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EFFECT OF SOWING DATE ON THE GROWTH AND YIELD OF LENTIL IN A RAINFED MEDITERRANEAN ENVIRONMENT

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SUMMARY

The effect of advancing the sowing date from early February to November on the growth and seed and straw yields of three large seeded and three small seeded lines of lentil (*Lens culinaris*) was studied under rainfed conditions in northern Syria between 1982 and 1985. The average seed and straw yields from early winter sowing were 838 and 2476 kg ha^{-1} compared with 679 and 1470 kg ha^{-1}, respectively, from a late sown crop. There were seasonal differences in the advantage in seed yield from early sowing, largely because infestation by *Orobanche* species limited the use of early sowing. There were no overall differences between the growth and yields of large and small seeded lines, but genetic variation within groups was apparent for all characters. A high rate of dry matter accumulation, manifested as early vigour, was always related to a high final economic biomass.

Efecto de la fecha de siembra en cuanto al crecimiento y rendimiento de la lenteja en el ambiente mediterraneo con riego por lluvia

RESUMEN

El efecto de adelantar la fecha de siembra de principios de febrero a noviembre en relación con el crecimiento y el rendimiento de semilla y paja de tres tipos de lentejas (*Lens culinaris*) con semillas grandes y tres tipos con semillas pequeñas fue estudiado bajo condiciones de riego por lluvia en el norte de Siria entre los años 1982 y 1985. El promedio de rendimiento de semilla y paja para la siembra temprana de invierno fue de 838 y 2476 kg ha^{-1} a comparación de 679 y 1470 kg ha^{-1}, respectivamente, para una cosecha con siembra tardía. Se observaron diferencias relativas a la estación, con ventajas en cuanto al rendimiento de semilla de la siembra temprana, en gran parte debido a que la infestación de las especie *Orobanche* limitó el uso de la siembra temprana. No se produjeron diferencias generales entre el crecimiento y rendimiento de los tipos con semillas grandes y semillas pequeñas, pero la variación genética dentro de los grupos resultó aparente para todos los caracteres. Una elevada tasa de acumulación de materia seca, manifestada en la forma de un vigor temprano, siempre estuvo relacionada con una elevada biomasa final.

INTRODUCTION

In west Asia and north Africa, lentil (*Lens culinaris* Med.) seed is an important source of protein in the human diet and its straw is a valued animal feed. Farmers usually sow the crop in late winter, from late December to early February

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(Saxena, 1981). The reproductive growth of the crop coincides with increasing water deficit and high temperatures from April onwards, and yields are low as a result. However, early sowing of a Syrian land race before mid-December resulted in increased seed and biological yields over late winter sowing, mainly because of the extended period for vegetative growth (Saxena, 1981; Saxena *et al.*, 1983). Although the ICARDA breeding programme has produced high yielding lines adapted to the region, genetic variability in the pattern of growth of the crop is unknown. The present investigation studied the effect of advancing the sowing date from late winter (early February) to early winter (November) on the growth and yield of a range of lentil lines.

MATERIALS AND METHODS

The experiment was conducted on a calcic luvisol soil at ICARDA's main station, Tel Hadya (36°N, 37°E and 392 m elevation) in northern Syria during the 1982/83, 1983/84 and 1984/85 cropping seasons. A split-plot design was used with sowing date as the main plots and genotypes as sub-plots with four replications. The early sowing dates were 17 November in 1982 and 1983 and 14 November in 1984 and the late dates were 4 February in 1983 and 1984 and 8 February in 1985. The lentils comprised three large seeded or *macrosperma* lines (seed size > 45 g per 1000 seeds) and three small seeded or *microsperma* lines (<45 g per 1000 seeds). The large seeded lines were a Syrian land race, ILL 4400, and two single plant selections, 78S26002 (ILL 8) and 78S26004 (ILL 9), both from germplasm originating from Jordan. The small seeded lines were a Syrian land race, ILL 4401, and two single plant selections, 78S26013 (ILL 16) and 76TA66088 (ILL 223), from germplasm originating from Jordan and Iran, respectively. Sub-plot size was 2.5 × 5 m with 25 cm between rows and a plant-to-plant spacing of 1.5 cm. A basal fertilizer dressing of 20 kg N and 50 kg P_2O_5 ha^{-1} was applied prior to sowing. Inoculation with *Rhizobium* was not undertaken, but nodulation was good in every season.

