	—	—	100.00
Triploid	(1-7)	(2-9)	(0-4)	(0-1)	15.71
(2*n* = 3*x* = 21)	2.90	5.25	2.40	0.10	

Range in parentheses.

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Agronomy and Mechanization

Response of lentil to irrigation and fertility levels

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Abstract

The response to irrigation and fertility levels in the lentil variety JLS-1 was studied during three growing seasons from 1974 to 1977. Two double irrigation schedules were studied; the first with one irrigation at the pre-flowering stage and one at pod-filling, and the second with one irrigation at pre-flowering and one at post-flowering. Both schedules gave higher seed yield; the first gave 1590 kg/ha and the second gave 1570 kg/ha, with additional returns of Rs 1963 (US$ 1 = Rs 12.75) and Rs 1903/ha, respectively.

A single irrigation at pre-flowering increased seed yield by 10.0, 24.0, and 50.6% , respectively, over the application of one irrigation at post flowering, pod filling stage, and control (no irrigation). This schedule provided an additional return of Rs 1214/ha.

Fertility level of 25 kg N + 50 kg P_2O_5/ha with inoculation gave significantly higher seed yield than all other levels with Rs 333/ha of additional economic return over the control. Application of two irrigations one at pre-flowering and one at post-flowering stages at a higher fertility level—showed an increase in seed yield of 134.1% over the control (no irrigation or fertilizer).

Introduction

Lentil is second in importance only to gram among winter pulse crops in Madhya Pradesh. Lentil is grown on an area of 301.7 thousand hectares scattered over widely diverse agro-climatic conditions with annual production of 112.5 thousand metric tons (MPDA 1982). Moisture and fertility status are the primary factors limiting crop production. Lack of moisture at critical growth stages can adversely affect the crop. This paper reports the results of an investigation on the influence of irrigation and fertility levels on lentil yield.

Methods and Materials

A field study was carried out at the Research Farm of Jawaharlal Nehru Krishi Vishwa Vidyalala, Campus of RAK College of Agriculture at Sehore for three years during the winter seasons of 1974-77. The experiment was carried out in a split-plot design with four replications. Six irrigation treatments were given in main plots and four fertility levels were tested in sub plots. The sub plot was 3.0 x 5.0 m with rows 30 cm apart. The irrigation treatments were I_1, control (no irrigation); I_2, single irrigation at pre-flowering stage 45 days after sowing (DAS); I_3, single irrigation at post-flowering stage (75 DAS); I_4, single irrigation during pod filling (85 DAS); I_5, irrigation at both pre-and postflowering stages (45 + 75 DAS); I_6, irrigation at both preflowering and pod filling stages (45 + 85 DAS). The fertility treatments were: F_1, control; F_2, inoculation with IARI culture; F_3, inoculation + 25 kg N/ha as urea; F_4, inoculation + 25 kg N/ha + 50 kg P_2O_5/ha as simple super phosphate. The fertility treatments were applied at plough soil depth near the seed rows prior to planting. The variety JLS-1 was sown in late October on the same field, but at a different site each year.

The crop received 70 mm water/irrigation. To ensure good germination, one pre-sowing irrigation was given during 1974/75 and 1976/77.

The soil of the experimental plots was clay loam with an average of 240, 15.6, and 532 kg/ha of available N, P_2O_5 and K_2O, respectively; and with pH 7.6. The rainfall distribution during crop seasons is given in Table 1.

Table 1. *Rainfall (mm) distribution during crop season at Sehore.*

Month	1974/75	1975/76	1976/77
Oct	–	74.40	–
Nov	–	–	8.51
Dec	–	–	–
Jan	0.40	–	–
Feb	1.10	–	39.60
Mar	–	–	9.80
Apr	–	–	10.10
Total	1.50	74.40	68.01

Results and Discussion

Irrigation significantly increased seed yield (Table 2). On the average, two irrigations yielded more than the other treatments. Irrigation increased plant height, 100-seed weight, and the number of pods/plant, but the effect on pod number did not reach the 5% significance level. These results concur with those of Panwar and Paliwal (1975), Ojha (1977), and Yusuf *et al.* (1977).

Table 2. *Lentil seed yield under different irrigation and fertility levels.*

Treatment	Seed yield kg/ha			Pooled data of 3 years			
	1974/75	1975/76	1976/77	Pooled	Height/ plant (cm)	Number of pods/ plant	100-seed weight (g)
Irrigation (I):							
I_1. Control (no irrigation)	1051	795	751	866	32.94	42.82	2.96
I_2. At pre-flowering stage (45 DAS)*	1446	1223	1244	1304	36.04	51.68	2.98
I_3. At post-flowering stage (75 DAS*)	1388	1051	1118	1186	36.57	56.07	2.95
I_4. At pod-filling stage (85 DAS*)	1183	880	1079	1052	35.11	48.29	3.08
I_5. At pre-flowering and post-flowering stages	1661	1507	1532	1567	39.30	61.17	2.99
I_6. At pre-flowering and pod-filling stages	1614	1430	1717	1587	38.19	55.50	3.01
S.F. ±	81	62	67	41	0.84	4.94	0.019
C.D. at 5%	243	188	200	115	2.37	–	0.054
Fertility Level (F):							
F_1. Control (no irrigation)	1304	1068	1056	1143	33.02	40.64	2.93
F_2. Inoculation (IARI culture)	1308	1090	1171	1190	36.15	52.21	2.98
F_3. Inoculation + 25 kg N/ha	1465	1158	1277	1300	37.83	58.36	3.04
F_4. Inoculation + 25 kg N + 50 kg P_2O_5/ha	1485	1283	1456	1405	38.44	59.13	3.04
S.E. ±	38	43	22	21	0.42	2.02	0.016
C.D. at 5%	108	121	63	57	1.17	5.59	0.044

*DAS: Days after sowing.

Among the single irrigation treatments, the pre-flowering irrigation gave the highest seed yield. Any delay in irrigation after 45 days sowing resulted in a reduced seed yield. Thus, irrigation after 75 days gave a loss of 9% seed yield in comparison with irrigation after 45 days; and irrigation after 85 days showed a decline of 19%

The 100-seed weight, however, was significantly higher when irrigation was given at pod-filling than at other stages. Similar observations were reported by IARI (1977), Mehratra *et al.* (1977), and Yusuf *et al.* (1977).

Fertility levels: Fertilizer application increased seed yield. Application of 25 kg N + 50 kg P_2O_5/ha along with a seed treatment with rhizobium culture (F_4) gave significantly higher seed yield than all other levels during the last two crop seasons (1975-77). During the 1974/75 season, however, this application did not give significantly higher yields over inoculation + 25 kg N/ha dose (F_3). This fertility level gave on the average 22.9, 20.0, and 8.1% higher seed yield than F_1, F_2, and F_3 levels, respectively. It increased plant height by 16.4 and 10.6% , and pods/plant by 45.5 and 13.3% over F_1 and F_2, respectively. However, fertility levels of inoculation + 25 kg N/ha, and inoculation + 25 kg N + 50 kg P_2O_5/ha, had almost the same effect on plant characters. These results corroborate the findings of Sharma (1970), Mahajan *et al.* (1972), and Ojha *et al.* (1977).

