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Lens NEWSLETTER

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

UNIVERSITY OF SASKATCHEWAN

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LENS

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COVER PHOTO: Winnowing lentil by hand in Syria.

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Genetic analysis of biological yield, harvest index, and seed yield in lentil

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Abstract

Fifty four genotypes of lentil were evaluated for time to maturity, 100-seed weight, biological yield, harvest index, and seed yield in Madhya Pradesh, India in the 1983-85 winter seasons. The variability, heritability estimates, and association analysis indicated that selection based on harvest index, biological yield, and seed yield will improve lentil yield.

Introduction

Information on genetic variability, heritability, and correlations is useful to formulate selection criteria for improvement of seed yield. Insufficient information is available on biological yield, harvest index, and seed yield in lentil. Hence, an attempt was made to formulate suitable selection criteria to improve seed yield in lentil.

Materials and Methods

Fifty four Indian lentil genotypes were sown on 21 Nov 1983 and 20 Nov 1984 in a randomized complete block design with two replications. Each plot consisted of a single row of 3 m long with 5 cm between plants within a row and 30 cm between plots. A border row was planted at the end of each replication. Ten competitive plants were selected from each plot to record time to maturity, 100-seed weight, biological yield, harvest index, and seed yield/plant.

The analysis of variance and pooled analysis of variance were carried out. Heritability in the broad sense was calculated by the method given by Hanson *et al.* (1956). The coefficient of variation was computed using the formula given by Burton (1952). Expected genetic advance was calculated by using the method of Johnson *et al.* (1955). The simple correlation of grain yield with four ancillary characters was calculated.

Results and Discussion

The mean squares were found to be significant for time to maturity, 100-seed weight, biological yield, and harvest index for the 1983/84 season, while 100-seed weight, harvest index, seed yield, and biological yield were significant for the 1984/85 season. In the pooled analysis of variance, the genotypes were significant for all the characters, but the interaction of genotypes and year was non significant for all the characters.

The range, mean, variance, coefficient of variation, heritability in the broad sense, and genetic advance for different characters are given in **Table 1.**

The range for the character time to maturity was from 106 days (JPL 401, JPL 923, and Lence 830) to 119.5 days (JPL 207, Pant L-406, JPL 306, JPL 384, and JPL 754) in the 1983/84 season, while in the 1984/85 season it ranged from 101.5 days (JPL 401) to 110 days (JPL 781, JPL 548, JPL 953, JPL 970, JPL 1059, RAU 101, and LL 56). One-hundred seed weight ranged from 1.14 g (LL 56) to 3.37 g (JPL 207) in the 1983/84 season, while in the 1984/85 season it ranged from 2.40 g (JPL 765) to 4.35 g (JPL 220). Biological yield/plant ranged from 7 g (JPL 306) to 21.5 g (JPL 1058) in the 1983/84 season, while it ranged from 4.5 g (JPL 542) to 12.30 g (LL 56) in the 1984/85 season. Harvest index ranged from 5.5% (JPL 953) to 28.7% (JPL 983) and 13.0% (L-a-830) to 32.6% (JPL 256) in the 1984/85 season. In the 1983/84 season, seed yield/plant ranged from 1.3 g

Table 1 Genetic parameters of variation for yield and its components in lentil

Character parameter	Time to maturity			100-seed weight (g)			Biological yield (g)			Harvest index (g)			Seed yield per plant (g)		
	1983/84	1984/85	Pooled	1983/84	1984/85	Pooled	1983/84	1984/85	Pooled	1983/84	1984/85	Pooled	1983/84	1984/85	Pooled
Mean	114.6	107.5	111.0	2.43	3.11	2.77	13.3	8.8	11.0	21.5	19.0	20.2	3.0	1.7	2.3
Minimum	106.0	101.5	103.8	1.43	2.4	2.06	7.8	4.5	7.6	13.0	5.5	11.2	1.3	0.7	1.1
Maximum	119.5	110.0	113.8	3.37	4.35	3.76	19.5	12.3	15.8	32.6	28.7	29.4	4.4	3.3	4.5
σ^2_p	14.85	3.22	5.04	0.27	0.23	0.16	7.46	2.82	4.50	22.0	30.8	14.58	0.57	0.41	0.39
σ^2_g	8.98	0.83	0.91	0.17	0.18	0.09	2.42	0.79	0.96	7.65	21.13	2.55	0.14	0.25	0.09
σ^2_e	5.87	2.39	4.13	0.10	0.05	0.07	5.04	2.03	3.54	14.37	9.67	12.03	0.43	0.16	0.30
PCV	3.36	1.67	2.02	21.38	15.42	14.44	20.55	19.08	19.23	21.78	29.29	18.91	25.17	37.8	27.03
GCV	2.61	0.77	0.86	19.96	13.64	10.83	11.70	10.10	8.88	12.84	24.26	7.90	12.47	23.6	12.98
h^2(B)%	60.47	25.78	18.06	62.96	78.26	56.25	32.43	28.01	21.33	34.74	68.60	17.49	24.56	60.97	23.08
G.A.	4.80	0.95	0.84	0.67	0.77	0.46	1.82	0.97	0.93	3.36	7.84	1.38	0.38	0.8	0.30
G.A. as % of mean	4.19	0.88	0.76	27.57	24.76	16.61	13.69	11.02	8.43	15.60	41.37	6.84	12.67	47.3	12.99

(L-a-830) to 4.4 g (JPL 923) and it ranged from 0.7 g (JPL 488) to 3.3 g (LL 56) in the 1984/85 season.

Significant genetic variability was observed for yield and its components. For the 1983/84 season, heritability estimates were moderate for time to maturity and 100-seed weight and the remaining characters exhibited low heritability. For the 1984/85 season, high heritability was observed for 100-seed weight and medium heritability for harvest index and seed yield/plant. Time to maturity and biological yield exhibited low heritability. The high genetic advance expressed as percentage of mean was recorded for 100-seed weight in the 1983/84 season, while in the 1984/85 season a high genetic advance expressed as percentage of mean was observed for 100-seed weight, harvest index, and seed yield/plant. The remaining characters showed medium to low genetic advance expressed as percentage of mean. A relative comparison of heritability estimates and genetic advance expressed as percentage of mean gives an idea of the nature of gene action dominating a particular character. A comparison of these two estimates revealed that 100-seed weight had high heritability with high expected genetic advance, expressed as percentage of mean, indicating the substantial contribution of additive gene action in the expression of this character. The remaining characters did not show high heritability with high genetic advance as percentage of mean. However, harvest index and seed yield/plant had medium heritability coupled with high genetic advance as percentage of mean indicating a significant contribution of non-additive gene effects in the expression of these characters.

Correlation coefficients for yield and other characters are given in **Table 2**. There was a positive correlation between grain yield and harvest index and biological yield for both seasons. Kumar *et al.* (1983) and Saraf *et al.* (1985) reported positive correlation between 100-seed weight and seed yield/plant. Agrawal and Lal (1985) reported the presence of high amounts of variability for seed yield in lentil accessions.

As overall observation of the findings of heritability estimates, parameters of genetic variability, and association analysis, it could be concluded that selection criteria based on harvest index and seed yield will serve the purpose of improvement of seed yield in lentil.

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Table 2 Correlation coefficients for yield and its components in lentil during the 1983/84 season (above diagonal) and the 1984/85 season (below diagonal)

Character	Maturity	100-seed weight	Biological yield	Harvest index	Seed yield per plant
Maturity	1.000	0.136	-0.171	0.073	-0.176
100-seed weight	0.038	1.000	0.174	0.192	0.072
Biological yield	0.232	0.264	1.000	0.179	0.569**
Harvest index	-0.254	-0.106	0.072	1.000	0.580**
Seed yield	-0.076	-0.001	0.639**	0.741**	1.000

** Significant at 1% level

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التحليل الوراثي للغلة البيولوجية ودليل الحصاد والغلة الحبية في العدس

ملخص

تم تقييم اربعة وخمسين طرازا وراثيا من العدس للصفات التالية : عدد الايام حتى النضج ، ووزن الالف حبة والغلة البيولوجية ، ودليل الحصاد ، والغلة الحبية في مدهايا براداش بالهند في الموسمين الشتويين 1983-85 . وقد أشارت تقديرات التباين والقابلية للتوريث وتحليل الاقتران الى أن الانتخاب الذى يقوم على صفات دليل الحصاد والغلة البيولوجية والحبية سوف يوءدى الى تحسين غلة العدس .

Differential radio-sensitivity in microsperma and macrosperma lentils

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Abstract

Microsperma and macrosperma lentils have differential radio-sensitivity for polygenic traits with macrosperma, the more sensitive.

Introduction

Lentils (*Lens culinaris* Medic.) is an important winter pulse crop grown in Northern India. It is known for its nutritive and cooking quality. *Microsperma* varieties are grown in the country, but *macrosperma* varieties require a cooler and temperate climate and are comparatively late in maturity. In the present study a comparison was made of the radio-sensitivity of *microsperma* and *macrosperma* varieties to gamma irradiation.

Materials and Methods

Dry seeds of two lentil varieties namely HPL-5 (*microsperma*) and HPL-4 (*macrosperma*) were irradiated with 5, 10, 15, 20, and 25 kR doses of gamma radiation. The material irradiated under different doses in each variety was raised as M_1 and the sown plants from M_1 generation were raised as M_2 generation. The progenies looking normal for various morphological traits and which have high potential for number of pods/plant and free from sterile or abnormal plants were harvested as bulk for raising M_3 generation during the 1981/82 season at Himachal Pradesh Agricultural University, Palampur, Himachal

Pradesh, India. The M_3 population of different doses with respect to each variety were raised separately in compact family design within completely randomised block design (CRBD) with two replications. Augmented design was superimposed for each variety in each replication. The checks used in the experiment were HPL-1, HPL-4, HPL-5, L-9-12, and L 830. In the augmented design superimposed on CRBD, each block consisted of 50 lines of irradiated progenies plus the five checks common for both varieties.

A. *Analysis of variance:* The data averaged over 10 plants in each line were analysed for all the traits as per completely randomised design (Panse and Sukhatme 1967) and augmented design (Federer 1955). Phenotypic, genotypic, and environmental components of variance were estimated for each dose and each variety. Similarly, coefficient of variability at phenotypic, genotypic, and environmental levels was estimated on the basis of standard deviation and mean value obtained for each dose.

B. *Within progeny analysis:* Within progeny analysis over replications was done with respect to biological yield and number of pods/plant, where data were recorded on single plant basis within lines.

Results and Discussion

In *microsperma* lentil, sufficient variation was induced under all the doses for all major yield components. However, for 100-seed weight it was induced only at 5, 10, and 15 kR doses (**Table 1**). The situation appears to be different in *macrosperma* lentil, where with the exception of variation for 100-seed weight the induction of variation was under 5 kR only (**Table 2**) for other traits namely biological yield and number of pods/plant. For seed yield, the doses 5, 10, and 15 kR generated variation in *macrosperma* type. Most of the doses induced variation for plant height in *microsperma* and only 15 kR dose in *macrosperma* type. All the doses were effective for induction of variation for time to 50% flowering in *microsperma* and time to maturity in *macrosperma* type. For *microsperma* lentil the doses 10, 15, and 20 kR induced variation in time to maturity (days), whereas in *macrosperma* the doses 5, 10, and 15 kR were responsible for the induction of variation. The results obtained from the comparison of control versus different doses further reveal that in *macrosperma* lentil, the variation was induced in the population raised from the irradiated seeds under 5 kR dose for all the traits except for harvest

Table 1 Analysis of variance for completely randomised block design (CRBD) with respect to induced polygenic variation in HPL-5 (*microsperma*) variety of lentil for various traits

Source	df	Mean squares: Seed yield (g)	Biological yield (g)	Harvest index	Number of pods/ plant	100-seed weight (g)	Plant height (cm)	Time to 50% flowering (days)	Time to maturity (days)
Replications	1	9.50*	69.06*	88.32*	510.15*	0.04*	89.04*	109.14*	1.21*
Lines	274	1.13*	10.81*	29.94	142.52*	1.05*	7.82*	66.83*	5.03*
Irradiated:									
5 kR	64	1.02*	8.45*	32.1	117.5*	0.04*	2.2*	14.3*	4.9
10 kR	49	1.35*	10.25*	24.2	164.64*	0.03*	2.9*	10.83*	8.61*
15 kR	59	0.76	8.54*	30.4	119.40*	0.1*	2.92*	5.94*	5.8*
20 kR	25	3.8*	11.81*	31.25	163.05*	0.01	0.7	6.40	8.81*
25 kR	48	1.40*	12.72*	14.41	137.3*	0.02	2.4*	3.91*	4.8
Unirradiated (control)	4	0.6	3.1	80.13	22.82	0.03	0.4	4.85	0.85
Comparison of:									
Control vs 5 kR	1	0.6	1.7	154.34*	138.8*	0.05*	0.02	15.02*	2.5
Control vs 10 kR	1	0.01	9.20*	173.3*	41.9	0.15*	2.42*	28.8*	0.32
Control vs 15 kR	1	0.2	14.5*	251.42*	26.80	0.2*	1.8	26.27*	0.80
Control vs 20 kR	1	0.55	14.9*	218.6*	65.61	0.14*	4.9*	21.2*	2.14
Control vs 25 kR	1	2.32*	0.8	297.51*	247.73*	0.2*	5.34*	30.93*	1.60
Error	274	0.93	8.05	34.80	111.7	0.02	1.91	3.8	5.2
Pooled error over control and error	278	0.92	7.1	35.45	110.40	0.02	1.9	3.8	5.12

* Significant at 5% level

Table 2 Analysis of variance for completely randomised block design (CRBD) with respect to induced polygenic variation in HPL-4 (*macrosperma)* variety of lentil for various traits

		Mean squares							
Source	**df**	**Seed yield (g)**	**Biological yield (g)**	**Harvest index**	**Number of pods/ plant**	**100-seed weight (g)**	**Plant height (cm)**	**Time to 50% flowering (days)**	**Time to to maturity (days)**
Replications	1	6.13*	173.96*	20.66*	43.34*	0.02*	76.51*	366.98*	7.57**
Lines	164	0.98*	8.25*	94.86	104.37*	3.70*	9.39*	80.81*	61.42*
Irradiated:									
5 kR	38	0.80*	7.35*	58.81	99.80**	0.17*	3.66	8.27**	15.52*
10 kR	52	0.79*	4.71 *	69.18	63.25 *	0.21*	2.87*	10.76*	11.02*
15 kR	38	0.77*	5.81*	60.76	70.81	0.22*	5.39*	8.82*	20.50*
20 kR	9	0.98	3.89 *	102.05	33.86 *	0.26	4.97	11.56	21.16*
25 kR	8	0.70	5.24	269.26	55.23	0.20	4.54	7.18	29.30*
Unirradiated (control)	2	0.65	6.20	4.50	73.81	0.11	5.46	2.00	20.67
Comparison of:									
Control vs 5 kR	1	2.62*	20.90*	27.88	225.08*	0.34*	0.15	130.85*	63.29*
Control vs 10 kR	1	0.23	4.17	0.03	6.52	0.14	1.31	137.64*	44.00*
Control vs 15 kR	1	0.04	0.06*	14.49	4.36	0.11	2.73	178.90*	33.67*
Control vs 20 kR	1	0.61	15.73*	99.54	201.65*	0.18	14.21*	147.33*	76.95*
Control vs 25 kR	1	0.18	4.15	0.32	22.46	0.43*	21.78*	88.91*	48.92*
Error	164	0.71	6.63	107.29	76.43	0.16	4.37	6.70	10.66
Pooled error over control and error	166	0.71	6.63	99.67	76.39	0.16	4.38	6.64	10.78

index and plant height, whereas higher doses were effective in inducing variation in other characters such as the doses 15 and 20 kR for biological yield, 20 kR for number of pods/plant, 25 kR for 100-seed weight, and plant height and all doses for time to 50% flowering (days) and time to maturity (days). In *microsperma* lentil, 25 kR dose for seed yield; 10, 15, and 20 kR doses for biological yield; 5 and 25 kR doses for number of pods/plant; 10, 20, and 25 kR doses for plant height; and all doses for 100-seed weight and time to flowering (days) increased variation over the control. The increase in the variation in the irradiated material of both *microsperma* and *macrosperma* lentil may be due to changes in the nature of genes or chromosomal re-arrangements or both after radiation.

Besides between progeny analysis, the results obtained from within progeny analysis in M_3 generation for both *microsperma* and *macrosperma* lentils with special reference to biological yield and number of pods/plant further revealed that in the present material the induction of increased variation is not only limited to between progenies, but it has increased manyfold within progeny variance too. There is a number of progenies for both the characters of both types of lentils showing more variation within them

Table 3 Number of progenies with significant "within progeny" variance for biological yield and number of pods/plant characters in *macrosperma* and *microsperma* type lentils

	HPL-5 (*microsperma*)		HPL-4 (*macrosperma*)	
Dose kR	**Biological yield**	**Number of pods/ plant**	**Biological yield**	**Number of pods/ plant**
5	12	10	22	9
10	5	7	23	16
15	10	6	13	7
20	18	15	1	-
25	-	-	2	-

in comparison to the control (**Table 3**). This is more evident for *macrosperma* type where a large number of progenies under 5 kR dose showed increased variation. The number of progenies under both types of lentil are given in **table 3** for both characters as mentioned above with significant within progeny variance as compared to control.

Thus, it can be concluded that *macrosperma* lentil is more radio-sensitive than *microsperma* lentil, This is evident from the fact that *microsperma* lentil polygenic variation was induced at higher doses, whereas in *macrosperma* it was induced at lower doses.

الحساسية الاشعاعية التفاضلية في العدس ذى الحبة الكبيرة والصغيرة

ملخص

يوجد للعدس الكبير والصغير الحبة حساسية اشعاعية تفاضلية لصفات متعددة الجينات ، وكان العدس الكبير الحبة اكثر حساسية .

