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Effects of Sowing Dates on the Phenology, Seed Yield and Yield Components of Flax

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Abstract: This experiment was conducted to test a range of sowing dates, between 01.03.99 and 07.06.99 and in this way covering a wide range of environmental situations. Seed yield, yield component and different development periods of flax were measured and compared. It was found that seed yield generally decreased by delayed sowing. The effects were significant for number of seeds per m^2, number of capsules per plant, number of seeds per plant and number of seeds per capsule but not for number of capsules per m^2.

Key words: Flax, seed, sowing date, yield

Introduction

For seed production very poor physiological and agronomic care is taken which are necessary for a seed crop rather than a commercial crop for grain. These include use of appropriate sowing and harvest time, sowing density, fertilizer requirements, irrigation, seed processing and drying at appropriate temperature, seed cleaning and storing in good storage environments. Adjustment of sowing date plays an important role in increasing the seed yield.

Flax is a small seeded oil seed with high lipid content. Linseed or flax is a long day plant which requires uniformly moderate to cool temperatures and adequate moisture during its vegetative, capsule and seed growth stages. However, in the later phases of its life cycle, e.g. at the time of capsule ripening or harvesting, warm dry weather is desirable for high quality fibre and seed production. It is known to grow best in fertile, well drained, medium to heavy textured soils of pH ranging 5.5-7.0 (Dempsey, 1975).

Seed yield in linseed is highly influenced by environmental factors (Hansen and McGregor, 1954; Davidson and Yermanso, 1965). In linseed, seed yield generally decreases with delay in sowing (Dixit *et al*., 1994; Fontana *et al*., 1996; Shahidullah *et al*., 1997). Some workers reported that in Italy yields were higher from autumn than spring sowings (Marras and Scarpa, 1997). Rossini *et al*. (1997) reported that autumn sowing gave double the yields of spring sowing.

With the above views, the experiment was conducted to identify the effects of sowing dates on development periods, plant growth, seed yield and yield components of flax.

Materials and Methods

The experiment was conducted at the Henfaes Research Centre of the University of Wales, Bangor, Gwynedd, UK during 1999. Important meteorological parameters i.e., mean weekly maximum and minimum temperature, sunshine, total number of rainy days and rainfall experienced by the seed crop during the growing season were recorded in a standard agrometerological station, located less than 1 km from the experimental site following eight sowing (S) dates were tested:

S1 = 01.03.99;	S2 = 15.03.99;
S3 = 29.03.99;	S4 = 12.04.99;
S5 = 26.04.99;	S6 = 10.05.99;
S7 = 24.05.99	S8 = 07.06.99.

A randomized complete block designs was used. The flax variety Tomba was used, flax variety and collected from John Turner Seeds, Cambridge, UK.

Clay loam top soil (0-15cm) was collected from an agricultural field, sieved, mixed with composed (B & Q multipurpose compost, B and Q Plc, Chandlersford, Hants, SO 53 3YX) and used to fill 32 pots (holding capacity of 70 litres), 44 cm diameter and 65 cm deep. Approximately 240 seeds were sown per pot to achieve a plant population of 1000 plants per m^2. The number of seedlings emerged was determined at 21 days after sowing and this was used to calculate emergence percentage. Crop establishment ranged from 43 to 59% and no thinning was done.

Phosphorus and potassium fertilizer were applied by broadcasting as a basal dose @ 50kg each (as P_2O_5 and K_2O) per ha^{-1} before sowing in the form of a compound fertilizer (0-24-24). As soil was fertile and additional nitrogen requirements were low because of mixing compost, no nitrogenous fertilizer was applied. The plants were watered with tap water as and when required. Weeds were removed manually in all pots whenever necessary.

Date of emergence (when the first shoot appeared above the ground surface), date of first flowering, date of average flowering (when flowers were visible and open at most of the nodes and the first capsules were visible on the plants), last date of visible flowers and date of harvest were recorded. Flowering period was calculated from the difference between first flowering date and last date of visible flowers.

The plants in each pot were harvested by hand as they matured. All plants were removed by hand pulling and counted. All capsules were removed, counted and threshed by hand. The seeds were counted using an automatic seed counter, dried in trays in the air in an unheated glasshouse and then weighed. The empty capsules were collected, put with the straw and dried in an oven at 80°C for 48 hours to determine the straw dry weight. These data were then used to calculate number of capsules per plant, number of seeds per plant, number of seeds per capsules, seed weight per plant, straw dry weight per plant and 1000 seed weight.