Sequential harvests, each of 0.125 m^2, were taken at intervals for growth analysis. Guard rows were left between harvest areas. Measurements were made of the photosynthetic area after separation into leaves and stems, which were oven-dried at 65°C for 48 h and weighed.

At maturity, plots were harvested by hand, discarding the two outer rows and 0.5 m plot ends. Harvested plants were sun dried to a seed moisture of approximately 8% and subsequently weighed, threshed, cleaned and their seed weight obtained. Straw weight was derived by difference. In the 1984/85 season, the protein content of seed and straw, and percentage digestibility of the straw, were determined by Kjeldahl and pepsin-cellulase methods, respectively (Williams *et al.*, 1986).

Rainfall in 1982/83 was favourable for crop growth with a total of 323.3 mm received (Fig. 1). February and March were slightly wetter than average, and April was wet with 49.5 mm rain. The last effective rainfall of 14.8 mm was

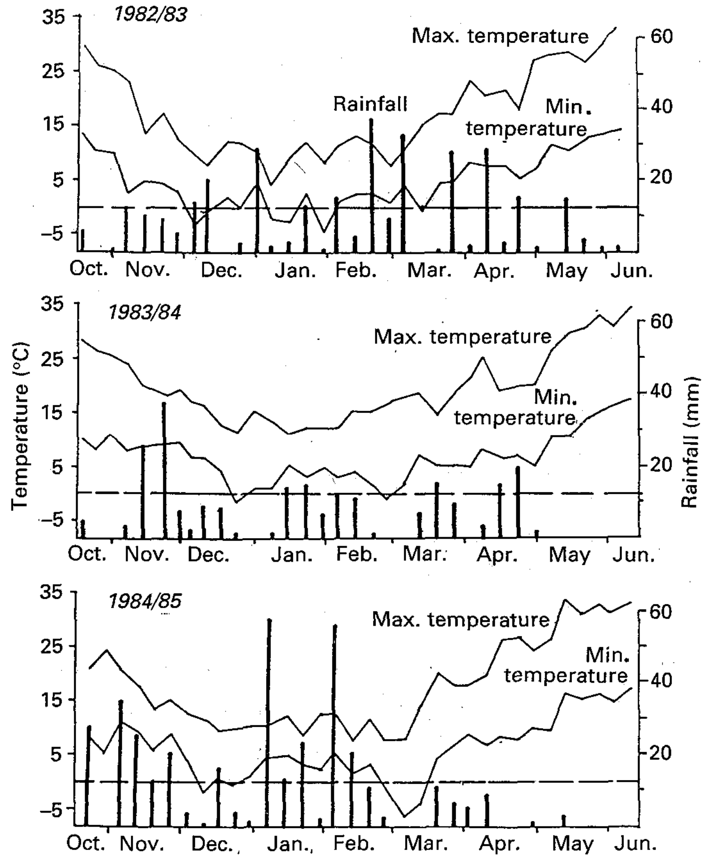

Fig. 1. Weekly mean maximum and minimum temperature (°C) and weekly total rainfall (mm) for the 1982/83 to 1984/85 cropping seasons.

recorded in mid-May. In 1983/84, plots received below average precipitation (a total of 229 mm) with severe drought in parts of February and March. During 1984/85, total seasonal rainfall was 373 mm, most received between November and February (Fig. 1 and Table 1).

The 1982/83 season was abnormally cold during the period of vegetative growth (December–February). Temperatures in 1983/84 were slightly warmer than usual until March, and there was an average number of frost days. There was a prolonged period of unusually late frost between 21 February and 12 March 1985 with −9.5°C recorded on 3 March.

RESULTS

Effect of sowing date on phenology

November sown lentil had a longer growing season than that sown in February, particularly for vegetative growth. For example, in the November sowing (1984/85 season) the average times from sowing to 50% flowering and from 50%

flowering to physiological maturity were 143 and 32 days, respectively, but for the February sowing they were only 74 and 28 days, respectively. In addition, sowing date altered crop phenology in relation to the occurrence of temperature and moisture stress. In 1985, flowering occurred between 31 March and 7 April with early sowing, but between 21 and 30 April for the late crop, coinciding with a period of high temperature.