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Developing a bold-seeded tetraploid lentil line

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Abstract

A polyploid breeding programme was initiated to produce a bold-seeded variety with good yield. The tetraploid plant was raised by treating shoot tips at the two leaf stage. Meiotic studies of the C_2, C_3, and C_4 generations showed that the frequency of multivalent configurations decreased with the passage of the generations, while bivalent frequency increased. Chiasma frequency/chromosome also followed the same pattern as bivalents and had positive correlations with pollen fertility and number of seeds/plant. Autotetraploid plants were more robust and vigorous for morphological characters. The percent diploid value for yield contributing components increased over the generations. The C_3 and C_4 generations showed great variation for different quantitative characters which provide potential for selection to improve the yield of autotetraploid plants in advanced generations. A plant was selected in the C_4 generation which had a higher seed yield (8.9 g) than the diploid control (8.3 g). Thus, polyploid breeding in lentil may be successful and after selection for a few generations the yield can be improved with the whole population of the bold-seeded type.

Introduction

Polyploidy is one of the most outstanding features in plant evolution (Stebbins 1950). It has also been exploited in crop improvement (Muntzing 1951; Randolph 1932). Polyploid breeding has been unsuccessful because raw polyploids generally have low seed setting. However, fertility can be improved to some extent through selection. Species respond differently to induced autotetraploidy and encouraging results of economic value have been obtained in buck wheat (Sacharov *et al.* 1945), *Brassica campestris* var. Toria (Swaminathan and Sulbha 1959), rye (Muntzing 1951), and *Brassica rape* (Schwanitz 1949). In some cases, the initial fertility of the raw autotetraploids was reasonably high and was further improved to near the diploid level by selection over a number of generations (Muntzing 1951; Parthasarthy and Rajan 1953; Rajan 1955).

Materials and Methods

The seeds of *Lens culinaris* Med. were obtained from the Pulse Directorate Kalyanpur, Kanpur, India. Tetraploid plants were raised in the laboratory by 0.2% aqueous colchicine treatments of shoot tips of young seedlings in the 1982/83 season. The seeds of tetraploid plants were collected and the C_2 generation was studied in the 1983/84 season. The seeds of the C_2 generation were collected separately from each plant. The seeds of C_2 generation were sown at a distance of 30.5 cm between the plants. The generations of C_3 and C_4 were studied in the 1984/85 and 1985/86 seasons, respectively. For meiotic studies, proper sized buds were fixed in Carnoy's fluid (1 part acetic acid and 3 parts absolute alcohol) saturated with iron. Acetocarmine (2%) squashes were prepared for scoring chromosomal anomalies and pollen fertility. Data of chiasma frequency and other meiotic configurations were subject to statistical analysis, applying the formula given by Mather (1964). Data on plant morphology were also collected between the germination and maturity stages and statistically analysed.

Results

Cytological characters

The diploids (2n = 14) had normal meiosis which regularly formed seven bivalents at metaphase I (**Fig. 1**) while multivalents were observed in all the autotetraploid genera-

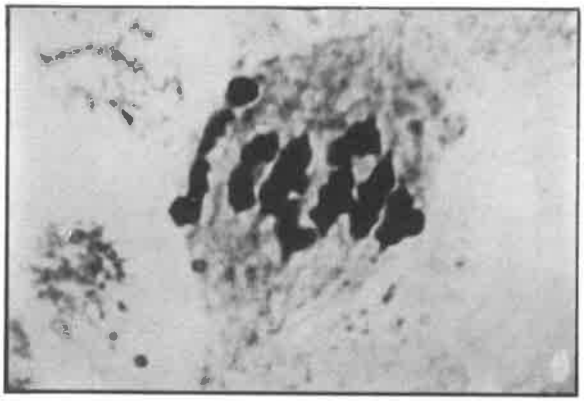


Fig. 1 Metaphase I of diploid

Fig. 2 Metaphase II of autotetraploid

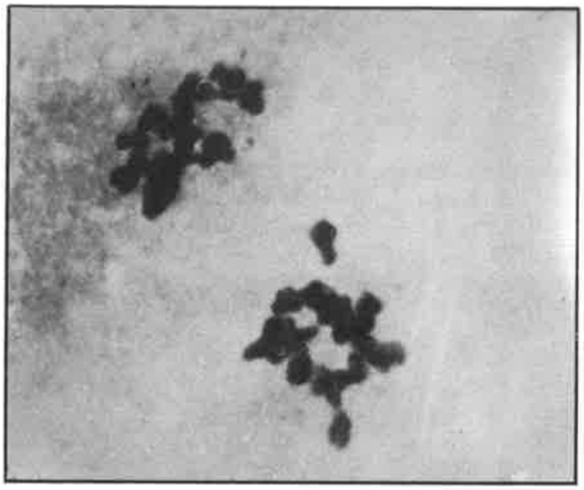


Fig. 3 Anaphase I of autotetraploid

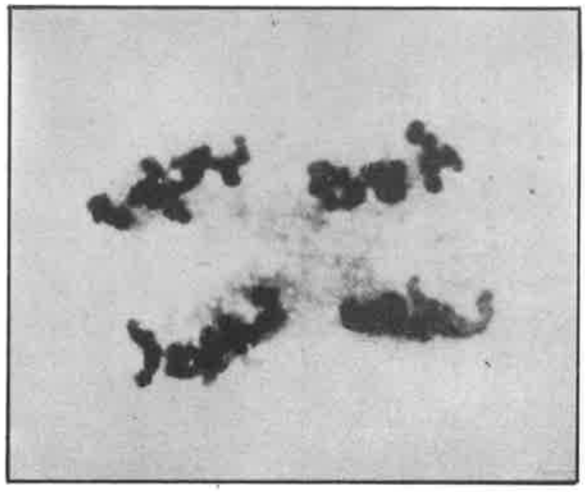


Fig. 4 Anaphase II of autotetraploid

tions (4x = 28). The configuration at metaphase I (**Fig. 2**) of the autotetraploid generations was 14 bivalents, but a variety of chromosome associations was found.

Quadrivalent, trivalent, bivalent, and univalent frequencies per cell were observed in the C_2, C_3, and C_4 generations (**Table 1**). Ring quadrivalents were present in all the three generations studied. It ranged from 0 to 2/pollen mother-cell (PMC) in the C_2 and C_3 generations, while it ranged from 0 to 3 in the C_4 generation. Rod quadrivalents were absent in the C_2 generation, but present in the C_3 and C_4 generations. They ranged from 0 to 1 in both generations. The ring trivalents displayed a similar trend, i.e. they were present only in the C_3 and C_4 generations. They ranged in the C_3 generation from 0 to 2/PMC and from 0 to 1 in the C_4 generation. The rod trivalents ranged between 0 and 2 in the C_2 generation and between 0 and 3/PMC in the C_3 and C_4 generations. Univalents were present in all the three generations ranging between 0 and 3/PMC in the C_2 generation and between 0 and 4/PMC in the C_3 generation, and between 0 and 3/PMC in the C_4 generation. The actual mean (AM), the standard error (SE) of values of ring quadrivalents, rod quadrivalents, ring trivalents, rod trivalents, and univalents decreased gradually from the C_2 to C_4 generation (Table 1).

Diploid had higher chiasma frequency per chromosome than the autotetraploid generations (**Table 2**). However, in autotetraploids the chiasma frequency per chromosome increased with the generation.

Variance ratios between nuclei and within nuclei were calculated as non-significant in different autotetraploid and diploid generations. The intraclass correlation value was negative in diploids, while it was positive in the autotetraploids (**Table 2**).

The other stages of meiosis in the autotetraploids were normal (**Figs. 3** and **4**) and no anomaly was observed.

The average values of different meiotic configurations per PMC of different generations of the autotetraploids showed that quadrivalents, trivalents, and univalents decreased with the passage of generations. Bivalents, however, increased with the generations (**Fig. 5**). The chiasma frequency per chromosome increased with the generations (**Fig. 7**).

Table 1 Range, actual mean (AM) + standard error (SE) and value of different meiotic configuration in the diploid C_2, C_3, and C_4 generations of tetraploids in lentil

Source of variation	Range				AM $\pm$ SE				Value			
	2n	C_2	C_3	C_4	2n	C_2	C_3	C_4	2n	C_2	C_3	C_4
Ring quadrivalent		0 - 2	0 - 2	0 - 3	-	1.32 $\pm$ 0.09	1.05 $\pm$ 0.20	0.69 $\pm$ 0.34	-	1.01	0.76	0.53
Rod quadrivalent		-	0 - 1	0 - 1	-	-	0.10 $\pm$ 0.08	0.02 $\pm$ 0.01	-	-	1.73	1.01
Ring trivalent		-	0 - 2	0 - 1	-	-	0.15 $\pm$ 0.29	0.02 $\pm$ 0.01	-	-	0.52	1.05
Rod trivalent		0 - 2	0 - 3	0 - 3	-	0.99 $\pm$ 0.23	0.65 $\pm$ 0.35	0.34 $\pm$ 0.05	-	1.04	0.97	3.16*
Ring bivalent	2 - 7	3 - 8	2 - 12	5 - 12	4.47 $\pm$ 0.22	5.00 $\pm$ 0.33	6.25 $\pm$ 0.31	7.98 $\pm$ 0.35	0.03	1.09	0.28	1.57
Rod bivalent	0 - 5	2 - 10	0 - 9	5 - 9	1.97 $\pm$ 0.18	6.05 $\pm$ 0.60	5.60 $\pm$ 0.47	4.94 $\pm$ 0.25	0.33	0.99	0.71	0.28
Univalent		0 - 3	0 - 4	0 - 3	-	1.10 $\pm$ 0.02	0.80 $\pm$ 0.31	0.50 $\pm$ 0.08	-	2.00	0.45	0.53

* = Significant at 5% level.

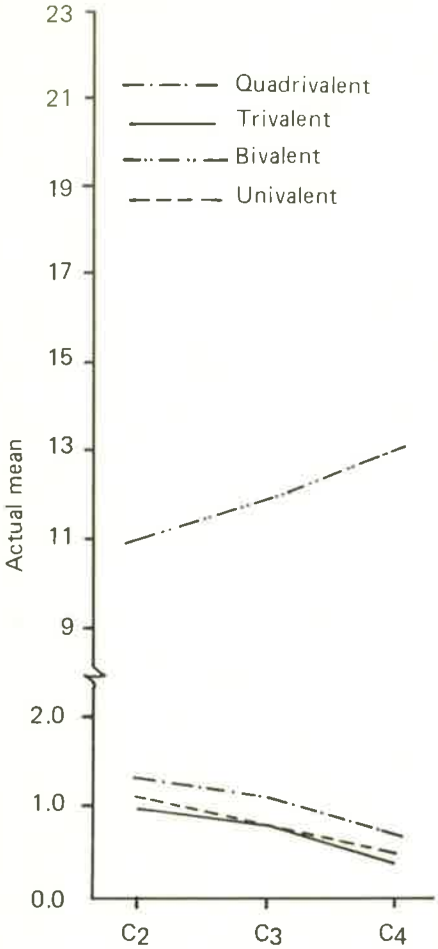
Table 2 Chiasma frequency/chromosome, plant to plant variation, and pollen fertility in diploid and different generations of autotetraploid of lentils

Source of variation	Chiasma frequency/chromosome		Sum of sq within nuclei	Sum of sq between nuclei	Variance ratio	Intra class correlation value	Value	Pollen fertility		
	AM $\pm$ SE	Range						AM $\pm$ SE	Range	Value
2n	0.846 $\pm$ 0.013	0.806 - 0.883	-2.830	-17.764	0.159	-19.673	0.441	97.6 $\pm$ 0.493	89.5 - 99.2	0.6375
C_2	0.718 $\pm$ 0.020	0.500 - 0.824	252.001	138.994	0.110	0.617	0.121	37.5 $\pm$ 0.465	37.1 - 38.0	-
C_3	0.790 $\pm$ 0.012	0.748 - 0.832	-1.830	-36.077	0.051	1.322	-0.713	56.8 $\pm$ 5.859	40.3 - 82.9	0.5907
C_4	0.825 $\pm$ 0.009	0.804 - 0.850	1376.6	-1161.7	-0.093	6.519	1.011	89.4 $\pm$ 1.736	48.1 - 939	0.9812

Fig. 5 Average mean value of different meiotic parameters in C_2, C_3, and C_4 generations

Fig. 6 Average mean value of pollen fertility (%) seed fertility (in number) in C_2, C_3, and C_4 generations of autotetraploid

Fig. 7 Average mean value of chiasma frequency/chromosome in C_2, C_3, and C_4 generations of autotetraploid



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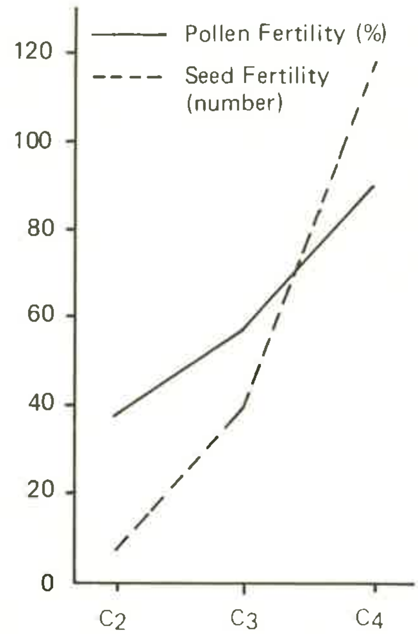

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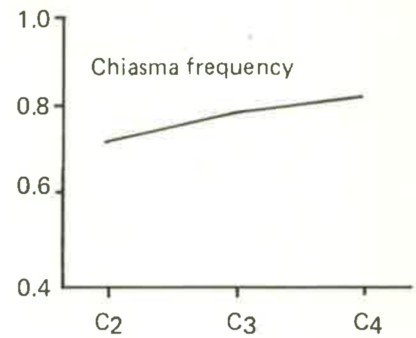

7

Quantitative traits

The autotetraploid plant (**Fig. 8**) was more vigorous and robust in habit with an increase in the different morphological parameters compared to a diploid plant (**Fig. 9**). The percent of the control (diploid) value for the different quantitative traits was calculated for different generations of autotetraploids (**Table 3**). The morphological characters of plant height, number of branches/plant, number of nodes/plant, internodal length, and stem perimeter were more or less similar in different autotetraploid generations, but yield contributing components increased in the advanced generations resulting in the increase in total seed yield with generation. The percent diploid value for the total seed yield was 4.2 in the C_2 generation, 36.1 in the C_3 generation, and 64.5 in the C_4 generation (**Table 3**).

Pollen fertility was extremely poor 37.1 - 38.0% with a mean of 37.5 $\pm$0.47 in the C_2 generation, 40.3 - 82.9% with a mean of 56.8 $\pm$5.85 in the C_3 generation, and the highest 48.1 to 93.9% with a mean of 89.4 $\pm$ 1.74 in the C_4 generation. Pollen fertility in the diploid plants was 97.6 $\pm$ 0.49.

Pollen fertility and the number of seeds/plant increased in the C_3 and C_4 generations over the C_2 generation (**Fig. 6**). These followed the same pattern as chiasma frequency per chromosome and bivalent frequency per PMC in the C_3 and C_4 generations.

In the C_4 generation, the data for different quantitative characters of 20 randomly selected plants showed great variation among the plant progeny of the C_4 generations (**Fig. 10**).

Selection and segregation patterns in autotetraploid plants in different generations

One autotetraploid plant was obtained in the C_1 generation. Seed setting was extremely poor and only two seeds were obtained. Tetraploid seeds (**Fig. 11**) were larger in size than diploid (**Fig. 12**). The two plants raised from these seeds were both morphologically distinct. The first plant (P1) was tall and vigorous (**Fig. 13**) while the other (P2) was bushy (**Fig. 14**). At maturity, their morphological characters were studied (**Table 4**). The seeds from these plants were collected separately and further studies were carried out in the subsequent generations.

P1 Plant Progeny

In the C_2 generation, the P1 plant was vigorous, tall, and robust in habit with 32.0 cm height, 72 flowers, and 12 pods with 38.0% pollen fertility. Total seed yield was 0.2 g and each pod contained a single seed. All the twelve seeds were sown to obtain the C_3 plant progeny.

In the C_3 generation, only four plants survived to maturity. The mean, range, and standard error for the various morphological characters of these plants are given in **Table 5**. The maximum yield in the C_3 generation of P_1 progeny was 2.6 g/plant, near to diploid (2.96 g/plant). Selection was made in the C_3 generation on the basis of higher number of pods/plant and the total seed yield/plant.

Table 3 Percent of diploid value of different morphological characters in different generations of autotetraploid of lentil.

Quantitative	C_2	C_3	C_4
Plant height (cm)	108.2	103.2	111.4
Number of branches/plant	108.2	132.4	99.4
Number of nodes/plant	108.2	113.2	115.6
Internodal length (cm)	80.6	73.7	90.1
Stem perimeter (cm)	122.8	112.0	118.8
Number of flowers/plant	114.6	128.1	146.9
Number of pods/plant	3.0	16.8	22.9
Number of seeds/pod	62.5	62.5	80.4
25 seed wt. (g)	-	178.1	182.7
Total yield/plant (g)	4.2	36.1	64.5
Pollen fertility (%)	48.1	66.1	91.4

One C_3 plant studied had 115 pods/plant. Only 80 out of 115 seeds sown to raise C_4 plants survived. At maturity, data for morphological characters of 20 plants were taken at random and subjected to statistical analysis.