Table 3. *Interaction effect (3 years pooled data) of irrigation and fertility level with lentil seed yield (kg/ha).*

Irrigation	Fertility level Control	Inoculation (IARI)	Inoculation + 25 kg N/ha	Inoculation + 25 kg N + 50 kg P_2O_5/ha
Control (no irrigation)	806	816	926	915
At pre-flowering stage (1)	1260	1187	1356	1424
At post-flowering stage (1)	1043	1170	1246	1286
At pod-filling stage (1)	930	1018	1061	1197
At pre-flowering + post flowering stages (2)	1360	1407	1615	1887
At pre-flowering + pod filling stages (2)	1459	1542	1597	1751
	I* x F**	F x I		
S. Em. ±	60	50		
C.D. at 5%	165	140		

*I: Irrigation

**F: Fertility

Table 4. *Yield (3 year mean) and economic analysis of lentil under different irrigation and fertility levels.*

Treatment	Seed yield (kg/ha)	Increase over control (kg/ha)	Value of additional produce (Rs/ha)	Additional expenditure over control (Rs/ha)	Additional return (RS/ha)
Irrigation:					
Control (no irrigation	866	–	–	–	–
At pre-flowering stage	1304	438	1324.00	100.00	1214.00
At post-flowering stage	1186	320	960.00	100.00	860.00
At pod-filling stage	1052	186	538.00	100.00	458.00
At pre-flowering + post flowering stages	1567	701	2103.00	200.00	1903.00
At pre-flowering + pod filling stages	1587	721	2163.00	200.00	1963.00
Fertility level:					
Control (no fertilizer)	1143	–	–	–	–
Inoculation	1190	47	143.00	20.00	121.00
Inoculation + 25 kg N/ha	1300	157	471.00	150.75	320.25
Inoculation + 25 kg N + 50 kg P_2O_5/ha	1405	262	786.00	453.25	332.75

Cost of lentil at Rs 300/kg, N at Rs 5.26/kg, P_2O_5 at Rs 6.05/kg, and irrigation Rs 100/irrigation (70 mm).

Significant interaction: The interaction effect of irrigation and fertility level on seed yield was significant (Table 3). Both schedules of two irrigations gave higher seed yield than all other irrigation treatments at each fertility level. Among schedules with one irrigation, irrigation at pre-flowering stage produced significantly higher grain yields at each fertility level than did late irrigation at pod-filling stage. The crop responded more to higher fertility levels when the supply of moisture increased. The maximum seed yield of 1887 kg/ha was achieved when the crop was irrigated twice, at flowering and post-flowering stages, and at the highest fertility level, showing 134.1% increase in seed yield over the control (no fertilizer or irrigation).

Economic analysis: The economic analysis of various treatments based on the three year mean and rates prevailing at harvest during 1983 is presented in Table 4.

Both schedules of two irrigations gave net returns of more than Rs 1900/ha over the control of no irrigation. One irrigation at pre-flowering stage resulted in a net return of Rs 1214/ha. Returns decreased by Rs 354 with irrigation at post-flowering stage and by Rs 756/ha with irrigation at pod filling. Fertilizer levels of F_3 and F_4 gave additional returns of Rs 320 and 333/ha, respectively, over control (no fertilizer).

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Late-sown lentil in Bihar, India

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Abstract

The potential of late-sown lentils in Bihar, India was tested in an experiment with 12 genotypes in the 1983/84 season. A mean yield of kg/ha was realized indicating the potential of late-sowing.

Microsperma, a subspecies of *Lens culinaris* grown on the plains of India, is classified by seed size into small-seeded or large-seeded. Lentil is one of the important winter pulse crops of Bihar along with chickpea and *Lathyrus sativus*. The major large-seeded lentil growing area is southern Bihar, south of the river Ganges. Lentil sowing starts there by the end of October in summer (June-Oct) fallows. In North Bihar, where soil is calcareous and loam to sandy loam in texture, small-seeded lentil is grown and sowing starts in the second week of November. Generally, lentil is sown alone or as a mixed crop after harvest of summer crops. Sometimes, lentil sowing is delayed due to late harvesting of summer crops. Also the monsoon ceases earlier in some years, leaving insufficient soil moisture for preparatory tillage. Under these conditions, delayed winter pulse sowing can be expected. If it rains or a farmer gives one irrigation for field preparation, lentil can be sown as late as the end of November. But because a suitable variety is not available for these conditions, the lentil area is not increasing.

To select suitable varieties, a number of released and pre-released varieties were tested under late-sowing at Dholi Farm of Rajendra Agricultural University, Bihar. The 12 tested small-seeded varieties were the local check BR 25, previously released for these conditions, and the national checks: Pant L 406, Pant L 639; and L 9-12; the pre-released varieties developed at this center: RAU 101, DL 221, and DL 315; varieties from Ludhiana (Punjab): LL-56, LL-78, and LL-153; L 1304 from Delhi; and VL 1 from Almora, U.P. The seeds were sown on 30 November 1983 in a randomized complete block design with three replications. Plots were 7 m^2 and the harvested area was 5 m^2. The crop was grown on residual fertility after rice. One inter-row cultivation was done a month after sowing. It rained twice during the growing season, which is normal for the region.

The pre-released variety RAU 101 gave the highest yield. Although the other two high-yielding varieties were LL 78 and L 9-12 from Ludhiana (Punjab), they were insignificantly superior to varieties BR 25, Pant L 406, LL 56, and LL 153 (Table 1).

Table 1. *Time to maturity (days) and seed yield (kg/ha).*

Variety	Time to maturity	Seed yield
RAU 101	110	1557
LL 78	110	1353
L 9-12	108	1323
BR 25	100	1293
Pant L 406	105	1253
LL 153	115	1200
LL 56	102	1163
DL 315	100	1163
Pant L 639	106	1083
DL 221	100	1050
VL 1	104	1010
L 1304	106	967
C.D. at 5%		203

Yields under late sowing are generally lower than under normal sowing. However, all varieties tested yielded higher than the state average of 604 kg/ha. The low average may be attributed to poor crop management.

Physiology and Microbiology

Photoperiodic response of some diverse genotypes of lentil (*Lens culinaris* Med.)

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Abstract

Photoperiodic response of a large number of lentil (*Lens culinaris* Med.) genotypes from diverse geographical regions was studied in pot culture in a plastic house. The plants were exposed to three photoperiods: "short day" (8 hrs light period), "normal day" (13.5 - 14.4 hrs light period in summer, 1978 , and 9.5 - 13.5 hrs light period in winter, 1978/79), and "long day" (15 hrs light period in summer, 1978 and 16 hrs in winter, 1978/79). All genotypes behaved as "long day" plants, although they differed in the length of their critical photoperiod and quantitative response to "long day." The genotypes originating from lower latitudes (Ethiopia, Sudan, Egypt, and India) had a shorter critical day length than the genotypes from higher latitudes.

Introduction

Photosensitivity is one of the factors responsible for the narrow adaptability of most local lentil (*Lens culinaris* Med.) cultivars (Hawtin 1979). Reduced photosensitivity is thus an important attribute in breeding for wider adaptability.

A few photoperiodic studies have been reported but on a limited number of genotypes. Shukla (1955) and Moursi and Gawad (1963) used one genotype each and Saint-Clair (1972) studied the response of two genotypes. These studies concluded that lentil behaved as a "long day" plant. They also showed that genotypes differed markedly in the length of their critical photoperiod and in the magnitude of hastening the onset of their reproductive growth in longer photoperiods. This encouraged us to conduct studies on the photoperiodic response of a large number of lentil genotypes originating in diverse geographical regions from a wide range of latitudes. Our objective was to identify partially photosensitive or photo-insensitive genotypes.

Materials and Methods

The study started in the summer of 1978. Thirty-two genotypes from diverse geographical regions were planted on 1 April 1978 in pots using a soil and sand medium in a small plastic house in Aleppo (36.1^{o}N latitude). Germination occured in six days. A set of five plants was maintained/pot. The pots were all kept under natural day length up to 25 days after planting, until the five-leaf stage was reached. Thereafter, they were subjected to three photoperiodic treatments:

i) Normal day: light period ranging from 13.5 hrs at the onset of the differential treatment to 14.4 hrs at the end of the experiment;

ii) Long day: 15 hrs light period provided by supplementing the normal day length with flourescent lamps from 5 A.M. to 8 P.M.;

iii) Short day: 8 hrs light period provided by cutting off natural light before 8 A.M. and after 4 P.M. by using a dark cotton cloth cover. Such a cover was used to ensure adequate ventilation.

