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Lens NEWSLETTER

Pierre Kiwan

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COVER PHOTO: Opening the keel of a lentil flower for emasculation.
Photo credit: Murtada Seraj El-Dine, ICARDA.

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Character association in lentil

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Abstract

Forty eight genotypes were studied for character association and direct and indirect contribution of eight characters on seed yield. The results showed that plant height, number of pods/plant, 100-seed weight, time to maturity, and number of pods/peduncle are the most important characters for seed yield improvement in lentils.

Introduction

Lentil is a rich source of protein. However, its productivity is very low. To plan a meaningful breeding strategy for an improvement in its productivity, knowledge of character association is essential. Thus, the present investigation using 48 lentil genotypes was conducted to study the character association as well as the direct and indirect contribution of component characters toward grain yield.

Materials and Methods

Forty eight lentil genotypes were evaluated in a randomized block design with three replications. The genotypes were considered a random sample of Indian germplasm and comprised entries from IARI, New Delhi; G. B. Pant University, Pantnagar; C. S. A. University, Kanpur; J.N.K.V.V, Jabalpur; and Punjab Agricultural University, Ludhiana. The trial was conducted at the Research Farm of Meerut University, Meerut, during the winter season of 1980/81. The genotypes were grown in a single 3 m long row with 30 cm between rows and 10 cm between plants within a row. Data were recorded on five random and competitive plants in each row of the two replications, as the third replication was damaged. The data were recorded on the following nine characters: time to flowering (days), time to maturity (days), plant height (cm), number of pods/plant, number of pods/peduncle, number of seeds/pod, 100-seed weight (g), biological yield (g), and seed yield/plant (g). Estimates of correlation coefficients and path coefficient analysis were made following al-Jibouri *et al.* (1958) and Dewey and Lu (1959), respectively.

Results and Discussion

At genotypic level, only 21 out of 36 correlation coefficients were significant (Table 1). Out of these, the associations of time to maturity with number of pods/plant and number of seeds/pod were negative. In general, the estimates of the genotypic correlation coefficients were higher than the estimates of phenotypic correlation coefficients. At genotypic level, the significant associations of time to maturity with time to flowering, number of pods/peduncle, number of pods/plant, number of seeds/pod, seed yield, and also of number of seeds/pod with plant height and number of pods/peduncle exhibited insignificant associations at phenotypic level. This indicates little use of these associations in lentil improvement. The associations of time to maturity with plant height and the number of seeds/pod with biological yield and grain yield were purely due to environment. Seed yield showed positive and significant associations with plant height, number of pods/peduncle, number of pods/plant, and biological yield at phenotypic and genotypic levels, suggesting the importance of these traits in the determination of seed yield.

Table 1. Phenotypic, genotypic, and environmental correlation coefficients among nine characters.

No.	Character		2	3	4	5	6	7	8	9
1	Time to flowering (days)	P	0.07	0.51**	0.47**	0.46**	0.01	-0.27	0.40*	0.07
		G	0.71**	0.74**	0.79*	0.60**	0.18	-0.34*	0.54**	0.71*
		E	-0.03	0.25	-0.08	-0.12	-0.20	-0.04	0.06	-0.03
2	Time to maturity (days)	P		0.20	0.10	-0.05	-0.00	0.00	-0.07	0.02
		G		-0.19	0.87**	-0.35*	-0.58**	-0.02	-0.18	0.34*
		E		0.30*	-0.00	0.01	0.07	0.01	-0.09	0.04
3	Plant height (cm)	P			0.43**	0.58**	-0.06	0.01	0.71*	0.59**
		G			0.73**	0.87**	0.29*	-0.03	0.91**	0.94**
		E			0.12	0.05	-0.30*	0.14	0.48**	0.15
4	Number of pods/ peduncle	P				0.39**	0.17	-0.23	0.40**	0.43**
		G				0.47**	0.45**	-0.19	0.40**	0.48**
		E				0.27	-0.08	-0.47**	0.41**	0.32*
5	Number of pods/ plant	P					0.02	-0.20	0.85**	0.76**
		G					0.06	-0.21	0.94**	0.85**
		E					-0.09	-0.07	0.47**	0.41**
6	Number of seeds/ pod	P						0.07	-0.01	-0.00
		G						0.09	0.22	0.30
		E						0.11	-0.33*	-0.39**
7	100-seed weight (g)	P							-0.15	0.18
		G							0.00	0.28
		E							-0.12	-0.28
8	Biological yield (g)	P								0.77*
		G								0.89**
		E								0.40**
9	Seed yield (g)	P								-
		G								-
		E								-

P = Phenotypic; G = Genotypic; E = Environmental.

*, ** Significant at P = 0.05 and P = 0.01, respectively.

Table 2. Correlation coefficients and direct (diagonal) and indirect effects of eight characters on seed yield.

Character		Effect via 1	2	3	4	5	6	7	8	Correlation Coefficient
1 Time to flowering (days)	P	-0.00	-0.00	0.03	0.10	0.10	0.00	-0.09	0.06	0.35**
	G	-0.02	-0.08	0.45	0.06	0.30	0.00	-0.14	0.09	0.48**
2 Time to maturity (days)	P	-0.00	0.09	0.01	0.02	-0.30	0.00	0.00	-0.01	0.25
	G	-0.02	0.12	0.11	0.06	-0.17	-0.00	-0.8	-0.03	0.34*
3 Plant height (cm)	P	-0.00	-0.00	0.05	0.09	0.34	0.00	0.00	0.11	0.59**
	G	-0.02	0.02	0.60	0.05	0.04	0.00	-0.01	-0.16	0.94**
4 Number of pods/ peduncle	P	-0.00	-0.00	0.02	0.21	0.23	-0.01	-0.08	0.06	0.43**
	G	-0.02	-0.10	0.44	0.07	0.24	0.00	-0.07	-0.07	0.48**
5 Number of pods/ plant	P	-0.00	0.00	0.03	0.08	0.58	0.00	-0.07	0.14	0.76**
	G	-0.01	0.04	0.53	0.03	0.51	0.00	-0.08	-0.16	0.85**
6 Number of seeds/ pod	P	0.00	0.00	-0.00	0.03	0.01	-0.07	0.03	-0.00	-0.00
	G	-0.00	0.07	1.17	0.03	0.03	0.00	0.03	-0.04	0.31*
7 100-seed weight (g)	P	0.00	-0.00	0.00	-0.05	-0.12	-0.00	0.35	-0.00	0.18
	G	0.09	0.00	-0.02	-0.01	-0.01	0.00	0.40	-0.00	0.28
8 Biological yield (g)	P	-0.00	0.00	0.04	0.08	0.50	0.00	-0.00	0.16	0.77**
	G	-0.01	0.02	0.55	0.30	0.48	0.00	0.00	-0.17	0.89**

P = Phenotypic; G = Genotypic.

*, ** Significant at P = 0.05 and P = 0.01, respectively.

The path coefficient analysis revealed that number of pods/plant and 100-seed weight exhibited high positive direct contribution toward seed yield (Table 2). However, time to maturity and plant height at genotypic level and number of pods/peduncle at phenotypic level showed high positive direct contribution toward seed yield. The direct contribution of biological yield was positive at phenotypic level, while it was negative at genotypic level. Plant height, number of pods/peduncle, and biological yield showed maximum indirect contributions via number of pods/plant. However, time to maturity showed negative indirect contribution via number of pods/plant. Time to flowering, time to maturity, number of pods/peduncle, number of pods/plant, and biological yield exhibited high indirect contribution via plant height only at genotypic level.

Thus, on the basis of character association and direct and indirect contribution of component characters toward seed yield, it is concluded that plant height, number of pods/plant, 100-seed weight, time to maturity, and number of pods/peduncle are the most important characters for effecting improvement in lentil.

Acknowledgement

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Genetic divergence in lentil

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Abstract

A study on 48 Indian lentil lines of genetic divergence, measured as Mahalanobis's D^2 on nine characters, revealed 12 clusters among the genotypes. The largest cluster contained 14 lines and the smallest one line.

Introduction

Lentil is a rich source of protein. However, its productivity is very low. The productivity may be improved by incorporating desirable genes into a genotype through hybridization of diverse parents. Thus, knowledge of genetic divergence among genotypes helps in selecting genetically diverse parents for hybridization. The present investigation with 48 lentil genotypes was conducted to study genetic divergence among genotypes.

Materials and Methods

Forty eight lentil genotypes were evaluated in a randomized block design with three replications. The genotypes were considered a random sample of Indian germplasm and comprised entries from the Indian Agricultural Research Institute, New Delhi; G. B. Pant University, Pantnagar; C.S.A. University, Kanpur; J.N.K.V.V, Jabalpur; and Punjab Agricultural University, Ludhiana. The trial was conducted at the Research Farm of Meerut University, Meerut during the 1980/81 winter season. The genotypes were grown in a single 3 m long row with 30 cm between rows and 10 cm between plants within a row. Data were recorded on five random and competitive plants in each row of the two replications, as the third replication was damaged. The data were recorded on the following nine characters: time to flowering (days), time to maturity (days), plant height (cm), number of pods/plant, number of pods/peduncle, number of seeds/pod, 100-seed weight (g), biological yield (g), and seed yield/plant (g). Mahalanobis's D^2 statistic was used to measure the genetic divergence among genotypes following Rao (1952). The grouping in various clusters was done by Tocher's method (Rao 1952).

Results and Discussion

The analysis of variance revealed significant differences among genotypes for all traits except number of pods/peduncle and seeds/pod. This indicates absence of variability for these traits in the present material. The statistical distance (D^2 values) represents the index of genetic diversity among genotypes belonging to different clusters. Thus, the clustering pattern indicated that the genotypes studied were genetically diverse and were grouped into 12 clusters (Table 1). The cluster I included 14 and clusters II and III included nine

Table 1. Distribution of 48 lentil genotypes in 12 clusters.

Cluster number	Number of genotypes	Genotype name
I	14	Pusa 1, LH1259, LG120, P285, LG114, PO639, P332, P872, LL72, P545, P531, L830, LE73, and L1278.
II	9	LG60, LL98, LL116, LL30, LL78, P579, L2724, LG108, and LL1.
III	9	L1282, P599, LG112, LG312, T36, LL19, PL406, HPL5, and JLS1.
IV	2	K80 and JLS4.
V	2	K75 and P509.
VI	4	P39, LL86, LL83, and P106.
VII	3	Pusa 2, LL178, and LL107.
VIII	1	L9-12.
IX	1	JLS3.
X	1	L1205A.
XI	1	PKVL1.
XII	1	LG103.

Table 2. Average of inter and intracluster (parentheses) distances (D^2 values) among 12 clusters in lentil.

Cluster number	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
I	(27.37)	57.27	60.96	141.25	68.78	65.00	53.91	138.25	243.81	61.36	144.27	69.17
II		(22.68)	114.85	277.30	157.31	51.04	77.64	45.03	425.08	116.29	245.45	219.56
III			(30.86)	115.16	134.32	60.67	149.93	218.62	263.02	48.14	50.58	103.95
IV				(12.23	95.36	216.75	197.32	431.22	55.75	137.23	106.18	109.17
V					(13.69)	187.81	54.68	269.55	103.61	113.25	234.41	39.99
VI						(29.78)	141.40	100.37	402.37	82.40	107.44	185.38
VII							(29.67)	144.28	245.62	132.78	279.98	85.50
VIII								(0.00)	615.66	216.71	247.66	322.92
IX									(0.00)	269.77	288.53	147.94
X										(0.00)	99.94	83.99
XI											(0.00)	190.82
XII												(0.00)

genotypes each. Whereas clusters VI and VII included four and three genotypes, respectively. Other clusters up to cluster XII included one genotype each. The genotypes L9-12, JLS3, L1205A, PKVL1, and LG103 appeared to be genetically most divergent from the rest of the 43 genotypes and thus, formed their independent clusters.

The intracluster distances ranged from 39.9 (between clusters V and XII) to 615.66 (between clusters VIII and IX) (Table 2). The other high intracluster distances were between clusters IV and VIII (431.22), between clusters II and IX (425.08), and between clusters VI and IX (402.37).

The intercluster distances ranged from zero to 30.86 which suggests that genotypes within a cluster were related.

As pointed out earlier, statistical distance represents the index of genetic diversity among genotypes of different clusters. Therefore, depending on the breeding objectives it would be reasonable to effect crosses between genotypes belonging to clusters separated by high estimates of statistical distances to recover desirable segregants with high productivity.

Acknowledgement

The authors are grateful to the Head, Department of Agricultural Botany, Meerut University, Meerut for providing necessary facilities.

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Chloromutations and seedling morphology mutations induced by separate and simultaneous applications of gamma rays and NMU in lentil

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Abstract

Chloromutations and seedling morphology mutations were induced in lentil var T.36 by separate and synergistic action of gamma rays and nitrosomethyl urea (NMU). Seed germination % in the M_2 population (subjected to various treatments) was less than that of the control. Frequencies and spectra of chlorophyll and seedling morphology mutations were recorded based on percent of segregating families as well as mutants/thousand of M_2 seedlings. The frequency of chlorophyll mutations in terms of segregating families was higher in the NMU treatment, while on the basis of per thousand M_2 seedlings, the frequency was much higher in the gamma ray treatments. The frequency of seedling morphology mutations in the NMU treatment, however, was higher than in any of the gamma ray treatments, based on both criteria.

Introduction

Mutation breeding is rapidly becoming a significant method of modern plant breeding. The efficiency of a number of chemical and physical mutagens has been tested on lentil (*Lens culinaris* Med.) (Sharma and Kant 1975; Sharma *et al.* 1976; Sinha 1979; Sharma and Sharma 1981). However, simultaneous treatment with the two types of mutagens has not been reported. Our study was to investigate the mutagenic effects of a physical (gamma rays) and a chemical (NMU) mutagen, both in separate and simultaneous treatments, on *microsperma* lentil var T.36 (Dixit and Dubey 1983). Results were recorded on both chlorophyll and morphological mutants at the seedling stage in the M_2 generation.

