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Studies on the Effects of Capsule Position on the Mother Plant and Sowing Density on Flowering, Capsule Production, Seed Yield, Yield Components and Viability (Germination) of Flax Seeds

A.B.Siddique, [1]D.Wright, A.Khatun and Z.Naher
Genetic Resources and Seed Division, Bangladesh Jute Research Institute,
Manik Mia Avenue, Dhaka-1207, Bangladesh
[1]School of Agricultural and Forest Sciences, University of Wales, Bangor, Gwynedd, United Kingdom

Abstract: Studies were provided evidence that high density plants produced seeds of poorest quality. As density increased seed yield per plant decreased. Number of capsules per plant and per branch, number of seeds per plant and per branch, seed weight per plant and per branch and 100 seed weight also decreased with increasing density. On the other hand number of capsules per branch, number of seeds per branch and seed weight per branch were all highest on the main stem and decreased in the order first, second and remaining branches.

Key words: Flax, capsule, spacing, germination

Introduction

The heterogeneity observed within commercial seeds may be due to inter or intra plant variation. Cavers and Harper (1966) observed in *Rumex* spp., considerable differences in germination and dormancy characteristics between seeds harvested from different plants grown in the same environment, between inflorescences on the same plant and between different positions of the same inflorescence. The effects of seed position have also been demonstrated in carrot (Borthwick, 1931; Hawthorn *et al*., 1962; Shevtsova and Koral, 1977; Jacobsohn and Globerson, 1980) where the primary umbels produced heavier seeds with higher germinability than did tertiary umbels. Observations on broccoli (*Brassica oleracea* L.) (Baranauskiene, 1977), celery (*Apium graveolens* L.) (Thomas *et al*., 1979) and lettuce (Smith *et al*., 1973) have all shown that seed position may affect seed yield and quality.

Understanding the physiological processes underlying seed production such as vegetative growth, formation of storage organs and seed filling, helps to determine the best combination of agronomic and climatic factors and also suggests what improvements may be necessary to achieve further increases in seed yield and quality under given conditions (Flin and Pate, 1970; Egli, 1975; Hedley and Ambrose, 1981). This paper reports results of the experiments performed to investigate the effects of capsule position on the mother plant and sowing density on seed yield, yield components and seed quality (germination) of flax seeds. Plants were grown singly in pots, with two spacings between plants. Individual branches were tagged as they were borne, harvested separately and seed yield and quality determined.

Materials and Methods

This experiment was conducted in a glasshouse and laboratories at the Henfaes Research Centre, of the University of Wales, Bangor, Gwynedd, United Kingdom. The flax variety was Tomba, which is a combinable flax variety and collected from John Turner Seeds, Cambridge, United Kingdom. Top soil was collected from an agricultural field, sieved and 48 pots of 20 cm diameter were filled. Twenty four pots were placed close together so that centre to centre distance was 20 cm. A second series of 24 pots were prepared and placed spaced so that centre to centre distance was 40 cm. Three seeds were sown per pot on 04.06.98. Fertilizer 50 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1} were applied as a basal dose in the form of compound fertilizer (0-24-24). When the seeds germinated twenty eight days later the plants were thinned to leave one plant per pot. The plants were watered as required. However, when the capsules were starting to show signs of ripening (yellowing) watering was reduced to two times per week, followed by once per week and finally was stopped. The maximum and the minimum glasshouse air temperatures were recorded daily and are presented in Fig. 1.

When the plants were produced branches they were tagged with light plastic rings using varying colours according to their appearance time and position on the mother plant. The first flowering date was recorded. At 40 cm spacing, the flax plants first flowered on 29.07.98