Dry matter production and photosynthetic area index

In all three seasons, dry matter build-up from early winter sowing occurred over a longer growth period than from late winter sowing and in 1983/84 and 1984/85, total dry matter from early sowing surpassed the late sowing (Fig. 2). However, in the 1982/83 season, the dry matter production from late winter sowing approached that from the earlier sowing.

The pattern of dry matter accumulation did not vary over cultivars. However, the rate of dry matter build-up did vary, ILL 8 exhibiting a faster rate of dry matter accumulation (also referred to as high growth vigour) except in the early winter sowing of 1984/85 when there was late frost. In 1984/85, both ILL 223 and ILL 4401 had the fastest build-up of dry matter in early winter sown crops.

Photosynthetic area index (PAI) increased to a maximum and then declined (Fig. 3). As in the case of dry matter build-up, early winter sown lentil had a higher maximum PAI and a longer leaf area duration than late winter sown crops. ILL 8, which had a fast build-up of dry matter, had the highest PAI, particularly after early winter sowing.

Table 1. *Total rainfall (mm), number of frosty days (minimum temperature* $<0°C$*) and minimum temperature (°C) in 1982/83, 1983/84 and 1984/85*

	1982/83	1983/84	1984/85
Total seasonal rainfall	323	229	373
November			
No. of frosty days	4	0	1
Minimum temperature	−4.4	—	−1.1
December			
No. of frosty days	15	10	16
Minimum temperature	−6.4	−3.9	−6.0
January			
No. of frosty days	18	6	3
Minimum temperature	−9.8	−2.4	−0.8
February			
No. of frosty days	11	10	10
Minimum temperature	−3.6	−4.1	−6.8
March			
No. of frosty days	4	1	12
Minimum temperature	−5.6	−0.5	−9.5

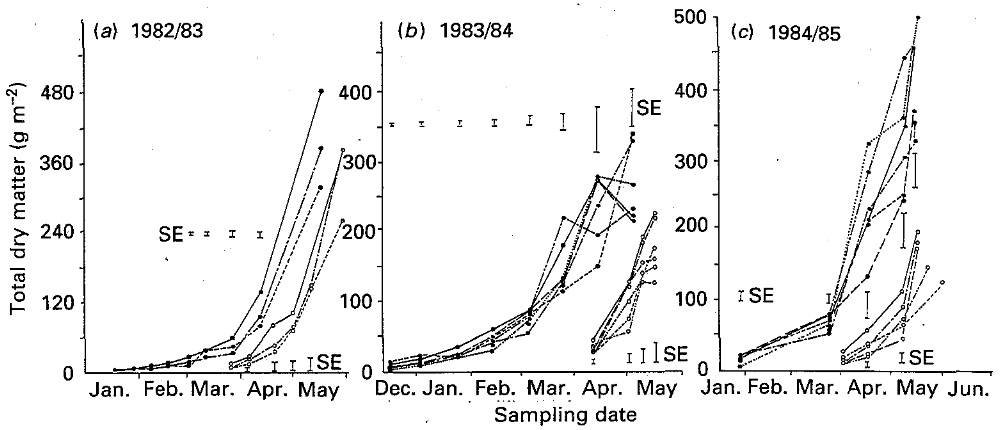

Fig. 2. Total dry matter accumulation of selected lentil lines sown in November (●) and February (○) in (a) 1982/83, (b) 1983/84 and (c) 1984/85. ILL 8 (——), 9 (— — —), 16 (— · —), 223 (— ·· —), 4400 (- - - -) and 4401 (......).