Materials and Methods

Dry and dormant seeds of lentil var T.36 were subjected to gamma irradiation at the Genetics Division, Indian Agricultural Research Institute, New Delhi. Three doses of radiation-5, 10, and 15 kR- were applied to 200 seeds in each case. One hundred radiated and 100 fresh seeds were soaked in a 0.02% solution of NMU for six hours. M_1 seeds were collected from individual plants, and 50 seeds from each M_1 plant were sown in sand culture in large petri dishes. Seed germination % was recorded 15 days after sowing and seedlings were scored for chlorophyll mutations and for any morphological changes. The progress of mutant seedlings was observed for 20 days afterwards.

Results and Discussion

Chlorophyll mutants

Data on seed germination, frequency, and spectrum of chlorophyll mutations are presented in table 1. Seed germination percentage in the M_2 population of various treatments was less than that of the control. The decrease in germination percentage was more pronounced in the gamma ray treatments than in the NMU treatment or in the combined treatments of the two mutagens.

The frequency of chlorophyll mutations, in terms of percentage of segregating families, was higher in the NMU treatment than in the various gamma ray treatments. No synergistic effect of the two mutagens was discerned on the basis of the segregating families, and in only one of the combined treatments (15 kR+NMU) the percentage of segregating families was slightly higher than the individual application of either mutagen. However, on the basis of number of mutants/thousand M_2 plants, the frequency in gamma ray treatments was much higher than the NMU treatment. The frequency of mutants/thousand M_2 plants was far lower in the combined treatments of the two mutagens.

Various categories of chlorophyll mutants found during the study were as follows:

A. Xantha: These mutants were light yellowish-green; carotenoides predominate while chlorophylls do not form. Although these were the most frequent type of mutants in almost all the treatments, they failed to survive for long. Xantha mutants were more frequent in the gamma ray treatments than in the NMU or in the combined treatments of the two mutagens.

Table 1. Seed germination and spectrum and frequency of chlorophyll mutations in the M_2 generation of lentil.

Treatment	Germination (% of control)	Number of M_1 families	% of families segregating	Spectrum of Chlorophyll Mutations: Xantha	Viridis	Alboxantha	Viridoxantha	Striata	Tigrina	Total number of mutants	Chloromutants/ 1000 M_2 seedlings
Gamma rays											
5 kR	83.6	25	80.0	24	8	3	-	3	16	54	58.1
10 kR	89.3	18	84.9	14	7	2	-	-	18	41	62.2
15 kR	84.0	32	81.3	24	6	-	-	3	8	41	58.6
NMU											
0.02%	91.2	32	90.6	19	13	1	1	1	13	48	44.3
Gamma rays + NMU											
5 kR + 0.02%	90.0	14	85.7	4	8	-	-	-	1	13	38.2
10 kR + 0.02%	94.9	30	83.3	14	7	-	-	-	5	26	25.7
15 kR + 0.02%	92.9	26	92.3	16	18	-	-	4	8	46	35.6

Table 2. Spectrum and frequency of seedling morphology mutations in lentil.

Treatment	% of families segregating	Spectrum of mutations for seedling morphology: Curled Apex	Stunted	Radicle hypertrophy	Bi-lobed cotyledon leaves	Tricotyly	Barren apex	Folded leaflets	Giant seedlings	Total number of mutated seedlings	Number/ 1000 M_2 seedlings
Gamma rays											
5 kR	81.0	4	10	11	2	2	-	7	1	37	30.9
10 kR	83.2	3	12	-	-	1	-	-	-	16	24.3
15 kR	78.1	8	16	2	-	1	2	2	-	31	28.8
NMU											
0.02%	87.5	2	5	-	10	12	-	4	4	37	34.2
Gamma rays + NMU											
5 kR + 0.02%	92.9	6	2	1	-	4	3	7	5	28	82.4
10 kR + 0.02%	90.0	11	7	4	5	8	9	10	4	58	57.3
15 kR + 0.02%	88.5	11	19	1	3	6	-	8	2	50	60.4

B. Viridis: This type was light green to yellowish-green in color. A few of these survived and developed into viable plants; the rest degenerated within a few days. These mutants occurred in all treatments, but were more common in the NMU treatments or high doses of the combined treatments than in the individual gamma ray treatments.

C. Alboxantha: These were characterized by yellowish leaves with white tips. The yellow pigment became more intense in color from the tip to the base. These mutants survived for only a few weeks. These were found only in the individual treatments with gamma rays or NMU.

D. Viridoxantha: These were the rarest of all the chloromutants. They were yellowish green, with leaves that were yellow at the base, but increasingly light green toward the tip. These mutants failed to survive. Only one mutant of this class occurred in the NMU treatment, while no such mutant occurred in any of the other treatments.

E. Striata: This type of mutant had bright green and yellow longitudinal stripes. These were more frequent than alboxantha or viridoxantha, but much less frequent than xantha, viridis, or tigrina.

F. Tigrina: These mutants were characterized by a varying degree of anthocyanin pigmentation in the seedlings, and occurred in almost all the treatments.

The chlorophyll mutants produced in this study are ranked here according to frequency of occurrence: Xantha > Tigrina > Viridis > Striata > Alboxantha > Viridoxantha

Seedling morphology mutants:

Besides the chlorophyll mutations, some seedlings with morphological anomalies occurred in all the treatments. Table 2 shows the frequency and spectrum of these mutants. The data show that such mutations occurred more frequently in the NMU treatment than in any of the gamma ray treatments. Simultaneous application of two mutagens, however, induced these mutants at a higher frequency than an individual treatment with either mutagen, showing that the NMU and gamma ray treatments act synergistically to produce these abnormal seedlings. This is evident based upon the percentage of segregating M_2 families as well as the number of mutants/thousand of M_2 seedlings. Seedling morphology mutants produced in this study were classified as follows:

A. Curled apex: These seedlings were normal up to the cotyledonary leaves. Above this level, the shoot apex became curled downwards and appeared twisted. The curled apex mutants dried up 20-25 days after emergence. These mutants appeared fairly frequently in all the treatments.

B. Stunted: The stunted seedling mutants were characterized by reduced height and shorter internode length, compared to normal seedlings. Most of these mutants survived up to maturity when transferred to pots. The combined treatment with 15 kR gamma rays and NMU produced the most stunted seedling mutants, followed by the individual treatment with 15 kR gamma rays.

C. Radicle hypertrophy: Mutant seedlings of this category did not grow beyond the cotyledonary leaf stage. When these seedlings were dug out of the sand, the base of the radicle was hypertrophied due to formation of a ball-shaped callus tissue. The thin radicle tip extending beyond the callus soon dried up, which ultimately killed the seedlings. We could not explain the fact that these mutants occurred at a much higher frequency in the lowest dose gamma ray treatment than in all the other treatments.

D. Bi-lobed cotyledon leaves: The cotyledonary leaves in these seedlings were deeply notched at their apex, almost bifurcated into two, so that each cotyledonary leaf became a bi-lobed structure. These mutants occurred more frequently in the NMU treatment than in the individual gamma ray treatments or the combined treatments with the two mutagens.

E. Tricotyly: Mutants with three cotyledonary leaves instead of the normal two occurred in all the treatments, but most frequently in the NMU treatment. Tricotyly occurred more frequently in the combined treatments with the two mutagens than in the individual gamma ray treatments.

F. Barren apex: These seedlings developed normally up to the three-to-four leaf stage. The shoot apex extended upward above this level, but no leaves developed on this portion. These mutants dried up within three weeks after emergence.

G. Folded leaflets: In some of the seedlings, the first three or four leaves were folded toward the abaxial surface in such a way that the leaflets of the two sides of a leaf· appeared to be fused together. Leaves subsequently produced by these seedlings, however, were normal in shape. This anomaly was more commonly induced by NMU alone or by the combined treatment of the two mutagens than by the individual gamma ray applications.

H. Giant seedlings: Fifteen days after sowing, the control seedlings attained a height of 5-7 cm. The giant seedlings, however, became as tall as 10-15 cm within the same period, due to a very rapid elongation of hypocotyl. These seedlings dried up within 20-25 days of sowing.

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Karyotype study in lentil

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Abstract

A karyotype study was undertaken of somatic chromosomes in lentil (*Lens culinaris* Med.) var T.36. Two pairs of chromosomes were metacentric while the remaining five were sub-metacentric. The total metacentric u chromosome length was 31.77μ; the average length was 4.54μ. No satellited chromosomes were observed. This study and others discussed suggest that it does not seem possible to identify a single standard karyotype of lentil.

Introduction

For any cytogenetic study of a crop, a standard karyotype is essential. The existing information on the karyotype of lentil is quite contradictory (Sharma and Mukhopadhyaya 1962; Naithani and Sarbhoy 1973; Sinha and Acharya 1972, 1974; Gupta and Singh 1981; Lavania and Lavania 1983); thus, this study on the karyotype of lentil var T.36 was undertaken.

Materials and Methods

The seeds of lentil var T.36 were germinated in petri dishes lined with moist filter paper. The root tips 2-3 mm in length were pre-treated with 8-hydroxyquinoline for six hours at 10-15°C. The pre-treated root tips were fixed in acetoalcohol (1:3) and stored in 70% ethyl alcohol at a low temperature. Prior to squashing, the root tips were hydrolyzed by heating in N HCl (9:1). Cytological studies were made from temporary aceto-orceine (1%) squash preparations. The diploid number of chromosomes was found to be 14. Measurements of the chromosomes were made from well spread metaphase plates and a karyotype was prepared by arranging the chromosomes according to size from longest to shortest. Average values obtained from observations on 15 such metaphase plates were utilized to draw conclusions regarding the karyotype. Idiograms of

Table 1. Somatic chromosome morphology in lentil.

Chromosome pair	Total length (μ)	Arm ratio	Relative length (%)	F%[1]	Tc1%[2]	Classification
1	6.35	2.78	100.00	26.45	19.98	Sub-metacentric
2	5.35	1.45	84.25	40.93	16.83	Sub-metacentric
3	4.86	1.25	76.53	44.44	15.29	Metacentric
4	4.26	2.56	67.08	28.16	13.40	Sub-metacentric
5	3.83	1.68	60.31	37.33	12.05	Sub-metacentric
6	3.61	3.12	56.85	24.37	11.36	Sub-metacentric
7	3.51	1.00	55.27	49.85	11.04	Metacentric

Total chromatin length = 31.77μ; Average length of chromosomes = 4.54μ; TF %[3] = 35.76

1 F% = Ratio of length of short arm to whole chromosome.

2 Tcl% = Ratio of chromosome to total chromatin length.

3 TF% = Ratio of total length of short arms to total chromatin length.

the seven chromosomes showing average chromosome length and the position of the centromere are presented in fig. 1. Based on the centromere position, the chromosomes were classified metacentric (M) with a median centromere, or sub-metacentric (SM) with a sub-median centromere. TF% has been calculated according to the formula suggested by Huziwara (1962):

$$TF\% = \frac{\text{Total sum of short arm length}}{\text{Total sum of chromosome length}} X100$$

Results and Discussion

The morphological characteristics of the chromosomes are presented in table 1. Only two pairs of chromosomes were metacentric while the remaining five were sub-metacentric. The two metacentric chromosomes could be distinguished by their size, while the five pairs of sub-metacentric chromosomes could be distinguished by their length and the arm length ratio.

In earlier work on this subject by Sinha and Acharya (1972), three varieties (Exotic Collections) imported into India, (out of 15 varieties studied) had four metacentric and three sub-metacentric chromosomes, while the three Russian varieties had three metacentric and four sub-metacentric chromosomes. Among nine (New Pusa) varieties studied, all had one acrocentric chromosome, while the proportion of metacentric to sub-metacentric chromosomes was either 3:3 or 2:4. Gupta and Singh (1981) observed four metacentric and three sub-metacentric chromosomes in var Pant L-639, while Sindhu *et al.* (1983) found one metacentric, three sub-metacentric, and three acrocentric chromosomes in this species. However, Lavania and Lavania (1983) found that all seven chromosomes in var L.3847 were sub-metacentric.

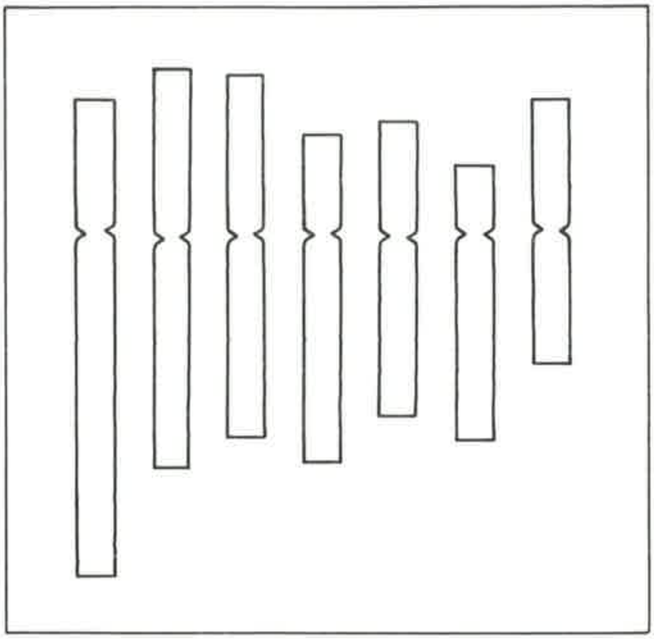

Fig. 1. Idiograms of the chromosomes of lentil var Type 36.