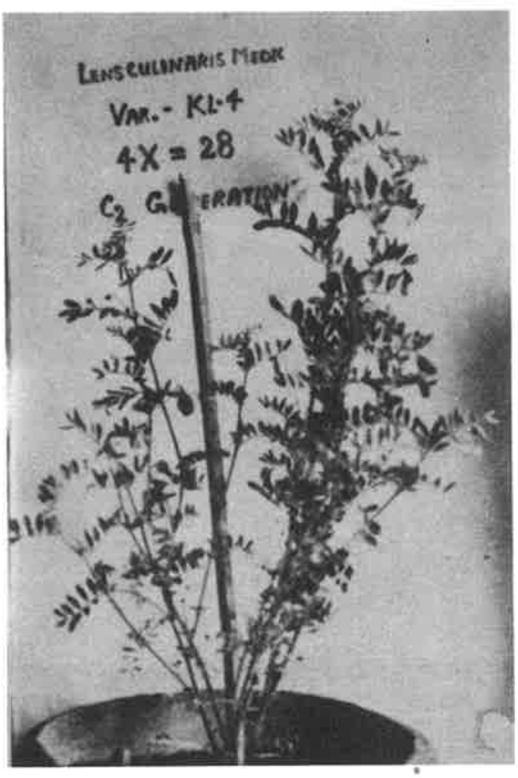

Fig. 8 Autotetraploid plant

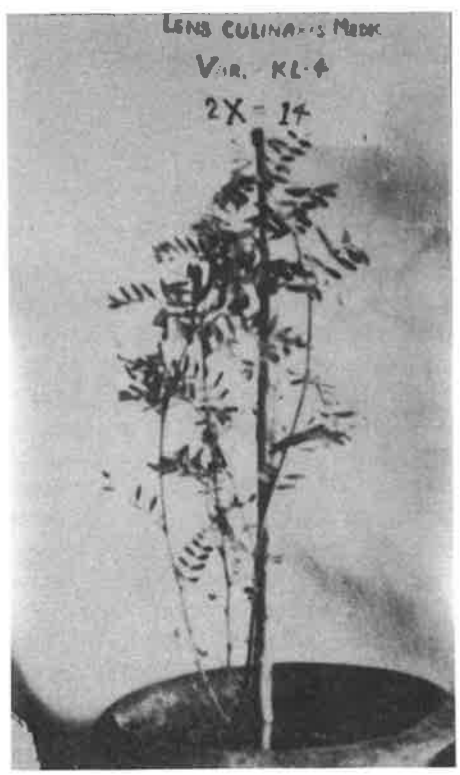

Fig. 9 Diploid plant

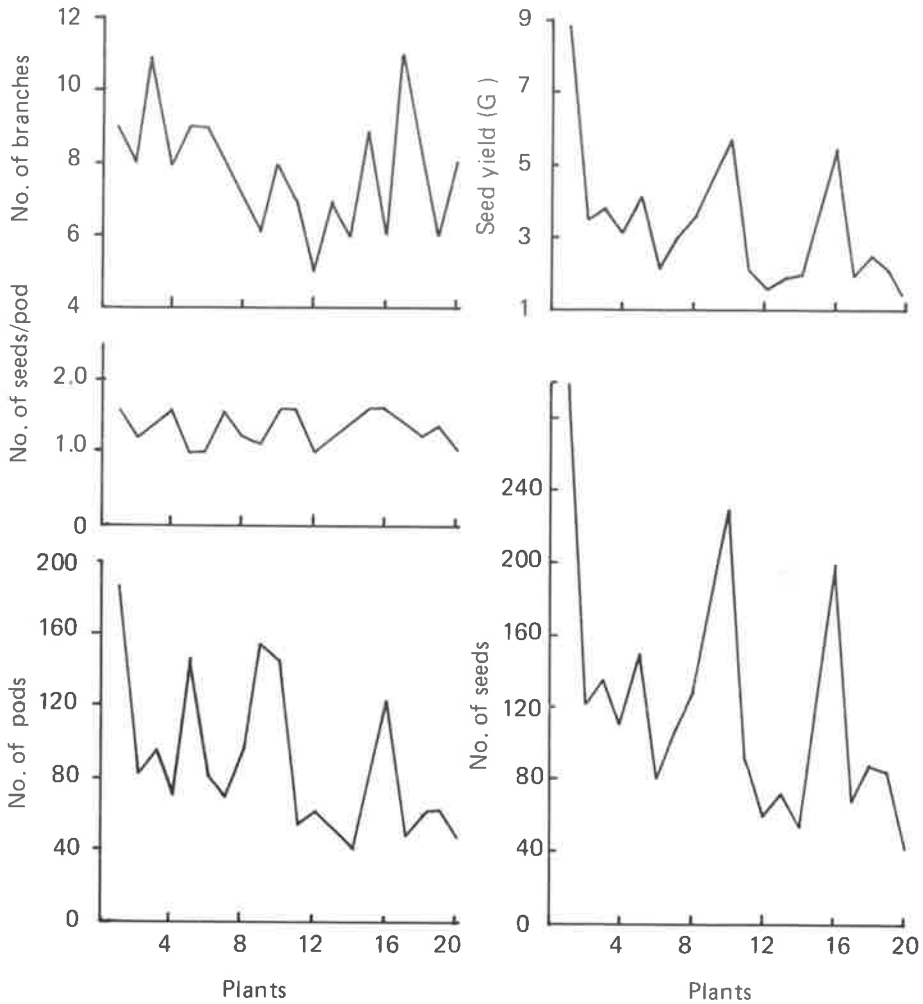

Fig. 10 Variation among C_4 plant population

The range, mean and its standard error are given in **Table 4** for plant height, number of branches/plant, number of nodes/plant, internodal length, stem perimeter, number of flowers/plant, number of pods/plant, number of seeds/ pod, test weight, and seed yield/plant. Seed yield/plant (g) ranged from 1.27 to 8.88 g with a mean of 3.35 $\pm$ 0.407 and pollen fertility ranged from 83.2 to 95.1 with a mean of 91.6 $\pm$ 1.63. The total seed yield of one of the C_4 plants of P_1 progeny was 8.88 g which was slightly higher than the diploid plant i.e. 8.26 g/plant.

P2 Plant Progeny

The height of the bushy plant in the C_2 generation numbered as P2 was 28.5 cm. It had 70 flowers, but seed setting was extremely poor. Only two seeds were obtained and its pollen fertility was 37.1% and total yield was 0.05 g.

The two seeds of the P2 plant progeny of the C_2 generation were sown to raise the C_3 generation, but only one of the two plants survived. Its morphological characters are given in **Table 4**. Like its parent, it was again bushy in habit with a height of 21.5 cm. There were 1050 flowers, but only 6 mature pods were obtained. The total seed yield of the plant was 0.12 g and pollen fertility was 38.6%.

All the seeds obtained were sown to raise the C_4 generation. Only one out of six C_3 plants survived till maturity. The morphological parameters are given in **Table 4**. Like its parent, the plant was 35.2 cm in height and had 1120 flowers with 15 pods at maturity. But in the C_4 generation the number of seeds/pod in this line ranged from 1 to 2 with a mean of 1.4 seeds/pod. The total seed yield of the plant was 0.63 g and its pollen fertility was 48.1%.

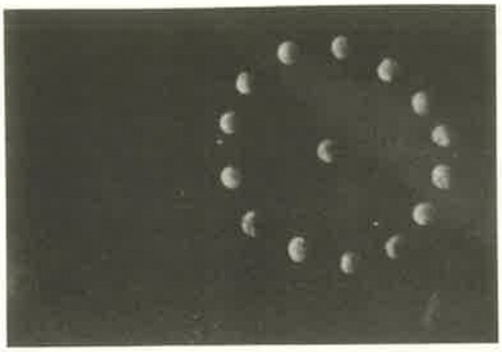

Fig. 11 Seeds of autotetraploid

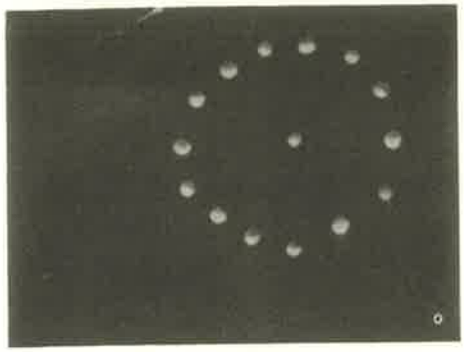

Fig. 12 Seeds of diploid

Fig. 13 Autotetraploid plant no 1

Fig. 14 Autotetraploid plant no 2

Discussion

Diploid plants had distinctly higher chiasma frequency per chromosome than the different autotetraploid generations. But chiasma frequency per chromosome increased with the generations in polyploids. Similar results were reported by Raghuvanshi and Chauhan (1970) in *Tabernae montana divericata*, Raghuvanshi *et al.* (1980) in *Melilotus alba*, and Raghuvanshi and Singh (1980) in *Trigonella foenum graecum* L.

All the meiotic configurations *viz.* quadrivalent, trivalent, and univalent decreased while bivalents increased with the passage of generations in the autotetraploids (**Table 1**). Similar observations were also reported by Gilles and Randolph (1951), Plarre (1954), Hilpert (1957), Aaslveit (1968), and Simonson (1973; 1975). Bivalents in this case are obviously being formed at the expense of multivalents. The frequency of quadrivalents in general was considerably lower than bivalent frequency. The low frequency of quadrivalent association observed in the autotetraploids may suggest that certain factors restrict the association of four homologous chromosomes into quadrivalents. Similar findings were also reported in the autotetraploid *Fragaria* by Sebastiampillai and Jones (1977), in *Festuca pratensis* by Simonson (1975), and in *Melilotus alba* by Raghuvanshi *et al.* (1980).

The observed trend in the increased formation of the rings in contrast to the chain quadrivalents is promising from the point of view of the increased fertility, because the rings have more chance of an equal disjunction at anaphase I. A comparable trend was also reported by Gopal and Singh (1979) in advanced generations of autotetraploid of fenugreek.

It was found that the number of univalents exceeded that of the trivalents resulting from an early disjunction of bivalents (Gopal and Singh 1979). The mean frequency of bivalents was greater than that of quadriva-

Table 4 Range, actual mean ± standard error (AM ± SE), and t value for different morphological characters in different generations of autotetraploid of lentil

	C_2			C_3			C_4		
Character	Range	AM ± SE	t	Range	AM ± SE	t	Range	AM ± SE	t
Plant height (cm)	28.5 - 32.0	30.2 ±1.75	-	21.5 - 45.0	31.9± 4.3	-0.14	35.2 - 65.0	53.9± 4.3	7.1
Number of branches/plant	7 - 8	7.5 ±0.5	-	7 - 14	9.8± 1.8	0.63	6 - 11	8.5± 0.7	0.7
Number of nodes/plant	20 - 21	20.5 ±0.5	-	26 - 32	29.0± 1.1	1.75	22 - 28	26.2± 1.4	0.11
Internodal length (cm)	1.49 - 1.65	1.6 ±0.1	-	0.83 - 1.5	0.98± 0.2	-0.48	1.3 - 2.4	1.1± 0.0	0.3
Stem perimeter (cm)	1.3 - 1.5	1.4± 0.1	-	1.2 - 1.6	1.4± 0.1	-1.19	1.3 - 1.7	1.5± 0.1	0.3
Number of flowers/plant	70 - 72	71.0± 0.1	-	130	470.0± 179.7	1.39	700 - 1200	11.3± 83	0.1
Number of pods/plant	2 - 12	7.0± 5.1	-	6 - 1	40.2 ± 19.4	0.53	45 - 188	72.5± 24	0.5
Number of seeds/pod	1 - 1	-	-	1 - 1	-	-	1 - 1.6	1.37± 0.1	0.3
Test weight (g)	-	-	-	-	-	-	1.38 - 1.50	1.432± 0.0	0.9
Seed yield/plant (g)	0.05 - 0.20	0.12 ±0.07	-	0.13 - 2.6	0.882± 0.44	0.547	0.7 - 8.9	3.231± 1.2	0.1

Table 5 Range and AM ± SE (Actual mean ± Standard Error) of plant progenies in C_2, C_3, and C_4 generations of autotetraploid of lentil

	C_2		C_3			C_4		
			P_1 plant progeny			P_1 plant progeny		
Character	P_1	P_2	Range	AM ± SE	P_2 plant progeny	Range	AM ± SE	P_2 plant progeny
Plant height (cm)	32.0	28.5	23.5 - 45.0	34.5 ± 4.49	21.5	45.0 - 68.2	58.2 ± 1.21	35.2
Number of branches/plant	8.0	7.0	5 - 14	8.75 ± 1.93	14.0	5 - 11	7.85 ± 0.38	6.0
Number of nodes/plant	20.0	21.0	27 - 33	30.0 ± 1.29	26.0	21 - 32	27.75 ± 0.71	24.0
Internodal length (cm)	1.65	1.49	0.84 - 1.16	1.02 ± 0.26	0.83	1.62 - 2.35	1.94 ± 0.05	1.28
Stem perimeter (cm)	1.5	1.3	1.2 - 1.5	1.45 ± 0.09	1.2	1.3 - 1.6	1.52 ± 0.03	1.3
Number of flowers/plant	72	70	150 - 1130	325.0 ± 137.02	1050.0	700 - 1350	1085.45 ± 52.66	1120
Number of pods/plant	12	2	6 - 115	48.75 ± 22.49	6.0	45 - 188	88.0 ± 9.50	15.0
Number of seeds/pod	1	1	1 - 1	-	1	1.2 - 1.6	1.35 ± 0.05	1.4
Test weight (g) (25 seeds)	-	-	0.50 - 0.56	0.53 ± 0.02		0.62 - 0.70	0.67 ± 0.02	0.7
Total seed yield/plant (g)	0.20	0.05	0.30 - 2.60	1.07 ± 0.52	0.13	1.88 - 8.88	3.35 ± 0.41	0.630
Pollen fertility (%)	38.0	37.1	45.6 - 82.9	61.03 ± 7.84	38.6	83.2 - 95.1	91.9 ± 1.63	48.1

lents, trivalents, and univalents. This may indicate that the disomic type of association of chromosomes is predominant, and that a comparatively lower number of chromosomes show tetrasomic association giving rise to multivalent formation. Two distinct causes have been recognised for disomic pairing, the first is based on the evidence of genetic control of bivalent pairing (Ladizinsky 1973; Harberd 1975; Jauhar 1975) and the other is based on the structural differences between the two pairs of homologous chromosomes (Reinberg *et al.* 1970).

The percentage of pollen fertility in advanced autotetraploid generations tremendously increased as was also reported by Raghuvanshi *et al.* (1980) in *Melilotus alba*, Raghuvanshi and Singh (1980) and Gopal and Singh (1979) in fenugreek. Pollen fertility can be influenced by environmental as well as genetic and cytological factors. The improvement in pollen fertility could be attributed to selection of more fertile types during the successive generations of polyploidy, but not to any distinct role of chromosomal pairing and behaviour during meiosis.

Improvement of meiotic regularity in induced autotetraploids of Lens culinaris

A characteristic feature of the cytogenetics of induced autotetraploids is the gradual regularization of the meiotic behaviour taking place through selection, either natural or human, covering succeeding generations after doubling. This is achieved almost invariably by a decrease in the formation of univalents and trivalents, whereas the corresponding changes in the frequency of the bivalents and quadrivalents can follow different pathways in advanced generations (Simonson 1975; 1973) *viz.* (I) increased frequency of the bivalents at the expense of the univalents, trivalents, and quadrivalents or (ii) increased frequency of quadrivalents at the expense of all the other types of associations.

According to Simonson (1975) the selection for improved meiotic regularity should be carried out on characters considering all the cytological factors responsible for regular disjunction of chromosomes at first anaphase. The selected sample of the highest yielding individuals can then easily be analysed cytologically and the regularization process may be speeded up if the tetraploid individuals exhibiting a high frequency of abnormal segregations are also excluded.

Brewer and Reinders (1954) found that the selection over the seven generations increased seed set from about 60 to 75%. They also concluded that selection for high seed set had led to a higher regularity of the meiotic division. Hilpert (1957) found that selection for high seed set and tillering capacity during the three generations had resulted in a significant increase in meiotic regularity. Percent of pollen fertility and number of seeds/plant increased with the passage of the generations (**Fig. 1**) which showed positive correlation with chiasma frequency and bivalents and negative correlation with the multivalents (Simonson 1973; Gopal and Singh 1979).

Segregation patterns in successive generations of autotetraploids of lentil

The autotetraploid plant of the C_1 generation had only two bold seeds in comparison to the diploids. The plants, raised by these two seeds in the C_2 generation, showed differences in their habit. The first one was bushy with few pods and the other one was tall and vigorous with a large number of pods. The nature of both plant progeny was inherited in subsequent generations as studied up to the C_4 generation.

The progeny of the bushy plant were low yielding, but there was a slight improvement with the advancement of the generations.

The progeny of the tall vigorous plant was high yielding and the average yield per plant in the C_2 generation was 0.20 g and 3.35 g in the C_4 generation. This provides potential for selecting a high yielding plant in the succeeding generations. Thus, it is apparent in this study that the original diploid plants which were treated to raise the C_1 autotetraploids were heterozygous having started segregation in the C_2 generation.

It is noted that amongst the different plants in the C_4 generation there was a significant variation for yield parameters and total yield. This clearly indicated that the selection can still be effectively carried out in improving yield. Sybenga (1973) reported that the selection in an autotetraploid crop is difficult because tetraploidy has a buffering effect against homozygosity and recessiveness continues to segregate for a number of generations. The number of plants and generations needed to achieve homozygous lines is considerable, so selection must be continued in the successive generations of autotetraploid of *Lens culinaris* Medic. to obtain a good yielding, bold seeded, and stable variety.

Thus, tetraploid material is very promising because there is an increase in yield besides bold seededness.

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استنباط سلالة عدس كبيرة الحبة ورباعية التضاعف الكروموزومي

الملخص

انشئ برنامج التربية بالتضاعف الكروموزومي لانتاج صنف كبير الحبة وذو غلة جيدة . وقد تم تربية النبات الرباعي التضاعف بمعالجة قمم الفروع عند مرحلتي الطور الورقي . ان دراسات الانقسام الاختزالي للاجيال C2 و C3 و C4 أظهرت أن تكرار تشكل وحدات تزاوجية عديدة الكروموزومات قد تناقص مع تقادم الاجيال في حين ازداد تكرار الوحدات التزاوجية الثنائية التكافوء bivalent. كما تبع تكرار الكيازما/الصبغي نفس نموذج الوحدات التزاوجية الثنائية التكافوء وكان له ارتباطات موجبة مع خصوبة حبوب اللقاح وعدد البذور/النبات . وكانت النباتات الرباعية المجموعة الصبغية الذاتية اكثر قوة ونشاطا من حيث الصفات الشكلية . وقد ازدادت النسبة المئوية لقيمة ثنائي التضاعف الكروموزومي للمكونات المساهمة في الغلة على مدى الاجيال . وقد اظهر الجيلان C3 و C4 تباينا واسعا في مختلف الصفات الكمية التي تعطي امكانية الانتخاب لتحسين النباتات الرباعية المجموعة الصبغية الذاتية في الاجيال المتقدمة . وقد تم انتخاب نبات من الجيل C4 يتمتع بغلة حبية (8.9 غ) أعلى من الشاهد الثنائي التضاعف الكروموزومي (8.3 غ) . وهكذا فان التربية بالتضاعف الكروموزومي في العدس يمكن أن تكون ناجحة بحيث تؤدي الى تحسين الغلة بعد اجراء الانتخاب لبضعة اجيال على مجمل العشيرة ذات الطراز الكبير الحبة .