Seed yield

Advancing the date of sowing to early winter did not influence seed yield significantly in 1982/83 and 1983/84, but in 1984/85 seed yield was doubled by early sowing (Tables 2–4). Seed yields were poor in 1983/84 largely due to heavy infestation with *Orobanche* species on the earlier sown plots, and to drought. There were no overall differences between the groups of large and small seeded

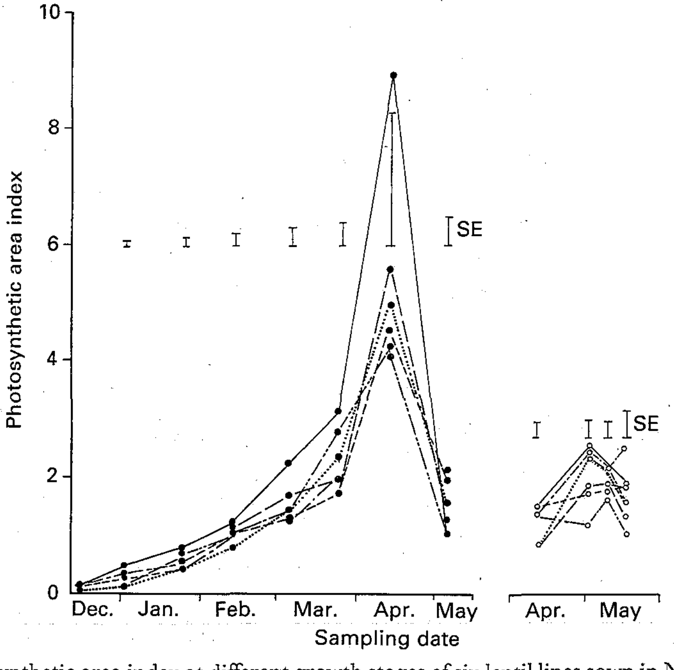

Fig. 3. Photosynthetic area index at different growth stages of six lentil lines sown in November (●) and February (○) in 1983/84. Code for varieties as in Fig. 2.

Table 2. *The effect of date of sowing on seed and straw yield (t ha^{-1}) and harvest index of six lentil lines in 1982/83*

Date of sowing	Genotype	Seed yield	Straw yield	Harvest index
17 November	ILL 8	1.30	2.99	0.30
	ILL 9	0.89	2.42	0.26
	ILL 4400	0.86	2.43	0.27
	ILL 16	1.06	2.48	0.28
	ILL 223	1.01	2.23	0.31
	ILL 4401	0.85	2.20	0.28
4 February	ILL 8	1.16	2.23	0.34
	ILL 9	0.82	1.82	0.31
	ILL 4400	1.05	1.01	0.36
	ILL 16	1.10	1.99	0.36
	ILL 223	1.01	1.92	0.35
	ILL 4401	0.78	1.90	0.29
Means for dates: November		1.00	2.46	0.28
February		0.99	1.96	0.33
Means for genotypes	ILL 8	1.23	2.61	0.32
	ILL 9	0.85	2.12	0.28
	ILL 4400	0.95	2.17	0.31
	ILL 16	1.08	2.23	0.32
	ILL 223	1.01	2.07	0.33
	ILL 4401	0.82	2.05	0.29
SE for date of sowing (S)		0.03	0.03	0.01
for genotypes (G)		0.08	0.14	0.01
for S × G		0.11	0.19	0.02

genotypes in seed yield. However, ILL 8 gave the highest seed yield in 1982/83 and 1983/84 and was the second highest yielder after ILL 4401 in 1984/85. There were significant interactions between genotypes and date of sowing for seed yield; for example, in 1984/85, ILL 223 was the highest yielding cultivar from November sowing, but from February sowing its yield was significantly lower than that of ILL 8 (Table 4). The seed yields in 1982/83 and 1984/85 were strongly correlated with biomass ($r = 0.81$ for 1982/83, $r = 0.79$ for 1984/85).

Straw yield and harvest index

Straw yield from November sowing was consistently higher than from February sowing (Tables 2–4). In 1982/83 and 1983/84, the highest yielding line was ILL 8 and in 1984/85, it was the second highest yielder after ILL 4401. There were significant interactions between time of sowing and genotype. For example, in all three seasons, the highest straw yield from February sowing was from ILL 8, but from November sowing its yield varied from year to year, being second lowest in 1983/84.

The harvest index from November sowing was always less than that from February sowing. There were differences in harvest index among cultivars, but the ranking varied over seasons.