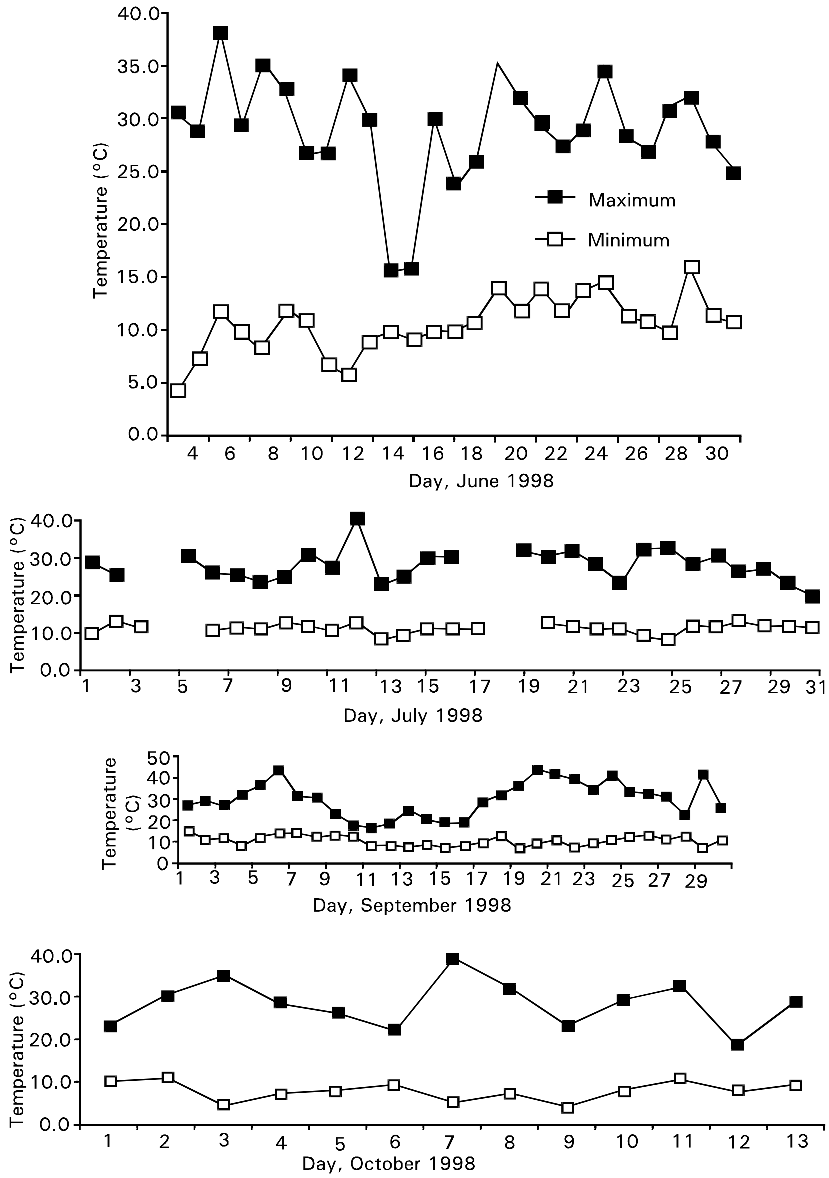

Fig. 1: Showing the glasshouse temperatures during the study

and at 20 cm spacing it was on 02.08.98. So, from sowing to first flowering it took 54 and 58 days respectively. However, the individual pairs of branches were marked with plastic rings. The capsules were harvested separately according to their branch position and the capsules and seeds from each branch pair kept separate.

Harvesting: Plants were harvested by hand as they were matured. The branches are borne in pairs. All the plants had the first branch pair, the second branch pair and main stem. Some plants had some extra branches apart from these. During harvesting capsules were harvested separately from the main stem, first branch pair, second branch pair and remaining branches. After harvesting the capsules were air dried in the laboratory at room temperature and threshed by hand, cleaned and stored in paper bags in the same laboratory at room temperature for dormancy breaking. Samples of seed were tested periodically for germination to assess whether or not dormancy had been broken. When dormancy was broken their germination was tested. Seeds were allowed to germinate in 9.5 cm diameter plastic petri dishes with two layers of Whatman No. 1 filter paper and kept moist with distilled water. The petri dishes were kept at 20°C in the dark in an incubator. One hundred seeds from every branch of every plant were tested for germination, using four replications of 25 seeds. Germination was recorded every day and a seed was considered germinated when its radicle protruded out about 2 mm. Germinated seeds were counted until no further germination occurred.

Statistical analysis: All the data were analyzed using Minitab Statistical Package, Version-12. Basic statistics was performed on the data for calculation of standard error of the means and a two sample-t-test was performed to compare the effects of spacings (40 and 20 cm) on seed yield and yield components. The individual pots were considered as replicates.

Results

Differences between the main stem and branches must be treated with care, as the flax plant produced a pair of branches at each node. Hence the data were presented for both branches and per branch. The results showed that at 40 cm spacing most of the capsules and seeds were borne on the first branches. The main stems had fewer capsules and seeds than the first branches. The second and remaining branches had fewer capsules and seeds. Total seed weight per branch position and 100 seed weight were highest on the first branch and were lower on the main stem, followed by the second and remaining branches (Table 1). Number of seeds per capsule was highest on the main stem, decreased on the first and second branches and slightly increased on the remaining branches. Number of capsules per branch, number of seeds per branch and seed weight per branch (Table 1) were all highest on the main stem and decreased on the first, second and remaining branches. Number of seeds per capsule and 100 seed weight are relatively constant compared to number of capsules per plant and number of seeds per plant. Germination percentage of seeds (Table 1) was relatively constant on the main stem, first and second branches and slightly decreased on the remaining branches.