Two pots/genotype were kept under each of the photoperiodic treatments. The maximum and minimum values for air temperature in the plastic house, averaged over five days, are given in Table 1. Temperature differed little in different sections of the plastic house. The temperature, increasing as the season advanced, became too high by the middle of June to permit continued satisfactory growth, so the experiment was terminated by 17 June 1978. However, several genotypes reached maturity by then in "normal" and "long day" conditions.

The experiment was repeated during the winter season of 1978/79. Thirty-six genotypes, most of them studied earlier, were planted on 6 December 1978. Germination was complete by 16 December 1978. The plants were grown in a plastic house under uniform "normal day" condition up to 10 January 1979. As in the previous study, differential photoperiodic treatment began on 11 January

Table 1. *Mean maximum and minimum temperatures (C^{O}) in the plastic house for different photoperiodic treatments during summer, 1978 and winter, 1978/79.*

	Summer 1978					Winter 1978/79			
	Normal and short day		Long day			Normal and short day		Long day	
Date	Max.	Min.	Max.	Min.	Date	Max.	Min.	Max.	Min.
Apr 1-5	37.0	11.9	39.0	10.8	Jan 1-5	31.0	9.3	31.0	8.6
6-10	39.3	12.6	30.7	12.3	6-10	12.6	4.3	12.3	4.0
11-15	41.6	13.3	42.0	13.0	11-15	24.0	6.0	25.0	6.3
16-20	32.0	10.2	33.5	11.5	16-20	19.0	8.6	23.3	8.0
21-25	31.5	8.2	30.3	9.0	21-25	14.6	6.0	30.2	6.0
26-30	35.3	11.6	38.0	10.3	26-31	34.5	8.0	39.0	7.5
May 1-5	43.6	18.0	43.0	18.0	Feb 1-5	35.4	7.8	37.4	7.0
6-10	41.0	14.0	41.6	14.0	6-10	28.8	12.4	29.4	12.1
11-15	39.0	15.3	39.0	14.0	11-15	31.7	12.3	28.5	11.8
16-20	42.0	17.0	40.0	17.0	16-20	33.3	11.8	32.7	12.8
21-25	43.0	15.0	42.0	15.0	21-25	26.6	9.0	26.3	8.5
26-31	46.0	20.0	46.0	19.0	25-28	31.0	9.0	33.0	9.0
Jan 1-5	45.0	20.0	44.5	19.0	Mar 1-5	28.6	6.5	32.0	9.0
6-10	47.0	21.0	46.5	19.5	6-10	28.1	8.6	22.1	8.0
11-15	45.0	20.0	45.0	19.5	11-15	36.4	10.8	32.4	11.8
16-20	46.0	20.5	45.0	20.0	16-20	39.6	15.3	39.2	13.2
21-25	47.0	19.5	46.5	19.0	21-25	27.2	14.8	31.0	13.1
					26-31	36.8	10.4	31.0	9.0
					Apr 1-5	37.9	16.6	37.3	17.7
					6-10	40.1	15.3	39.5	15.4
					11-15	36.2	13.4	38.4	12.3
					16-20	44.3	15.3	45.3	17.3
					21-25	40.3	19.5	39.7	16.3
					26-30	45.5	14.2	45.1	12.7

1979 (i.e. 36 days after planting). The day length under "normal day" ranged from 9.75 hrs at the start of differential treatment to 13.5 hrs at the termination of the experiment (end of April 1979), whereas day length under "long day" was 16 hrs (4 A.M. - 8 P.M.). The temperatures during the first three months of the experiment were relatively lower than those to which the 1978 summer crop was exposed. During April, however, temperatures became quite high and the experiment had to be terminated by the end of the month. Most of the genotypes under "long day" and many under "normal day" had reached maturity by then.

The number of days from planting to the appearance of one well-differentiated flower bud in each of the five plants/pot were recorded to evaluate the genotypic differences in photoperiodic response. Table 2 gives the averages for 10 plants/treatment.

Results and Discussion

Summer 1978

No genotype began reproductive growth under the 8 hr photoperiodic condition. Under "long photoperiod," on the other hand, all genotypes started the reproductive phase. Thus, the tested genotypes were all photosensitive and behaved as "long-day" plants.

All the genotypes except four (ILL-92, -119, -504, and -854) reached the reproductive phase under "normal day" condition.

The vegetative phase under "normal day", in general, was longer than that under "long day". However, there were conspicuous genotypic differences. Eight genotypes (ILL-44, -206, -242, -342, -851, -2526, -2530, and -4353) attained the reproductive phase at the same time under "normal day" as under "long day". Five additional genotypes (ILL-6, -35, -54, -213, and -244) showed a little hastening (2 - 4 days) in their reproductive growth under "long day". In the remaining genotypes, the hastening of reproductive growth was of much larger magnitude (6 - 30 days), and four of these genotypes did not form flower buds under "normal day" (maximum day length 14.4 hrs) until the experiment was terminated (78 days after planting). Thus, the tested genotypes showed a wide range in their long day response, some with qualitative long day requirement and others with varying degrees of quantitative response.

The study also revealed that genotypes originating from lower latitudes, particularly from Ethiopia and India, started reproductive growth very early, whereas those from the USSR and Turkey began much later. As mentioned earlier, the genotypes ILL-92 and ILL-504 (both from USSR) and ILL-183 (from Turkey) did not reach the reproductive phase under "normal day" by the time the experiment ended.

Winter 1978/79

As in the summer of 1978, none of the genotypes during the winter of 1978/79 showed reproductive growth under 8 hrs photoperiod, whereas under "normal day" and "long day", all the genotypes showed reproductive growth (Table 2). Even those four genotypes that had failed to reach the reproductive phase under "normal day" in summer, 1978 began flowering during the winter season of 1978/79. The maximum day length to which they were exposed under "normal day" in summer, 1978 was higher than that reached in the winter of 1978/79. Therefore, lack of critical day length was not the reason for the failure of reproductive growth to begin under "normal day" in summer, 1978. Perhaps the required number of cycles of critical day length to which the genotypes should have been exposed before reproductive growth could start were not undergone in summer, 1978 because the experiment had to be terminated 78 days after planting. For these four genotypes, days to first flower bud under "normal day" during winter, 1978/79 ranged from 98 (ILL-504) to 116 (ILL-854), which supports the above inference. However, the possibility that the prevailing temperature and photoperiod interacted to cause this differential response cannot be ruled out.

The genotypes took longer to reach the stage of first flower bud under "normal day" and "long day" during winter, 1978/79 than during summer, 1978. The temperature differences between the two seasons could have been the cause.

The magnitude of hastening in the onset of reproductive growth under the "long day" treatment was greater during winter, 1978/79 than in summer, 1978. Larger differences between the photoperiod of "normal" and "long day" during winter, 1978/79 may be partly responsible for this.

The general trend in the genotypic differences in the hastening of reproductive growth because of "long day" was more or less similar to that in summer, 1978, although some genotypes (ILL -44, -206, -242, -244, -504, -851, and -2530) showed conspicuous deviations. In both studies, genotypes ILL-204 (Ethiopia), ILL-324 (Italy), and ILL-2526 (India) showed little or no hastening effect owing to "long day".

The genotypes that took longer to flower under "normal day" also showed the most hastening in the onset of reproductive growth under "extended day". Their critical day length should be relatively much higher than those that flowered earlier under "normal day".