Table 3. *The effect of date of sowing on seed and straw yield (t ha^{-1}), harvest index and* Orobanche *species damage score of six lentil lines in 1983/84*

Date of sowing	Genotype	Seed yield	Straw yield	Harvest index	*Orobanche* species damage score†
17 November	ILL 8	0.27	2.47	0.10	5.5
	ILL 9	0.29	2.50	0.12	3.5
	ILL 4400	0.44	1.84	0.23	3.5
	ILL 16	0.46	2.57	0.17	3.5
	ILL 223	0.32	2.52	0.13	4.0
	ILL 4401	0.54	2.61	0.19	2.5
4 February	ILL 8	0.81	1.82	0.45	3.0
	ILL 9	0.69	1.66	0.41	2.8
	ILL 4400	0.36	1.27	0.28	3.3
	ILL 16	0.55	1.70	0.31	3.0
	ILL 223	0.37	1.23	0.30	3.0
	ILL 4401	0.41	1.45	0.27	2.5
Means for dates: November		0.39	2.42	0.16	3.8
February		0.53	1.52	0.34	2.9
Means for genotypes	ILL 8	0.54	2.14	0.27	4.3
	ILL 9	0.49	2.08	0.27	3.2
	ILL 4400	0.40	1.56	0.25	3.4
	ILL 16	0.50	2.13	0.24	3.3
	ILL 223	0.34	1.88	0.21	3.5
	ILL 4401	0.47	2.03	0.23	2.5
SE for date of sowing (S)		0.06	0.18	0.02	0.28
for genotypes (G)		0.03	0.14	0.02	0.25
for S × G		0.09	0.26	0.02	0.42

†Scored from 1, no damage, to 9, complete crop kill.

Seed and straw quality

The protein content of seed from early sowing was less than that from late sowing in 1984/85 (Table 4). However, the protein content of the straw was greater from the early sowing, though the digestibility was less in those lines analyzed for both sowing dates (Table 4).

DISCUSSION

An advance in the sowing date of lentil from the traditional late winter sowing to mid-November resulted in improved productivity, with increases of 22% in seed yield and 68% in straw yield averaged over three seasons. It also resulted in increased canopy height, facilitating harvest mechanization.

The advantage of early winter sowing on seed yield varied over seasons. Seed yield from early sowings was double that from late sowings in 1984/85 because, as reported by Saxena *et al.* (1990) for chickpea, vegetative growth occurred under cool, moisture-assured conditions and drought stress was deferred to the later

Table 4. *The effect of date of sowing on seed and straw yield (t ha^{-1}), harvest index and quality characters of six lentil lines in 1984/85*

Date of sowing	Genotype	Seed yield	Straw yield	Harvest index	Protein (%) Seed	Protein (%) Straw	Digestibility of straw dry matter (%)
17 November	ILL 8	1.16	2.74	0.30	23.0	7.8	53.5
	ILL 9	1.11	2.08	0.35	22.5	8.3	52.5
	ILL 4400	0.90	2.23	0.29	24.0	5.9	52.6
	ILL 16	0.97	1.83	0.34	24.2	7.2	53.2
	ILL 223	1.34	2.62	0.34	24.7	4.8	50.7
	ILL 4401	1.33	3.20	0.29	23.7	4.2	51.9
4 February	ILL 8	0.66	1.03	0.40	24.0	7.0	55.1
	ILL 9	0.59	1.06	0.35	23.6	6.7	56.3
	ILL 4400	0.34	0.74	0.32	24.2	—	—
	ILL 16	0.55	0.92	0.37	25.3	5.8	54.4
	ILL 223	0.46	0.80	0.37	25.5	—	—
	ILL 4401	0.54	1.02	0.35	25.2	—	—
Means for dates: November		1.13	2.45	0.32	23.7	—	—
February		0.52	0.93	0.36	24.6	—	—
Means for genotypes	ILL 8	0.91	1.88	0.35	23.5	—	—
	ILL 9	0.85	1.57	0.35	23.0	—	—
	ILL 4400	0.62	1.49	0.30	24.1	—	—
	ILL 16	0.76	1.38	0.36	24.7	—	—
	ILL 223	0.90	1.71	0.35	25.1	—	—
	ILL 4401	0.93	2.11	0.32	24.4	—	—
SE for date of sowing (S)		0.06	0.07	0.01	0.15	—	—
for genotypes (G)		0.06	0.09	0.1	0.86	—	—
for S × G		0.09	0.14	0.02	0.41	0.14	1.1