In this study, the longest chromosome in var T.36 was found to measure 6.35µ, while the shortest was 3.51µ. Previous reports show the length of individual chromosomes to range between 3.8-9.8µ (Sharma and Mukhopadhyaya 1962); 3.0-5.5µ (Naithani and Sarbhoy 1973); 4.0-7.36µ (Gupta and Singh 1981) and 1.9-3.4µ (Lavania and Lavania 1983).

In the present study, the total chromatin length was 31.77µ, while the average chromosome length was 4.54µ. Earlier reports also give widely-differing values for total chromatin length. Sinha and Acharya (1972) found that, in different varieties, the total chromatin length ranged between 28.2-72.3µ, whereas Gupta and Singh (1981) reported the total chromatin length as 39.31µ in var Pant L-639. Sindhu *et al.*(1983) found the total chromatin length in *Lens culinaris* to be 27.43µ, while Lavania and Lavania (1983) reported that the total chromatin length was 16.9µ in var L-3847.

In different lentil varieties, the variations in total chromatin length and the centromere position in different chromosomes indicate that these varieties have evolved along divergent paths. Stebbins (1951) pointed out that species with more sub-metacentric chromosomes should be viewed as more highly evolved than those with fewer such chromosomes.

In a number of studies, one of the chromosome pairs in *L. culinaris* was satellited (Sharma and Mukhopadhyaya 1962; Bhattacharji 1951; Naithani and Sarbhoy 1973; Sindhu *et al.* 1983; Lavania and Lavania 1983). Sinha and Acharya (1972) found that New Pusa varieties had one satellited chromosome, while E.C. and Russian varieties had none. Gupta and Singh (1981) did not find a satellited chromosome in var Pant L-639, nor did this study in var T.36.

This discussion shows that there is genuine variation in the karyotype of different lentil varieties, and that it does not seem possible to identify a single standard karyotype of *L. culinaris.*

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Effect of time of sowing, phosphorus, and herbicides on the response to Rhizobium inoculation

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Abstract

Field trials were conducted during the 1980-85 seasons on loamy sand soil at the Punjab Agricultural University, Ludhiana. The best sowing time for lentil was between 20 Oct and 10 Nov. The efficiency of *Rhizobium* inoculation in increasing yield was highest up to 10 Nov. The response of seed inoculation to lentil decreased when sowing was done on 30 Nov and there was no effect of *Rhizobium* concerning 20 Dec sowing. The application of *Rhizobium* and phosphorus improved nodulation, nitrogenase activity, and yield. A positive interaction between *Rhizobium* and phosphorus was observed. The combination of *Rhizobium* and 20 kg P_2O_5/ha gave almost equal yield to that obtained with 40 kg P_2O_5/ha without *Rhizobium* inoculation. Pre-emergence application of Methabenzthiazuron at 1.05 kg a.i./ha and Terbutryne at 0.6 kg a.i./ha controlled weeds effectively and produced grain yield almost equal to two hoeings done 30 and 60 days after sowing. These herbicides did not show any adverse effect on the efficacy of *Rhizobium*.

Introduction

Lentil is an important food legume crop grown during winter in India. Seed inoculation with *Rhizobium* is known to influence nodulation, biological N-fixation, growth, and yield of lentil. Moreover, *Rhizobium* inoculation is the cheapest means of increasing lentil yield. The response to *Rhizobium* inoculation, however, is mainly governed by the efficiency of the strain used. Besides these, many genetic and environmental factors may also influence the efficiency of *Rhizobium* inoculation. Agronomic factors like sowing time, application of phosphorus and herbicides for weed control help greatly in increasing lentil yield. But the information regarding their relationship with *Rhizobium* was lacking. The present investigation was, therefore, undertaken to examine the effect of sowing time, phosphorus, and herbicides on the response to *Rhizobium* inoculation in lentil.

Materials and Methods

Field experiments were conducted under irrigated conditions on loamy sand soil during the 1980-85 seasons at the Punjab Agricultural University, Ludhiana. The soil of the experimental site had pH 8.2 and was low in organic carbon and available nitrogen, but medium in available phosphorus and potash.

Experiment 1

The study was initiated in 1980/81 season with three dates of sowing (10, 30 Nov, and 20 Dec) and two levels of *Rhizobium* (inoculated and uninoculated). The treatments were allocated in split plot design with four replications keeping dates of sowing in the main-plots and *Rhizobium* in the sub-plots. In 1981/82 and 1982/83 the experiment was conducted with four dates of sowing with 20 Oct sowing as the additional treatment.

Experiment 2

To study the relationship of phosphorus and *Rhizobium*, the experiment was designed with four levels of phosphorus (0, 20, 40, and 60 kg P_2O_5/ha) and two levels of *Rhizobium* (inoculated and uninoculated) in a randomized block design with four replications. The sowing was done on 19, 7, 4, and 8 Nov during the 1980-1983 seasons, respectively.

Table 1. Grain yield (kg/ha) of lentil as influenced by dates of sowing and *Rhizobium* inoculation.

Date of sowing	1980/81 - *Rhizobium*	1980/81 + *Rhizobium*	1980/81 Mean	1981/82 - *Rhizobium*	1981/82 + *Rhizobium*	1981/82 Mean	1982/83 - *Rhizobium*	1982/83 + *Rhizobium*	1982/83 Mean
20 Oct	-	-	-	835	881	858	965	1048	1007
10 Nov	1413	1654	1533	696	846	771	936	1112	999
30 Nov	1440	1330	1385	644	689	666	752	833	793
20 Dec	954	959	956	510	527	593	687	676	681
Mean	1269	1314		671	736		835	905	

L.S.D. at 5% level	1980/81	1981/82	1982/83
Dates of sowing	270	174	128
Rhizobium	NS	44	76
Interaction	NS	137	128

NS = Non significant.

Experiment 3

The experiment comprising six treatments of herbicides (Table 4) was initiated in 1980/81 season in a randomized block design. In the 1981-83 seasons the treatments were compared under two levels of inoculation (inoculated and uninoculated). The studies continued during the 1983-85 seasons without inoculation.

In the experiments 2 and 3 the number of nodules, their dry weight, and nitrogenase activity was recorded 50 days after sowing. The dry matter production of weeds was taken at the time of harvest. The weeds were sun-dried for recording dry weight.

Results and Discussion

Relationship between sowing time and Rhizobium

Grain yield of lentil was affected significantly by time of sowing (Table 1). The best time of sowing was found between 20 Oct and 10 Nov. Any delay in sowing reduced the yield. On average, *Rhizobium* inoculation increased the yield by 11.4, 9.8, and 8.3% over uninoculated during the 1980-83 seasons, respectively. Interestingly, the efficiency of *Rhizobium* varied under different dates of sowing. The response to inoculation of lentil was highest between 20 Oct and 10 Nov and decreased under delayed sowings. Regarding sowing on 20 Dec, there was no effect of *Rhizobium* on lentil yield. This may be because the efficiency of *Rhizobium* goes down under low temperatures. Roughley (1970) observed that nitrogen fixation/unit of bacteriod was highest at 19°C. Furthermore, Gibson (1970) revealed that temperatures below 20°C adversely affected the symbiosis in tropical legumes.

Relationship between phosphorus and Rhizobium

There was significant effect of phosphorus on lentil yield in all the seasons except the 1981/82. On average, the application of 20, 40, and 60 kg P_2O_5/ha produced 19.4, 27.3, and 29.7% higher yield over no phosphorus (Table 2). The application of phosphorus increased the number of nodules and nitrogenase activity (Table 3). The response of lentil to *Rhizobium* inoculation was also significant. The increase with inoculation over no inoculation treatment was 11.5, 12.2, and 6.0% during the 1980/81 and 1982-84 seasons, respectively. A positive interaction between *Rhizobium* and phosphorus was observed. In case of inoculation, yield increased up to 20 kg P_2O_5 whereas in the absence of inoculation yield increased up to 40 kg P_2O_5/ha. The combination of *Rhizobium* and 20 kg P_2O_5 gave almost equal yield to that obtained with 40 kg P_2O_5/ha without inoculation. This may be true as both the factors work in the same direction. The application of phosphorus and *Rhizobium* showed an increase in the number of nodules as well as nitrogenase activity (Table 3).

Relationship between herbicides and Rhizobium

Pre-emergence application of Methabenzthiazuron and Terbutryne significantly increased the lentil grain

Table 2. Grain yield (kg/ha) of lentil as influenced by *Rhizobium* inoculation and phosphorus.

P_2O_5 (kg/ha)	1980/81 - *Rhizobium*	1980/81 + *Rhizobium*	1980/81 Mean	1981/82 - *Rhizobium*	1981/82 + *Rhizobium*	1981/82 Mean
0	831	913	872	755	748	751
20	847	1079	963	773	800	786
40	942	1027	985	846	732	789
60	1037	1023	1030	789	799	794
Mean	914	1010		791	769	

L.S.D. at 5% level	1980/81	1981/82
Phosphorus	58	NS
Rhizobium	41	NS
Interaction	92	NS

Cont'd

P_2O_5 (kg/ha)	1982/83 - *Rhizobium*	1982/83 + *Rhizobium*	1982/83 Mean	1983/84 - *Rhizobium*	1983/84 + *Rhizobium*	1983/84 Mean
0	528	758	642	910	1067	988
20	766	1088	927	1141	1279	1210
40	1015	1122	1069	1297	1297	1297
60	1053	1126	1089	1316	1302	1309
Mean	840	1024		1166	1236	

L.S.D. at 5% level	1982/83	1983/84
Phosphorus	147	86
Rhizobium	61	70
Interaction	122	84

NS = Non significant

Table 3. Effect of P_2O_5 and *Rhizobium* inoculation on the number of nodules/plant and nitrogenase activity (μ moles/h/g) dry weight of intact root nodules of lentil.

	Number of nodules/plant						Nitrogenase activity (μ moles/h/g)		
	1980/81			1983/84			1982/83		
P_2O_5 (kg/ha)	- *Rhizobium*	+ *Rhizobium*	Mean	- *Rhizobium*	+ *Rhizobium*	Mean	- *Rhizobium*	+ *Rhizobium*	Mean
0	11.2	13.7	12.4	11.9	15.1	13.5	14.6	20.5	17.5
20	16.5	18.4	17.4	17.9	19.0	18.4	18.2	27.1	22.6
40	19.3	20.2	19.7	20.3	19.9	20.1	22.3	32.5	27.4
60	18.8	21.0	19.9	22.7	21.7	22.2	23.7	34.7	29.2
Mean	16.4	18.3		18.2	18.9		19.7	28.7	

L.S.D. at 5% level	1980/81	1983/84
Phosphorus	2.8	2.6
Rhizobium	NS	NS
Interaction	NS	NS

NS = Non significant

Table 4. Effect of weed control treatments on the grain yield (kg/ha) of lentil.

Treatment	Dose (kg a.i./ha)	1980/81	1981/82 - *Rhizobium*	1981/82 + *Rhizobium*	1981/82 Mean	1982/83 - *Rhizobium*	1982/83 + *Rhizobium*	1982/83 Mean	1983/84	1984/85
Unweeded check	-	449	320	360	340	370	490	430	507	527
(control)	-	634	600	760	680	700	1000	850	1290	1194
Two hoeings (30 and 60 days after sowing)										
Methabenzthiazuron	0.7	629	-	-	-	-	-	-	922	1077
"	1.05	687	-	-	-	890	958	924	1222	1116
Terbutryne	0.6	743	640	690	665	868	1010	939	1229	1113
"	0.8	778	-	-	-	-	-	-	1318	1135
L.S.D. 5% level		161			88			146	201	238

Table 5. Effect of weed control treatments on the dry weight of weeds in lentil.

Treatment	Dose (kg a.i./ha)	Dry weight of weeds (q/ha) 1980/81	1981/82	1982/83	1983/84	1984/85
Unweeded check (control)	-	27.8	31.80	36.46	15.57	11.25
Two hoeings (30 and 60 days after sowing)	-	-	4.00	5.72	1.61	1.70
Methabenzthiazuron	0.70	12.9	-	-	5.57	2.45
"	1.05	11.7	-	6.90	4.47	2.25
Terbutryne	0.6	11.9	4.40	5.85	2.05	2.45
"	0.8	7.9	-	-	1.88	2.07
L.S.D. 5% level		-	1.56	3.84	3.22	2.88

Table 6. Number of nodules, dry weight of nodules, and nitrogenase activity μ moles/h/g) dry weight of nodules as influenced by weed control treatments (1982/83).

Treatment	Dose (kg a.i./ha)	Number of nodules/ plant		Dry weight of nodules (mg)		Nitrogenase activity (μ moles/h/g) (1982/83)	
		1981/82	1982/83	1981/82	1982/83	- *Rhizobium*	+ *Rhizobium*
Unweeded check (control)	-	5.4	9.0	2.3	5.1	17.2	28.7
Two hoeings (30 and 60 days after sowing)	-	6.7	12.0	3.4	9.1	22.2	30.0
Methabenzthiazuron	1.05	-	11.5	-	7.4	19.3	29.3
Terbutryne	0.6	5.9	10.0	2.8	7.6	20.3	29.9
"	0.8	-	-	-	-	-	-
L.S.D. at 5% level		1.0	2.1	0.6	1.4	-	-

yield by controlling weeds (Tables 4 and 5). Methabenzthiazuron at 1.05 kg a.i./ha gave more yield than 0.7 kg a.i./ha. The treatment of Terbutryne at 0.6 kg and 0.8 kg a.i./ha did not differ significantly. Thus, Methabenzthiazuron at 1.05 kg a.i./ha and Terbutryne at 0.6 kg a.i./ha controlled weeds effectively and produced grain yield equivalent to that of two hand weedings done 30 and 60 days after sowing.