Table 2. *Effect of photoperiodic treatments on the response of some diverse lentil genotypes, measured by time to first flower budding (days).*

			Days from planting to first flower bud					
			Summer 1978			Winter 1978/79		
No.	Genotype	Origin	Normal day	Long day	Difference	Normal day	Long day	Difference
1.	ILL-6	Jordan	48	44	4	91	74	17
2.	ILL-20	Jordan	48	41	7	94	70	24
3.	ILL-25	Syria	44	41	3	96	75	21
4.	ILL-44	Syria	41	41	0	97	75	22
5.	ILL-54	Iraq	39	37	2	84	75	9
6.	ILL-58	Iraq	53	44	9	102	75	27
7.	ILL-92	USSR	*	62		111	98	13
8.	ILL-119	Turkey	*	48		106	86	20
9.	ILL-183	Turkey	77	62	15	107	87	20
10.	ILL-204	Ethiopia	35	33	2	89	84	5
11.	ILL-206	Ethiopia	41	41	0	83	71	12
12.	ILL-213	Afghanistan	39	37	2	101	78	23
13.	ILL-215	Afghanistan	65	48	17	101	91	10
14.	ILL-242	Iran	39	39	0	98	79	19
15.	ILL-244	Pakistan	52	48	4	98	77	21
16.	ILL-296	Greece	66	55	11	-	-	-
17.	ILL-305	Greece	68	56	12	107	79	28
18.	ILL-340	Spain	77	52	25	100	76	24
19.	ILL-341	Italy	55	43	12	97	75	22
20.	ILL-342	Italy	33	33	0	71	67	4
21.	ILL-360	Chile	77	47	30	107	77	30
22.	ILL-364	Chile	48	42	6	94	73	21
23.	ILL-496	Mexico	53	44	9	91	77	14
24.	ILL-504	USSR	*	62		98	96	2
25.	ILL-598	USSR	62	52	10	102	81	21
26.	ILL-764	Iran	65	56	9	108	81	27
27.	ILL-776	Iran	66	56	10	98	78	20
28.	ILL-784	Egypt	-	-	-	77	69	8
29.	ILL-828	Egypt	-	-	-	76	65	11
30.	ILL-845	Lebanon	-	-	-	108	82	26
31.	ILL-851	Lebanon	48	48	0	89	76	13
32.	ILL-854	Algeria	*	48		116	92	24
33.	ILL-1861	Sudan	-	-	-	70	64	6
34.	ILL-2526	India	36	36	0	81	76	5
35.	ILL-2530	India	32	32	0	82	71	11
36.	ILL-4353	India	34	34	0	-	-	-
37.	ILL-4400	Syria	-	-	-	102	79	23
38.	ILL-4401	Syria	-	-	-	100	68	34

* Did not form flower bud by the time experiment was terminated (17 June 1978).

\- Genotype not included in the study.

The genotypes ILL-1861 (Sudan), ILL-784 and -828 (Egypt), ILL-342 (Italy), ILL-2526 and -2530 (India), ILL-206 (Ethiopia), and ILL-54 (Iraq) took the shortest period (48-70 days) to reach the first flower bud stage under "normal day" during winter 1978/79. The hastening in the onset of reproductive growth in these genotypes ranged from four days (in ILL-342) to 12 days (in ILL-206) under "long day", thus reflecting differences in their quantitative response to extended photoperiod. The maximum day length for this group of genotypes under "normal day" ranged from 10 hrs and 45 minutes (ILL-1861 from Sudan) to 11 hrs and 15 minutes (ILL-54 from Iraq).

The above studies showed that all the tested genotypes were photosensitive and behaved as "long day" plants. However, there were large differences in the length of their critical photoperiod. Genotypes originating from lower latitudes, particularly from Ethiopia, Sudan, Egypt, and India, had a shorter critical day length than the genotypes from higher latitudes. The genotypes also differed in their quantitative response to long days. This study has further highlighted that differences in temperature can cause conspicuous changes in the magnitude of photoperiodic response.

Because all the tested genotypes were found photosensitive, more genotypes must be screened to identify "day-neutral" material. At present, the genotypes ILL-1861, -342, -784, and -2526, which require a shorter critical day length and show a lesser quantitative response to "long day", seem promising to introduce wider adaptability into the breeding program.

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Pests and Diseases

Further studies on factors influencing the mechanism of resistance in lentil (*Lens culinaris* M.) to rust (*Uromyces fabae* (Pers.) de Bary)

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Abstract

The differences between four rust-susceptible cultivars and three resistant cultivars were assessed for a range of structural and biochemical parameters. The effect of inoculation with rust on biochemical parameters was also tested. There were no differences between susceptible and resistant cultivars for such structural characters as stomatal density, stomata size, cuticle thickness, and thickness of guard and epidermal cells. Resistant cultivars had more surface wax, phenol, P, K, S, Zn, Fe, and Cu; whereas susceptible cultivars had a higher leaf permeability, and greater content of free amino acids, N, protein, sugars, and Mn.

Introduction

Resistance and susceptibility of a cultivar to a pathogen is governed by morphological, environmental, genetic, anatomical, and biochemical factors. Influence of several factors on the mechanism of resistance to rust (*Uromyces fabae* (Pers.) de Bary) was studied in lentil (*Lens culinaris* M.).

Reddy (1980) studied factors such as cultivar, plant structure, and chemical and biochemical constituents in resistant and susceptible varieties of lentil. He also studied preformed structural and biochemical differences. The present study investigated preformed structural and pre- and post-formed biochemical differences.

Seven varieties were selected for studying the structural characters and biochemical constituents. The resistant varieties were Pant L-639, PLMA-183, and K-75, and susceptible varieties were Bombay-18, HPL-5, JL-1, and Jabalpur local.

Structural Differences

The structural parameters included were: number of stomata on both leaf surfaces, length and width of stomata, thickness of guard and epidermal cells, and cuticle thickness in leaves. The results presented in Table 1 showed no significant differences in the structural characters of susceptible and resistant varieties. Although there were differences between cultivars, these differences were unrelated to disease reaction.

Biochemical Constituents

Resistant lentil varieties contained more leaf surface wax (Table 2) than did susceptible varieties. Electrolyte leakage was higher in susceptible varieties than in resistant ones. In inoculated plants, electrolyte leakage was higher than in uninoculated plants. No quantitative differences were observed for chlorophyll content in resistant and susceptible varieties, although chlorophyll content decreased after inoculation with rust fungus. The quantities of all types of sugars (total, reducing and non-reducing) were greater in susceptible plants than in resistant ones. Sugar content increased in inoculated plants compared to uninoculated ones. Total phenols, orthodihydric phenols, and leucoanthocyanin contents were higher in resistant varieties than in susceptible varieties. Phenolic compounds increased more in all varieties of inoculated plants than in those of uninoculated ones. At advanced stages of infection, leucoanthocyanin content decreased. Susceptible varieties contained more free amino acids and the accumulation was greater in inoculated susceptible varieties. In resistant varieties, only a slight increase in amino acid content was observed.

Table 1. *Variation in structural characters between lentil varieties susceptible and resistant to rust.*

Parameter	Susceptible varieties		Resistant varieties	
	Range	Mean	Range	Mean
1. Stomata number/microscopic field (600 x)				
i. Lower surface	3.00-4.73	3.57	1.66-2.60	2.24
ii. Upper surface	14.98-17.36	15.87	12.33-15.65	14.41
2. Length of stomata	20.34-24.23 μ	22.33	21.82-24.42 μ	22.81
3. Width of stomata	4.80-7.58 μ	5.84	4.80-5.82 μ	5.38
4. Thickness of guard cells	5.91-6.84 μ	6.46	6.65-6.93 μ	6.74
5. Thickness of epidermal cells	17.92-18.19 μ	18.07	17.75-18.09 μ	17.95
6. Thickness of cuticle	1.60-1.62 μ	1.61	1.59-1.63 μ	1.61

Table 2. *Biochemical differences in lentil varieties susceptible and resistant to rust.*