The results show that at 20 cm spacing most capsules and seeds were borne on the first, lowest branches. The main stem had fewer capsules and seeds. The second and the remaining branches had relatively few capsules and seeds. Seed weight was also highest on the first branches and decreased in the order first branches > main stem > second branches > remaining branches. 100 seeds weight was more consistent between branches. Number of capsules per branch, number of seeds per branch, seed weight per branch were all highest on the main stem and decreased in the order: main stem > first branches > second branches > remaining branches. However, number of seeds per capsule was highest on the first branches, was slightly lower on the second branch pair, the remaining branches and the main stem. At both spacings the first branch pair produced the highest percentage of yield and the remaining branches produced the lowest percentage of yield. Germination percentages of seeds were relatively constant on the main stem, first and second branch pair, but markedly decreased on the remaining branches.

At 40 cm spacing a much higher number of capsules and seeds were produced from all the branches than at 20 cm spacing. Total number of seeds per plant, seed weight per plant, 100 seeds weight, number of capsules per branch, number of seeds per branch and seed weight per branch were all higher at 40 cm spacing than at 20 cm spacing. However, number of seeds per capsule was generally higher at 20 cm spacing than at 40 cm spacing. Differences between spacings in number of capsules per branch, number of seeds per branch, seed weight per branch and 100 seeds weight were largest on the main stem, and decreased with the order: main stem > first branch pair > second branch pair > remaining branches.

Table 2 shows the effects of spacing at 40 and 20 cm on seed yield and yield components. Seed yield per plant, number of branches per plant, number of capsules per plant, number of seeds per plant and 100 seeds weight were all higher at 40 cm spacing than at 20 cm spacing. However, the number of seeds per capsule was slightly lower at 40 cm spacing than at 20 cm spacing. These differences between spacings were significant for seed yield per plant, number of capsules per plant, number of seeds per plant and 100 seeds weight, but not significant for number of branches per plant and number of seeds per capsule.

In general, at both spacings, most of the flowers, capsules, seeds and yield was found on the main stem and decreased in the order main stem > first branch pair > second branch pair > remaining branches of the plant. Closer spacing did not affect the germination percentage of seed on the main stem, first branches or second branches but resulted in a decrease in germination percentage of seeds on the remaining branches.

Discussion

It is well known that large differences in viability and vigour occur between commercial batches of seeds. These differences might be due to the environment in which the parent plants are grown. A further factor affecting the characteristics of seeds within any batch is the source of the seeds within the seed crop. Another source of variability in seed quality may be associated with seed position on the mother plant (Cavers and Harper, 1966;

Table 1: Effects of spacing at 40 and 20 cm on capsule production, seed yield and germination of flax from different branches. Data are means (± S.E) of 24 plants