During the 1981-83 seasons, inoculated treatment gave higher yield than uninoculated treatment under the pre-emergence application of Methabenzthiazuron and Terbutryne. There was slight reduction in the number and dry weight of nodules/plant with the application of herbicides than two hand hoeings (Table 6). However, the nitrogenase activity remained unaffected with the use of herbicides. The grain yield data also indicate that there was no adverse effect of herbicides on the efficacy of *Rhizobium*.

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Effect of sowing date and row spacing on the performance of lentil cultivars

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Abstract

The investigation was carried out with five sowing dates (1 Nov, 16 Nov, 1 Dec, 16 Dec, and 1 Jan) using four varieties (L9-12, Pant L 406, Pant L 639, and LG 60) and three row spacings (15, 22.5, and 30 cm) in one season in India. Sowing either on 1 Nov, 16 Nov, 1 Dec, and 16 Dec produced significantly higher grain yield/ha than 1 Jan sowing. The varieties - Pant L 406 and Pant L 639-gave significantly higher yield than L9-12 and LG 60. Grain yield was unaffected by variation in row spacing.

Introduction

Sowing date is an important factor which affects the grain yield of lentils. Deviation from optimum sowing date may affect plant growth and development adversely due to environment change. Moreover, it is important to study the varietal responses to planting dates since varieties differ in their growth and development. Plants manifest a remarkable capacity to exploit the environment with varying competitive stresses. Too wide row spacing may not utilize the natural resources efficiently, whereas narrower row spacing may result in severe inter and intra-row spacing competition. Therefore, there is a need to manipulate the row spacing to minimize the inter plant competition and to increase plant productivity. The present study investigates the effect of planting date and row spacing on the performance of lentil cultivars.

Materials and Methods

An experiment was carried out at the Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, India during the 1980/81 season. The treatments consisted of five sowing dates (1 Nov, 16 Nov, 1 Dec, 16 Dec, and 1 Jan), four varieties (L9-12, Pant L 406, Pant L 639, and LG 60), and three row spacings (15, 22.5, and 30 cm). The experiment was laid out in a single split plot design with three replicates. Sowing dates were applied in the main plot and combination of varieties and row spacings in the sub plot. Application of 100 kg of diammonium phosphate (18% N and 46% P_2O_5)/ha was made before planting. All varieties were planted in rows as per treatment at a seed rate of 45 kg/ha. Post-planting operations were given where needed. Data were recorded on time to maturity, plant

Table 1. Grain yield, plant population, biological yield, harvest index, and time to maturity of lentil varieties as affected by sowing date and row spacing.

Treatment	Grain yield (kg/ha)	Plant population (m/ha)*	Biological yield (kg/ha)	Harvest index (%)	Time to maturity (d)
Sowing date					
1 Nov	2038	2.0	5914	34.7	145.0
16 Nov	1993	1.8	5473	36.6	132.3
1 Dec	1896	2.4	5417	36.7	120.5
16 Dec	1718	2.4	4149	41.4	108.2
1 Jan	1087	1.2	2198	50.8	102.3
L.S.D. at 5%	421	0.5	1108	5.1	0.7
Variety					
L9-12	1677	2.1	4492	38.8	121.0
Pant L 406	1805	2.0	4611	41.4	121.5
Pant L 639	1874	2.0	4704	42.1	121.2
LG 60	1630	1.7	4714	37.4	123.0
L.S.D. at 5%	104	0.3	NS	2.7	0.8
Row spacing (cm)					
15	1775	2.9	4723	39.6	121.4
22.5	1764	1.10	4673	40.2	122.1
30	1700	1.7	4495	39.9	121.5
L.S.D. at 5%	NS	0.2	73	NS	NS

* m = million

NS = Not significant at 5%

population, grain yield and its attributes, grain yield and biological yield (above ground)/ha, and harvest index.

Total rainfall was 108.3 mm during the crop period. Major rainfall was received during the fourth week of December and also January.

Results and Discussion

Grain yield/ha significantly decreased with the delay in sowing (Table 1). Sowing on 1 Nov, 16 Nov, 1 Dec, and 16 Dec produced significantly higher grain yield as compared to 1 Jan sowing (1087 kg/ha). The differences among the first four dates were not significant, though the highest yield (2038 kg/ha) was obtained from 1 Nov sowing. Higher biological yield under earlier sowings must be the result of higher dry matter accumulation and also plant population. The reduction in harvest index under earlier sowings was compensated for by the increase in biological yield. Grain yield/plant and its attributes were adversely affected by the delay in sowing (Table 2). An inadequate period for vegetative as well as reproductive growth might be responsible for this trend. This is clear from the data on time to maturity, which was reduced from 145 to 102 days due to delay in planting from 1 Nov to 1 Jan. Besides, higher temperatures during seed development period of the late planted crop might have resulted in forced maturity and poor seed development. Upadhyaya and Saharia (1977), Saharia (1980), Singh and Saxena (1982) had similar opinions regarding the effect of planting date on seed yield.

The cultivars Pant L 406 and Pant L 639, which yielded equally, both yielded significantly more than L 9-12 and LG 60. The difference in the yield of L 9-12 and LG 60 was not significant. Superiority of

Table 2. Yield attributes and yield of lentil varieties as affected by sowing date and row spacing.

Treatment	Plant height (cm)	Number of branches/ plant	Number of pods/ plant	Number of seeds/ pod	1000-seed weight (g)	Grain yield/plant (g)
Sowing date						
1 Nov	53.4	8.7	125.4	1.7	19.1	3.7
16 Nov	40.9	6.9	92.9	1.8	18.0	2.7
1 Dec	41.7	6.2	74.8	1.6	18.2	2.2
16 Dec	35.5	5.6	66.0	1.7	17.7	1.9
1 Jan	33.7	6.1	82.9	1.4	17.4	2.1
L.S.D. at 5%	0.7	1.3	34.2	0.1	NS	0.9
Variety						
L9-12	41.8	6.7	86.0	1.6	17.6	2.3
Pant L 406	40.6	6.4	82.3	1.7	19.0	2.6
Pant L 639	41.5	7.1	97.0	1.7	17.5	2.6
LG 60	40.3	6.6	88.4	1.6	18.1	2.6
L.S.D. at 5%	NS	NS	NS	0.1	0.6	NS
Row spacing (cm)						
15	40.5	6.7	84.8	1.6	18.1	2.4
22.5	40.9	7.1	96.5	1.6	18.1	2.8
30	41.6	6.4	83.9	1.6	18.0	2.4
L.S.D. at 5%	NS	NS	NS	NS	NS	NS

NS = Not significant at 5%

Pant L 406 and Pant L 639 could be explained on the basis of higher harvest index, grain yield/plant, and its attributes particularly number of pods, number of seeds/pod, and 1000-seed weight (Table 2).

Variation in row spacing did not influence grain yield significantly. None of the interactions affecting grain yield/ha were found significant.

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Effect of zinc fertilization on lentil yield and yield attributes

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Abstract

A field experiment was conducted during the 1981-83 seasons on sandy loam soil low in available zinc to study the effect of zinc application on lentil grain yield and its yield attributes in India. Among the treatments, seed coating with ZnO at 0.10 and 0.20% followed by foliar spray of $ZnSO_4$ at 15+30 and 15+45 days after emergence resulted in higher number of branches/plant, pods/plant, and seeds/pod; and

increased 1000-seed weight, grain yield/plant, harvest index, and grain yield/ha. However, straw and biological yields/ha were not influenced significantly by zinc application.

Introduction

Lentil (*Lens culinaris* Medic.) is a crop of considerable importance in winter pulse production in India. India produces 380 000 (metric tonnes) of lentil grain annually with an average production of 393 kg/ha (Anonymous 1983) which is lower than 577 kg/ha, the world's average production. Poor agronomic management, particularly inadequate supply of nutrients, may be the reason for low lentil yields in the country. Intensive use of macro-nutrient fertilizers and cultivation of high yielding varieties resulted in the wide spread of micro-nutrient deficiencies particularly of zinc, which causes physiological disorders on account of nutrient imbalance and affects the yield seriously. This present study was undertaken to study the effect of various sources, methods, and rates of zinc application on lentil yield and its yield attributes and to establish zinc requirements for better growth and yield of lentil under Tarai conditions of Uttar Pradesh, India.

Materials and Methods

A field trial was conducted during the 1981-83 seasons at the Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar on sandy loam soil, neutral to slightly alkaline in reaction with 1.33-1.57% organic carbon, 110-125 kg P_2O_5/ha (available), 152-167 kg K_2O/ha (available), and 0.72-0.85 ppm DTPA extractable available zinc. A total of 14 treatments, consisting of different methods, sources and rates of zinc application, were tested in a randomized block design with four replicates during both seasons (Table 1). Application of zinc through zinc oxide was made by mixing moist seed with ZnO at 0.05, 0.10, 0.20, and 0.40% by seed weight. Similarly, application of zinc through zinc sulphate was done as basal application of $ZnSO_4$ at 5, 10, 15, and 20 kg Zn/ha in furrows opened beside the sown rows, and the foliar spray of zinc sulphate (0.5% $ZnSO_4 \cdot 7H_2O$ +0.25% lime) was done at 1000-litre/ha at 15, 30, 45, 15+30, and 15+45 days after emergence. Cultivar Pant L 406 was sown at 40 kg/ha and post-planting operations were performed when needed. Observations were recorded on grain, straw and biological yields/ha, and yield and yield attributes namely number of branches/plant, pods/plant, seeds/pod, 1000-seed weight, grain yield/plant, and harvest index (%) at maturity during both seasons.

Results and Discussion

Grain yield of lentil increased significantly over the control with zinc application (Table 1). Treatments of seed coating with ZnO, basal application of $ZnSO_4$ at 5 kg Zn/ha, and foliar spray of $ZnSO_4$ at 45, 15+30, and 15+45 days after emergence gave significantly higher grain yield/ha over control during both seasons. The maximum grain yield/ha was recorded by zinc application through seed coating with ZnO at 0.10% followed by ZnO at 0.20% and foliar spray of $ZnSO_4$ at 15+45 days after emergence during both seasons. Seed coating with ZnO at 0.10% remained at par with ZnO at 0.05, 0.20, and 0.40% and foliar spray of $ZnSO_4$ at 30, 45, 15+30, and 15+45 days after emergence during both seasons, and with basal application of $ZnSO_4$ at 5 kg Zn/ha only in the 1981/82 season.

Zinc application did not significantly affect the straw and biological yields. However, higher straw and biological yields/ha were recorded by treatments with zinc application as foliar spray of $ZnSO_4$ at 15 days after emergence and basal application of $ZnSO_4$ at 5 kg Zn/ha. Maximum harvest index was noticed when seed coating was done with ZnO at 0.10% during 1981/82 season and foliar spray of $ZnSO_4$ at 15+45 days after emergence during 1982/83 season.

Significant improvement in yield attributes, except number of seeds/pod was recorded by zinc application during 1981/82 season (Table 2). Among all the treatments of zinc application, seed coating with ZnO at 0.10% gave maximum number of branches/plant, pods/plant, and increased 1000-seed weight and grain yield/plant during both seasons. However, number of seeds/pod was highest from seed coating with ZnO at 0.20% and foliar spray of $ZnSO_4$ at 15+30 days after emergence during 1982/83 season. The differences in number of branches/plant, pods/plant, seeds/pod, and 1000-seed weight between seed coating with ZnO at 0.05 and 0.40% and between basal application of $ZnSO_4$ at 15 and 20 kg Zn/ha, were insignificant during both seasons, but significant for basal application of $ZnSO_4$ at 15 and 20 kg Zn/ha during 1982/83 season for number of seeds/pod. Similarly, differences in number of

Table 1. Effect of zinc application on grain, straw and biological yields/ha, and harvest index at harvest.

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)		Biological yield (kg/ha)		Harvest index (%)	
	(1981/82)	(1982/83)	(1981/82)	(1982/83)	(1981/82)	(1982/83)	(1981/82)	(1982/83)
1 Control	1608	1313	4575	4084	6193	5407	26.3	25.2
2 Seed coating with ZnO at 0.05%	2534	1837	5051	4198	7594	6035	33.3	30.7
3 Seed coating with ZnO at 0.10%	2629	2161	3857	3389	6496	5692	40.5	38.5
4 Seed coating with ZnO at 0.20%	2612	2056	4100	3550	6721	5607	38.9	36.8
5 Seed coating with ZnO at 0.40%	2430	1780	4169	3398	6599	5178	36.8	34.6
6 Basal application of $ZnSO_4$ at 5 kg Zn/ha	2240	1637	5631	4464	7880	6111	28.7	27.5
7 Basal application of $ZnSO_4$ at 10 kg Zn/ha	1998	1513	4593	3960	6591	5483	30.6	29.5
8 Basal application of $ZnSO_4$ at 15 kg Zn/ha	1911	1408	5224	4055	7162	5464	27.6	26.5
9 Basal application of $ZnSO_4$ at 20 kg Zn/ha	1877	1389	5051	4417	6937	5816	27.2	24.5
10 Foliar spray of $ZnSO_4$ at 15 DAE*	2171	1694	5899	4883	8070	6587	28.2	26.2
11 Foliar spray of $ZnSO_4$ at 30 DAE*	2197	1742	4869	4131	7075	5883	31.2	29.8
12 Foliar spray of $ZnSO_4$ at 45 DAE*	2396	1799	4835	4293	7240	6102	33.3	31.5
13 Foliar spray of $ZnSO_4$ at 15+30 DAE*	2517	1894	4610	3703	7127	5607	35.4	34.3
14 Foliar spray of $ZnSO_4$ at 15+45 DAE*	2517	1989	4325	3198	6842	5197	37.3	38.6
S.E. ±	155	152	458	609	449	704	2.73	2.56
L.S.D. at 5%	449	447	-	-	-	-	7.82	7.32
C.V. (%)	14.1	18.1	19.5	30.8	12.8	24.7	16.8	16.5

* DAE = Days after emergence.