Stability of seed yield of some lentil genotypes in relation to seed size

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Abstract

Twenty genotypes of lentil, with different seed sizes, were evaluated in the field for three cropping seasons at the Research Farm of Haryana Agricultural University, Hisar, India to study the difference between *microsperma* and *macrosperma* types in stability parameters. Small-seeded types showed better results in terms of stability parameters. Genotypes with a 100-seed weight of about 2 g had a comparatively high mean yield, an average response to their environment, and a non-significant deviation around unit regression. The use of one or two cycles of mechanical mass selection for average seed sized lentils (2 g/100 seeds) in segregating generations, followed by single plant selections has been advocated for lentil improvement.

Introduction

Seed size is considered an important factor in seedling vigour, plant growth, and yield (Wood *et al.* 1977; Agrawal 1982). Distinct morphological and physiological differences exist between *macrosperma* and *microsperma* types in lentils (Solh 1980), where large seed size is given more emphasis in varietal improvement now. On the other hand, yield stability is also a desirable character, but environmental conditions have always been a major constraint for stable lentil yields. Such uncertainty in yield makes lentil growers cautious about growing on a large scale. Therefore, clear information about yield stability of lentil genotypes is desirable. The present investigation studies seed yield stability on 24 newly developed lentil genotypes with varying seed sizes.

Materials and Methods

Twenty four lentil genotypes with 100-seed weight ranging from 1.75 g to 4.35 g **(Table 1)** were tested for yield stability during the 1983-86 winter seasons at Research Farm of Haryana Agricultural University, Hisar, India. Most of these diverse genotypes, collected from different centres in India **(Table 2)**, were

Table 1 Stability parameters for yield in 24 lentil genotypes with different seed sizes

Genotype	Origin	100-seed weight (g)	Mean yield (kg/ha)	Regression coefficient (bi)	Deviation (S^2di)
LH 82-2	Hisar	1.85	1431	1.57	11146
LH 82-4	do	1.95	1253	0.75	-15799
LH 82-6	do	3.00	1429	0.97	75246*
LH 82-7	do	2.75	1608	0.90	2720
LH 82-8	do	1.75	1398	0.92	29283
LH 83-1	do	1.90	1551	0.86	11020
LH 83-2	do	3.45	1386	1.17	-15972
LH 83-3	do	2.15	1599	1.24	50116*
LH 83-4	do	1.90	1625	1.03	-15602
LH 83-8	do	2.00	1541	1.32*	-8802
LH 83-9	do	1.90	1549	1.66*	-3229
LH 83-11	do	2.55	1596	1.25	66776*
LH 83-12	do	1.65	1366	0.93	-4277
LH-15	do	1.95	1772	0.95	42558
LH-21	do	2.60	1244	0.71*	-8751
LH-97	do	2.10	1816	1.34*	1543
LH-162	do	2.45	1705	0.95	3518
LH-261	do	2.75	1553	1.12	-15010
LH-319	do	1.70	1524	1.02	-8527
Precoz Selection	IARI New Delhi	4.35	491	0.07*	-10292
Sehore-34	Sehore	3.65	665	0.03*	-10255*
L 4076	Ludhiana	2.90	1091	0.62*	17741
L9-12	Uttar Pradesh	1.90	1548	0.98	1360
Pant-639	do	1.75	1607	1.24	-15469
General mean			1431		

* Significant at 5% level

pure lines developed through hybridization. Randomized block design with three replications was followed in each year. Observations on seed yield were recorded on a 4 x 2 m^2 plot basis and subsequently converted into kg/ha. Pooled analysis of variance of yield for the 24 genotypes was made. Phenotypic stability parameters were worked out following the method of Eberhart and Russell (1966).

Results and Discussion

Pooled analysis of variance showed significant differences among the genotypes as well as among the environments (**Table 2**). The genotype x environment interactions (G x E), including the linear effect due to environments i.e. E(L), were found to be significant. Mean squares due to environments were significantly different and had considerable influence on seed yield. The G x E (linear) interaction showed significant differences among regression coefficients pertaining to the varieties on the environmental means. The significant variance due to pooled deviation showed that both linear and non-linear components were equally important, however, the magnitude of the former was higher.

As was mentioned before, stability of yield in commercial lentil cultivars is a desirable attribute under varying environments. According to the model of Eberhart and Russel (1966) in stability studies, the three stability parameters: mean, regression coefficient, and deviation from regression need to be considered simultaneously. Accordingly, a genotype with a high mean, unit regression, and non-significant deviation (S^2di) is ideal in terms of stability. However, the regression coefficient measures the response of a genotype to a given environment and the deviation measures the stability of performance. With these points in view, nine small-seeded genotypes *viz.* LH82-7, LH83-1, LH83-4, LH15, LH162, LH261, LH319, L9-12, and Pant 639 were found to have a satisfactory yield and average response to its environment, in addition to being stable (**Table 1**). The ramaining small-seeded genotypes showed non significant deviation, with low yields sometimes.

All *macrosperma* genotypes i.e. with a 100-seed weight of about 3 g (Precoz Selection, Sehore 34, LH83-2, L 4076, and LH82-6) were invariably poor yielders, with the boldest-seeded (Precoz Selection) having the lowest yield (**Table 1**). Their response to their environment was generally poor and no specific trend appeared in deviation. Thus, considering the three stability parameters, none of the bold-seeded genotypes (3 g or above/100 seeds) was desirable.

In lentil breeding, therefore, emphasis on selecting average seed sized plants should be given. Mechanical mass selection for average seed size can be done in a bulk population like F_2 or F_3 before sowing.

Table 2 Pooled analysis of variance for yield in 24 lentil genotypes

Source of variation	d.f.	Mean square
Genotypes (G)	23	291322**
Environment (E)	2	15512399**
G x E	46	96925**
E+ (G x E)	48	739237**
E (L)	1	31024799**
G x E (L)	23	164343**
Pooled deviation	24	28278**
Pooled error	144	5422

** Significant at 1% level

Single plant selections can be made later, after one or two generations of mechanical mass selections. Genotypes bred in this way are likely to be desirable in terms of yield response to better environment and stability.

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استقرار غلة بذور بعض الطرز الوراثية للعدس وعلاقتها بحجم الحبة

تم تقييم عشرين طرازا وراثيا من العدس ذات بذور مختلفة الحجوم في الحقل خلال ثلاثة مواسم زراعية في محطة البحوث التابعة لكلية الزراعة في هاريانا ، هيسار بالهند ، وذلك لدراسة الفرق بين انماط microsperma و macrosperma فى معايير الاستقرار. وقد أظهرت الطرز الوراثية الصغيرة الحبة نتائج أفضل من حيث معايير استقرار الغلة . وأعطت الطرز الوراثية التي يبلغ وزن المئة حبة فيها حوالي 2 غ x متوسط غلة مرتفعا نسبيا ، واستجابت بدرجة متوسطة للبيئة ، مع انحراف غير معنوى حول وحدة الانحدار Unit regression. ان استخدام دورة أو دورتين من الانتخاب الاجمالي الميكانيكي للعدس ذى البذور المتوسطة (2 غ/ 100 بذرة) في الاجيال الانعزالية يعقبه انتخاب لنباتات فردية ، كان قد كرس لتحسين محصول العدس .

Response of lentil to different irrigation schedules

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Abstract

A study on the effect of irrigation on the growth and yield of lentil was conducted on a silty clay loam soil at the Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, India during the winter season of 1980/81. Irrigation increased plant height, number of green leaves/plant, number of pods/plant number of branches/plant, and grain yield/hectare. The increase in grain yield was mainly associated with an increase in the number of pods/plant, number of grains/pod, and 100-grain weight. Irrigation also increased harvest index and delayed maturity by 5-6 days. The highest grain yield (2.46 t/ha) was obtained when one irrigation was applied at the flowering stage. Maximum water use efficiency was obtained with one irrigation at flowering and the minimum with two irrigations, at flowering and pod formation, respectively. Maximum consumptive use of water (24.9 cm) was observed with two irrigations at flowering and pod formation and the minimum (19.5 cm) in the control.

Introduction

Although lentil is an important food legume in India, its productivity, however, is low (438 kg/ha) due to lack of adequate soil moisture during its growth and development stages. Lentil normally meets most of its water requirement from conserved soil moisture. In the absence of enough stored soil moisture and adequate winter rains the crop responds very well to supplemental irrigation. Water being a scarce commodity in lentil growing areas of India, it warrants judicious use to achieve higher efficiency. Lentil production/unit volume of water used can be raised by irrigating the crop at a stage which responds best to water application. From the little literature available on irrigating lentil at different growth stages, Panwar and Paliwal (1975) indicated that one irrigation at early pod filling stage was observed to be most effective in lentil, whereas Sharar *et al.* (1976) reported that the maximum yield of lentil was obtained with one irrigation at flowering compared to no irrigation, two and three irrigations under Faisalabad conditions in Pakistan. Ojha *et al.* (1977) also reported better yield response in lentil when one irrigation was applied either at pre or post flowering stage. However, Yusuf *et al.* (1979) found that grain yield of lentil was highest with three irrigations applied at seedling, branching, and pod filling stages under Delhi conditions. The following investigation was done to study the effect of irrigation on the growth and yield of lentils.

Materials and Methods

The field experiment was conducted at the Crop Research Centre, Govind Ballabh Pant Krishi Evam Praudyogik Vishwavidyalaya, Pantnagar, Nainital, Uttar Pradesh, India during the 1980/81 season on a silty clay loam of pH 6.7, organic carbon 1.7% and available P_2O_5 27.0 kg/ha; and with a field capacity, permanent wilting point, and bulk density (0-60 cm depth) of 22.3%, 5.9%, and 1.51 g/cc, respectively. The experiment was laid out in a randomized complete block design with four replications. Four irrigation levels were tested *viz.* no irrigation (control), one irrigation at the flowering stage (90 days after seeding), one irrigation at the pod formation stage (115 days after seeding), and two irrigations at the flowering and pod formation stages. Nitrogen (20 kg/ha) and P_2O_5 (60 kg/ha) fertilizers were applied as basal. The lentil seeds of the test variety Pant L-406 were planted on 16 Nov 1980 with a row spacing of 20 cm and an intra-row plant distance of 5 cm. A uniform pre sowing irrigation was given to all the treatments and later irrigations were given as per treatment. Soil samples were collected by layers (0-15, 15-30, 30-45, and 45-60 cm depth) at planting and at harvest times as well as before and after each irrigation to determine soil moisture depletion. Precipitation was 79.5 mm during the crop season. Water use efficiency (WUE) and consumptive use of water (CUW) were computed from the crop and soil moisture data.

Results and Discussion

Plant growth

Irrigation had significant effects on plant height, the number of green leaves/plant, number of branches/plant, number of nodes/plant, and number of pods/plant, and on time to maturity (days) (**Table 1**). The tallest plants were observed when two irrigations were applied at the flowering and pod formation stages, respectively. The highest number of branches/plant (32.3) and number of green leaves/plant (207.2) were recorded when the crop was irrigated at the pod formation stage. However, the highest number of nodes/plant (317.4) was recorded when the crop was irrigated at flowering stage. Irrigation prolonged maturity by 5-6 days providing more time for photosynthesis and translocation of photosynthesis from source to sink, thus leading to higher yield of lentil when irrigated. Plant growth measured as dry weights of leaf, stem, pod and total plant was highest when irrigation was applied at the flowering stage (**Table 2**). This improved growth might be associated with increased plant size due to an increase in cell elongation and cell division by irrigation, where turgor pressure of the cell is most sensitive to moisture stress. A minimum level of turgor is necessary for cell expansion, which is associated with shoot and root elongation, leaf enlargement and flower expansion and for stomata opening which controls the supply of carbon dioxide to photosynthesis. This increase in crop growth and grain yield in lentil due to irrigation had also been reported by several workers (Panwar and Paliwal 1975; Sharar *et al.* 1976; Ojha *et al.* 1977; Saxena and Wassimi 1980).

Yield and yield attributes

Irrigation increased the number of pods/plant significantly compared to the control, irrespective of its time of application, which indicates that the poor growth and development in the control could be attributed to water deficiency. However, a significant increase in the number of grains/pod over the control was observed when one irrigation was applied either at the flowering or at the pod formation stages (**Table 3**). A significant increase in 100-grain weight over the control was confined to one

Table 1 Effect of irrigation on growth characters of lentil at maturity at Pantnagar, 1980/81

Irrigation level	Plant height (cm)	Number of branches/plant	Number of green leaves/plant	Number of nodes/plant	Time to maturity (days)
Control	44.9 d*	17.6 c	36.5 c	214.2 c	135.0 b
One at flowering	56.1 b	30.6 a	204.6 a	317.4 a	140.9 a
One at pod formation	53.7 c	32.3 a	207.2 a	298.1 b	140.0 a
One each at flowering and pod formation	65.0 a	26.0 b	134.5 b	201.0 d	141.0 a
Mean	54.9	26.6	145.7	257.7	139.2

* Treatment means of a single character followed by the same letters do not differ significantly at 5% probability level according to Duncan's Multiple Range Test

Table 2 Leaf, stem, pod, and total plant dry matter accumulation (g/m row length) of lentil at maturity as influenced by irrigation levels at Pantnagar, 1980/81

	Dry matter accumulation (g/m row length)			
Irrigation level	Leaf	Stem	Pod	Total
Control	16.1 c*	52.0 c	66.7 c	134.8 c
One at flowering	28.9 a	79.8 a	109.4 a	217.9 a
One at pod formation	23.0 b	68.7 b	74.3 c b	166.3 b
One each at flowering and pod formation	21.5 b	53.3 c	84.5 b	159.2 b
Mean	22.4	63.4	83.7	169.5

* Treatment means of a single character followed by the same letters do not differ significantly at 5% probability level according to Duncan's Multiple Range Test

Table 3 Effect of irrigation on yield contributers, grain yield, biological yield, and harvest index of lentil in Pantnagar, 1980/81

Irrigation level	Number of pods/plant	Number of grains/pod	100-grain weight (g)	Grain yield (q/ha)	Biological yield (q/ha)	Harvest index
Control	88.3 d*	1.5 c	1.9 b	17.6 c	50.0 c	0.36 b
One at flowering	174.5 a	1.7 a	2.1 a	24.6 a	52.4 b c	0.46 a
One at pod formation	122.4 c	1.6 b	2.0 b	19.6 b	66.2 a	0.31 c
One each at flowering and pod formation	137.7 b	1.4 c	1.7 c	19.0 b	60.3 a b	0.30 c
Mean	130.5	1.5	1.9	20.2	57.2	0.36

* Treatment means of a single character followed by the same letters do not differ significantly at 5% probability level according to Duncan's Multiple Range Test.

Table 4 Effect of irrigation on soil moisture extraction, total consumptive use of water and water use efficiency in lentil in Pantnagar, 1980/81

Irrigation level	Moisture extraction (cm)	Effective rainfall (cm)	PET (cm) (E_0 x 0.6)	Total consumptive use of water (cm)	Water use efficiency (kg grain/ha/ cm of water)
Control	7.06	9.85	-	16.91	104.3
One at flowering	12.67	9.85	0.62	23.14	106.1
One at pod formation	10.99	9.85	0.95	24.79	89.9
One each at flowering and pod formation	13.68	9.85	1.37	24.90	76.3
Mean	11.4	9.85	-	22.4	94.1

irrigation at flowering which shows that the flowering stage is the most critical stage for irrigation, where an increase of 700 kg/ha in grain yield could be achieved under Tarai conditions of Uttar Pradesh in India. It is interesting to note that two irrigations applied at flowering and pod formation decreased significantly the number of grains/pod (1.5 to 1.4 g) and 100-grain weight (1.9 to 1.7 g) compared to the control (**Table 3**). Similarly, Duthion (1977) reported a decrease in the number of flower heads, number of pods/plant, and 100-seed weight of spring beans when excess water was present at the time of pod initiation.

Water use efficiency (WUE) and consumptive use of water (CUW)

Grain yield/cm of water applied was highest when the lentil crop was irrigated at flowering and lowest when two irrigations at flowering and pod formation stages were applied, respectively (**Table 4**). This high WUE in the plots receiving irrigation at flowering was associated with increased grain yield at a faster rate than CUW. The minimum amount of soil water excluding rainfall (7.1 cm) was extracted when no post planting irrigation was applied and the maximum (13.7 cm) when two irrigations were applied at flowering and pod formation stages. The maximum CUW (24.9 cm) was recorded in plots receiving two irrigations at flowering and pod formation, respectively and the minimum (19.5 cm) in the control. This shows that the consumptive use of water in different irrigation treatments increased as the moisture supply through irrigation was improved. An increase in CUW with irrigation in lentil was also observed by Singh *et al.* (1979).

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استجابة العدس لبرامج رى مختلفة

ملخص

اجريت دراسة حول تأثير الرى على نمو وغلة العدس في تربة طمية غضارية متوسطة في مركز بحوث المحاصيل لدى جامعة جوفيند بالاباه بانت للزراعة والتكنولوجيا في بانتجار بالهند خلال الموسم الشتوى 1980/81 . وقد ادى الرى الى زيادة طول النبات وعدد الاوراق الخضراء/النبات وعدد القرون/النبات ، وعدد الفروع/النبات والغلة الحبية/الهكتار . وقد كانت الزيادة في الغلة الحبية مقترنة بشكل رئيسي مع زيادة في عدد القرون/النبات ، وعدد الحبات/القرن ووزن المائة حبة . كما أدى الرى الى زيادة دليل الحصاد والى تأخير النضج 5-6 أيام . وتم الحصول على أعلى غلة حبية (2.46 طن/هـ) عند اعطاء رية واحدة في طور الازهار ، وبلغت كفاءة استعمال الماء الحد الاقصى عند اعطاء رية واحدة عند الازهار ، والحد الادنى عند اعطاء ريتين في طورى الازهار وتشكل القرون على التوالي . وقد لوحظ أقصى حد لاستهلاك المياه (24.9 سم) عند اعطاء ريتين في طورى الازهار وتشكل القرون وأدنى حد (19.5 سم) في معاملة الشاهد .