part of reproductive growth. In the 1982/83 season seed yields from both sowing dates were similar, for two reasons. The early growth of the early sown crop remained slow because of exceptionally low temperatures between December and February, emphasizing the need for cold tolerance and capacity to grow at low temperatures, while the late sown crop benefited more from the late rain in April and May. Studies with peas (Hedley and Ambrose, 1981) and chickpeas (Saxena *et al.*, 1990) have shown that high dry matter production is one of the major prerequisites for high seed yield and this characteristic should be accompanied by improved partitioning between the seeds and straw. In 1983/84, high total dry matter was achieved but seed yield was poor. Total rainfall that year was low so that sowing in early winter probably resulted in the early establishment of a large photosynthetic area and rapid early water use, followed by severe water deficits during the reproductive growth stage and hence low seed yield. Seed yield was also reduced by the high level of infestation by *Orobanche* species in the early sown plots. Early winter sowing is known to increase the incidence of *Orobanche* species in Spain on both lentil and faba bean (Cubero and Moreno, 1979; Cubero, 1983) and in Syria on lentil (Basler, 1981; ICARDA, 1985). Early sowing must be avoided on land infested by *Orobanche* species because there is a rapid increase in the seed load in the soil unless the inflorescences are removed by costly hand-pulling.

Large seeded and small seeded lentils occupy 15 and 85%, respectively, of the lentil area in Syria and are utilized in different ways; the red cotyledon, small seeded lentils are usually split and dehulled for use in soup, and the yellow cotyledon, large seeded lentils consumed whole. The study showed no overall difference in growth pattern between the groups although there was evidence of variation in growth rate among the cultivars used. Those varieties showing early vigour, an easily scored character, tended also to have a high value for final economic biomass as shown by ILL 8 in 1982/83 and 1983/84; and by ILL 4401 and ILL 223 in 1984/85. These varieties are particularly suited to the Mediterranean environment where crop growth is limited by cool temperatures during winter and by moisture stress and high temperatures in the spring (Smith and Harris, 1981).

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REFERENCES

Basler, F. (1981). Weeds and their control. In *Lentils*, 143–154 (Eds C. Webb and G. Hawtin). Slough: Commonwealth Agricultural Bureaux (CAB).

Cubero, J. I. (1983). Parasitic diseases in *Vicia faba* L. with special reference to broomrape (*Orobanche crenata* Forsk). In *The Faba Bean*, (*Vicia faba* L.), 493–521 (Ed. P. D. Hebblethwaite). London: Butterworths.

Cubero, J. I. & Moreno, M. T. (1979). Agronomic control and sources of resistance in *Vicia faba* to *Orobanche* spp. In *Some Current Research on Vicia faba in Western Europe*, 41–80 (Eds D. A. Bond, G. T. Scarascia-Mugnozza and M. H. Poulsen). Brussels: Commission of European Communities.

Hedley, C. L. & Ambrose, M. J. (1981). Designing 'leafless' pea plants for improving yields of the dry pea crop. *Advances in Agronomy* 34:255–277.

ICARDA (1985). *Annual Report, 1984.* Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

Saxena, M. C. (1981). Agronomy of lentils. In *Lentils*, 111–129 (Eds C. Webb and G. Hawtin). Slough: Commonwealth Agricultural Bureaux (CAB).

Saxena, M. C., Murinda, M. V., Turk, M. & Trabulsi, N. (1983). Productivity and water use efficiency of lentils as affected by date of sowing. *LENS Newsletter* 10 (1):28–29.

Saxena, M. C., Silim, S. N. & Singh, K. B. (1990). Effect of supplementary irrigation during reproductive growth on winter and spring chickpea (*Cicer arietinum*) in a Mediterranean environment. *Journal of Agricultural Science*, Cambridge 114: 285–293.

Smith, R. C. G. & Harris, H. C. (1981). Environmental resources and restraints to agricultural production in a Mediterranean-type environment. *Plant and Soil* 58:31–57.

Williams, P. C., Jaby El-Haramein F., Nakkoul, H. & Rihawe, S. (1986). *Crop Quality Evaluation Methods and Guidelines. ICARDA Technical Manual No. 14*, 142. Aleppo, Syria: ICARDA.