Table 2. Effect of zinc application on number of branches/plant, number of pods/plant, number of seeds/pod, 1000-seed weight, and grain yield/plant at harvest.

Treatment	Number of branches/ plant		Number of pods/ plant		Number of seeds/ pod		1000-seed weight (g)		Grain yield/ plant (g)	
	(1981/82)	(1982/83)	(1981/82)	(1982/83)	(1981/82)	(1982/83)	(1981/82)	(1982/83)	(1981/82)	(1982/83)
1 Control	4.1	4.3	91.5	83.9	1.7	1.5	17.7	17.4	3.2	2.9
2 Seed coating with ZnO at 0.05%	5.7	5.7	95.2	88.5	1.8	1.7	18.0	17.5	3.8	3.5
3 Seed coating with ZnO at 0.10%	9.2	9.2	125.6	139.3	1.9	1.7	19.3	19.0	5.4	5.3
4 Seed coating with ZnO at 0.20%	7.2	6.7	117.7	114.5	1.8	1.9	18.8	18.7	4.8	4.6
5 Seed coating with ZnO at 0.40%	5.8	5.8	96.6	95.8	1.8	1.7	18.3	18.3	4.3	4.1
6 Basal application of $ZnSO_4$ at 5 kg Zn/ha	6.4	6.1	108.9	112.9	1.9	1.8	18.4	18.3	4.5	4.3
7 Basal application of $ZnSO_4$ at 10 kg Zn/ha	5.9	5.3	99.2	93.2	1.8	1.7	18.9	18.5	4.2	4.1
8 Basal application of $ZnSO_4$ at 15 kg Zn/ha	5.1	4.9	94.5	87.6	1.7	1.7	17.8	17.5	3.5	3.4
9 Basal application of $ZnSO_4$ at 20 kg Zn/ha	5.0	4.9	92.8	87.0	1.7	1.5	17.7	17.5	3.3	3.0
10 Foliar spray of $ZnSO_4$ at 15 DAE*	4.5	4.5	93.9	88.9	1.8	1.8	17.9	17.8	4.3	4.1
11 Foliar spray of $ZnSO_4$ at 30 DAE*	4.9	4.7	92.9	87.1	1.8	1.7	18.4	18.1	4.4	4.4
12 Foliar spray of $ZnSO_4$ at 45 DAE*	5.8	5.6	95.6	89.2	1.9	1.8	18.7	18.3	4.2	4.2
13 Foliar spray of $ZnSO_4$ at 15+30 DAE*	6.7	7.1	111.6	106.5	1.8	1.9	18.9	19.0	4.1	4.9
14 Foliar spray of $ZnSO_4$ at 15+45 DAE*	7.9	8.2	119.6	112.4	1.9	1.8	19.0	18.8	4.8	4.1
S.E. ±	0.2	0.2	3.2	3.4	0.1	0.1	0.1	0.2	0.21	0.21
L.S.D. at 5%	0.7	0.9	9.1	9.8	-	0.2	0.4	0.5	0.62	0.60
C.V. (%)	9.0	11.6	6.3	6.9	5.5	5.6	1.4	2.0	10.2	10.2

* DAE = Days after emergence.

branches/plant, pods/plant, and grain yield/plant between foliar spray of $ZnSO_4$ at 15 and 30 days after emergence were also insignificant during both seasons. Kapur (1972) in soybean and Shukursha (1976) in lentil observed significantly higher grain yield and attributes by application of zinc at 5 ppm as compared to control. The increase in lentil grain yield due to zinc application may be expected since zinc affects the production of indole acetic acid and growth hormones (Skoog 1940) which, in turn, might have affected the plant growth and yield favorably.

The results show that among the sources/methods of zinc application, seed coating with zinc oxide proved to be more or equally effective compared with foliar spray and basal application of zinc sulphate. This may be attributed to the increased availability of zinc in the vicinity of plant roots, since zinc application on the seed surface might have prevented the soil fixation of zinc and made the zinc more available to the plants right from the early stage of growth, when plants are invariably under stress of zinc. Basal application of zinc gave lower yields than seed coating with ZnO and foliar spray of $ZnSO_4$ This trend is expected on account of lower availability of zinc to the plants, primarily because of various reactions taking place in the soil involving zinc. Secondly, placement of zinc in adjacent rows leaves a major portion unutilized because zinc is an immobile element.

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Effect of zinc application on the yield and its attributes of lentil grown on zinc deficient soil

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Abstract

An experiment was conducted during the 1981-1983 winter seasons in pots containing soil deficient in zinc to study the influence of zinc application on lentil yield and yield attributes. Among the 14 treatments of zinc application, 1) foliar sprays of $ZnSO_4$ at 15 and 45 days after emergence followed by 2) foliar sprays of $ZnSO_4$ at 15 and 30 days after emergence then 3) seed coating with ZnO at 0.20% and basal application of zinc sulphate at 10 kg Zn/ha in descending order resulted in increased grain straw and biological yields/plant above the control. Yield attributes namely number of branches/plant, pods/plant, seeds/pod, and 1000-seed weight were also higher than the control when zinc was applied either as foliar sprays of $ZnSO_4$ at 15 and 45 days after emergence or as a seed coating of ZnO at 0.20%. Maximum harvest index was recorded from foliar sprays of $ZnSO_4$ at 15 and 45 days after emergence and seed coating with ZnO at 0.10% during the first and second year, respectively.

Introduction

In India, lentil (*Lens culinaris* Medic.) is generally grown on marginal and submarginal lands as a rainfed crop. The lentil productivity under low fertility conditions is relatively low and unstable due to variation in nutrient availability. Increased removal of micro-nutrients under intensive cropping and the heavy use of nitrogenous, phosphatic, and potassic fertilizers have resulted in micro-nutrient deficiencies in general and zinc deficiency in particular. Application of zinc is beneficial for the growth and yield of lentil (Saxena and Singh 1971; Shukursha 1976). Thus, it is necessary to assess the zinc requirement of this crop for better growth and yield. The present study was undertaken to get information on the response to yield and yield attributes of lentil related to zinc nutrition (sources/methods and rates) under the humid sub-tropical conditions of Nainital Tarai in north India.

Materials and Methods

A pot experiment was conducted in the winter seasons of 1981-1983 at the Crop Research Centre of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. The soil zinc was collected from an area where zinc deficiency symptoms were noticed in the preceding paddy rice crop. The soil was air-dried, ground by a wooden hammer, and sifted through a 2 mm ϕ sieve. The processed soil weighing was distributed as 6.5 kg/pot. The soil was rich in available nitrogen (1.07 - 1.19% organic carbon), available phosphorus (132.5 - 155.3 kg P_2O_5/ha), and medium in available potash (138 - 170 kg K_2O/ha) with a slightly alkaline reaction. The zinc content varied from 0.35 to 0.40 ppm available zinc (DTPA extractable). All the 14 treatments consisted of various methods/sources and rates of zinc application (Table 1) were tested in randomized block design with four replications during both years. Application of zinc through ZnO was done by mixing moist seeds with ZnO at 0.05, 0.10, 0.20, and 0.40% by seed weight. Basal application of zinc through $ZnSO_4$ was done at

Table 1. Effect of zinc application on grain, straw and biological yields/plant, and harvest index.

Treatment	Grain yield/ plant (g)		Straw yield/ plant (g)		Biological yield/plant (g)		Harvest index (%)	
	1981/82	1982/83	1981/82	1982/83	1981/82	1982/83	1981/82	1982/83
1 Control	1.27	1.04	4.04	2.71	5.32	3.76	23.93	27.91
2 Seed coating with ZnO at 0.05%	1.66	1.49	3.81	2.68	5.47	4.18	30.34	35.80
3 Seed coating with ZnO at 0.10%	2.06	1.77	4.13	2.62	6.19	4.39	33.23	40.31
4 Seed coating with ZnO at 0.20%	2.37	1.93	4.54	2.93	6.92	4.37	34.22	39.80
5 Seed coating with ZnO at 0.40%	1.87	1.67	4.38	3.04	6.26	4.72	29.97	35.53
6 Basal application of $ZnSO_4$ at 5 kg Zn/ha	1.71	1.61	4.11	2.61	5.82	4.22	29.35	38.25
7 Basal application of $ZnSO_4$ at 10 kg Zn/ha	2.27	1.92	4.29	3.46	6.57	5.38	34.56	35.75
8 Basal application of $ZnSO_4$ at 15 kg Zn/ha	1.76	1.62	4.27	2.69	6.03	4.32	29.15	37.64
9 Basal application of $ZnSO_4$ at 20 kg Zn/ha	1.69	1.23	4.19	2.96	5.89	4.19	28.87	29.44
10 Foliar spray of $ZnSO_4$ at 15 DAE*	1.83	1.39	4.11	2.79	5.94	4.19	30.89	33.20
11 Foliar spray of $ZnSO_4$ at 30 DAE*	1.97	1.71	4.17	2.81	6.14	4.52	32.19	38.05
12 Foliar spray of $ZnSO_4$ at 45 DAE*	1.87	1.61	4.04	2.87	5.92	4.48	31.69	36.62
13 Foliar sprays of $ZnSO_4$ at 15 and 30 DAE*	2.49	2.04	4.66	3.17	7.16	5.47	34.91	38.26
14 Foliar sprays of $ZnSO_4$ at 15 and 45 DAE*	2.68	2.24	4.58	3.84	7.27	6.09	36.88	36.97
S.E. $\pm$	0.07	0.05	0.13	0.18	0.14	0.16	1.08	1.78
L.S.D. at 5%	0.21	0.16	0.37	0.51	0.42	0.17	3.10	5.11
C.V. (%)	7.78	6.95	6.24	12.30	4.73	7.13	6.89	9.94

*DAE = Days after emergence.

5, 10, 15, and 20 kg Zn/ha. For foliar spray, a solution of $ZnSO_4$, $7H_2O$ (0.5%), and lime (0.25%) was used at 1000 l/ha at different stages of crop growth as per treatment. Ten plants were maintained in each pot. The variety Pant L406 was used. Post-planting operations were given when needed. Observations were recorded on grain, straw and biological yields/plant, and yield attributes namely number of branches/plant, pods/plant, seeds/pod, and 1000-seed weight during both years.

Results and Discussion

Application of zinc through various sources increased the grain yield/plant significantly over the control during both years (Table 1). The grain yield increased significantly with the increase of the ZnO rate up to 0.20% and decreased significantly at 0.40%. Basal application of $ZnSO_4$ at 10 kg/ha produced significantly higher grain yield than 5, 15, and 20 kg Zn/ha. Foliar sprays of $ZnSO_4$ at 15 and 30 days after emergence produced significantly higher grain yield/plant over foliar spray of $ZnSO_4$ given at either 15, 30, and 45 days after emergence during both years. The increase in grain yield/plant over control was 111.0, 96.0, 86.6, and 78.7% during the first year and 109.0, 77.4, 67.8, and 66.7% during the second year by foliar spray of $ZnSO_4$ at 15 and 45 and 15 and 30 days after emergence, seed coating with ZnO (0.20%) and basal, and application of $ZnSO_4$ at 10 kg Zn/ha. These treatments also brought significant improvement in biological yield/plant. However, significant higher straw yield/plant was recorded only in the treatments where zinc was applied as foliar sprays of $ZnSO_4$ at 15 and 30 and 15 and 45 days after emergence, seed coating with ZnO at 0.20% during the first year, and foliar sprays of $ZnSO_4$ at

Table 2. Effect of zinc application on number of branches and number of pods/plant, number of seeds/pod, and 1000-seed weight at harvest.

Treatment	Number of branches/plant		Number of pods/plant		Number of seeds/pod		1000-seed weight (g)	
	1981/82	1982/83	1981/82	1982/83	1981/82	1982/83	1981/82	1982/83
1 Control	3.4	3.0	61.6	52.7	1.3	1.1	16.7	16.6
2 Seed coating with ZnO at 0.05%	3.9	3.5	71.1	64.7	1.4	1.2	17.0	16.8
3 Seed coating with ZnO at 0.10%	4.3	3.7	91.3	85.0	1.4	1.2	17.8	17.6
4 Seed coating with ZnO at 0.20%	5.3	4.2	97.7	91.3	1.7	1.7	17.9	18.0
5 Seed coating with ZnO at 0.40%	4.1	3.4	96.6	72.6	1.5	1.4	17.3	17.3
6 Basal application of $ZnSO_4$ at 5 kg Zn/ha	4.3	3.6	79.1	74.7	1.6	1.4	17.4	17.2
7 Basal application of $ZnSO_4$ at 10 kg Zn/ha	4.8	4.0	88.8	84.2	1.7	1.6	17.9	18.2
8 Basal application of $ZnSO_4$ at 15 kg Zn/ha	4.2	3.4	74.4	69.9	1.4	1.2	16.8	17.7
9 Basal application of $ZnSO_4$ at 20 kg Zn/ha	4.1	3.3	72.7	68.9	1.3	1.2	16.7	16.8
10 Foliar spray of $ZnSO_4$ at 15 DAE*	4.0	3.5	73.9	71.4	1.5	1.4	16.9	16.7
11 Foliar spray of $ZnSO_4$ at 30 DAE*	4.4	3.4	75.6	70.7	1.7	1.5	17.7	17.5
12 Foliar spray of $ZnSO_4$ at 45 DAE*	4.4	3.6	72.3	67.9	1.6	1.5	17.4	17.2
13 Foliar sprays of $ZnSO_4$ at 15 and 30 DAE*	5.7	4.4	99.2	93.8	1.8	1.5	18.1	18.1
14 Foliar sprays of $ZnSO_4$ at 15 and 45 DAE*	6.2	5.1	105.1	101.4	1.9	1.8	18.2	18.2
S.E. $\pm$	0.4	0.2	3.9	4.2	0.1	0.1	0.2	0.2
L.S.D. at 5%	0.2	0.6	11.2	12.2	0.2	0.2	0.5	0.5
C.V. (%)	19.43	12.25	9.64	11.19	6.68	7.36	1.89	1.81

*DAE = Days after emergence.