All data were analyzed by the analysis of variance (ANOVA) method, using Minitab statistical package version-12. Tests of differences between means were made at the 5 % probability level when a significant F value was obtained for sowing date effect. Different treatment means were compared by calculating a least significance difference (LSD) as follows:

$$LSD = \sqrt{(2EMS)/n} \times t(0.05), df.$$

Where EMS = error mean square; from analysis of variance table
n = number of replications (4);
t = (0.05),
df = value from the t distribution table at 5 % probability level and appropriate error degrees of freedom (df).

Results

The effects of date of sowing on the length of different development periods of flax are shown in Fig. 1. As sowing was delayed the number of days from sowing to emergence,

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Table 1: Mean weekly maximum and minimum temperature, sunshine and total number of rainy days and rainfall recorded during the growing season of peas and flax in 1999 (sowing started on First March 1999)

Dates	Weeks after first sowing	Temperature (°C) Max.	Min.	No. of rainy days	Rainfall/day (mm)	Sunshine/day (h)
1-7 March	1	7.6	4.4	7	8.2	0.0
8-14 March	2	9.5	3.5	3	0.4	4.0
15-21 March	3	11.8	7.0	3	1.5	5.0
22-28 March	4	10.0	5.3	6	2.5	2.2
29 March-4 April	5	15.9	8.9	5	1.5	6.3
5-11 April	6	13.4	9.3	4	3.3	4.1
12-18 April	7	8.1	2.4	6	3.3	5.1
19-25 April	8	12.2	6.3	6	3.9	4.7
26 April-2 May	9	12.3	7.3	1	0.3	8.1
3-9 May	10	17.4	9.2	4	2.8	5.3
10-16 May	11	14.5	10.3	5	2.7	6.7
17-23 May	12	15.1	9.6	3	0.5	6.2
24-30 May	13	15.7	10.5	6	1.3	4.5
31 May-6 June	14	14.8	10.0	6	3.9	5.3
7-13 June	15	14.1	8.7	2	0.4	6.0
14-20 June	16	18.7	11.6	2	2.6	8.8
21-27 June	17	18.5	10.6	4	5.0	6.2
28 June-4 July	18	18.9	12.4	4	1.0	6.0
5-11 July	19	21.5	14.6	1	0.5	8.2
12-18 July	20	19.2	12.9	3	0.3	7.1
19-25 July	21	19.4	13.2	2	1.0	5.8
26 July-1 August	22	22.1	12.1	0	0.0	12.4
2-8 August	23	19.7	15.0	6	6.8	2.5
9-15 August	24	17.3	12.6	4	2.2	6.0
16-22 August	25	18.0	10.8	4	1.1	8.8
23-29 August	26	19.5	13.1	4	2.3	3.9
30 Aug-5 Sept.	27	21.0	13.0	0	0.0	5.5
6-12 September	28	20.6	11.5	4	7.5	7.4
13-19 September	29	17.6	10.5	3	9.7	6.3

Table 2: Effect of date of sowing on emergence percentage, duration of development period, yield and yield components of flax

Parameters	Date of sowing 01.03.99	15.03.99	29.03.99	12.04.99	26.04.99	10.05.99	24.05.99	07.06.99	SED	LSD
Emergence %	43.0	58.1	55.30	54.0	58.6	59.4	55.2	50.4	5.98	NS
Emergence % (transformed dates)	0.44	0.63	0.59	0.58	0.635	0.64	0.59	0.53	0.07	NS
flowering periods	24.0	23.8	22.0	20.0	21.5	18.2	20.0	18.8	0.81	1.66***
Days from 1st flowering to harvest	57.5	55.0	51.2	43.0	42.0	38.2	39.0	39.5	0.95	1.96***
Number of plants/m^2	678.0	917.0	872.0	868.0	925.0	938.0	871	795	94.4	NS
Number of capsul/m^2	9434.0	12732.0	10780.0	10816.0	10152.0	8940.0	9196	7314	1626.4	NS
Number of seeds/m^2	68174.0	88885.0	83512.0	81084.0	63021.0	55816.0	54715	47233	11648.6	24042.7*
Seed weight/m^2 (g)	285.0	317.0	266.0	240.0	233.0	161.0	166	158	34.6	71.5***
Straw dry weight/m^2 (g)	728.0	918.0	781.0	853.0	789.0	801.0	793	717	94.0	NS
1000 seed weight/m^2	6.0	5.95	5.54	5.34	5.04	4.87	4.78	4.56	0.31	0.64***
Number of capsules/plant	13.9	13.9	12.5	12.5	11.0	9.6	10.5	9.2	1.21	2.50***
Number of seeds/plant	100.0	97.0	96.0	95.0	68.0	59.0	63	59	8.50	17.5***
Number of seeds/capsule	7.2	6.9	7.7	7.6	6.2	6.3	6.1	6.4	0.51	1.05***
Seed weight /plant	0.42	0.37	0.31	0.29	0.25	0.17	0.20	0.20	0.053	0.110***
Straw dry weight/plant (g)	1.08	0.99	0.92	1.00	0.86	0.86	0.92	0.82	0.112	NS
Harvest index %	28.0	26.9	25.4	21.9	22.9	16.7	16.9	18.1	3.11	6.41*