Parameter	Susceptible varieties		Resistant varieties	
	Range	Mean	Range	Mean
1. Leaf surface wax (mg/sq. cm.)				
i. 75 day old plants	0.02-0.03	0.02	0.04-0.08	0.07
ii. 105 day old plants	0.01-0.08	0.07	0.08-0.11	0.10
2. Permeability (μ mhos/sq. cm.)				
i. 75 day old plants:				
Healthy	20.1-29.7	25.1	18.0-20.5	19.2
Inoculated	27.4-38.8	31.9	19.9-24.4	22.1
ii. 105 day old plants:				
Healthy	23.1-30.1	26.9	22.8-24.1	23.3
Inoculated	30.2-39.5	34.2	25.9-26.8	26.3
3. Total chlorophyll (mg/g fresh weight)				
i. 75 day old plants:				
Healthy	2.78-2.87	2.83	2.77-2.93	2.83
Inoculated	2.24-2.52	2.38	2.41-2.87	2.62
ii. 105 day old plants:				
Healthy	2.49-2.58	2.54	2.60-2.76	2.69
Inoculated	1.69-2.35	2.14	2.36-2.53	2.46
4. Chlorophyll 'a' (mg/g fresh wt.)				
i. 75 day old plants:				
Healthy	1.72-1.79	1.75	1.69-1.84	1.75
Inoculated	1.39-1.56	1.48	1.49-1.78	1.62
ii. 105 day old plants:				
Healthy	1.56-1.62	1.59	1.64-1.75	1.68
Inoculated	1.00-1.44	1.30	1.48-1.58	1.55
5. Chlorophyll 'b' (mg/g fresh wt.)				
i. 75 day old plants:				
Healthy	1.05-1.09	1.07	1.07-1.09	1.08
Inoculated	0.84-0.96	0.90	0.92-1.09	1.00
ii. 105 day old plants:				
Healthy	0.93-0.96	0.94	0.45-1.06	1.01
Inoculated	0.65-0.91	0.83	0.88-0.95	0.92
6. Total sugars (mg/g fresh wt.)				
i. 75 day old plants:				
Healthy	56.3-66.3	61.2	46.3-52.0	49.2
Inoculated	67.0-75.0	71.1	51.3-56.0	53.1
ii. 105 day old plants:				
Healthy	43.0-73.0	67.7	49.3-56.3	52.4
Inoculated	49.3-60.3	54.7	41.7-47.3	44.4
7. Reducing sugars (mg/g fresh wt.)				
i. 75 day old plants:				
Healthy	32.3-37.3	34.7	27.3-32.3	29.1
Inoculated	34.3-39.7	37.5	30.0-35.7	32.1
ii. 105 day old plants:				
Healthy	34.3-39.7	36.1	29.7-34.3	32.2
Inoculated	30.7-36.3	33.2	27.7-30.7	29.3
8. Non-reducing sugars (mg/g fresh wt.)				
i. 75 day old plants:				
Healthy	24.0-29.0	26.5	16.0-21.3	18.1
Inoculated	31.0-35.7	33.9	16.0-22.0	20.1
ii. 105 day old plants:				
Healthy	28.7-33.3	30.7	16.7-22.0	20.2
Inoculated	18.7-24.0	21.4	12.0-16.7	15.1
9. Total phenols (mg/g fresh wt.)				
i. 75 day old plants:				
Healthy	14.6-24.1	18.8	25.1-28.6	26.9
Inoculated	19.5-28.1	23.0	26.4-28.9	27.7

ii. 105 day old plants:				
Healthy	12.5-22.2	16.4	24.3-28.2	26.1
Inoculated	27.4-30.3	28.5	27.2-30.2	29.0
10. Ortho-dihydric phenol (mg/g fresh wt.)				
i. 75 day old plants:				
Healthy	3.96-4.28	4.08	5.96-6.75	6.28
Inoculated	4.23-4.78	4.49	6.13-6.83	6.42
ii. 105 day old plants:				
Healthy	3.48-3.96	3.72	5.36-6.83	6.10
Inoculated	3.01-3.46	3.18	4.93-6.18	5.60
11. Leucoanthocyanins (Optical density)				
i. 75 day old plants:				
Healthy	0.56-0.70	0.64	0.71-0.77	0.74
Inoculated	0.59-0.72	0.67	0.75-0.79	0.77
ii. 105 day old plants:				
Healthy	0.51-0.58	0.55	0.64-0.65	0.65
Inoculated	0.49-0.62	0.57	0.67-0.75	0.72
12. Total amino acids (mg/g fresh wt.)				
i. 75 day old plants:				
Healthy	9.74-9.93	9.79	9.15-9.25	9.19
Inoculated	11.09-12.26	11.67	9.29-9.35	9.32
ii. 105 day old plants:				
Healthy	10.02-10.36	10.18	9.26-9.61	9.37
Inoculated	12.39-13.98	13.27	9.72-10.32	10.05
13. Protein (%)				
i. 75 day old plants:				
Healthy	35.62-37.37	36.53	27.02-30.97	28.46
Inoculated	42.87-44.84	44.01	31.93-36.66	33.45
ii. 105 day old plants:				
Healthy	28.93-31.16	30.20	25.25-25.62	25.41
Inoculated	21.29-23.47	22.33	20.39-21.45	20.85

Susceptible lentil varieties contained higher amounts of nitrogen and protein than did resistant varieties (Table 3). Total nitrogen and protein increased initially in inoculated plants, but they decreased when the disease became severe. Healthy plants of resistant varieties contained a higher percentage of phosphorus as compared to healthy plants of susceptible varieties. Phosphorus content decreased in inoculated plants more than it did in uninoculated ones. Lentil varieties resistant to rust contained a higher percentage of potassium compared to susceptible varieties. During initial stages of infection, potassium content decreased, while it increased during advanced stages of infection. Significant increases in calcium and magnesium contents were found in inoculated plants.

Table 3. *Content of elements in rust resistant and susceptible cultivars.*

Parameter	Susceptible varieties		Resistant varieties	
	Range	Mean	Range	Mean
1. Nitrogen (%)				
i. 75 day old plants:				
Healthy	5.69-5.98	5.83	4.29-4.96	4.54
Inoculated	6.86-7.19	7.04	5.06-5.34	5.17
ii. 105 day old plants:				
Healthy	4.64-4.98	4.83	4.04-4.10	4.06
Inoculated	3.42-3.76	3.57	3.27-3.43	3.33
2. Phosphorus (%)				
i. 75 day old plants:				
Healthy	0.25-0.28	0.26	0.29-0.36	0.32
Inoculated	0.22-0.26	0.23	0.26-0.32	0.29
ii. 105 day old plants:				
Healthy	0.21-0.25	0.23	0.27-0.34	0.30
Inoculated	0.17-0.21	0.19	0.23-0.31	0.27
3. Potassium (%)				
i. 75 day old plants:				
Healthy	3.40-4.10	3.97	3.72-4.30	4.00
Inoculated	3.14-4.00	3.64	3.76-4.01	
ii. 105 day old plants:				
Healthy	3.48-3.85	3.48	3.11-3.40	3.23
Inoculated	4.07-4.56	4.25	3.99-4.39	4.18
4. Calcium (%)				
i. 75 day old plants:				
Healthy	3.05-3.77	3.43	3.75-4.26	3.97
Inoculated	3.33-4.06	3.69	3.83-4.32	4.06
ii. 105 day old plants:				
Healthy	3.30-4.28	3.74	3.81-4.46	4.21
Inoculated	3.82-4.35	4.02	4.07-4.40	4.29
5. Magnesium (%)				
i. 75 day old plants:				
Healthy	0.46-0.58	0.50	0.29-0.40	0.34
Inoculated	0.51-0.73	0.63	0.46-0.68	0.58
ii. 105 day old plants:				
Healthy	0.40-0.63	0.49	0.25-0.98	0.37
Inoculated	0.86-0.97	0.90	0.37-0.50	0.45
6. Sulphur (%)				
i. 75 day old plants:				
Healthy	0.13-0.15	0.13	0.16-0.20	0.18
Inoculated	0.16-0.20	0.19	0.19-0.21	0.20
ii. 105 day old plants:				
Healthy	0.11-0.14	0.12	0.11-0.15	0.13
Inoculated	0.08-0.10	0.10	0.10-0.11	0.10
7. Zinc (ppm)				
i. 75 day old plants:				
Healthy	84.22-126.94	100.67	94.06-139.95	109.36
Inoculated	83.65-116.94	113.98	102.38-170.20	138.63