Effect of sowing method, rate, and date on lentil in Shendi area of the Sudan

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Abstract

Field experiments were conducted at Shendi Research Station in the north Sudan for two seasons to measure the effect of sowing date, method of planting, and seeding rate on lentil grain yield and yield components. Sowing on 10 Dec caused drastic reductions in grain yield and yield attributes (number of pods/plant, number of seeds/plant, and 1000-seed weight). Lentils, sown between the end of October and the end of November, gave the highest grain yield. Broadcasting and ridge planting produced higher yields than planting in 60 cm ridges, or drilling in rows 20 cm apart. Variation in seeding rate from 108 kg/ha to 214 kg/ha produced little differences in grain yield and a seeding rate of 143 kg/ha was optimal.

Introduction

Lentil (*Lens culinaris*) in Sudan is grown by a few farmers in small areas in the northern region for home consumption. The average yields are low due to poor management, lack of high yielding varieties, late planting, and bird damage. Almost all of Sudan's requirement of lentil is imported. The average import over 11 years (1970 - 1980) was 4017 tonnes (metric) costing 618725 Sudanese pounds per annum (el Sarrag 1983).

Preliminary research trials conducted at Hudeiba Research Station indicated the suitability of the northern region for lentil production (el Hilo 1971). The present investigation was undertaken to determine the most suitable sowing date, seeding rate, and method of planting for lentils to obtain high yields and encourage farmers to produce lentils to satisfy domestic consumption.

Materials and Methods

Two experiments were conducted in the 1982 - 1984 seasons at Shendi Research Station in a heavy clay soil with a paste pH of 8.2. Shendi lies in the arid region of northern Sudan at latitude 16°42'N and longitude 33°26'E.

In the first experiment the treatments were a 3 x 4 factorial combination where the treatments consisted of three methods of seed sowing. M_1, sowing on both sides of 60 cm ridges; M_2, broadcasting and ridging into 60 cm ridges; and M_3 drilling in rows 20 cm apart on flat plots, and of four seeding rates: 107, 143, 179, and 214 kg/ha. These treatments were arranged in a split plot design where methods of planting constituted the main plots and seeding rates the sub-plots with four replications.

The second experiment comprised a 4 x 3 factorial combination of four sowing dates: 29 Oct, 12 Nov and 26 Nov, and 10 Dec; and three seeding rates, 107, 143, and 179 kg/ha. These treatments were arranged in a randomized complete block design with four replications. The varieties used in the first and second experiments were Selaim and Giza 9, respectively.

The experiments, with plot sizes of 6 x 3 m, were furrow irrigated and each received about 10 irrigations at intervals of 10 days. Chemical spraying with 50% Folimat[R] was applied to control laphygma (*Spodoptera exigua*) at the early vegetative phase. Aphids (*Aphis craccivora*) and thrips (*Caliothrips sudanesis* Bagh and can) were controlled by Endophos[R] at the rate of 2.4 l/ha. Total seed yield was recorded for every plot from a harvested area of 1.8 x 5 m. Pods/plant, 1000-seed weight, and number of seeds/plant were determined from 10 plants/plot selected at random from the middle row, and the number of plants/linear meter were counted at harvest time.

Table 1 The effect of method of planting and seeding rate on lentil grain yield (kg/ha) during the 1982-1984 seasons

	Grain yield (kg/ha)		
Treatment	**1982/83**	**1983/84**	**Mean**
Sowing method[1]			
M_1	1458	800	1129
M_2	1778	1335	1556
M_3	1778	870	1324
S.E. ±	66.8	165	
Significance level	**	*	
LSD 0.05	163.4	404.8	
Seed rate (kg/ha)			
107	1612	859	1235
143	1643	1007	1325
179	1766	1007	1386
214	1664	1134	1399
S.E. ±	101	134	
Significance level	ns	ns	
LSD 0.05	207.5	275.8	

1. M_1 = Planting on both sides of 60 cm ridge
M_2 = Broadcasting and ridging into 60 cm ridges
M_3 = Drilling in rows 20 cm apart on flat plots
** = significant at 1% level
* = significant at 5% level
ns = non-significant

Results and Discussion

Grain yield differences due to planting methods were significant (**Table 1**). Broadcasting and ridging (M_2) in-increased grain yield by 38% and 18% over planting on ridges (M_1) and drilling in rows (M_3), respectively when averaged over the two seasons. Planting on ridges 60 cm wide (M_1) gave the lowest yield in both seasons. On the other hand, drilling in rows 20 cm apart (M_3) significantly produced less number of pods/plant, lighter seeds, but higher number of seeds/plant than the other two planting methods (**Table 2**). From the average of the two years, it was noticed that grain yield slightly increased (13%) when seeding rate was increased from 107 to 214 kg/ha, but the differences in both seasons were not significant (**Table 1**). Similar results were reported by Hakam *et al.* (1974), Muehlbauer (1973), and Saxena (1976). Lentil shows a high degree of adjustability to the available space and its response to plant density depends on the growing conditions and the plasticity of the cultivar. Pods and seeds/plant were not significantly affected by the seeding rate in both seasons, but there was a slight drop in these attributes with increasing seeding rate. On the other hand, the lowest seeding rate produced significantly the lightest seeds (**Table 2**). This illustrates to a great extent the compensation among yield components as suggested by Adams (1967).

In the second experiment, grain yield was significantly (P = 0.01) affected by planting date (**Table 3**). In the 1982/83 season the highest grain yield was obtained from 26 Nov planting date significantly outyielding earlier and later plantings. In the 1983/84 season, 29 Oct, 12 Nov and 26 Nov planting dates were similar in their yields and were significantly (P = 0.01) better than 10 Dec planting. Ageeb (1974) reported that planting in the first fortnight of November produced the highest yield and Salih (1979) found that planting from middle to end of November was optimal for Sudan. A considerable reduction in grain yield was noticed in both seasons when planting was delayed to 10 Dec (**Table 3**). This might be due to the reduced vegetative growth and early termination of crop growth period caused by the adverse effect resulting from the rise in temperature early in the reproductive phase. The number of pods/plant,

Table 2 Effect of planting method and seeding rate on lentil yield components during the 1982-1984 seasons

Treatment	1982/83 Number of pods/ plant	1982/83 Number of seeds/ plant	1982/83 1000-seed wt (g)	1983/84 Number of pods/ plant	1983/84 Number of seeds/ plant	1983/84 1000-seed wt (g)
Planting method[1]						
M_1	21.2	38.4	26.9	32.6	33.4	23.1
M_2	22.6	36.9	26.3	30.9	31.1	23.2
M_3	18.3	34.2	26.5	36.6	38.1	22.2
SE ±	0.78	2.0	0.51	2.2	2.0	0.23
Significance level	**	ns	ns	ns	*	**
LSD 0.05	1.9	4.8	1.2	5.4	4.8	0.6
Seed rate (kg/ha)						
107.1	2.1	40.4	25.5	36.0	34.6	22.0
142.9	1.2	40.3	27.1	34.5	35.8	22.8
178.6	9.3	33.5	26.9	32.4	33.8	22.8
214.3	0.2	31.9	26.8	30.6	32.6	23.5
SE ±	1.7	4.4	0.62	3.9	3.0	0.40
Significance level	ns	ns	*	ns	ns	**
LSD 0.05	3.5	9.0	1.3	8.1	6.1	0.8

1. M_1 = planting on both sides of 60 cm ridge
M_2 = broadcasting and ridging in 60 cm ridges
M_3 = drilling in rows 20 cm apart on flat plots

** = significant at 1% level
* = significant at 5% level
ns = non-significant

number of seeds/plant, and 1000-seed weight were lower in December planting (**Table 4**). The effect of seeding rate on grain yield was similar to that mentioned above except that in the 1982/83 season, the seeding rate of 143 kg/ha gave lower grain yield than 107 or 179 kg/ha (**Table 3**). The effects of seeding rate on number of pods/plant, number of seeds/plant, and 1000-seed weight were not significant in either seasons (**Table 3**). The first-order interactions on grain yield and yield attributes were not significant.

In conclusion, the results indicated that lentils sown between the end of October and the end of November gave high grain yields. Delaying planting till 10 Dec caused a drastic reduction in yield and yield attributes (number of pods/plant, number of seeds/plant, and 1000-seed weight). Broadcasting the seed and ridge planting out-yielded the other two methods of planting. Increasing the seeding rate from 107 kg/ha to 214 kg/ha did not significantly increase grain yield.

Table 3 Effect of sowing date and seeding rate on lentil grain yield (kg/ha) during the 1982-1984 seasons

Treatment	Grain yield (kg/ha) 1982/83	1983/84	Mean
Sowing date			
29 Oct	544.3	995.3	769.8
12 Nov	501.7	884.2	693.0
26 Nov	673.6	974.5	824.1
10 Dec	470.6	435.2	452.9
Significance level	**	**	
LSD 0.05	117.1	217.7	
Seeding rate (kg/ha)			
107	588.3	720.4	654.4
143	473.8	868.0	670.0
179	580.5	878.4	729.5
Significance level	*	ns	
LSD 0.05	101.4	188.5	

* = Significant at 5% level   ns = non-significant
** = Significant at 1% level

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Table 4 Effect of sowing date and seeding rate on lentil yield components during 1982-1984 seasons

Treatment	1982/83			1983/84		
	Number of pods/ plant	Number of seeds/ plant	1000-seed wt (g)	Number of plants	Number of pods/ plant	Number of seeds/ plant
Sowing date						
29 Oct	30.1	40.3	26.5	227	30.9	36.2
12 Nov	15.1	19.5	26.5	256	23.0	28.3
26 Nov	18.7	17.1	27.6	315	18.9	21.4
10 Dec	16.8	16.6	261	317	11.3	9.3
Significance level	**	**	ns	**	**	**
LSD 0.05	5.7	7.8	1.1	44	6.1	7.4
Seeding rate (kg/ha)						
107.1	22.4	27.2	26.4	242	23.8	22.0
142.9	19.5	20.3	26.6	268	20.0	24.8
178.6	18.7	22.6	27.0	326	19.2	24.6
Significance level	ns	ns	ns	**	ns	ns
LSD 0.05	5.0	6.7	0.9	38.0	5.3	6.4

** = Significant at 1% probability level

* = non-significant

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تأثير طريقة وموعد الزراعة ومعدل البذار على غلة العدس في منطقة شندى بالسودان

ملخص

اجريت التجارب الحقلية في محطة بحوث شندى بشمال السودان على مدى موسمين لقياس تأثير طريقة وموعد الزراعة ومعدل البذار على الغلة الحبية للعدس ومكوناتها • وقد ادت الزراعة في العاشر من كانون الاول/ديسمبر الى احداث انخفاضات شديدة في الغلة الحبية والصفات المكونة لها (عدد القرون/النبات ، عدد البذور/النبات ، ووزن الالف حبة) • وتم الحصول على أعلى غلة حبية من العدس الذى زرع ما بين نهاية تشرين الاول/اكتوبر ونهاية تشرين الثاني/نوفمبر • وقد اعطت الزراعة بالنثر والزراعة على خطوط (زراعة الحدر ridge planting) غلالا اعلى من الزراعة على خطوط المسافة بينها 60 سم أو التسطير بالبذارة على سطور المسافة الفاصلة بينها 20 سم • وقد نجم عن التباين في معدل البذار ما بين108 كغ/هالى 214 كغ/هـ فرق طفيف في الغلة الحبية ، وكان معدل البذار143 كغ/هـ هو الافضل •

Differential reaction of lentil varieties to boron application in calcareous soil

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Abstract

The differential reaction of six lentil varieties to B deficiency was studied in highly calcareous soil in the field. Among the varieties studied, L 9-12 was highly susceptible, whereas DL 77-2 and Pant 406 were tolerant to B deficiency. The remaining varieties Pant-639, RAU-101, and BR-25 occupied the intermediate positions on the basis of yield response and B uptake. In the control treatment (with no B added), the difference in yield and B uptake within varieties was larger and became narrower under B applied conditions. The grain yield was positively and significantly correlated with B uptake by grain and straw. Also, the B uptake by grain and straw was positively and significantly correlated with B concentration in grain and straw.

Introduction

Lentil (*Lens culinaris* Medic.), grown in winter season, is an important pulse crop of Bihar state (India). Large responses of black gram and chickpea to boron application have been recorded on highly calcareous soils of north Bihar, India (Anonymous 1984-85). Information regarding the varietal reaction of lentil to boron was lacking. The present investigation was undertaken to find out the differential reaction of some lentil genotypes to B application on highly calcareous soils, since such an information would be useful to crop growers and pulse breeders in evolving suitable varieties which can be grown under B stress conditions.

Materials and Methods

A field experiment was conducted in a sandy loam calcareous soil belonging to great group calciorthents at Dholi Experiment Station, Bihar (India). In a split - plot design, the B levels were kept in the main plots and lentil varieties in the sub-plots with three replications. There were six lentil varieties *viz.* BR-25, Pant-639, Pant-406, L9-12, RAU-101, and DL 77-2, and three B levels *viz.* 0, 1.5, and 2.5 kg B/ha, applied at sowing in the form of borax. The crop received a basal application of 25 kg N, 50 kg P_2O_5, 40 kg K_2O, and 5 kg Zn/ha through urea, triple superphosphate, muriate of potash and zinc sulphate, respectively. The crop was harvested at full maturity and the grain and straw yields were recorded. Plant samples were washed in acidified detergent solution, dried in hot air circulation oven at 65°C and pulverised in a Wareing blender. Boron was estimated colorimetrically using carmine (Hatcher and Wilcox 1950).

The composite soil sample, taken from the experimental site before starting the experiment, was analysed for some important physical and chemical characteristics employing standard procedure (Jackson 1967). The available B from soil was extracted with boiling water in a 1:2 soil/water suspension for 5 minutes (Berger and Truog 1939), and its amount was estimated colorimetrically using carmine. In order to know the deficiency/sufficiency of Zn, Fe, Cu, and Mn the soil was extracted with DTPA-$CaCl_2$ solution (Lindsay and Norvell 1978) and their quantities were estimated in clear aliquot with an atomic absorption spectrophotometer. The pH, EC, Org. C, free $CaCO_3$ available B, and DTPA- extractable Zn, Cu, Fe, and Mn were 8.3, 0.37 ds/m, 0.32%, 35.8%, 0.37 ppm, 0.48 ppm, 8.50 ppm, 0.85 ppm, and 6.50 ppm, respectively.

Results and Discussion

Grain yield: The yielding ability and magnitude of grain yield response to B application varied from one variety to another (**Table 1**). Out of six varieties, only four responded to B application as the percentage increase in grain yield over control was more than 10 (Rathore *et al.* 1978; Sakal *et al.* 1985). The other two varieties did not respond to it, but they provided negative response at both levels of applied B. This sort of differential response may be due to differences in the genetic make up of these varieties. The experimental soil may be regarded as deficient in available B as its value was less than the threshold value of 0.53 ppm worked out by Sakal *et al.* (1985) for these calcareous soils. In the control treatment (with no B added) the difference in grain yield within varieties was wide and under B applied conditions it became narrower. Variety L9-12 was most responsive in grain yield to B application, whereas DL 77-2 and Pant-406 were unresponsive to B application. The variety with the highest response to B application was rated to be most susceptible and those giving no response were classified as tolerant to B deficiency. On the basis of percent response to grain yield (figures in parenthesis), the relative susceptibility of lentil varieties to B deficiency was as follows:

L9-12 > Pant-639 > RAU-101 > BR-25 > DL 77-2 > Pant-406
(37) (28) (26) (13) (-12) (-27)

Table 1 Effect of boron application on grain yield of lentil varieties

Variety	Grain yield (kg/ha) Boron level (kg B/ha) 0	1.5	2.5	Mean	Percent increase (+) or decrease (-) in yield over control
BR-25	933	1050	917	967	+13
Pant-639	900	1050	1150	1033	+28
Pant-406	1350	983	1017	1117	-27
L9-12	1000	1367	1233	1200	+37
RAU-101	1033	1100	1300	1144	+26
DL 77-2	1250	1100	1167	1172	-12
Mean	1078	1108	1131	-	

LSD 5% level for B levels mean = Non significant

LSD 5% level for varieties mean = 114

LSD 5% level for B x varieties = 198

Table 2 Effect of boron application on B uptake by grain and straw of lentil varieties

Variety	Boron uptake by grain (g/ha) Boron level (kg B/ha) 0	1.5	2.5	Mean	Boron uptake by straw (g/ha) Boron level (kg B/ha) 0	1.5	2.5	Mean
BR-25	15.2	19.4	19.3	18.0	29.9	48.8	43.7	40.8
Pant-639	15.1	21.3	29.3	21.9	31.6	43.8	53.3	42.9
Pant-406	34.9	26.8	30.1	30.6	62.6	50.1	53.2	55.3
L9-12	12.9	30.2	32.5	25.2	38.3	63.7	66.1	56.0
RAU-101	18.4	26.9	34.5	26.6	37.6	45.8	68.6	50.6
DL 77-2	24.2	23.3	27.3	24.9	51.7	45.3	54.4	50.5
Mean	20.1	24.7	28.8	-	41.9	49.6	56.5	-
LSD 5% level for B levels mean =				2.54				5.19
LSD 5% level for varieties mean =				3.74				5.61
LSD 5% level for B x varieties =				9.70				17.30

The grain yield was found to be positively and significantly correlated with B uptake by grain (r = 0.755**) and straw (r = 0.822**).

Boron uptake: Application of B significantly increased the mear B uptake by grain and straw from 20.1 to 28.8 and 41.9 to 56.5 g/ha, respectively (**Table 2**). Boron uptake by grain and straw was positively and significantly correlated with B concentration in grain (r = 0.881**) and straw (r = 0.856**), respectively. The total B uptake (grain + straw) in the control with zero B added ranged from 45.1 to 92.5 g/ha, and at 1.5 and 2.5 kg B/ha levels it ranged from 65.1 to 93.9 and 63.5 to 103.1 g/ha, respectively. This indicates that in the control, the difference in B uptake within varieties was larger than under B applied conditions. On the basis of percent increase in total B uptake over control (figures in parenthesis), the relative susceptibility of lentil varieties to B deficiency was as follows:

L9-12 > RAU-101 > Pant-639 > BR-25 > DL 77-2 > Pant-406
(93) (84) (77) (51) (8) (-10)

Total B uptake was positively and significantly correlated with B concentration in grain (r = 0.799**) and straw (r = 0.887**), and also with B uptake by grain (r = 0.963**) and straw (r = 0.989**).