Part of the plant	Main stem	First branch pair	Second branch pair	Rest of the branches
% of plants having parts				
40 cm spacing	100.00	100.00	100.00	83.33
20 cm spacing	100.00	100.00	100.00	70.83
Total number of branches per plant				
40 cm spacing	1.00±0.00	1.95±0.04	2.00±0.00	3.00±0.41
20 cm spacing	1.00±0.00	2.00±0.00	1.95±0.04	2.47±0.26
Total number of capsules per plant				
40 cm spacing	38.25±1.17	49.17±1.95	23.83±1.48	16.05±2.28
20 cm spacing	31.04±0.87	39.37±2.06	20.04±1.50	11.18±1.34
Number of capsules per branch				
40 cm spacing	38.25±1.17	25.56±1.35	11.91±0.73	5.27±0.31
20 cm spacing	31.04±0.87	19.69±1.03	10.10±0.71	4.64±0.37
Total number of seeds per plant				
40 cm spacing	284.1±14.7	343.0±15.9	162.6±10.1	106.3±14.4
20 cm spacing	227.3±10.6	303.6±19.8	149.4±10.7	82.8±9.7
Number of seeds per branch				
40 cm spacing	284.10±14.70	178.60±10.70	81.31±5.07	35.89±2.09
20 cm spacing	227.30±10.60	151.81±9.89	75.44±5.07	34.70±2.80
Total seed weight (g)				
40 cm spacing	1.90±0.07	2.40±0.11	1.08±0.06	0.68±0.09
20 cm spacing	1.40± 0.05	1.97±0.11	0.97± 0.07	0.54± 0.06
Seed weight per branch (g)				
40 cm spacing	1.90±0.07	1.25±0.07	0.54±0.03	0.23±0.01
20 cm spacing	1.40±0.05	0.98±0.05	0.47±0.03	0.22±0.02
% of yield/branch position				
40 cm spacing	32.89±0.71	40.39 ±1.56	18.26±0.99	11.35±1.48
20 cm spacing	30.28±1.04	41.65±1.36	20.47±1.21	10.72±1.19
Number of seeds per capsule				
40 cm spacing	7.44±0.37	6.97±0.15	6.83±0.14	6.86±0.18
20 cm spacing	7.34±0.30	7.64±0.18	7.59±0.20	7.53±0.23
100 seed weight (g)				
40 cm spacing	0.68±0.01	0.70±0.01	0.67±0.00	0.64±0.01
20 cm spacing	0.63±0.01	0.66±0.01	0.65±0.01	0.65±0.01
Germination percentage				
40 cm spacing	99.83±0.11	99.92±0.08	99.92±0.08	91.14±0.27
20 cm spacing	99.58±0.19	99.83±0.11	99.41±0.42	72.92±0.98

Table 2: Effects of spacing at 40 cm and 20 cm on yield and yield components of flax seeds

	Spacings (cm)		
	40	20	P-value
Number of branches/plant	6.46±0.42	5.71±0.32	NS
Number of capsules/plant	124.3±3.70	99.3±4.30	0.0001
Number of seeds/plant	878.4±27.90	740.2±35.20	0.0035
Number of seeds/capsule	7.09±0.17	7.50±0.20	NS
100 seed weight (g)	0.69±0.01	0.64±0.01	0.021
Seed yield (g/plant)	5.98±0.17	4.75±0.22	0.0000

Baranauskiene, 1977; Gray and Steckel, 1983). Several studies with seeds of carrot have indicated that seed size plays an important role in germination performance and the largest seeds were usually found on primary umbels with better germination performance. Seed size declines with order of umbel (Borthwick, 1931; Austin and Longden, 1965; Hunter, 1971; Shevtsova and Khleborodov, 1976; Gray and Steckel, 1980). The position of the seed on the parent plant has been suggested as a cause of variability in seed quality within individual seed lots (Malik and Kanwar, 1969; Ries *et al*., 1976; Thomas *et al*., 1979; Gray and Steckel, 1980).

The results of the present studies showed that in flax percentage of seed yield per branch position decreased in the order: first branch pair > main stem > second branch pair > rest of the branches but seed weight per branch decreased in the order main: stem > first branch pair > second branch pair > rest of the branches. The germination percentage of flax seed was similar on the main stem, first branch pair and second branch pair but this also decreased on the remaining branches. Thus the results of the present study add further support to these observations of other workers with different crops. This is in agreement with the findings of Baudet *et al.* (1977). They found that in peas seed weight decreased as distance from roots increased.

Normally changing the spacing alters competition above and below ground but in this study, plants were grown in individual pots and maintained at 20 and 40 cm spacing between plants. So in this experiment spacing altered the competition above ground only. Although spacing altered competition above ground only, yet the spacings 40 and 20 cm between plants showed a clear marked difference of seed yield. Seed weight (per branch position and total seed weight) were higher at 40 cm spacing than at 20 cm spacing. This higher seed weight per plant at 40 cm spacing was associated with higher number of branches per plant, number of capsules per plant, number of seeds per plant and higher 100 seed weight. As 40 cm spacing experienced less competition than 20 cm spacing, this might be the cause of showing better performance in producing yield and yield components.

Spacing affected the seed weight per branch, but not the percentage of yield at each branch position (Table 1). Branch position had little effect on germination except that at both spacings there was a decrease in germination of seeds on the rest of the branches. Closer spacing did not affect the germination percentage of seed on the main stem, first branches or second branches but resulted in a decrease in germination percentage of seeds on the remaining branches. This might be due to more intra-plant competition than at higher spacing. Due to competition the rest of the branches of flax might have less chance to develop properly because competition appear earlier in stands of high density and progressively later in stands of lower densities (Donald, 1958, 1963; Harper, 1961).

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