ii. 105 day old plants:				
Healthy	58.64-100.07	76.87	139.22-133.55	131.41
Inoculated	47.87-96.82	61.05	58.68-100.18	81.31
8. Iron (ppm)				
i. 75 day old plants:				
Healthy	128.80-10	148.65	137.93-190.74	158.11
Inoculated	103.61-134.32	116.81	126.44-160.26	139.95
ii. 105 day old plants:				
Healthy	116.17-142.70	130.81	120.43-131.23	125.28
Inoculated	50.45-89.30	63.71	38.81-88.79	57.00
9. Manganese (ppm):				
i. 75 day old plants:				
Healthy	44.66-59.33	49.82	40.33-56.00	48.11
Inoculated	56.00-69.33	63.83	54.00-64.00	60.00
ii. 105 day old plants:				
Healthy	36.00-40.66	38.99	32.33-34.66	33.44
Inoculated	68.00-89.66	76.08	64.33-74.66	69.88
10. Copper (ppm):				
i. 75 day old plants:				
Healthy	11.66-15.00	12.41	9.92-17.00	13.49
Inoculated	7.86-10.23	9.15	9.07-11.33	9.99
ii. 105 day old plants:				
Healthy	14.50-23.75	18.25	18.37-23.20	20.94
Inoculated	9.99-12.48	11.24	10.00-12.15	11.28

The quantities of sulphur and zinc were higher in resistant varieties than in susceptible ones. During initial stages of infection, sulphur and zinc contents increased, while they decreased during advanced stages of infection. Iron and copper were significantly higher in resistant varieties, but decreased after inoculation with rust fungus. Manganese content, higher in susceptible varieties, increased in inoculated plants.

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Reddy, P.N. 1980. Mechanism of resistance in lentil (*Lens culinaris* M.) to rust (*Uromyces fabae* (Pers.) de Bary). M.Sc. thesis. Jawaharlal Nehru Agricultural University, Jabalpur, India.

LENTIL INFORMATION

Lens Bookshelf

The International Center for Agricultural Research in the Dry Areas (ICARDA) Introduces. . .

363 pages, Paperback

LENTIL GERMPLASM CATALOG

By W. Erskine and J.R. Witcombe

ICARDA presents a 363 page catalog designed for all lentil breeders. This work serves as a catalyst for the exploitation of the variation of cultivated *Lens.*

ICARDA has a worldwide mandate for the improvement of lentils. To this end, the Food Legume Improvement Program (FLIP) at ICARDA has assembled a collection of 5424 lentil accessions from 53 countries from some 40 donor organizations to serve as a genetic base for the crop's improvement. Passport data on these accessions is in the catalog. A major emphasis has been placed on the evaluation of the collection for its subsequent use in breeding, and the evaluation data for 19 characters are also included in the catalog.

The catalog aims to serve as a catalyst for the exploitation of the variation of cultivated *Lens.* A section entitled 'How to use the catalog' outlines some of the ways the catalog may be utilized. In Section 1 of the catalog, detailed analyses of the variation for each character and lists of extreme accessions are supplemented by discussions of the difference between *macrosperma* and *microsperma* germplasm and the association of country of origin with plant characteristics. The catalog is the most detailed study of the variability in *Lens* and, as such, is an important document for lentil breeders.

Copies of the publication are available from ICARDA, FLIP, P.O. Box 5466, Aleppo, Syria.

Key Lentil Abstracts

D'Arcy, A.L. 1982. **Study of root exudates of soyabean and lentil. I. Kinetics of exudation of phenolic compounds, amino acids and sugars during the first days of seedling growth.** *Plant and Soil* 68(3): 399-403. Universite Claude-Bernard Lyon, Laboratoire de Phytochimie, 69622, Villeurbanne, France.

In soyabean cv. Amsoy 71 and lentil cv. Anicia seedlings grown for five days in sand culture or water culture under sterile conditions, exudation of phenolic compounds was high during the first 24 hours and was up to 50 µg/plant in sand culture. In water culture but not sand culture, the phenols were then reabsorbed along with previously exuded amino acids and sugars, followed by resumption of exudation on day 5. Exudation of phenols was 10-fold higher in sand culture than in water culture.

Haddad, N.I. 1983. **Effects of date of planting and plant population on yield and other agronomic characteristics of lentils (*Lens culinaris* medic.).** *Dirasat* 10(1): 153-167. University of Jordan, Faculty of Agriculture, Amman, Jordan.

In field trials at Jubeiha Research Station, Jordan in 1979-1981 growing seasons and at Marrow Research Station in 1980/81 growing season, four plant populations (333, 332, 166, and 133 plants/m^2) were sown from late Oct to Feb. Early planting from late Oct to mid-Dec gave more seed and biological yield at both sites during the two growing seasons. At Jubeiha site, seed yield decreased (683 and 329 kg/ha) when sown from mid-Sept to the first week of Jan in both seasons, respectively. But reduction in seed yield was greatest with further delay in sowing in late Jan or mid-Feb. Early sowing increased plant length 6-7 cm, primary branches and pods/pl, and seeds/pod. The results showed that there was a significant correlation between these characters and seed yield. Plant population of 333 plants/m^2 gave the highest seed and biological yield. This is equivalent to a seeding rate of 150 kg/ha of the local variety.

Jenkins, D.J.A., Thorne, M.J., Camelon, K., Jenkins, A., Rao, A.V., Taylor, R.H., Thompson, L.U., Kalmusky, J., Reichert, R. and Francis, T. 1982. **Effect of processing on digestibility and the blood glucose response: a study of lentils.** *American Journal of Clinical Nutrition* 36(6): 1093-1101. Toronto University, Faculty of Medicine, Department of Nutritional Sciences, Toronto, Canada M5S IA8.

Breakfasts of lentils or wholemeal bread of identical carbohydrate content were taken by seven healthy adults. The lentils produced a significant 71% decrease in the blood glucose area and flattened the plasma insulin and gastric inhibitory polypeptide responses compared with the bread. The lentil breakfast was followed by a significantly flatter blood glucose response to the standard bread lunch which followed four hours later (by 38%). The blood glucose pattern was mimicked by taking the bread breakfast slowly during the four hours before lunch. Giving a bread breakfast containing a quarter of the carbohydrate decreased the breakfast glucose profile but resulted in a significantly impaired blood glucose response to lunch (168% of control). The results, and breath hydrogen studies on a separate group of four subjects, indicate that the flattened response to lentils is not due to carbohydrate malabsorption. Slow release of "lente" carbohydrate foods such as lentils may form a useful part of the diets of persons with impaired carbohydrate tolerance.

Rai, R. and Prasad, V. 1983. **Effect of soil acidity factors on nodulation, active iron content of nodules and relative efficiency of symbiotic N$_2$-fixation by mutant strains of** *Lens esculenta Rhizobium. Journal of Agricultural Science Cambridge* 100(3): 607-611. Rajendra Agricultural University, Dholi Campus; Muzaffarpur 843121, Bihar, India.

Nitrosoguanidine-induced acid-tolerant mutants S$_1$ and M$_1$ of *Rh. leguminosarum* were tested on *L. esculenta* 'L9-12.' The range of soil pH and associated acidity factors under which nodulation and N$_2$-fixation occurred varied, depending on the mutant strain. However, M$_1$ was more responsive and effective than S$_1$.

Reichert, R.D., Oomah, B.D. and Youngs, C.G. 1984. **Factors affecting the efficiency of abrasive-type dehulling of grain legumes investigated with a new intermediate-sized, batch dehuller.** *Journal of Food Science* 49(1): 267-272. National Research Council of Canada, Plant Biotechnology Institute, Saskatoon, Saskatchewan, Canada S7N 0W9.