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التفاعل التفاضلي لاصناف من العدس لاضافة البور في تربة كلسية

ملخص

جرت دراسة في الحقل للتفاعل التفاضلي لستة أصناف من العدس لنقص البور B في تربة تحتوى على نسبة عالية من الكلس . ومن بين الاصناف المدروسة كان الصنف L 9-12 حساسا جدا ، والصنفان DL 77 - 2 و Pant 406 حساسين لنقص البور . أما الاصناف المتبقية وهي Pant-639 و RAU - 101 و BR - 25 فقد احتلت المواقع المتوسطة على اساس استجابة الغلة وتمثل أو امتصاص البور . وفي معاملة الشاهد (بدون اضافة البور) كان الفرق في الغلة وفي تمثل البور ضمن الاصناف اكبر ثم اصبح أقل تحت ظروف اضافة البور . وقد ارتبطت الغلة الحبية بشكل ايجابي ومعنوى مع تمثل البور في الحبة والتبن . كما أن تمثل الحبة والتبن للبور كان مرتبطا ايجابيا ومعنويا مع تركيزه في الحب والتبن

Effects of inoculation and phosphate fertilizer on lentil under rainfed conditions in upland Baluchistan

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Abstract

The experiment was conducted at Quetta in the 1985-87 seasons and at Khuzdar only in the 1986/87 season to study the effects of phosphate fertilizer and rhizobium inoculum on lentil (*Lens culinaris*) under arid rainfed conditions. A large response to inoculation was observed in both locations and seasons. Nodule number and root dry weight significantly increased, thus resulting in an increase of more than 50% in seed and straw production. Inoculation is therefore a necessary input in food and forage legume germplasm evaluation nurseries in upland Baluchistan. In contrast, the addition of 60 kg/ha of phosphate fertilizer did not influence plant growth and productivity significantly. It was also evident that the effects of environmental variation in rainfall and air temperature on crop growth considerably extended the growth season of lentil as well as productivity.

Introduction

Lentil is the second most important grain legume crop in Pakistan. It is grown in winter over an area of 82,300 ha with an annual production of 29,900 metric tonnes (Bashir *et al.* 1986). Out of four provinces of Pakistan, 70% of the cultivated area is in the Punjab while Baluchistan has the lowest hectarage (Anwar *et al.* 1986). Lentil can be grown in the poor soil and extreme climate of upland Baluchistan. However, the outlook for increased cultivation and productivity of lentils in Baluchistan was not favourable in the past. Farmers view cropping under rainfed conditions to be a risky exercise in the arid uplands and have very little financial resources to invest in new technological agronomic innovations (Rees *et al.* 1988). As a result, research is required to maintain an acceptable soil nutrient status, without a recourse to the expensive inputs such as addition of nitrogen fertilizer, which substantially improve legume productivity.

Inadequate nitrogen nutrition is one of the factors seriously limiting the productivity of lentil as well as the other food and forage legumes in Baluchistan. The Arid Zone Research Institute has recently established a program of germplasm evaluation to determine whether food and forage legume crops can be successfully grown in the rainfed uplands of Baluchistan (ICARDA 1987 and 1988). At present, the mono-cropping of wheat or wheat in rotation with long unproductive fallows are the present cropping practices under the traditional low input system of husbandry. The introduction of more legume crops may intensify agricultural production and reduce the risks of disease-induced total crop failure. Epiphytotic conditions of yellow rust in wheat have been experienced in Baluchistan with resultant severe crop losses at least twice in the last decade. The experiment was designed to obtain further information on the subjects of introduction or intensification of legume cropping:

1. Are native soil rhizobial populations adequate to nodulate food and forage legume screening nurseries successfully?
2. Is rhizobial inoculation likely to be an economically sound innovation into the dryland cropping systems of upland Baluchistan?

Materials and Methods

The experiment was first planted at the AZRI Farm, Quetta (altitude 1750 m, latitude 30° 14'N, longitude 67° 2'E) in late December 1985 following the first rain of the winter season. Subsequently, it was repeated at the AZRI Farm and extended to Khuzdar (altitude 1100 m, latitude 27° 46'N, longitude 66° 39'E) during the 1986/87 growing season. The planting dates were 1 Nov 1986 at Quetta and 13 Oct 1986 at Khuzdar. Residual soil moisture from late summer rains allowed early crop establishment. Crop maturity occurred in early summer with little variation from location to location or year to year. The experiment was conducted in a 2 x 2 factorial design with four replications and four treatments. The plot size was 5 m x 1.5 m with 6 rows, 25 cm apart, and 5 m long. Phosphate fertilizer, as triple super phosphate, was incorporated at a rate of 60 kg P_2O_5/ha with the seed at sowing time. The experiment was planted with a single row drill. All observations were made from the central two rows of the plot to exclude border effects. A wide range of plant growth parameters were assessed and the number of nodules/plant and root dry weights were monitored periodically before crop maturity. Analysis of variance was conducted both separately and collectively to examine specific location or season effects and averaged over environments.

Climatic conditions

The climatic conditions in Baluchistan are highly inconsistent. The 200 mm of precipitation or less are expected in at least three years in ten (Keatinge and Rees 1988). Furthermore, rainfall is often not well distributed throughout the year. Most of the rain occurs in winter but occasionally a small but important summer monsoonal rain is experienced. Late rainfall in winter may delay the sowing of winter crops and subsequent crop emergence due to low air temperatures at altitudes above 1000 m. In the 1985/86 season the first rains of the winter season occured in the last week of December at Quetta. Dry conditions in April and May, coupled with dessicating winds, resulted in premature maturity and poor yields of lentils in the 1985/86 season, while in the 1986/87 season yields were good due to an early well distributed and higher than the average rainfall at Quetta and Khuzdar (**Table 1**).

Air temperature in upland Baluchistan is usually very low in winter and the growth of lentil in late November to mid February is very slow. In both seasons, minimum air temperatures well below freezing were experienced (**Table 1**), but the local lentil landrace is well adapted to such conditions. High air temperatures in early summer in the absence of rainfall may become an important factor in inducing crop maturity as was experienced in the 1985/86 season in Quetta.

Results and Discussion

The effect of inoculation was highly significant ($P < 0.1$) and resulted in large increases in the number of nodules/plant (200%), root dry weight (70%), shoot dry weight (114%), seed yield (67%), and straw yield (52%) when compared to uninoculated treatments (**Tables 2-5**).

The effect of phosphate was not significant and gave no increase in the growth parameters, such as the number of nodules/plant and straw yield over the control treatment (**Tables 2** and **5**). Root dry weight may have been a minor exception (**Table 3**).

Only inoculation was considered in the economic analysis as the biological effect of phosphate was insignificant. An increase of Rs. 112 in the net revenue during the 1985/86 season and Rs. 2738 during the 1986/87 season were estimated for the trials at Quetta. Similarly, an increase of Rs. 2383 in the net revenue was obtained by inoculation in the 1986/87 season at Khuzdar (**Table 6**).

The importance of inoculation with rhizobia for lentil productivity is in concurrence with the results of Sekhon *et al.* (1986) and Sandhu (1984) who recorded in the other areas of the sub-continent 80-90% increase in seed yield in comparison to uninoculated lentils on a variety of soil types.

The clear response to inoculation in lentil in this experiment indicates the need to use inoculation routinely in AZRI's legume germplasm screening nurseries. This policy has been adopted in the 1987/88 season. The lack of native rhizobia in the soil or their inefficiency to promote active nodulation in lentils (**Table 2**) suggests that the use of inoculation could be an important innovation to the agricultural system of Baluchistan.

Table 1 Climatic Data

Month	Quetta 1985/86 Total Rainfall (mm)	Quetta 1985/86 Mean Max. Temp.* (°C)	Quetta 1985/86 Mean Min. Temp. (°C)	Quetta 1986/87 Total Rainfall (mm)	Quetta 1986/87 Mean Max. Temp. (°C)	Quetta 1986/87 Mean Min. Temp. (°C)	Khuzdar 1986/87 Total Rainfall (mm)	Khuzdar 1986/87 Mean Max. Temp. (°C)	Khuzdar 1986/87 Mean Min. Temp. (°C)
July	0	32.0	28.0	2.0	33.7	21.8	81.3	38.2	21.9
August	6.5	31.0	22.0	73.2	30.0	19.0	380.2**	37.5	20.2
September	0	30.6	17.1	0	30.4	10.2	0	35.0	14.0
October	0	25.5	4.3	0	26.4	6.1	0	35.6	9.3
November	0	20.5	0.0	6.9	20.2	-0.1	4.2	27.9	4.8
December	50.5	12.1	-1.0	11.4	11.7	-3.6	0	25.7	3.3
January	10.1	10.7	-4.1	28.2	12.9	-3.0	9.5	25.5	3.2
February	63.1	11.3	-0.7	64.5	14.7	3.2	46.7	26.4	4.2
March	77.9	15.8	4.3	06.0	17.9	8.4	0	27.0	7.9
April	0	25.2	9.0	11.8	24.1	12.1	0	32.8	10.8
May	0	30.6	11.4	9.4	29.0	16.4	25.0	36.6	11.6

* Screened air temperature at 1.5 m

** Monthly total received from two intense storms of more than 100 mm each, runoff will have occurred at this site

Table 2 Number of nodules/plant at 120 days after sowing

	Quetta 1985/86	Quetta 1986/87	Khuzdar 1986/87	Mean	% of effect
- Phosphate	3.5	13.4	9.5	8.8	
					0
+ Phosphate	3.7	13.6	8.6	8.6	
- Inoculum	0	0	0	0	
					>100%
+ Inoculum	7.3	27.0	18.1	17.5	
Mean	3.6	13.5	9.1	8.7	
Standard Error	0.31	1.24	0.48	0.66	
Prob. of Phosphate	NS	NS	NS	NS	
Prob. of Inoculum	< 0.1%	< 0.1%	< 0.1%	< 0.1%	

Table 3 Root dry weight/plant after 120 days of sowing (mg)

	Quetta 1985/86	Quetta 1986/87	Khuzdar 1986/87	Mean	% of effect
- Phosphate	55.0	88.6	252.5	132.1	
					+13
+ Phosphate	57.0	112.5	281.3	150.4	
- Inoculum	26.3	80.0	170.0	92.1	
					+70
+ Inoculum	86.3	121.3	363.8	190.4	
Mean	56.2	100.6	266.9	141.3	
Standard Error	2.43	10.80	7.40	6.28	
Prob. of Phosphate	NS	NS	NS	NS	
Prob. of Inoculum	< 0.1%	< 0.2%	< 0.1%	< 0.1%	

Table 4 Seed yield (kg/ha)

	Quetta 1985/86	Quetta 1986/87	Khuzdar 1986/87	Mean	% of effect
- Phosphate	37.8	620.5	369.8	342.7	
					+3
+ Phosphate	38.0	583.0	435.6	352.2	
- Inoculum	29.8	421.4	246.0	232.4	
					+67
+ Inoculum	46.0	782.1	559.4	462.5	
Mean	37.9	601.8	402.7	347.5	
Standard Error	2.12	35.97	37.37	24.47	
Prob. of Phosphate	NS	NS	NS	NS	
Prob. of Inoculum	< 0.1%	< 0.1%	< 0.1%	< 0.1%	

Table 5 Straw yield (kg/ha)

	Quetta 1985/86	Quetta 1986/87	Khuzdar 1986/87	Mean	% of effect
- Phosphate	154	1680	2184	1339	
					-5
+ Phosphate	172	1530	2122	1275	
- Inoculum	124	1079	1690	964	
					+52
+ Inoculum	202	2130	2616	1649	
Mean	163	1605	2153	1307	
Standard Error	14.1	152.9	202.2	119.7	
Prob. of Phosphate	NS	NS	NS	NS	
Prob. of Inoculum	< 0.1%	< 0.1%	< 0.1%	< 0.1%	

Table 6 Net benefit analysis of lentil with and without inoculation at Quetta 1985-87 and Khuzdar 1986/87

	Location					
	Quetta 1985/86		Quetta 1986/87		Khuzdar 1986/87	
	Control	Inoculum	Control	Inoculum	Control	Inoculum
Net revenue (Rs./ha)*	257	369	3127	5865	2621	5004
Net revenue gain above control (Rs./ha)	-	112	-	2738	-	2383
Marginal rate of return	320%		7823%		6809%	

Note: Lentil seed price of Rs. 5.5/kg, straw price of Rs. 0.75/kg, and inoculation cost of Rs. 35/ha were used in the net benefit calculation

* Rs. = Pakistani rupees. US$ 1 = (approx.) Rs. 17.5

Although inoculation of lentils requires a small amount of extra labour and time, it is evident from the net benefits calculated for the experiment that this is likely to be a highly profitable innovation, particularly if the introduced rhizobia can survive in the extreme climate of Baluchistan. However, the commercial availability of adapted rhizobia in Pakistan is extremely restricted at present. It is hoped that in the light of the results from more widespread agronomic testing of inoculation (in progress; ICARDA 1988) that investment to allow inoculum production on a commercial scale may be forthcoming.

The lack of response to phosphate in this experiment is somewhat surprising as P Olsen values were less than 7 mg/kg at both locations (Harmsen 1984). However, as the phosphate status of dryland soils in upland Baluchistan is largely undetermined, these results should not be considered to be definitive, particularly as the soils are generally alkaline. This implies that phosphate responses, particularly in dry years, might be expected. Preliminary observations (ICARDA 1988) indicate some positive responses to phosphate under dry conditions.

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تأثير التلقيح بالبكتيريا والسماد الفوسفاتي على العدس تحت الظروف البعلية في المناطق المرتفعة من بلوخستان

الملخص

اجريت التجربة في كويتا خلال الموسمين1985-87 وفي خزدار خلال موسم 87/1986 فقط وذلك لدراسة تأثير السماد الفوسفاتي والتلقيح بالبكتيريا العقدية على العدس (Lens culinaris) تحت الظروف البعلية الجافة .وقد لوحظ وجود استجابة كبيرة للتلقيح بالبكتيريا في كلا الموقعين والموسمين . وقد ازداد عدد العقد البكتيرية والوزن الجاف للجذور بدرجة معنوية ، الامر الذى أدى الى زيادة في انتاج البذور والتبن بأكثر من 50 % . لذا فان التلقيح بالبكتيريا يعتبر مدخلا ضروريا في تقييم مشاتل الاصول الوراثية للبقوليات الغذائية والعلفية . وعلى العكس فان اضافة 60 كغ/هـ من السماد الفوسفاتي لم تؤثر معنويا على نمو النبات وعلى انتاجيته . كما كان واضحا أن تأثيرات التباين البيئي في الامطار ودرجات الحرارة على نمو المحصول قد أطالت بشكل ملحوظ موسم نمو العدس وعززت انتاجيته .

Morphological and development trait association in lentils

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Abstract

A series of experiments were carried out at Universidade Federal de Santa Maria (Brazil) to determine the relationship between lentil seed yield and several morphological traits and development data. Seed yield was positively and significantly correlated with the number of pods/plant, number of one-seeded pods/plant, number of two-seeded pods/plant, and number of empty pods/plant. Seed yield was also significantly and positively correlated with the number of days from seeding to maturity, number of days from seeding to beginning of flowering, and number of days from flowering to maturity. These correlations suggest that seed yield could be increased by selecting later maturing plants with a greater number of pods.

Introduction

Although lentil is a highly nutritious pulse crop, its use is limited due to its high price and the lack of knowledge about its nutritional properties.

Grain production is a function of yield components. Therefore, in a breeding program it is more efficient to select plants based on traits that contribute to yield rather than for yield *per se* (Sarwar *et al.* 1982). According to Bhatt (1977) unilateral selection frequently results in little or no progress in plant improvement. Several experiments have been conducted to establish the association among various plant traits in order to improve selection efficiency. Singh and Dixit (1970) observed that grain yield was phenotypically associated with number of primary and secondary branches/plant. Wilson (1977) observed that lentil yield was inversely correlated with seed size and plant height. Tikka *et al.* (1977) concluded that there is a co-heritability among seed yield and plant height, time to maturity (days), and seed weight. On the other hand, Todorov (1980) observed a negative association between seed yield and length of the period from plant emergence to flowering.

Due to the lack of research in this respect in Brazil and knowing the importance of these associations in an improvement program at the Departamento de Fitotecnia of the Universidade Federal de Santa Maria, this experiment was carried out to determine the relationship among several morphological traits and development data in lentil seed yield.

Materials and Methods

The experiment was conducted for three consecutive years in the Experimental Field of the Departamento de Fitotecnia of the Universidade Federal de Santa Maria, where the soil is a Hydromorphic Brunizen (Ministerio da Agricultura, DPP 1973). The four lentil lines used- DF4/69, DF5/69, DF6/69, and DF7/69- were selected from a genetically heterogeneous land race. The experimental design was a randomized block with five replications. As indicated by the soil test, 8.50 and 10 kg/ha of N, P, and K, respectively, were incorporated in the soil prior to seeding. Soil acidity was corrected 30 days before seeding, and seeds were inoculated with *Rhizobium leguminosarum* using a solution of ammonium molybdate (700 mg/100 ml distilled water). Sowing was done during the first half of May in plots consisting of five rows, 1.5 m long and 0.20 m inter-row distance, resulting in a population of 1,000,000 plants/ha.

Ten plants were sampled from each plot on which the following data were recorded: plant height (H), number of pods/plant (NP), number of two-seeded pods/plant (NP2), number of one-seeded pods/plant (NP1), number of empty pods (NEP)/plant, seed yield/plant (Y) as well as time from seeding to beginning of flowering (days) (DSF), time from seeding to beginning of pod set (days) (DSP), time from seeding to maturity (days) (DSM), and time from flowering to maturity (days) (DFM).

The means phenotypic variance and standard deviation of traits and phenotypic correlation coefficient were calculated.

Results and Discussion

It can be observed that plant height ranged from 35.6 to 49.5 cm and averaged 41.7 cm (**Table 1**). These values when compared with data obtained by Erskine and Witcombe (1984), (a range of 10.0 to 45.0 cm and averaging 25.8 cm), show that these lines were taller, but less variable. Such results were expected because the mentioned authors analysed a greater number of cultivars, in addition to the environmental effect.

No data were found in the literature on the traits NP, NP1, NP2, and NP for comparison. In this experiment, one-seeded pods were predominant. The number of pods with two seeds was low and the number of empty pods was almost 50% of the total pod number. This can be probably explained by lodging, the occurence of fungal diseases as well as by flower abortion due to high temperatures and rainfall during spring. In this regard, Summerfield (1981) pointed to the lack of knowledge about the physiological or environmental causes of flower drop or abortion in leguminous plants.