15 and 45 days after emergence during the second year. Maximum harvest index was observed from foliar sprays of $ZnSO_4$ at 15 and 45 days after emergence during the first year and seed coating with ZnO (0.10%) during the second year.

Further examination of yield and its components revealed that higher numbers of branches/plant, pods/plant, seeds/pod, and 1000-seed weight were found in treatments giving an increased grain yield/plant because of the positive association of grain yield with its components (Table 2).

Halvorson and Bergman (1983) reported an average increase of 293 kg/ha in grain yield of dry beans by, foliar application of $ZnSO_4$ over all zinc sources. This increase in grain yield of lentil may be expected because this foliar application contributes in the production of indole acetic acid (Skoog 1940). There is also a possibility that application of zinc may have increased the auxin content which might have affected the growth of the plant along with yield attributes favorably. The plants under no zinc application were stunted in growth and had poor podding and seed formation which are responsible for lower harvest index. Failure of these plants (under no zinc application) to fix nitrogen in sufficient quantity and its subsequent metabolism may be one of the reasons for poor seed formation.

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Response of lentil to seeding rates and fertility levels under semi-arid conditions

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Abstract

A field experiment was conducted on lentil cultivar L9-12 during the winter seasons of 1975-1977. Different levels of nitrogen, phosphorus, and seeding rates were applied. The highest grain yield (1872 kg/ha) was obtained with seed inoculation and there was no additional gain when 20 kg N/ha was applied. Response to phosphorus was observed up to the level of 40 kg P_2O_5/ha. The optimum seed rate was 40 kg/ha. The protein content of grain was unaffected by seed rate and phosphate application.

Introduction

Lentil is widely cultivated in temperate and subtropical regions as well as at high altitudes in the tropics where it is grown in the coldest season for its frost tolerance. The average yield, however, is very low. The principal causes of low productivity are poor crop husbandry, inadequate application of phosphatic fertilizers and seed treatment with rhizobium culture. Lentil performs better under limited water supply in semi-arid areas, if properly managed. The present study was conducted to investigate the performance of lentil to applied nitrogen, phosphorus, and seed inoculation and also to work out the optimum seed rate for this crop.

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Materials and Methods

The experiment was conducted at the R.B.S. College Research Farm, Bichpuri (Agra) during the winter seasons of 1975-1977 on sandy loam soil with a slightly alkaline reaction showing a minor difference between the seasons in pH 8.1 and 7.7, respectively. The soil had sufficient potassium (280.0 and 324.2 kg K_2O/ha), low available nitrogen (176 and 203.2 kg N/ha), and moderate available phosphorus (32.0 and 44.3 kg P_2O_5/ha). The rainfall totals during the crop seasons were 4.3 mm in 1975/76 and 13.8 mm in 1976/77. The experiment was sown in rows 30 cm apart on 16 and 21 Nov and harvested on 3 Apr and 25 Mar in the two seasons, respectively.

Thirty six treatment combinations, comprising of four nitrogen levels (control, seed inoculation, 20 kg N/ha, and inoculation + 20 kg N/ha), three levels of phosphorus (0, 40, and 80 kg P_2O_5/ha), and three rates of seeding (20, 40, and 60 kg/ha) were sown in a factorial design with three replications. The seed, except in inoculation treatment, was sown without culture. The entire quantity of urea (N) and single superphosphate (P) as per requirement was applied as plough sole placement at the time of sowing.

Results and Discussion

Nitrogen and inoculation

The grain yield increased significantly with seed inoculation in both years (Table 1). The highest grain yield (1872 kg/ha) was obtained with seed inoculation alone and the application of N at 20 kg/ha did not increase grain yield over the control. These findings confirm the results of Mohamed (1976) and Ojha *et al.* (1977).

The significant increase due to seed inoculation in yield components *viz.* number and weight of grains/pod, number of pods/plant, and 1000-grain weight increased the seed yield significantly (Table 2). Similar results have been reported by Mohamed (1976) for test weight and Chundawat *et al.* (1976) for number of pods/plant. Protein content in grain was higher with seed inoculation (Table 1) which might have improved seed size and weight (Black 1957).

Table 1. Yield and quality of lentil under different fertility levels and seed rates.

Treatment	Grain yield (kg/ha)			Protein content in grain (%)	
	1975/76	1976/77	Pooled	1975/76	1976/77
Nitrogen level					
Control	1202	1880	1541	2200	2440
Inoculation	1686	2058	1872	2330	2530
20 kg N/ha	1267	1882	1575	2220	2440
Inoculation + 20 kg N/ha	1689	2018	1854	2350	2440
SEm $\pm$	27	26	21	25	12
L.S.D. at 5%	78	74	58	70	-
Phosphorus level (P_2O_5 kg/ha)					
0	1396	1834	1615	2240	2440
40	1480	2012	1746	2280	2470
80	1506	2033	1770	2310	2480
SEm $\pm$	23	22	19	24	11
L.S.D. at 5%	66	64	52	-	-
Seed rate (kg/ha)					
20	1342	1780	1561	2240	2430
40	1517	2023	1770	2300	2470
60	1524	2076	1800	2290	2480
SEm $\pm$	23	22	22	24	11
L.S.D. at 5%	66	64	52	-	-

Phosphorus levels

Phosphate fertilization of lentil was found beneficial in augmenting lentil seed yield. The increase in seed yield was recorded up to 40 kg P_2O_5/ha. Application of 41-80 kg P_2O_5/ha did not increase the yield significantly. An examination of yield components show that they were markedly improved with 40 kg P_2O_5/ha, which might have helped in augmenting the grain yield. These findings concur with those of Sharma (1970), Prasad *et al.* (1968), and Chowdhury *et al.* (1974). The percent protein content remained unaffected with the application of different levels of P_2O_5.

Seeding rates

The grain yield increased with the increase in seed rate up to 40 kg/ha. Further increase in seed rate from 40 - 60 kg/ha did not affect the yield significantly. These findings are in agreement with those of Sharma (1970) and Mohamed (1976). Due to better growth and development of individual plant under lower seed rates, the number of pods/plant increased significantly over its successive higher seed rate (Mohamed 1976). The lower seed rate (20 kg) was not high enough to compensate the overall advantage accrued due to more number of plants under higher seed rates. There was no significant effect of different seed rates on grain protein content.

Significant interaction

The interaction effect of phosphorus and seeding rates on seed yield was significant during both seasons as well as on a pooled basis (Table 3). Grain yield increased with increasing seeding rates under 0 and 40 kg levels of phosphorus only. But, the grain yield reduced significantly with 80 kg P_2O_5/ha under 60 kg seed rate.

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Table 2. Yield attributes of lentil under different fertility levels and seed rates.

Treatment	Number of pods/plant		Number of grains/pod		Grain weight/ pod (mg)		1000-grain weight (g)	
	1975/76	1976/77	1975/76	1976/77	1975/76	1976/77	1975/76	1976/77
Nitrogen level								
Control	52.3	86.5	1.36	1.54	20.0	25.6	16.1	17.2
Inoculation	85.4	98.9	1.45	1.59	21.6	26.3	16.3	17.6
20 kg N/ha	74.1	89.7	1.35	1.57	19.8	26.1	16.0	17.2
Inoculation + 20 kg N/ha	105.8	104.4	1.49	1.60	21.4	26.2	16.3	17.5
SEm ±	1.8	1.9	0.02	0.02	0.5	0.1	0.1	0.1
L.S.D. at 5%	5.2	5.4	0.06	0.05	1.4	-	-	0.3
Phosphorus level (P_2O_5 kg/ha)								
0	73.8	86.7	1.38	1.56	20.2	25.5	15.1	15.1
40	80.0	98.6	1.43	1.56	20.9	26.3	16.3	17.5
80	84.4	99.3	1.43	1.61	20.9	26.4	16.4	17.5
SEm ±	1.6	1.6	0.02	0.02	0.4	0.2	0.1	0.1
L.S.D. at 5%	4.5	4.6	-	-	-	0.7	0.3	0.3
Seed rate (kg/ha)								
20	92.1	139.0	1.4	1.56	20.2	25.9	16.1	17.2
40	80.9	84.9	1.4	1.59	20.1	26.1	16.2	17.4
60	65.2	60.6	1.4	1.58	20.8	26.2	16.2	17.5
SEm ±	1.6	1.6	0.0	0.02	0.4	0.2	0.1	0.1
L.S.D. at 5%	4.5	4.6	-	-	-	-	-	-

Table 3. Interaction effect of phosphorus and seed rate with lentil seed yield (kg/ha).

Phosphorus level (kg/ha)	Seed rate (kg/ha)								
	1975/76			1976/77			Pooled		
	20	40	60	20	40	60	20	40	60
0	1273	1435	1481	1519	1868	2114	1396	1652	1798
40	1384	1450	1607	1971	2042	2021	1678	1746	1814
80	1369	1668	1483	1846	2160	2094	1608	1914	1789
SEm ±		040			039			032	
L.S.D. at 5%		114			112			089	

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In vitro evaluation of fungicides against Ascochyta lentis

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Abstract

Twelve fungicides, separately and in combinations, were tested for their fungicidal effects on the growth of *Ascochyta lentis in vitro* at 100 PPM dosage rate. Mycelium of *A. lentis* was most sensitive to Tecto-60, Benlate, Calixin-M, Captan, Antracol, Topsin-M, Vitavax, Calixin-M + Benlate, and Calixin -M + Topsin-M. All these fungicides inhibited 100% the mycelial growth of the fungus *A. lentis*.

Introduction

Lentil (*Lens culinaris* Medic.) is the second most important pulse crop in Pakistan. It is grown in winter on an area of 82300 hectares with an annual production of 29900 (metric tonnes). Lentil suffers from a number of diseases which are caused by fungi, bacteria, viruses, and nematodes. These factors are responsible for the deterioration of seed quality, seed-rot, and seedling mortality. In Pakistan, the extent of damage to lentils due to various diseases is estimated at 20-25% annually (Ali 1982). Ascochyta blight on lentil was first recorded in Pakistan in 1983 and its seed-borne nature was also confirmed (Bashir *et al.* 1983). Investigations on blight of lentil caused by *Ascochyta lentis* were made by Bondartzeva *et al.* (1940). Khatri and Singh (1975) tested 947 lentil lines against the pathogen. Only one line showed no pod infection. Four other lines exhibited 1-5% pod infection. During 1984/85 season, a severe epiphytotic of *A. lentis* on lentil experimental plots, planted with local and exotic accessions from ICARDA (unpublished work), was observed at National Agricultural Research Centre, Islamabad, Pakistan. Most of the local and exotic lentil cultivars were susceptible to blight. Breeding for disease resistance is the ideal method to control this disease, but use of chemicals, though expensive, may also be an alternative control measure until resistant varieties become available. This study investigates the *in vitro* effect of some fungicides on mycelial growth of *A. lentis.*

Materials and Methods

The fungus was isolated from infected stems of lentil plants on PDA (Potato Dextrose Agar), purified, and increased on CSMA (Chickpea Seed Meal Agar, Chickpea, 20 g, Dextrose, 20 g Agar, and water 1000 ml). The toxicity of different fungicides was tested by poisoned food technique described by Nene (1979). All the fungicides were tested at a dosage rate of 100 PPM. Each fungicide was mixed separately in autoclaved melted CSMA to obtain the required concentration in poisoned medium. Poisoned melted medium (20 ml) was then poured into a sterilized plate of 10 cm to solidify. CSMA without fungicide served as control. After solidification, 3 mm Agar plugs, containing *A. lentis* mycelium, were cut from 10 days old CSMA culture plates using a sterile cork borer and placed in the middle of each plate. The experiment was conducted in three replicates at room temperature (10-20°C) and the mycelial growth was recorded after 18 and 25 days of inoculation.

Results and Discussion

It is evident from Table 1 that Tecto-60, Benlate, Captan, Vitavax, and Calixin-M in combination with Topsin-M, Captan, and Benlate inhibited the mycelial growth 100% during the test period. Calixin-M, Antracol, and Topsin-M gave 100% growth check up to the 18th day, but their efficacy was reduced thereafter. Daconil, Cobox, and Bayleton did not significantly control fungal growth after 18 and 25 days. When compared with control after 25 days, Daconil and Cobox proved ineffective in checking the vegetative growth of the fungus. Although the efficacy of Calixin-M, Antracol, and Topsin-M was

Table 1. *In vitro* sensitivity of *Ascochyta lentis* mycelium to various fungicides.

Fungicide	Average colony diameter in mm	
	After 18 days	After 24 days
Tecto-60	0.0	0.0
Benlate	0.0	0.0
Calixin-M	0.0	10.0
Captan	0.0	0.0
Dithane M-45	24.0	35.0
Daconil	64.7	90.0
Cobox	74.0	90.0
Antracol	0.0	12.0
Bayleton	50.0	70.0
Bayton	19.0	30.0
Topsin-M	0.0	8.0
Vitavax	0.0	0.0
Calixin-M + Benlate (1:1)	0.0	0.0
Calixin-M + Captan (1:1)	0.0	0.0
Calixin-M + Daconil (1:1)	22.7	25.0
Calixin-M + Topsin-M	0.0	0.0
Calixin-M + Bayleton	14.7	22.0
Control	76.0	90.0
L.S.D. (5%)	2.08	0.90
C.V. (%)	6.5	2.0

reduced after 18 days, these fungicides gave significant check of the fungal growth when compared with the control. Similarly, significant effects of Dithane M-45, Bayleton, Calixin-M + Daconil, and Calixin-M + Bayleton were obtained when compared with control. Daconil and Bayleton showed synergistic effect when used in combination with Calixin-M and reduced significantly the mycelial growth when compared with Daconil and Bayleton used alone. The efficacy of calixin-M was reduced thereafter, but when Calixin-M was used in combination with Benlate, it inhibited the growth 100% thereafter.