* = $P < 0.055$ *** = $P < 0.01$

Table 3: Values of the linear correlation coefficient (r) of seed yield/m^2 between capsule/plant, seeds/capsule and 1000 seed weight of flax. Values within brackets are the corresponding probability levels (n = 8)

Flax	r values
Capsule/plant	r = 0.956*
Seeds/capsule	r = 0.648^{NS}
1000 seed weight	r = 0.948*

* = $P < 0.01$

sowing to first flowering, emergence to first flowering, sowing to average flowering and sowing to harvest all decreased. Sowing date significantly affected the lengths of all periods, although differences between consecutive sowings were not always statistically significant.

Days sowing to emergence: As sowing date was delayed then days from sowing to emergence {D (S-E)} decreased. Days from sowing to emergence decreased markedly as sowing was delayed from 01.03.99 to 29.03.99. Days from sowing to emergence for S4 was greater than expected, it might be due to very cold and wet weather (Table 1). Days from sowing to emergence for S5 to S8 were similar.

Duration of different development periods: The effects of date of sowing on the number of days from sowing to first flowering decreased as sowing was delayed. The decrease was large in between S1 and S5 and relatively small from S5 to S8. The

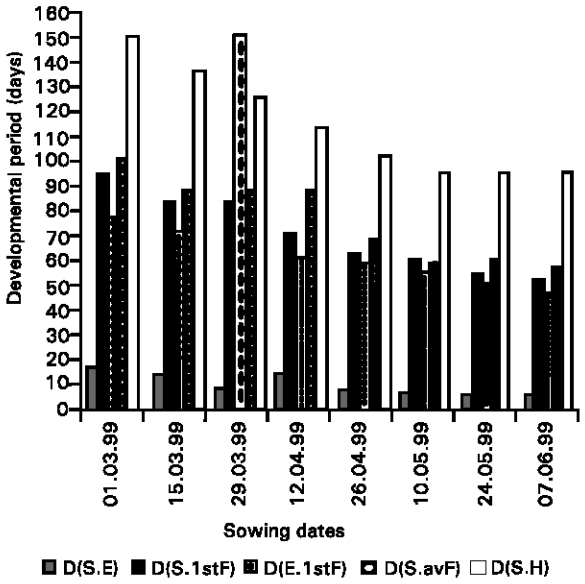

Fig.1: The effect of date of sowing on the length of different development periods (days) of flax plants between sowing (S), emergence (E), first flowering (1st F), average flowering (Av.F) and harvest (H) (vertical bars are ±SE of the means)

number of days from emergence to first flowering also decreased as sowing was delayed. There was a significant effect of sowing date on the number of days from sowing to harvest. The number of days from sowing to harvest decreased as sowing was delayed. This decrease was large up to S5 and relatively smaller from S6 to S8. Days from first flowering to harvest and the length of the flowering period also generally decreased as sowing was delayed (Table 2).

Emergence percentage: The effect of date of sowing on emergence percentage was not significant. The range of emergence percentage was 43 to 59% respectively (Table 2). Establishment and plants per m^2 were lower in S1 and S8. Although there were no significant differences between sowings in emergence and the number of plants per m^2, S1 and S8 had fewer plants per m^2 than other sowings, due to a lower emergence percentage.