An intermediate-sized, batch dehuller capable of processing 2-8 kg of a wide variety of cereal or legume grains was developed. Grains are dehulled by abrasion provided by abrasive wheels (10 in. diam) mounted on a horizontal shaft. The dehuller was successfully applied to eight legume grains varying widely in seed characteristics. The yield of dehulled grain, after at least 90% of the hull had been removed, ranged from 74-89% . Dehulling efficiency, a measure of the amount of hull in the abraded material, ranged from 0.11-0.72. Multiple-regression analysis showed that greater than 75% of the variability in dehulling efficiency or yield could be accounted for by seed hardness and resistance to splitting of the seed into individual cotyledons.

Sandhu, P.S. 1984. **Effect of sowing dates, phosphorus levels and herbicides on the response of *Rhizobium* inoculation in lentil.** *Ph.D. thesis.* Punjab Agricultural University; Ludhiana.

Field studies were conducted on the effect of sowing dates, phosphorus levels and herbicides on the response of *Rhizobium* inoculation in lentil (*Lens culinaris* Medic.). The field experiments were carried out with three replications during 1981-1983 seasons at the Punjab Agricultural University at Ludhiana in Punjab. The soil was loamy sand with low nitrogen and phosphorus levels.

Inoculation of seed with *Rhizobium* culture improved nodulation and nitrogen fixation capacity, and increased grain yield by 8-22% . The optimum sowing dates were 20 Oct and 10 Nov. Delayed sowing on 30 Nov and 20 Dec reduced the grain yield significantly by 17 and 32% , respectively. *Rhizobium* efficiency in terms of nodulation and nodules' dry weight/plant was affected by sowing date irrespective of inoculated or non-inoculated seeds. Vegetative and reproductive phases were considerably reduced in late-sown conditions, thus leading to significant reduction of branches and pods/plant. Application of up to 40 kg of P_2O_5/ha without inoculation and *Rhizobium* inoculation with up to 20 kg of P_2O_5/ha increased grain yield significantly.

Application of the herbicides Terbutryn (0.6 kg/ha) and Methabenzthiazuron (1.05 kg/ha) controlled weeds effectively.

Sindhu, J.S., Slinkard, A.E. and Scoles, G.J. 1983. **Karyotypic analysis of *Lens ervoides.*** *Crop Science* 23(3): 534-536.

A karyotype of five accessions of *Lens ervoides* Brign. was done to assist in determining phylogenetic relationships within the genus *Lens.* There were no differences in gross chromosomal morphology of the different lines. The diploid chromosome number was 14 and the total chromosome length was 42.9 μ. The karyotype was characterized by four submetacentric and three acrocentric chromosome pairs. The fifth longest chromosome pair carried a conspicuous secondary constriction. The karyotype formula was: K ($\underline{n}$ = 7) = 3 Sm + 1 Sm Sc + 3 Acro. A karyogram and idiogram were prepared to assist in further phylogenetic studies. The karyotype of *L. ervoides* is similar to that of the cultigen *L. culinaris* Medik., suggesting that specification involved chromosomal rearrangements that left minimal evidence in the karyotype.

Skibinski, D.O.F., Rasool, D. and Erskine, W. 1984. **Aspartate aminotransferase allozyme variation in a germplasm collection of the domesticated lentil (*Lens culinaris*).** *Theoretical and Applied Genetics* 68: 441-448. University College of Swansea, Department of Genetics, Singleton Park, Swansea SA2, Wales, UK 8pp.

Variation of a polymorphic Aspartate aminotransferase locus was assayed in a sample of 298 accessions from the ICARDA germplasm collection of the domesticated lentil (*Lens culinaris*). Two alleles Aat-I^f and Aat-I^s were detected with global frequencies of 0.51 and 0.49, respectively. Fifty-nine percent of accessions were polymorphic for both alleles. The frequency of outcrossing was estimated from the observed heterozygosity to be about 1% . This is higher than direct estimates of outcrossing and implicates selection in favour of heterozygous gene combinations. Significant variation in allele frequency and in the occurrence of polymorphic accessions was observed between countries or geographic areas. Significant associations were observed between the allozymes and agronomic characters. In particular, high frequency of Aat-I^f appeared to be associated with late flowering and maturity and low yield.

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Lens News Service

RECENT CONFERENCES AND MEETINGS

FABIS and LENS Users' Workshop

Aleppo, Syria, 28/29 November 1984

A workshop for the users of FABIS and LENS newsletters and services was held at ICARDA, 28-29 November 1984. The theme of the seminar was to assess and improve the LENS and FABIS services. Participants included nine delegates from nine countries, in addition to scientists and documentation staff from ICARDA.

The workshop provided a forum to discuss FABIS and LENS services, to assess FABIS and LENS Newsletters with a view to their improvement, to gauge the information needs of their client scientists, and to tailor the services to fulfill those requirements through documentation activities.

The following topics were covered: FABIS Newsletter-past, present and future; the evolution of LENS Newsletter; a survey of FABIS and LENS users; LENS and FABIS documentation services; the *Viciae* data base project; and the need for documentation in Arabic.

The following recommendations came from the workshop:

1. Those users of FABIS and LENS attending the meeting and those contacted through a questionnaire have all found the newsletters and their associated documentation acitivities invaluable sources of information.

2. The meeting was extremely appreciative of the financial support of the International Development Research Centre (IDRC) to FABIS and LENS.

3. Both newsletters, FABIS and LENS, should continue largely in their present form, frequency, and production process. There is no need to turn the newsletters into refereed journals, but preliminary results published in the newsletters can later be published in a more substantial form in refereed journals.

   In addition, the workshop recommends that a regional refereed journal on crop production be initiated, although not necessarily by ICARDA. Some of the participant scientists may take the initiative in this venture.

4. The newsletters should continue to include commissioned review and feature articles on aspects of research on lentils and faba beans.

5. FABIS should follow a similar format to LENS for research articles, including an abstract.

6. The Style Guides in the newsletters should clearly state that good quality black and white photos are acceptable to illustrate the articles. The Style Guide should also be more specific about the figure size for submission and where to submit articles.

   Clear, hand-written articles and figures are acceptable from certain developing countries, where authors have no secretarial assistance.

7. Appropriate FAO production data on lentils and faba beans should continue to be published in the newsletters.

8. Summaries and abstracts of unpublished reports such as Ph.D. theses should be included in the newsletters, as well as summaries of projects and reports of institutions such as research stations from the region. Summaries of such reports should be limited to 500 words. They may be solicited through an announcement in the newsletters as well as through the CARIS data base.

9. Membership of the Coordination Committee should be expanded to include, for FABIS, members from China and South and Central America; and, for LENS, a member from Turkey. Key legume researchers in the ICARDA region and Coordination Committee members should be requested to

   a. solicit more articles for the newsletters.
   b. procure relevant documents for the ICARDA documentation unit.
   c. assist in keeping the mailing list current.

10. New and obsolete cultivars should be listed in the newsletters, which should announce that contributions describing new cultivars are welcomed. The newsletters should also publish lists of current, established cultivars.

11. An address list of CGIAR centers working on legume documentation should be published in the newsletters.

12. Newsletters should be mailed under individual names, and not bulk mailed.

13. An appeal should be made both to ICARDA staff visiting national programs and to national program personnel visiting ICARDA to collect documents from national program libraries and other sources pertaining to lentils and faba beans for ICARDA's documentation unit.

14. A documentation/information component should be fitted into ICARDA training courses. Information should be gathered on training for documentalists at the other international centers as an initial step in the strengthening of documentation in the region. Increased familiarity with recent development in documentation is required by the staff of the ICARDA documentation unit.