The results obtained with Calixin-M + Benlate are in agreement with those of Reddy (1980) who reported that Calixin-M + Benlate was 100% effective in eradication of seed-borne *Ascochyta rabiei* of chickpea. Bashir *et al.* (1984) got 100% control of mycelial growth of *A. rabiei* on CSMA with Tecto-60 and Benlate, and this confirms our results. Bhatti *et al.* (1984) reported the effectiveness of Calixin-M, Topsin-M, Bayleton, and Captan on the eradication of seedborne *A. rabiei* of chickpea. The results, reported here on *A. lentis*, are similar to the results obtained on chickpea blight. The comparative effectiveness of Dithane M-45, Captan, Vitavax, Benlate, and Antracol in reducing mycelial growth was also reported on *A. rabiei* on CSMA by Jamil (1981) and is in conformity with the present results. The current research clearly shows that Tecto-60, Benlate, Calixin-M, Captan, Antracol, Topsin-M, Vitavax, Calixin-M + Benlate, Calixin-M + Captan, and Calixin-M + Topsin-M control the vegetative growth of *A. lentis*.

Clearly, the results of *in vitro* studies can not be extrapolated to the field. Nevertheless, they can identify effective fungicides, thus, allowing concentration of expensive field studies on those fungicides and combinations which could be effective.

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Assessment of losses in lentil yield due to rust caused by Uromyces fabae

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Abstract

The effect of lentil rust on yield was studied. The yield and disease indices are highly negatively correlated. The regression coefficient indicated that the yield decreased 11.5 kg/ha with a 1% increase in disease index.

Introduction

Lentil rust, caused by *Uromyces fabae*, causes severe damage to lentil in Uttar Pradesh and Punjab and even total losses in Madhya Pradesh. Losses depend on the crop stage at the time of infection. Under favorable conditions, the crop looks from a distance as if it is attacked by frost (Khare and Agrawal 1978). This study sought to assess losses in yield due to rust in the field.

Materials and Methods

The experiment was conducted at the Punjab Agricultural University farm, Ludhiana in 1980/81 winter season. The susceptible lentil variety L-1278 was grown in a randomized block design with three replications and a plot size of 1.50 x 4 m^2 with rows spaced 22.5 cm apart.

The different levels of disease index were made when the disease appeared by spraying Wettasul (0.3%) at weekly intervals and 1-6 sprays were applied in different plots. The control plots were not sprayed. Twenty plants were selected randomly from each plot and disease intensity was recorded on 1-9 scale.

Grade	Disease intensity
1	No infection
3	Up to 10% leaf area infected
5	10.1-25% leaf area infected
7	25.1-50% leaf area and stem also infected
9	Above 50% leaf area, stem, and pods heavily infected

The disease index was calculated by the following formula:

$$\text{Disease Index} = \frac{\text{Sum of numerical rating} \times 100}{\text{Number of plants observed} \times \text{Maximum disease grade}}$$

The yield of each plot was taken and the data on the disease index and yield was analyzed statistically.

Results and Discussion

Table 1 shows that there was a significant reduction in yield when the disease index increased from 27.1 to 38.8%. A drastic reduction in yield from 1010 kg/ha to 632 kg/ha was observed when the disease index was more than 67.0%. At 82.9% disease index, only 306 kg/ha was obtained. The yield and disease index are highly negatively correlated. The regression coefficient indicated that with 1% increase in disease index, there is 11.48 kg/ha decrease in yield.

Table 1. Seed yield (kg/ha) and disease indices.

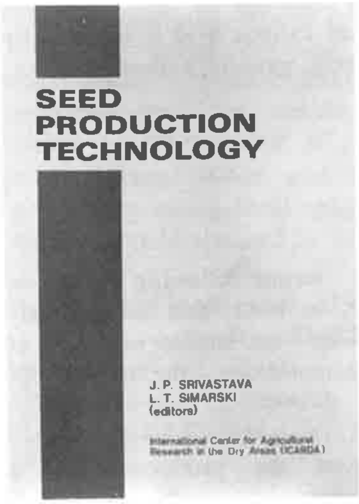
	Disease index	Yield
	27.1	1010
	34.0	927
	38.8	851
	39.1	815
	48.1	755
	67.0	632
	82.9	306
C.V.	14.2	8.9%
L.S.D. at 5%	12.2	120.2
Correlation coefficient (r)		-0.98
Regression coefficient (b)		-11.5

Reference

Khare, M.N. and Agrawal, S.C. 1978. Lentil rust survey in Madhya Pradesh. All India Pulse Workshop, Indian Council of Agricultural Research, New Delhi, India. 3pp.

LENTIL INFORMATION

LENS Bookshelf



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

SEED PRODUCTION TECHNOLOGY
Edited by J. P. Srivastava and L. T. Simarski

ICARDA presents a 287 page book for seed producers and technicians. This book lays out "ground rules" for seed production- a plethora of options from which each country must select the most suitable.

The genesis of this book was a symposium held in March 1981, which was attended by 33 seed specialists from 16 developing countries and sponsored by ICARDA and the Seed Testing Station of the Royal Netherlands Government (RPvZ). As a result, the same sponsors held a seed production course at ICARDA in April and May 1981, attended by seed technologists from 10 Middle Eastern and North African countries. The course lectures were published as Seed Production Technology in 1983. The information in this practical guide for seed producers and technologists has been distilled from two sources: the experience of the national research programs of the Middle East and North Africa, and the expertise of those who have conducted seed technology training courses in the region. The book is intended as a reference for all concerned with seed production, processing, marketing, and distribution, as well as for agricultural policy makers. The first section of the book gives an overview of the seed production situation in the region, and outlines the components of a seed production industry. The case studies that follow illustrate how seed industries have developed in different countries. The bulk of the book is devoted to techniques and methods for seed production, including the certification, testing, processing, storage, and marketing of seed. Producing seed of the crops on which ICARDA concentrates has special problems, which are addressed in the final section.

It is hoped that this revised version of Seed Production Technology- substantially expanded to cover a more comprehensive range of topics-will prove a valuable tool for seed growers both within and outside the region. The production of lentil seed and lentil seed pathology are covered in the publication.

AGPG:IBPGR/85/117

The International Center for Agricultural Research in the Dry Areas (ICARDA)
and
The International Board of Plant Genetic Resources (IBPGR)
Introduce...

LENTIL DESCRIPTORS

ICARDA and IBPGR offer a 15 page list for lentil breeders which provides an international format and a universally understood "language" for all plant genetic resources data.

This descriptor list has been prepared in an IBPGR standard format following advice on descriptors and descriptor states arising from a meeting held at ICARDA in 1982, and subsequently from crop experts throughout the world. The descriptors will enable the simple encoding of further characterization and evaluation data and can serve as examples for the creation of additional descriptors in the IBPGR form by any user.

The adoption of this scheme for all data encoding, or at least the production of a transformation method to convert other schemes to the IBPGR format, will produce a rapid, reliable, and efficient means for information storage, retrieval, and transfer. This will greatly assist the utilization of germplasm throughout the international plant genetic resources network. It is recommended, therefore, that information should be produced by closely following this descriptor list with regard to: ordering and numbering descriptors, using the descriptor specified, and using the descriptor states recommended.

Williams, P., Jaby al-Haramein, F., Nakkoul, H. and Rihawi, S. 1986. **Crop quality evaluation methods and guidelines: Cereals, food legumes, and forages.** Technical Manual no. 14. ICARDA, Aleppo, Syria. 142 pp.

This technical manual provides instructions to breeders and staff involved in quality screening of cereals, pulses (faba beans, kabuli chickpeas, and lentils), and forage crops. It gives a brief description of the tests used, their principles and interpretation, and includes instructions for each test. The tests for food legumes are for seed size, protein content, hydration capacity and hard seed coatedness, seed size distribution, sulphur-containing amino-acids, cooking time, cooking quality, husk percentage, protein digestibility, and anti-nutritional factors.

ICARDA (International Center for Agricultural Research in the Dry Areas). 1986. **Food legume nurseries 1983/84: International nursery report no. 8.** ICARDA, FLIP, Aleppo, Syria. 261 pp.

A number of trials and nurseries were supplied by the Food Legume Improvement Program (FLIP) of ICARDA to cooperating scientists within and outside the ICARDA region for 1983/84 growing season. Many of these trials and nurseries were also grown at ICARDA sites in Syria and Lebanon. This report summarizes the data returned by the cooperating scientists and those obtained at ICARDA sites from these trials and nurseries. The results received from cooperators till December 1985 have been included.

It is hoped that the results and discussion contained in this report will be of interest and use to the cooperating scientists.

Key Lentil Abstracts

Ahlawat, I.P.S., Singh, A. and Sharma, R.P. 1985. **Water and nitrogen management in wheat-lentil intercropping system under late-sown conditions.** *Journal of Agricultural Science (Cambridge)* 105: 697-701. Indian Agricultural Research Institute, Division of Agronomy, New Delhi 110012, India.

Experiments comprising various ratios of wheat and lentil in a mixed cropping system under two irrigation regimes and three levels of N application are described and the results discussed. In all experiments the highest yield of grain was obtained by growing wheat alone and the highest yield of lentil grain by growing lentil alone. No mixture could equal the yield obtained by wheat alone.

Friesen, G.H. and Wall, D.A. 1986. **Tolerance of lentil (*Lens culinaris* Medik.) to herbicides.** *Canadian Journal of Plant Science* 66: 131-139. Agriculture Canada, Research Station, Morden, Manitoba ROG 1JO Canada.

Lentil (*Lens culinaris* Medik.) was tolerant to trifluralin, ethalfluralin, triallate, metolachlor, and metribuzin applied preplant soil incorporated at rates of 1.1, 1.1, 1.7, 2.6, and 0.28 kg (a.i.)/ha, respectively. Chloramben and EPTC applied in a similar manner at rates of 2.0 and 3.0 kg (a.i)/ha, respectively, injured lentils. Diclofop methyl, sethoxydim, fluazifop butyl, haloxyfop methyl and several experimental grass-specific herbicides were tolerated by lentil but propanil and flamprop methyl were phytotoxic to this crop. Lentil was also tolerant to tank mixtures of trifluralin and triallate, trifluralin and metribuzin, metolachlor and metribuzin, and sequential treatments of dinitroaniline-type herbicides applied preplant incorporated followed by a post-emergence application of metribuzin or dinoseb. Lentil seed density was reduced by triallate in 1983 and seed size was reduced by flamprop methyl in 1982 and by trifluralin, triallate, metolachlor, EPTC, chloramben, metribuzin and trifluralin + metribuzin mixtures in 1983.

Ghani, A. 1984. **Variability and correlation determination for various characters in some varieties of lentil.** *B.Sc. thesis.* University of Agriculture, Faisalabad, Pakistan.

The present investigations were carried out to evaluate some statistical parameters like genetic variation, correlation, and coefficients and path analysis of different plant characters in the 23 lentil varieties under irrigation conditions. The experiment was conducted at the University of Agriculture, the Department of Plant Breeding and Genetics, Faisalabad during the 1982-83 season. The statistical differences for all the growth parameters like number of days to bloom, time to maturity, number of first pod formation, plant height, primary branches, secondary branches, number of flower clusters/plant, number of pods/plant, plant weight, grain yield, and 100-seed weight were recorded as highly significant among the varieties.

Variety 32-5 which was used as a check was earlier in blooming, maturity, and in the first pod formation. However, the highest number of pod set (128.40) was recorded in variety 1133 followed by 1135 (124.40), 1146 (111.67), and 1129 (99.53), respectively. Similarly the highest grain yield was obtained by variety 1135 followed by 1139, 1146, and 1129, respectively.

The correlation analysis revealed that time to maturity was positively correlated with number of flowers, clusters, and grain yield/plant at both genotypic and phenotypic levels. Number of days to first pod formation showed positive association with primary branches, but it was negatively associated with 100-seed weight. Similarly plant height showed significantly positive relationship with number of clusters/plant and highly significant and positive correlation with number of pods/plant. Positive and highly significant relationship was recorded between number of primary branches and 100-seed weight. The number of secondary branches, however, showed positive but nonsignificant inter-relationship with number of clusters/plant, number of pods/plant, and total weight at both genotypic and phenotypic levels. Positive and highly significant correlation existed between number of clusters/plant and each one of the characters like total weight of the plant, grain yield of the plant, and number of pods/plant. Total weight of the plant showed significant and positive relationship with grain yield and 100-seed weight of the plant, whereas 100-seed weight showed positive, but nonsignificant association with grain yield.

Path coefficient analysis of 11 characters revealed that direct effect of plant height and indirect effect via other characters were remarkable. Direct effect of time to maturity and number of days to first pod formation, secondary branches, and total weight of the plant on yield were also much pronounced. Direct effect of number of pods/plant was negative and the positive genetic association of this character to yield was mainly due to the indirect effects via time to maturity, plant height, and total weight of the plant.

The index of genetic association between time to maturity and yield was almost equal to the direct effects of time to maturity on yield. This phenomena revealed a true relationship between these two characters and suggested that the direct selection of the plants which mature in minimum number of days is effective for increasing the productivity of the plant.

Finally, it was concluded that plant height, time to maturity, first pod formation, and plant weight contributed directly to the grain yield of the plant.