Seed yield/plant varied between 0.3 and 4.3 g with an average yield of 1600 kg/ha. The narrow range in the plant growth stages DSM, DSF, DSP, and DFM is due to the low number of lines studied and to the common origin of these lines since they were selected from the same landrace. Variation in the duration of growth phases in Santa Maria was small, with a mean similar to the one observed by Erskine and Witcombe (1984). The traits NP and NP1 had the greatest phenotypic variability and therefore should be most responsive to selection.

Correlation analysis (**Table 2**) showed that plant height was positively correlated with the number of empty pods only. Such results disagree with other researchers who found a positive correlation between plant height

Table 1 Range, means, standard deviation, and phenotypic variance for several plant characters in the four lentil lines

Trait of growth stage	Range	Mean	Standard deviation	Phenotypic variance
Plant height H (cm)	35.6 - 49.5	41.7	3.43	11.7
Number of pods/plant NP	18.4 - 258	100	58.9	3.47
Number of two-seeded pods/plant NP2	1.00 - 18.6	6.00	3.94	15.3
Number of one-seeded pods/plant NP1	13.1 - 13.4	49.5	32.0	1.02
Number of empty pods/plant NEP	4.0 - 160	43.5	28.5	813
Seed yield /plant (Y) (g)	0.30 - 4.30	1.60	0.84	0.70
Time to flowering (DSF) (days)	106 - 118	113	5.03	25.3
Time to beginning of pod set (DSP) (days)	123 - 125	124	0.82	0.67
Time to maturity (DSM) (days)	162 - 176	169	5.78	33.4
Time from flowering to maturity (DFM) (days)	56.0 - 58.0	56.7	0.95	0.90

Table 2 Phenotypic correlation coefficients for the morphological traits and phenotypic data of the four lentil lines

	NP	NP2	NP1	NEP	Y	DSM	DSF	DSP	DFM
H	0.27	0.17	0.16	0.42**	0.11	0.24	0.24	0.24	0.24
NP		0.22	0.95**	0.91**	0.82**	0.59**	0.53**	-0.13	0.81**
NP2			0.23	0.10	0.40**	0.22	0.24	0.35**	0.02
NP1				0.77**	0.91**	0.56**	0.49**	-0.13	0.76**
NEP					0.62**	0.55**	0.48**	-0.16	0.78**
Y						0.46**	0.42**	-0.01	0.57**
DSM							0.99**	0.57**	0.82**
DSF								0.65**	0.75**
DSP									0.00

** $P < 0.01$

and seed yield (Tikka *et al.* 1977; Sarwar *et al.* 1982; Kumar *et al.* 1983; Todorov 1980). However, Wilson (1977) reported a negative correlation between plant height and seed yield. The significant positive correlation between seed yield and NP, NP1, and NEP and Y suggests that lentil seed yield can be increased by selecting plants with one seed/pod, which are the main yield component in lentils. The positive correlation of NP with yield confirms the results obtained by Singh (1977), Chauhan and Sinha (1982), Nandan and Pandya (1980), and Kumar *et al.* (1983), but disagree with Todorov (1980) when considering lentil lines. The positive correlation between DSM, DSF, and DFM was expected since the late cultivars normally have higher yields than early ones. NP2 showed a positive correlation with Y and DSP indicating that the two-seeded pods trait increases in late flowering plants. NP1 was positively correlated with NEP, Y, DSM, DSF, and DFM. These results are similar to those for NP showing a dependence among yield, number of pods, and maturity. Yield also was correlated with DSM, DSF, and DFM indicating that the late cultivars normally have higher seed yields. The positive association of DSF with DSP and DFM with DSM indicates an interdependence among them and the increase in one of these traits results in an increase in the others.

In general, lentil is a plant species that produces a great number of empty pods in the Santa Maria region. This can be explained partly by plant lodging, high relative humidity, and disease occurence at the flowering stage. The positive correlation of seed yield with number of pods/plant and other traits related to duration of plant growth can be useful in breeding lentils. This fact suggests that an increase in seed yield could be obtained by selecting late maturing plants with a high number of pods.

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اقتران الصفات الشكلية ومراحل نمو النبات في العدس

ملخص

اجريت سلسلة من التجارب في جامعة سانتا ماريا الاتحادية (البرازيل) لتحديد العلاقة بين غلة بذور العدس وعدد من الصفات الشكلية ومراحل نمو النبات . وقد ارتبطت غلة البذور بشكل ايجابي ومعنوي مع عدد القرون/النبات وعدد القرون ذات الحبة الواحدة/النبات وعدد القرون ذات الحبتين/النبات وعدد القرون الفارغة/ النبات . كما ارتبطت غلة البذور بشكل معنوي وايجابي أيضا مع عدد الايام من الزراعة وحتى النضج ، وعدد الايام من الزراعة وحتى بداية الازهار وعدد الايام من الازهار وحتى النضج . وتبدى هذه الارتباطات أنه يمكن زيادة غلة البذور بانتخاب نباتات متأخرة في النضج وذات عدد أكبر من القرون .

Sources of resistance to root-rot/wilt disease complex of lentil

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Abstract

Twelve cultivars and accessions of lentil were evaluated against root-rot/wilt disease complex using field glass-house, and laboratory experiments. Differences in host response to the disease were detected; cultivars H 5-6-81 and H 4-4-81 were resistant, F 29, R 270, and F 300 moderately resistant, and ILL 1 and G 370 susceptible. Almost similar results were obtained in the three kinds of tests used.

Introduction

Lentil (*Lens culinaris* Med.) is susceptible to a number of diseases (Khare 1981). In Egypt, root-rots/wilt are important diseases. Several soil-borne fungi were reported as the causal organisms, *viz.*, *Rhizoctonia solani*, *Fusarium solani*, *F. oxysporum*, *F. moniliforme*, *Gliocladium roseum*, *Verticillium* spp. and *Pythium butleri* (el-Shanawani 1973; Abd-el-kader 1977; Parveen and Parakash 1982). Sensitivity of lentil plants to irrigation systems used in both the newly introduced areas and traditional ones in addition to the lack of resistant cultivars has contributed to the yield losses in lentil in Egypt. In the present studies, 12 local and exotic lentil cultivars and accessions were screened against root-rots/wilt diseases using field, pods, and water culture screening techniques.

Materials and Methods

Field screening. Field screening was done at Bahteem Agricultural Research Station, Kolubia governorate during the 1985/86 crop season. The experimental plot (8 x 12 m^2) was divided into two equal parts: one half as a control, while the other half was infested with a mixture of *R. solani*, *Verticillium* spp, *F. oxysporum*, *F. moniliforme*, and *F. solani* by inoculating with 50 ml of of the fungus mixture grown on potato -dextrose liquid medium to each row. Five rows were used for each tested entry. The experimental plot was watered daily for three weeks before planting to enhance fungal growth. Hundred healthy seeds of each of the lentil entries, Giza 370, Giza 9, F 29, F 300, R 270, R 107, ILL 1, ILL 3838, H 5-8-81, H 4-1-81, H 4-4-81, and H 5-6-81 were sown in pairs about 3 cm deep and 20 cm apart. Infected plants were counted four months after planting.

Pot screening. The five fungi were grown for seven days on potato dextrose liquid medium, after which the fungal growth was collected and washed with sterilized distilled water and then macerated in a blender at a low speed. Fungal concentrations were adjusted to 10^5 spores/ml for spore-forming fungi and 3-4 mycelia fragments per microscope field (10 x) for *R. solani*. Twenty ml inoculum of each fungus were added to each 10 cm pot. The pots containing clay soil sterilized by formalin solution (one litre 5% for malin per cubic foot of soil) were used. The pots were watered daily for 10 days to enhance fungal growth in soil before sowing. Four seeds were sown/pot and 3 pots were used for each treatment. Pots with sterilized soil without fungi were used as controls. Infected plants were recorded three months after planting.

Screening through water culture technique. A modified water culture technique described by Wensley and Mckeen (1962) and Roberts and Kraft (1971) was adopted. Plastic containers (20 cm high x 30 cm diameter) covered from inside with black plastic sheet were filled with spore suspensions of *F. oxysporum*, *Verticillium* spp. (10^5 spores/ml), or sterilized distilled water. Lentil seedlings, previously grown in sterilized sand medium for 10 days, were fixed through a hole in the container's lid. The plants were supported by storage discs so that plant roots were dipped in the solution. Four plants were used for each entry. Supplemental light (100W) was placed 0.5 m above the plants. To provide aeration to the solution around roots, air pumps were used with a small air pipe connected to the container for 4-6 hrs/day (**Figure**). Sterilized water was added when necessary to keep the solution level in the containers above plant roots and to compensate the amounts of water taken up by the plants. Wilting in plants was recorded according to a 0 to 7 wilt disease scale of Dixon and Doodson (1971), where 0 = no symptoms visible; 0.5 = chlorosis

Table 1 Percentage of infected lentil roots of 12 entries in field pot screening

Entry	Percentage of infected roots					
	In field test	In pot tests				
		F. oxysporum	*F. moniliforme*	*R. solani*	*F. solani*	*Verticillium* sp.
H 4-4-81	32	9.6	2.2	8.2	8.1	
H 5-6-81	37	16.6	16.9	23.3	2.3	10.8
H 4-1-81	33	25.0	16.0	30.1	14.9	32.1
L 270	50	25.2	41.3	32.7	16.7	21.3
F 29	48	25.7	47.0	33.3	25.3	15.3
F 300	41	23.1	16.0	20.0	23.2	19.5
ILL 3838	68	33.3	41.7	25.6	27.0	41.7
L 107	42	33.4	33.4	33.9	26.9	26.0
G 370	66	41.3	33.3	50.3	58.1	40.0
H 5-8-81	52	50.0	25.1	49.0	42.2	35.6
ILL 1	61	58.2	48.4	51.0	57.6	39.5
G 9	72	65.0	50.0	25.1	24.7	30.0
LSD 5%	6.1	5.3				

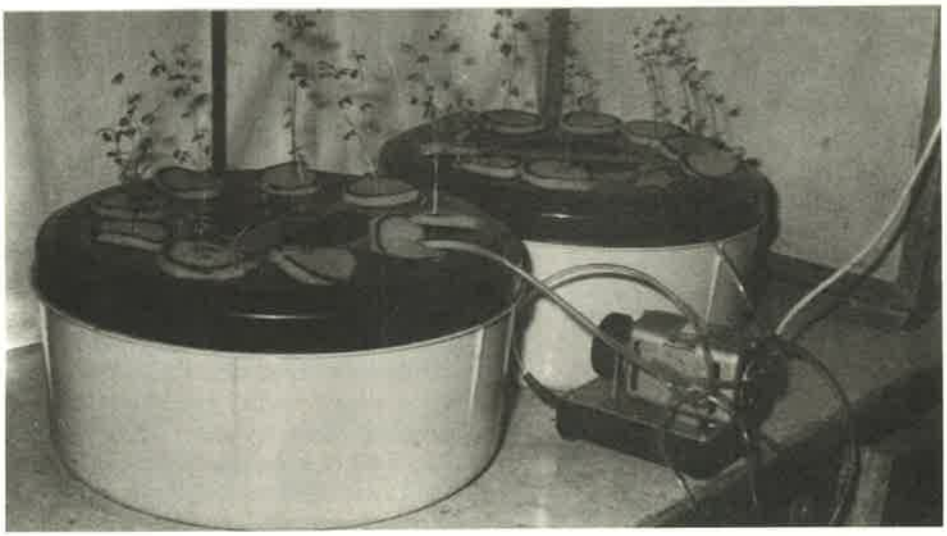

Figure Water culture technique

of basal leaves; 1 = chlorosis and rolling of basal leaves; 2 = necrosis and chlorosis of 5% leaves; 3 = necrosis and chlorosis of 10% leaves; 4 = necrosis and chlorosis of 25% leaves; 5 = necrosis and chlorosis of 50% leaves; 6 = necrosis and chlorosis of 75% leaves; and 7 = wilting of plant.

Results and Discussion

In field screening, the lines H 4-1-81, H 5-6-81, and H 4-4-81 showed less than 40% infected roots. The root infection in other entries ranged from 41 to 72% (**Table 1**). In pot screening also, H 4-4-81 and H 5-6-81 were the most resistant entries to all the tested fungi, followed by H 4-1-81 and F 300 (**Table 1**). The moderately resistant entries were L 270, L 107, F 29, and ILL 3838. Susceptibility of G 9, ILL 1, G 370, and H 5-8-81 to these diseases was markedly high. The results showed variability among the fungi in their pathogenicity. *F. oxysporum*, *F. moniliforme*, and *R. solani* exhibited higher pathogenicity than *F. solani* and *Verticillium* spp.

Water Culture Technique

Although the effect of both the wilt fungi on the tested entries was almost similar (**Table 2**), nevertheless, *F.*

Table 2 Reaction of 12 lentil entries to *F. oxysporum* and *Verticillium* spp. in water culture technique[1]

Entry	*F. oxysporum*	*Verticillium* spp.	Average
H 4-4-81	0[1]	0	0
H 5-6-81	0	0	0
H 4-1-81	3	1	1.5
L-270	1	0.5	0.75
F-29	4	2	3.0
F-300	1	0.5	0.75
ILL-3838	1	1	1.0
L-107	1	0.5	0.75
G-370	4	1	2.5
H 5-8-81	1	1	1.0
ILL-1	6	4	5.0
G-9	2	1	1.5

1. Disease reading on 0 to 7 scale where 0 = no symptoms and 7 = wilting of plants

oxysporum was more virulent than *Verticillium* spp. The highest scores on wilting were found in ILL 1, F 29, and G 370 entries, whereas no wilt symptoms were observed in H 4-4-81 and H 5-6-81 subjected to *F. oxysporum* and/or *Verticillium* spp.

The methods used for investigation and disease assessment were partially responsible for the differences in results obtained elsewhere (Rossall 1978). It is possible that field results often do not correspond completely with the glasshouse results since the environmental conditions are less controlled and a possible natural infection could be caused by unknown pathogens or factors. The system used in this investigation allowed more critical assessment of the results obtained. Resistance of H 4-4-81 and H 5-6-81 to root-rots and wilt diseases of lentil was confirmed in the three methods used. Nevertheless, slight differences in the order was observed. F 300 which demonstrated moderate resistance in the field ranked as resistant in the pot and water culture experiment. On the other hand, ILL 3838, the moderately resistant entry in the pot screening, was susceptible in the field screening.

The percentage of infection in the field screening exceeded that of the glasshouse. It has been shown in lentil, clover, and faba bean that the introduction of mixed fungi in the field has a greater impact on the plants than infection with the individual fungus in the glasshouse (Abd-el-kader 1977; Omar 1978; Abu-Blan 1983). Moreover, the shift in the environmental conditions has also to be considered.

Variability in pathogenicity by different fungi was detected (**Table 2**) which showed that *F. oxysporum*, *F. moniliforme*, and *R. solani* were more pathogenic fungi than others. These results were in agreement with Abd-el-kader (1977) who also found that *F. moniliforme* was the most virulent fungus to lentil.

It is important to mention that the water culture technique adapted in this investigation might provide a simple and quick system to examine certain aspects of host-parasite relationship. A considerable number of host genotypes can be examined when glasshouse facilities are limited.

Finally, the promising lentil entries which were found resistant to root-rots and wilt diseases should be used in the lentil breeding program to breed for root-rots and wilt resistant lentils in Egypt.

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مصادر المقاومة لمركب مرض تعفن الجذور/الذبول على العدس

ملخص

جرى تقييم اثني عشر صنفا ومدخلا من العدس لصفة مقاومة مركب مرض تعفن الجذور/الذبول وذلك ضمن تجارب تحت ظروف الحقل والدفيئة والمختبر ، وقد تم كشف اختلافات في مدى استجابة النبات العائل للمرض ، وقد تبين أن الصنفين H5-6-81 و H4-4-81 مقاومان ، والاصناف F 29 و R 270 و F 300 متوسطة المقاومة ، والصنفين ILL 1 و G 370 حساسان للاصابة ، وتم الحصول على نتائج مشابهة تقريبا من اشكال التجارب الثلاثة المتبعة في هذا البحث .

LENTIL INFORMATION معلومات متخصصة عن العدس

LENS Bookshelf مكتبة العدس

D. P. Beck and Materon L. A. (editors). 1988. **Nitrogen fixation by legumes in Mediterranean agriculture. Proceedings of a Workshop on Biological Nitrogen Fixation on Mediterranean-type Agriculture. ICARDA, Syria,** 14-17 Apr 1986. 379 pp. Martinus Nijhoff Publishers.

This book is the proceedings for a workshop organized at Aleppo, to examine the scope for regional research and development of biological nitrogen fixation in food, forage, and pasture legumes in semi arid Mediterranean agriculture. The book, which contains 36 chapters, is divided in the following sections: Biological nitrogen fixation in the Mediterranean region, genetic and physiological aspects of legumes and rhizobia, ecology and rhizobium and inoculation, and nitrogen fixation limitations and potential.

Key Lentil Abstracts ملخصات هامة عن العدس

Khan, M.A., Rana, I.A., Ullah, I. and Jaffer, S. 1987. **Physicochemical characters and nutrient composition of some improved lines of lentils grown in Pakistan**. *Journal of Food Composition and Analysis* **1**: 65-70.

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

McKenzie, B.A. 1987. **The growth, development and water use of lentils (*Lens culinaris* Medik.).** *Ph.D. thesis.* University of Canterbury, New Zealand.

A research programme to study the growth, development, and water use of lentils was initiated in 1984 and continued in 1985. In the first year, Titore and Olympic lentils were sown at six dates ranging from 16 Apr to 15 Nov, with full or no irrigation. In the second year, Titore lentils were sown on 20 May and 26 Aug under four irrigation regimes. A small separate experiment was also carried out in 1985, in which Titore lentils were sown on 28 May and grown beneath rain shelters. The crop was subjected to four irrigation regimes to ensure large soil moisture deficits. All crops were grown on a Templeton silt loam soil.

Sowing date caused the most marked effect on lentil yield. At populations of about 150 plants m^{-2}, autumn/winter sowings yielded from 2.4 to 3.3 t seed/ha and spring sowings yielded from 0.5 to 1.5 t seed/ha. Seed yields in the 1985/86 field experiment were much lower due to a severe outbreak of *Botrytis cinerea.* For the relatively disease free unirrigated plots, sowing date again had the major effect on seed yield. The unirrigated May sowing yielded 1.5 t seed ha^{-1}, with the August sowing yielding about 0.8 t/ha.