15. Donor agencies may be approached to develop a microfiche network for North Africa and West Asia.

16. Nile Valley Abstracts should be updated and a revised edition published.

17. The meeting recommended the production of a directory of lentil researchers and the revision of the directory of faba bean researchers.

18. The meeting recommended that articles in Arabic, with an English summary, be accepted for publication in the newsletters. Arabic abstracts of articles written in English should be done.

    These Arabic abstracts and Arabic articles should be published in a cover separate from the English newsletters and distributed to Arabic speakers with the English version.

19. The meeting noted with interest Dr. Bisby's presentation of factual botanical data bases, and plans for the International Legume Database, for possible linkage with germplasm databases such as those at ICARDA, and possible dissemination arrangements with BIOSIS TRF. It was agreed that the possibility of collaboration (as donors or recipients) be explored.

Participants in the FABIS/LENS Users' Workshop: Front row from left to right: Dr. M.C. Saxena (ICARDA), Miss J. Issa (ICARDA), Dr. A. Shuman (ICARDA), Mrs. S. Sheikho (ICARDA), Mr. P.J. Kemp (ICARDA). Second row: Dr. N.F. Haddad (Jordan), Mr. S. Dutta (ICARDA), Dr. M. Solh (Lebanon), Dr. S.H. Qureshi (Pakistan), Dr. B. Somaroo (ICARDA). Third row: Dr. S. Silim (ICARDA), Mr. K. Hindawi (ICARDA), Dr. F. Bisby (U.K.), Dr. A.M. Nassib (Egypt), Dr. W. Erskine (ICARDA), Mr. P. Neate (ICARDA), Dr. D. Bond (U.K.). Back row: Mr. M. Hamwieh (ICARDA), Mr. L. Chambers (ICARDA), Mr. B. Bishara (ICARDA), Dr. S. Varma (ICARDA), Dr. T. Nordblom (ICARDA), Dr. J.P. Srivastava (ICARDA), Dr. J. Stephens (ICARDA), Dr. P. Goldsworthy (ICARDA).

TOP TWENTY

Top twenty lentil producing countries with their annual area (A x 1000 ha) and production (P x 1000 tonnes), ranked on 1982 production.

Rank	Country	1966-70		1971-75		1976-80		1981		1982	
		A	P	A	P	A	P	A	P	A	P
1	India	792.8	364.8	851.1	404.8	908.0	401.0	915	456	1001	498
2	Turkey	102.0	100.2	113.4	105.6	193.2	205.6	255	280	213	236
3	USA	26.2	31.6	33.2	41.2	56.4	65.8	65	86	71	88
4	Canada	-	-	-	-	-	-	51	56	61	77
5	Syria	97.2	62.4	100.4	66.2	127.0	94.2	72	61	80	70
6	Ethiopia	171.6	104.4	157.6	80.8	61.6	36.8	53	60	55	60
7	Bangladesh	70.6	50.4	68.0	48.8	78.0	48.8	84	49	75	49
8	Pakistan	71.0	24.4	74.6	26.2	87.0	33.4	73	30	74	31
9	Spain	51.6	36.4	65.6	46.8	72.2	52.0	71	22	65	30
10	Iran	61.2	39.8	47.0	32.0	40.4	27.6	38	29	38	29
11	France	10.0	12.6	8.4	11.0	10.8	14.6	12	22	12	22
12	Chile	11.0	6.2	18.6	11.6	37.6	23.2	48	18	39	16
13	Argentina	20.4	12.0	11.0	8.6	28.6	25.2	22	13	14	14
14	Morocco	25.2	13.6	37.0	21.6	40.4	19.8	34	5	65	10
15	Jordan	21.8	14.6	22.0	16.8	14.4	6.0	11	8	11	9
16	Iraq	9.8	6.0	6.6	4.2	8.4	7.4	10	9	10	9
17	USSR	53.6	63.2	59.6	57.0	18.0	5.0	9	7	12	8
18	Mexico	6.8	4.4	8.0	6.4	10.2	8.8	10	8	10	8
19	Colombia	-	-	22.0	10.0	19.8	7.6	17	6	17	6
20	Egypt	24.0	34.0	27.6	51.2	15.4	18.8	5	5	5	6

Editor's note: The FAO Production Yearbooks are amended when new information becomes available. 1981 figures are updated from LENS 9; 1982 data are added. Figures from Canada are available for the first time (rank 4 in the table).

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Request your copy listing all currently available publications from Communications and Documentation.

ICARDA Research Highlights 1983
In English and Arabic, this full-color, illustrated brochure describes the highlights of ICARDA's research during 1983. The topics highlighted give a partial insight into the continuing work of ICARDA scientists and the progress they have already made. The projects described include the development of dual-purpose barley and food legumes, the use of pasture and forage crops as alternatives to fallow, research on improved farming systems, and the breeding of lentils, chickpeas, and barley, and pure lines of faba beans. The benefits of early planting of lentils are described as well as cooperation with the national programs in the use of ICARDA lentil selections in multi-location and on-farm trials. Special emphasis is also given to the use of the Center's research results in a partnership with the national programs to increase agricultural productivity in the region. For your copy, write Communications and Documentation.

ICARDA's Food Legume Improvement Program
In English and Arabic, the 24-page illustrated information brochure briefly describes research projects on lentil, faba bean and chickpea treated either as single crops or as a group. For your copy, write FLIP.

FABIS (Faba Bean Information Service)
This service was established in June 1979 when FABIS Newsletter No. 1 appeared. Now produced triannually, it publishes up-to-the-minute short scientific papers on the latest research results and news items. FABIS has also produced other publications, including *Genetic Variations within Vicia faba.* For further information, write FABIS.

ICARDA Information Brochure

ICARDA's historical background and research objectives are outlined in English or Arabic. For your copy, contact Communications and Documentation.

Opportunities for Training and Post-Graduate Research at ICARDA
ICARDA has active training courses on the development and improvement of food legumes, cereals, and forages with ICARDA's research scientists, trained instructors, and proven programs. For a complete brochure of the training opportunities at ICARDA, write Training Department.

RACHIS (Barley, Wheat and Triticale Newsletter)
This ICARDA service is aimed at cereals researchers in the Near East and North Africa region and Mediterranean-type environments. It publishes up-to-the-minute short scientific papers on the latest research results and news items. RACHIS seeks to contribute to improved barley, durum wheat, and triticale production in the region; to report results, achievements, and new ideas; and to discuss research problems. For further information, write RACHIS.

Screening Chickpeas for Resistance to Ascochyta Blight, A Slidetape Audio-tutorial Module
This slide-tape audio-tutorial module is the first in the food legume training series. It is designed for the use of legume trainees during the training courses at ICARDA as well as for scientists and their support staff in the various national programs. This module is also useful educational material for universities and training departments in national research systems. For your copy of this publication or package, write Training Department.

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Address requests for publications to the specific department or service cited above, at: **ICARDA, P.O. Box 5466**
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Contributors' Style Guide

Policy

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

Editing

Articles will be edited to preserve uniform style but substantial editing will be referred to the author for his approval; occasionally, papers may be returned for revision.

Disclaimers

The views expressed and the results presented in the newsletter are those of the author(s) and not the responsibility of ICARDA or the University of Saskatchewan. Similarly, the use of trade names does not constitute endorsement of or discrimination against any product by ICARDA.

Language

LENS Newsletter is published in English but ICARDA will endeavour to translate articles submitted in Arabic and French.

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.

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; $5^{o}C$; 1980/81 season; 1980-82; 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.

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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 Workshop, University of Aleppo (Hawtin, G. and Chancellor, G.J., eds.), ICARDA/Aleppo University, May 1979, Aleppo, Syria. ICARDA/IDRC, Ottawa, Ont., Canada.

Submission of articles: Contributions should be sent to LENS, Documentation Unit, ICARDA, P.O. Box 5466, Aleppo, Syria.

THE INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH
IN THE DRY AREAS (ICARDA)

UNIVERSITY OF SASKATCHEWAN