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

A foliar blight of lentil (*Lens culinaris*) was observed in June 1981 in several plant introductions in cold-tolerance trials planted in the fall of 1980 at Pullman and Central Ferry, W. A. *Ascochyta lentis* was the predominant fungus isolated from discolored, necrotic lesions on the foliage and seeds of diseased lentil. Isolates of *A. lentis* were pathogenic to the foliage of lentil, but not to the foliage of chickpea (*Cicer arietinum*) or pea (*Pisum sativum*). The fungus was isolated from 1.5-3.5% of the original introduced seed from three of five lentil PI accessions included in the 1980/81 cold-tolerance trials. Infection by *A. lentis* of seeds harvested from these trials (increase seeds) ranged from 0.5 to 68.5% and from 10 to 42.5% of Pullman and Central Ferry, respectively. Many seeds from heavily infected accessions were shriveled and discolored, and seed quality was adversely affected. Also, seed size was significantly correlated to the level of seedborne infection. A total of 17.060 original seeds from 284 accessions from 30 countries were screened for seedborne *A. lentis*. The fungus was isolated from 2.0% of the seeds which represented 16% of the accessions and 16 countries. Most severe infections were found on original seeds from Australia, India, Italy, Spain, and Turkey. Other fungi pathogenic to lentil that were also isolated, but less frequently than *A. lentis*, included: *Botrytis cinerea, Fusarium avenaceum, Macrophomina phaseolina, Phoma medicaginis* var. *pinodella,* and *Rhizoctonia solani*. Incidence of seedborne *A. lentis* from original infected seeds (5.0-61.7%) in 20 exotic PI accessions to increase seeds grown in typical spring plantings at Pullman was 0-2.5%. *A. lentis* remained viable in original seeds of several accessions stored for more than 30 years. The fungus survived over three years in naturally infected lentil pods and seeds at 4-6°C or in a shelter outdoors, and for 1.5 years on the soil surface, but it lost viability within 29 weeks at a soil depth of 16 cm.

Ladizinsky, G., Cohen, D. and Muehlbauer, F.J. 1985. **Hybridization in the genus *Lens* by means of embryo culture.** *Theoretical and Applied Genetics* 70(1): 97-101. USDA, ARS Washington State University, Pullman, Washington, USA.

The cultivated lentil *Lens culinaris* and the wild lentil *L. ervoides* are reproductively isolated from one another due to their hybrid embryo breakdowns. Using embryo culture, vegetatively normal hybrids were obtained. One specific hybrid, heterozygous for a reciprocal translocation, had about 50% gamete viability and produced aborted and viable embryos in a 1:1 ratio. In the F_2, vegetatively normal and highly fertile plants were selected. With the aid of embryo culture techniques. *L. ervoides* can be included in the wild gene pool of the cultivated lentil.

McKenzie, B.A., Sherrell, C., Gallagher, J.N. and Hill, G.D. 1986. **Response of lentils to irrigation and sowing date.** *Proceedings, Agronomy Society of New Zealand: 47-50.* Lincoln College, Plant Science Department, Canterbury, New Zealand.

Lentils (cv. Titore and Olympic) were sown on six dates from 16 Apr to 15 Nov 1984 on a sandy soil with 150 mm AWC in the top metre. The response of five of these sowings to irrigation was examined. Spring and summer rainfall was only 72% of average.

Seed yield was most strongly influenced by sowing date. Late sowing depressed yield from 3.3 to 0.5 t/ha. The response of seed yield to irrigation ranged from a 26% decrease in the July sowing to an 83% increase in the November sowing. Seed yields were highest from the May sowing where Titore and Olympic produced 3.5 and 3.1 t/ha, respectively.

Total dry matter accumulation was generally increased by irrigation. Irrigated Titore and Olympic produced 8.9 t DM/ha. Unirrigated, they produced 7.3 and 7.9 t/ha, respectively. Irrigated autumn sowings all lodged severely and this may have accounted for their lack of seed yield response to irrigation.

Irrigation generally decreased harvest index (HI). Mean HI was 0.35 for irrigated plants and 0.43 for unirrigated plants. In the July sowing, irrigation decreased HI from 0.46 to 0.34, but irrigation did not decrease HI of the October sowing.

The results suggested that on this soil type in Canterbury, autumn sowing is essential to ensure high yields. Only spring-sown lentils should be irrigated and then only in a dry season.

de Nitish, S. 1985. **Genetic variability and interrelationship studies among the metric traits in lentil** (*Lens culinaris* Medik.). *M.Sc. thesis.* Rajendra Agricultural University, Bihar, India.

An investigation was made for variability, correlation, and genetic diversity studies in two groups (small-seeded and bold-seeded) of *microsperma* sub species of lentil (*Lens culinaris* Medik.). Each group comprised 32 varieties. Experiment was conducted in randomized block design with three replications during the 1983/84 season, at Delhi Farm of Rajendra, Agricultural University, Bihar, India.

The observations were recorded on the following traits: days to flowering, time to maturity, plant height, number of branches/plant, number of pods/cluster, number of pods/plant, number of grains/pod, number of grains/plant, grain yield/plant, 100-grain weight dry matter/plant, and harvest index. These recorded observations were subjected to statistical analysis to estimate varietal performance, variability, association among different traits, and genetic diversity among the material in both sets.

Highly significant differences were observed among all the varieties for all the characters in both sets. In small-seeded group LG-128 gave the maximum grain yield followed by Pant L-406 (a check) and DLGS- 135. In bold-seeded group K-81 gave the highest yield followed by K-82 and DL 83-7. Varieties like LG-128, L-4152A, Pant L-406, and DLGS-135 in small-seeded group; K-81, K-82, DLGS-112, and LL-266 in bold-seeded group showed higher number of grains/plant. DL-83 gave the maximum 100-grain weight (3.650) followed by DL-83-7, DL 83-1, and K-82.

Rennie, R.J. and Dubetz, S. 1986. **Nitrogen-15-determined nitrogen fixation in field-grown chickpea, lentil, faba bean, and field pea.** *Agronomy Journal* 78: 654-660. Agriculture Canada, Research Station, Lethbridge, Alberta, Canada T1J 4B1.

Field-determined estimates of N_2 fixation by ^{15}N isotope dilution have been not determined in irrigated annual grain legumes in North America. Nor does knowledge exist as to which nonfixing control plants are most appropriate for these grain legumes when using ^{15}N isotope dilution methods. Within a crop species grown on two Typic Haploboroll soils for two years, lentil (*Lens culinaris* Medik.), faba bean (*Vicia faba* L. minor), and pea (*Pisum sativum* L.) cultivars adapted to western Canada did not differ in their ability to benefit from symbiotic N_2 fixation. When inoculated, N_2 fixed averaged 176, 84, 216, and 185 kg N/ha^{-1} for chickpea (*Cicer arietinum* L.), lentil, faba bean, and pea, respectively. The percent plant N derived from the atmosphere averaged 82, 67, 85, and 79%, respectively, for the same crops. Response to inoculation was dependent on the crop even though all were infected by *Rhizobium leguminosarum*. Uninoculated chickpea had no nodules or N_2-fixing activity. Inoculation increased N_2 fixation in faba bean by 19 - 67% and in lentil by 5 - 16% depending on the site. There was a response to inoculation in pea at only one of the two sites. The presence of indigenous soil *R. leguminosarum* precluded the use of uninoculated treatments as nonfixing controls (except for chickpea) for estimating N_2 fixation by ^{15}N isotope dilution. Barley (*Hordeum vulgare* L. 'Galt') or wheat (*Triticum aestivum* L. emend. Thell 'Columbus') appeared to be appropriate control plants for these grain legumes. Because the ^{15}N-determined fertilizer use efficiency of these controls was similar to that of the N_2-fixing legumes, estimates of N_2 fixation by N balance were not significantly different from those obtained by ^{15}N isotope dilution.

Savage, G.P., Scott, S.K. and Jermyn, W.A. 1985. **The effect of cooking on the nutritional quality of New Zealand grown lentils.** Abstract of a paper presented at the Thirteenth International Congress of Nutrition, 18-23 Aug 1985, Brighton, England. Lincoln College, Biochemistry Department, Canterbury, New Zealand.

The effect of cooking of four lentil varieties (*Lens culinaris*) grown in New Zealand on their nutritive value was determined. Sub samples of seed were either ground or ground and cooked and leached in running water for 65 hrs and freeze dried and ground. Proximate and amino acid analysis of the meal did not reveal any significant differences among genotypes. Once crude protein of the cultivar had been determined the raw or leached seed was mixed with standard ingredients to provide 8% crude protein and fed to rats. The ground lentils provided the sole source of protein.

Cooking and leaching improved the true digestibility of the protein of each lentil except for the cultivar Olympic, which showed a small fall in value. The biological values of Titore, Big Yellow, and Laird were uniform, with a mean for the raw samples of 34.3 and 43.7 when cooked. Cooking significantly improved the value of the lentil protein of all cultivars by 24%. The biological value for raw Olympic was 21% higher than in the other three raw lentils. However its cooked value was only 11% higher than the others.

Although all the lines had very similar proximate composition, our data indicates that one variety, Olympic, has a superior protein quality without any appreciable difference in the measured amino acid composition.

Summerfield, R.J., Roberts, E.H., Erskine, W. and Ellis, R.H. 1985. **Effects of temperature and photoperiod on flowering in lentils** (*Lens culinaris* Medic.). *Annals of Botany* 56: 659-671. University of Reading, Department of Agriculture and Horticulture, Plant Environment Laboratory, Shinfield Grange, Cutbush Lane, Shinfield, Reading, Berks RG2 9AD, UK.

Factorial combinations of three photoperiods (10, 13 and 16 h), two day temperatures (18 and 28°C) and two night temperatures (5 and 13°C) were imposed on nodulated plants of six diverse genotypes (cultivars and land-races) of lentil (*Lens culinaris* Medic.) grown in pots in growth cabinets from vernalized (1.5 ± 0.5°C for 30 d) or non-vernalized seeds (i.e. 144 'treatment' combinations). The times from sowing to the appearance of first open flowers were recorded. Vernalization, long days and warm temperatures hastened flowering, but genotypes differed in relative sensitivity to each of these factors and in time to flowering in the same most-inductive environment. Rates of progress towards flowering (i.e. $1/f$, the reciprocals of the times to first flower, f) in all genotypes, vernalized or not, were linear functions of both mean temperature, t, and photoperiod, p, with no interaction between the two terms. So, over a wide range of conditions (covering the photo-thermal regimes experienced by lentil crops world-wide), time to flowering can be described by the equation: $1/f = a+bt+cp$, where a, b, and c are constants which differ between genotypes and the values of which provide a sound basis for screening germplasm for sensitivity to temperature and photoperiod. Although these two environmental factors affect the same phenological event (i.e. time to flowering) our data suggest the responses are under separate genetic control. Seed vernalization consistently increased the values of both a and b in all genotypes. The implications of these collective findings for the screening of lentil germplasm are discussed.

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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.

Screening Chickpeas for Resistance to Ascochyta Blight- A Slide-tape 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.

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.

Opportunities for Field Research at ICARDA
This brochure is intended primarily to assist Master of Science candidates, who are enrolled at national universities within ICARDA region and selected for the Graduate Research Training Program. It explains to them the opportunity they have to conduct their thesis research work at ICARDA research sites under the supervision of distinguished international scientists. For your copy, write GRI Program, Training Coordination Unit.

TO OBTAIN PUBLICATIONS:
Address requests for publications to the specific department or service cited above, at: ICARDA, P.O. Box 5466, Aleppo, Syria.

اعلان الى العلماء الباحثين العرب الكرام

يسر المركز الدولي للبحوث الزراعية في المناطق الجافة (ايكاردا) ، اعلامكم بان مركز بحوث التنمية الدولية (IDRC) وافق على تقديم الدعم المادي لبرنامج LENS ، ولمدة ثلاث سنوات ، اعتبارا من بداية عام 1987 ولغاية 1989 . ويحيطكم علما بان ادراج اللغة العربية ضمن النشرة الاخبارية للعدس " LENS " يشكل أحد أهم اهداف هذا البرنامج .

وبمزيد من السرور تعلن اسرة تحرير " LENS " للعلماء العرب العاملين في مجال تحسين وتطوير العدس ، انها ستبدأ اصدار نشرتها الاخبارية ، باللغتين العربية والانكليزية ، وذلك بدأ من شهر آب القادم .

يرجى من الاخوة العلماء الراغبين في نشر ابحاثهم باللغة العربية التفضل بارسالها الى العنوان " LENS " ، ايكاردا – قسم التوثيق ، ص.ب 5466 ، حلب – سورية .

ملاحظة : تتم كتابة البحث بلغة عربية واضحة ، وفق الترتيب التالي :

1) ملخص البحث يكتب باللغتين العربية والانكليزية .
2) المقدمة .
3) مواد وطرق البحث .
4) نتائج البحث .
5) المناقشة ، ويمكن دمجها مع النتائج (نتائج البحث والمناقشة) .
6) قائمة المراجع .

Contributors' Style Guide

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

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

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 endeavor to publish and/or 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. Photographs and figures should preferably be 8.5 cm or 17.4 cm wide.

Units of measurement are to be in the metric system; e.g. t/ha, kg, g, m, km, ml (= milliliter), 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°C; 1980/81 season; 1980-82 seasons; Fig.; No.; FAO; USA. Fertilizers: 1 kg N or P_2O_5 or K_2O/ha.
Mon, Tues, Wed, Thurs, Fri, Sat, Sun; Jan, Feb, Mar, Apr, May, June, July, Aug, Sept, Oct, Nov, Dec. Versus = vs, least significant difference = LSD, standard error = SE +, coefficient(s) of variation = CV(s). Probability: Use asterisks to denote probability * = P<0.05; ** = P<0.01; *** = P<0.001.

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

References
Journal articles: Slinkard, A.E. 1981. Eston lentil. Canadian Journal of Plant Science 61: 733-734.

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

Articles from books: Solh, M. and Erskine, W. 1981. Genetic resources. Pages 53-67 in Lentils (Webb, C. and Hawtin, G., eds.). ICARDA/CAB, CAB, Slough, England.

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

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

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

UNIVERSITY OF SASKATCHEWAN