Yield and yield components: From the data it is observed that, seed weight per m^2 was not significantly affected by the date of sowing between S1 and S3. However, S4 had a significantly lower seed weight per m^2 than S2 and in later sowings seed weight per m^2 was further decreased. Seed weight per plant generally decreased as sowing was delayed. This decrease was not significant between S1 and S2, but S3 had a significantly lower seed weight per plant than S1. S6, S7 and S8 had a similar seed weight per plant and per m^2.

The decrease in yield due to delayed sowing was due to decreases in all yield components. Later sowings had fewer capsules per plant and per m^2, fewer seeds per capsule and lower 1000 seed weight (Table 2). The effects were significant for number of seeds per m^2, number of capsules per plant, number of seeds per plant, number of seeds per capsule but not for number of capsules per m^2.

S1 to S4 all had similar number of seeds per plant but, S5 to S8 had a significantly lower number. The decrease in seed weight per plant was due to significant decreases in the number of capsules per plant and 1000 seed weight. Although straw dry weight per plant was lower in the last three sowings than in the first three sowings, the effect of sowing date was not significant. Delaying sowing date resulted in a significant decrease in harvest index percentage.

Discussion

The environment during seed development is a major determinant of seed yield (Delouche, 1980). Sowing dates exhibit their effects on plants by affecting various physiological process. In this experiment sowing dates had a significant effect on most of the studied characters of flax including duration from sowing to emergence, the length of different development periods, seed yield and yield components. Emergence percentage, number of plants per m^2, number of capsules per m^2, straw dry weight per m^2 and per plant, all variables were significantly affected.

Effects of sowing date on plant development: As sowing date was delayed then due to rising temperatures (Table 1) and longer photoperiods, vegetative growth was very rapid and hence the flax plant matured quickly. The harvest dates of each sowing were much closer together than the sowing dates.

The first sowing took 154 days from sowing to harvest whereas the final sowing took 94 days only. This was also observed with different crop species by other workers (Friend *et al.*, 1962; Wall and Cartwright, 1974; Stern and Kirby, 1979). Examination of the records for the time when individual sowings became ready for harvest showed them to have a strong relation with date of sowing.

March and mid April sowings tended to be ready for harvest in the first week in August while late April to mid May sowings tended to become ready in the second week in August and late May and first week of June sowings before the second week of September. Delaying sowing decreased the length of all development periods. Comparing the first and final sowing dates, delaying sowing of flax decreased the length of the period from sowing to emergence by 11 days, from emergence to first flowering by 30 days and from first flowering to harvest by 19 days. Hence, delaying sowing had its greatest effect on the duration of the period between emergence and first flowering. The duration of the seed growth period (first flowering to harvest) was also affected. The shorter duration of the seed filling period was reflected in lower average seed weight (Table 2). The faster development of later sowings is probably due to the fact that they experienced higher temperatures and longer photoperiods. Other investigators have obtained similar results with other species (Peterson and Loomis, 1949; Gardner and Loomis, 1953; Lindsey and Peterson, 1964).

Effects of sowing date on yield and yield components: The number of capsules per plant, the number of seeds per capsule and the weight of 1000 seeds, each of these parameters needs to be looked at separately in order to interpret the results of the present study. The results show a clear yield trend in favour of early sowing. From this experiment it may be concluded that the crops are best drilled as soon after the middle of March as soil conditions allow. Comparison of the sowing dates (Table 2) show that the later sowings suffered a much more severe yield drop. The earliest sowings are likely to have suffered some yield loss in comparison with the second sowings, as early sowings experienced more cold and wet weather conditions. The yield decrease was due to decreases in capsules per plant, seeds per capsules and 1000 seed weight. Hence the greater effect of delayed sowing in flax was associated with effects of all yield components.

Relationship between sowing date, yield components and yield: The results (Table 3) show the values of the linear correlation coefficient of yield components with yield per m^2. Yield per m^2 was significantly correlated with 1000 seed weight and number of capsule per plant. There was no significant correlation of yield per m^2 with seeds per capsule. These suggest that the yield and yield components of flax were affected throughout the sowing date treatments.

Sowing after mid March resulted in yield reductions. This trend is in agreement with the findings of Mathur *et al.* (1984) and Verma and Pathak (1993). They found that in India yield was higher from

early sowing (October) than from late sowing (November). This may be because the crop gets sufficient time for its growth and development under suitable climatic conditions.

Late sowings had shorter vegetative periods (Fig. 1) and they also had fewer capsules. The shorter period from first flowering to harvest may have resulted in insufficient time for correct seed filling and development. This might be the cause of the lower average seed weight.

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