There was a highly significant linear relationship between dry matter accumulation and cumulative intercepted PAR for all sowing dates. Over both years, PAR was converted into dry matter at 1.76 g DM MJ^{-1}. The utilisation coefficient on a cumulative basis was relatively stable in both years, ranging from 1.51 g DM MJ^{-1} to 2.14 g DM MJ^{-1}.

Irrigation had little effect on seed yield even in the 1984/85 season when rainfall was only 70% of the long term average over the growing season. In the 1985/86 season, a wet growing season, irrigation in the field experiment caused significant yield losses. In the May sowing, unirrigated plots yielded 1.5 t seed/ha, while the fully irrigated plots yielded only 0.7 t seed/ha. There was no difference in yield between the irrigated treatments in the August sowings. Under the rain shelters, however, there was a large positive response to irrigation. The fully irrigated plants produced the equivalent of 2.4 t seed/ha, while the unirrigated plants produced only 0.32 t seed/ha.

In the field experiments, dry matter and seed yield were not related to potential evapotranspiration or to maximum potential soil moisture deficit. However, there was a significant linear relationship between cumulative dry matter production and the ratio of calculated crop transpiration to mean daily vapour pressure deficit. The crop showed a k value of 0.028 mb, indicating a water use efficiency lower than that for most arable crops.

Under the rain shelters, both dry matter and seed yield were related to actual evapotranspiration and to maximum potential soil moisture deficit. The crop had a calculated limiting deficit of around 130 mm on the soil in which they were grown. The water use efficiency of the plants was 1.3 g dry matter m^{-2} mm^{-1} of actual evapotranspiration and 0.72 g seed m^{-2} mm^{-1} of actual evapotranspiration.

In both seasons phenological development was dependent upon accumulated thermal time in all the stages except emergence to flowering. In this stage, a highly significant linear relationship was obtained between development rate and photoperiod corrected temperature.

A computer simulation model was developed which accurately predicts crop development and yield. The model uses weather input and is based on three parameters:

1. The relationship between accumulated dry matter production and intercepted PAR.
2. The relationship between development and thermal time or photoperiod corrected temperature.
3. Crop water use.

The model is useful for predicting the effects of altering sowing date on lentil yield and for determining the possible effects of irrigation on yield. The model does need further validation in regions outside Canterbury.

Rodd, V. 1986. **Effect of nitrogen addition on yield and symbiotic dinitrogen fixation of soybeans (Glycine max. L. merr. c.v. Maple Amber), fababeans (*Vicia faba* L. minor c.v. Aladin), and lentils (*Lens esculenta*).** *M.Sc. thesis.* University of Manitoba, Canada.

Soybeans, fababeans, and lentils are grown in Manitoba to alleviate local crude protein shortages, diversify agriculture and as a marketable commodities.

Field, lysimeter, and growth chamber experiments were undertaken in order to determine: 1) the nitrogen nutritional requirements of Maple Amber soybeans, 2) the amount of nitrogen fixed by Maple Amber, 3) the effect of nitrogen addition on dinitrogen fixation, and 4) the physiological stages of growth during which fixation occurs in Maple Amber. The addition of 0-200 kg N/ha, 0-100 kg N/ha, and 0-1800 mg N pot for field, lysimeter, and growth chamber experiments, respectively did not result in significant yield increases. By the classical difference method, Maple Amber soybeans were found to fix 79 kg N/ha, 71 kg N/ha, and 1216 mg N/pot for lysimeter, field, and growth chamber experiments, respectively when grown on soils which had not received additional nitrogen. Nitrogen addition decreased dinitrogen fixation, the decrease appeared to be proportional to the amount of fertilizer nitrogen utilized. The maximum fixation of dinitrogen occurred from early flowering to mid-pod formation (reproductive development), which corresponded to the period of maximum dry matter and nitrogen accumulation.

The nitrogen nutritional requirements of Aladin faba bean were studied in lysimeter and growth chamber experiments. Aladin faba beans did not respond to nitrogen additions of 0-100 kg N/ha and 0-1800 mg N/pot in lysimeter and growth chamber experiments, respectively and fixed (by the classical difference method) 250 kg N/ha and 1645 mg N/pot, respectively. As with Maple Amber soybeans, the fixation of dinitrogen decreased with the addition of fertilizer nitrogen, and the decrease appeared to be proportional to the amount of fertilizer utilized.

The nitrogen nutritional requirements of lentils were studied in growth chamber experiments. Unlike soybeans and faba beans, lentils responded to additional fertilizer nitrogen and hence, did not appear to fix enough nitrogen for their nutritional requirements. Lentils were also the least fixers of dinitrogen, 200 mg N/pot compared to 1645 and 1216 mg N/pot for faba beans and soybeans, respectively. Lentils also appeared to be more susceptible to the toxic effects of high rates of nitrogen addition as urea than soybeans or faba beans.

Various methods of assessing dinitrogen fixation were used: ^{15}N assisted difference method, difference method, "A" value method, acetylene reduction assay, and nodule counts. The ^{15}N assisted difference method and "A" value method in most cases gave similar estimates of the amount of dinitrogen fixed by the legumes. However, discrepancies between the two methods occurred when the control and the legume had different fertilizer nitrogen utilization. In such cases, the "A" value method was thought to give a better estimate of fixation. Acetylene reduction assay and nodule counts were suitable as qualitative estimates of fixation. Utilization of only the aerial plant portion for measurement of symbiotic nitrogen fixation by legumes was not uniformly distributed in the plant parts but tended to accumulate preferentially in the roots.

Turco, B.F. and Bezdicek, D.F. 1987. **Diversity within two serogroups of *Rhizobium leguminosarum* native to soils in the Palouse of eastern Washington.** *Annals of Applied Biology* **111:** 103-114. Lilly Hall of Life Sciences, Purdue University, West Lafayette, Indiana 47907, USA.

The effect of plant genotype, soil temperature, and moisture on recovery of *Rhizobium leguminosarum* serogroups WA01 and WA02 from soil, was evaluated in the greenhouse using three plant genotypes (*Pisum sativum* cv. Alaska, *Pisum sativum* cv. Paloma and *Lens culinaris* cv. Rechief), three temperatures (12, 20 and 24°C) and soil from two different slope positions. The impact of moisture was followed by assessing pea nodulation after incubation of soil at different preplanting moisture levels. Isolates were also evaluated for serogroup, response to low levels of antibiotics and efficacy of symbiotic characters.

Of the 33 antibiotic-strain combinations showing growth, 10 permitted 50% or more of the isolates to grow. Of the 24 clusters obtained, all except one were dominated by isolates in either serogroup, WA01 or WA02. There was no relation between either serogroup or cluster groupings and N_2 fixation. Serogroup recovery was influenced by plant genotype and temperature. At root temperatures of 12 and 24°C, serogroup WA02 occurred in a significantly lower fraction of the lentil nodules as compared to the pea species. At 12°C, recovery of WA02 was higher for the Paloma than Alaska pea. Recovery of WA02 in pea nodules generally increased as the soil moisture was preconditioned to drier levels of -0.5 and -1.5 MPa water potential.

Vandenberg, A. 1987. **Inheritance and linkage of several qualitative traits in lentil.** *Ph.D. thesis.* University of Saskatchewan, Canada.

The inheritance of newly described morphological genes and the linkage relationships among these and previously reported morphological genes in lentil were investigated. Monogenic inheritance was reported for the contrasting morphological traits: gray (*Ggc Ggc*) vs. green (*ggc ggc*) ground colour of the seed coat, tan (*Tgc Tgc*) vs. green (*tgc tgc*) ground colour of the seed coat, tendrilled (*Tll Tll*) vs. tendrilless (*tll tll*) leaves, red (*Grp Grp*) vs. green (*grp grp*) pod colour, pubescent (*Glp Glp*) vs. glabrous (*glp glp*) pod, normal (*Rpp Rpp*) vs. reduced (*rpp rpp*) pod parchment, normal (*Chl Chl*) vs. chlorina (*chl chl*, lethal chlorophyll mutation), and normal (*Xan Xan*) vs. xantha (*xan xan*, lethal chlorophyll mutation). A series of alleles (Scp^{m-1} - marbled-1, Scp^{m-2} - marbled-2, Scp^{s} - spotted, Scp^{d} - dotted, and *Scp* - absence of pattern) at the locus determining seed coat pattern (*scp*) phenotypes were reported. These alleles are listed in decreasing order of dominance with the exception of Scp^{s} and Scp^{d} are codominant. Black seed coat is inherited as a single recessive gene (*blsc*-1) in some crosses and as two recessive genes (*blsc*-1 and *blasc*-2) in others. Interactions between loci were noted. The gray and tan ground colour of the seed coat are expressed as brown ground colour of the seed coat when both genes are dominant, and as green when both are recessive. The zero tannin locus is epistatic to the locus determining tan ground colour of the seed coat. Black seed coat masks both the seed coat pattern and the ground colour of the seed coat. The genetic linkages were observed:

Yellow cotyledon colour (*yc*) and zero tannin (*tan*) - 37 + 1.2 cM, seed coat pattern (*scp*) and pod indehiscence (*pi*) -25 + 2.5 cM, and green stem colour (*gs*) and green pod colour (*grp*) -7 + 2.5 cM. This new genetic information will be useful to lentil researchers by allowing construction of a more detailed genetic map and by improving prediction of phenotypic segregation in lentil breeding programs.

Vandenberg, A. and Slinkard, A.E. 1987. **Inheritance of a xantha chlorophyll deficiency in lentil.** *Journal of Heredity* **78**: 130. Crop Development Centre, Department of Crop Science and Plant Ecology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada S7N OWO.

A xantha mutant was observed in segregating progeny of a hybrid between two subspecies of lentil, *Lens culinaris* spp. *culinaris* (Medik.) Williams and *L. c.* ssp. *orientalis* (Hand.-Mazz.) Williams. The xantha mutation is inherited as a single recessive gene (*xan*) that is epistatic to and independent of two loci determining cotyledon color. Cotyledons of seed homozygous for xantha are yellow, regardless of the genotype for cotyledon color.

Walley, F.L. 1986. **The effect of nitrogen and moisture availability on growth and symbiotic nitrogen fixation in lentils (*Lens culinaris*).** *M.Sc. thesis.* University of Manitoba, Canada.

Field and growth chamber studies were conducted to evaluate the effect of various soil conditions including nitrogen and moisture availability on yield and potential symbiotic nitrogen fixation of lentils. Application of fertilizer N at rates of 0-200 kg N/ha and 0-360 ppm N/ha in field and growth chamber experiments, respectively, resulted in dry matter and seed yield increases. Nitrogen stress, simulated by the addition of barley straw to the soil, limited lentil yields. The results showed that lentils are not capable of symbiotically fixing enough nitrogen to meet optimum plant growth requirements. Moisture availability was also found to be an important factor in attaining high dry matter and seed yield of lentils. Yields were significantly reduced by the application of moisture stress and were notably influenced by the physiological stage at which stress was applied. The effect of nitrogen availability on symbiotic nitrogen fixation was evaluated. The quantity of nitrogen symbiotically fixed in lentils was estimated using the "A" Value method, the ^{15}N Assisted Difference method, and the Classical Difference method. The nonnodulating soybeans served as the reference crop. Although these methods estimated similar quantities of nitrogen fixed under controlled conditions, the N balance techniques proved unreliable under field conditions. Increasing increments of applied N reduced symbiotic N fixation. Nitrogen stress delayed the onset of symbiotic fixation thus reducing the total quantity fixed.

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TOP TWENTY

Top twenty lentil producing countries with their annual area (A x 1000 ha) and production (P x 1000 tonnes), ranked on 1986 production

Rank	Country	1966-70		1976-80		1985		1986	
		A	P	A	P	A	P	A	P
1	Turkey	102	100.2	193.2	205.6	597	618	792	820
2	India	792.8	364.8	908	401	983	547	1069	645
3	Canada	-	-	-	-	75	65	134	182
4	USA	26.2	31.6	56.4	65.8	44	37	54	86
5	Ethiopia	171.6	104.4	61.6	36.8	50	65	50	65
6	Syria	97.2	62.4	127	94.2	66	48	67	63
7	Nepal	-	-	-	-	123	60	125	61
8	Morocco	25.2	13.6	40.4	19.8	88	46	90	53
9	Bangladesh	70.6	50.4	78	48.8	71	49	71	49
10	Spain	51.6	36.4	72.2	52	61	49	66	39
11	Iran	61.2	39.8	40.4	27.6	73	33	75	34
12	Chile	11	6.2	37.6	23.2	36	25	37	29
13	Pakistan	71	24.4	87	33.4	80	30	73	26
14	France	10	12.6	10.8	14.6	10	20	9	20
15	Mexico	6.8	4.4	10.2	8.8	20	20	20	20
16	USSR	53.6	63.2	18	5	37	13	43	20
17	Egypt	24	34	15.4	18.8	8	13	9	15
18	Argentina	20.4	12	28.6	25.2	16	12	16	12
19	Iraq	9.8	6	8.4	7.4	6	5	7	6
20	Colombia	-	-	19.8	7.6	17	6	17	6

Source: Food Production Yearbooks of Food and Agriculture Organization of the United Nations System, Rome

اعلان الى العلماء والباحثين العرب الكرام

يسر المركز الدولي للبحوث الزراعية في المناطق الجافة (ايكاردا) وجامعة ساسكاتشيوان ، كندا ، اعلامكم بأن مركز بحوث التنمية الدولية (IDRC) في أوتاوا بكندا ، قد وافق على تقديم دعم مالي لمشروع لنس مدته ثلاث سنوات اعتبارا من بداية عام 1987 ولغاية 1989 ، علما بأن ادراج اللغة العربية ضمن النشرة الاخبارية للعدس يشكل أحد أهم أهداف هذا المشروع ·

وبمزيد من السرور تعلن اسرة تحرير " LENS " للباحثين العرب العاملين في مجال تحسين محصول العدس أنها ستصدر نشرتها العلمية باللغتين العربية والانكليزية · لذا ، فيرجى من الزملاء الباحثين الراغبين في نشر بحوثهم باللغة العربية التفضل بارسالها الى العنوان التالي : نشرة " لنس " ، ايكاردا ــ برنامج المعلومات العلمية والفنية ، ص·ب· 5466 حلب ــ سورية ·

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Style

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

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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 ug; 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.

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

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لنس

نشرة علمية متخصصة بالعدس

لنس ، نشرة علمية ، مجلد 15 ، عدد 1 ، 1988

المحتويات

ايكاردا والمجموعة الاستشارية للبحوث الزراعية الدولية

يتمثل الهدف العام للمركز الدولي للبحوث الزراعية في المناطق الجافة (ايكاردا) في زيادة الانتاجية الزراعية والموارد الغذائية المتاحة في المناطق الريفية والحضرية بهدف تحسين الوضع الاجتماعي والاقتصادي لشعوب البلدان النامية وخاصة في شمال أفريقيا وغرب آسيا . وتركز ايكاردا اهتماماتها بصورة رئيسية على المناطق التي تعتمد في زراعتها على الامطار الشتوية التي تتراوح من 200-600 مم سنويا ، وعندما تستدعي الضرورة ستمتد دائرة بحوثها لتغطي مناطق بيئية مروية او ذات أمطار موسمية .

ويضطلع المركز بمسوءولية عالمية في تحسين الشعير والعدس والفول ، وبمسوءولية اقليمية في تحسين القمح والحمص والنظم الزراعية والثروة الحيوانية والمراعي والمحاصيل العلفية . كما ويعتبر تدريب وتأهيل الباحثين الزراعيين في البلدان النامية ، وتبادل نتائج البحوث معهم أحد أهم الانشطة التي تقوم بها ايكاردا .

وقد ساهمت المجموعة الاستشارية للبحوث الزراعية الدولية (CGIAR) بتأسيس ايكاردا في سورية عام 1977 كمركز للبحوث لا يتوخى الربح . أما المجموعة الاستشارية للبحوث الزراعية الدولية فهي هيئة غير رسمية من المتبرعين تضم حكومات ومنظمات وموءسسات خاصة ، وتدعم البحوث الزراعية في جميع انحاء العالم بهدف تحسين الانتاج الغذائي في البلدان النامية ، وذلك من خلال شبكة موءلفة من ثلاثة عشر مركزا دوليا للبحوث من بينها ايكاردا . وتغطي أعمال الشبكة بحوثا على أنظمة المحاصيل والثروة الحيوانية التي تسهم في تأمين ثلاثة ارباع الغذاء في البلدان النامية .

لنس

تصدر النشرة العلمية " لنس " في ايكاردا مرتين في السنة بالتعاون مع جامعة ساسكاتشيوان " Saskatchewan " بكندا ، وبدعم مالي من مركز بحوث التنمية الدولية IDRC في اوتاوا بكندا . و"لنس" عبارة عن نشرة اخبارية متخصصة بمحصول العدس . لذا فانها تعتبر منبرا لتبادل نتائج البحوث حول هذا النبات . وتضم النشرة بحوثا مختصرة تهدف الى ايصال المعلومات بسرعة ، اضافة الى بعض المقالات العامة التي تدعو اليها أسرة التحرير بشكل منتظم وتتناول مجالات معينة من بحوث العدس . كما تضم النشرة مراجعات في الكتب وملخصات رئيسية حول العدس وأحدث المراجع التي تهتم بهذا المحصول . وتقدم نشرة لنس المعلومات دون مقابل من خلال قسائم الاستجواب والتصوير النسخي (الفوتوكوبي) وجمع الوثائق العلمية المتعلقة بالعدس .

آخر موعد لاستلام اسهامات القراء لعدد "لنس " مجلد 15(2) هو 30 نيسان/ابريل 1988 و مجلد 16 (1) هو 31 تشرين الاول/اكتوبر 1988 .

الاشتراكات

توزع نشرة " لنس " دون مقابل للباحثين المعنيين بنبات العدس وذلك بموجب منحة مقدمة من مركز بحوث التنمية الدولية (IDRC) . وللاشتراك فيها يرجى الكتابة الى :

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لنس

نشرة علمية متخصصة بالعدس

مجلد 15 ، عدد 1 ، 1988

المركز الدولي للبحوث الزراعية في المناطق الجافة
(ايكاردا) ، حلب ، سورية

جامعة ساسكاتشيوان
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