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Effects of Time of Sowing on the Quality of Flax Seed

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Abstract: An experiment was conducted to identify the effects of time of sowing on the quality of flax seed. Eight sowing dates from 01.03.99 to 07.06.99 with an internal of fifteen days were tested for covering a wide range of environmental variations. Seed quality was determined by using germination percentage, emergence percentage and controlled determination test (ageing test). Starch, protein, water soluble carbohydrate and fat percentages of seeds from four selected sowings were also determined. Germination percentage of unaged seeds ranged from 94 to 99%. Germination percentage was slightly lower at the last sowing date but the effect was not significant. Raising seed moisture content followed by ageing at 50 °C for 36 h decreased germination percentage markedly. In aged seeds germination increased from S1 to S4 and then decreased as sowing was delayed after that. Emergence percentage of unaged seeds ranged from 73 to 95%. Raising seed moisture content followed by ageing at 50 °C for 36 h decreased emergence percentage. Sowings from 01-03-99 to 12-04-99 were given vigorous seeds but sowing made on 12-04-99 had the highest vigour.

Key words: Flax, seed, sowing date, viability, vigour

Introduction

Linseed or flax is a long day plant which required uniformly moderate to cool temperature and adequate moister 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).

Flax is a small seeded oil seed with high lipid content. At a moisture content of 10 % the seed contains approximately 40% oil (Scarisbrick *et al.*, 1980). Linotenic acid constitutes a high percentage of the oil and this favours its use as a drying oil in the manufacture of points and varnishes. For this reason it is an increasingly important industrial crop in Europe.

Qualitative parameters of seed are largely controlled genetically. But these genetical potentials are always expressive under appropriate environmental and technological environmental and technological conditions leaving behind a scope for adjustment and manupulations (Blum and Punel, 1990).

The adjustment of sowing date plays an important role in improving the quality of seeds for sowing purposes (Srivastava *et al.*, 1976). In linseed the assimilates and nutrients translocated into the seeds during growth and development are absrobed during embryogenesis by the embryo. Therefore, except the seed coat, the embryo as a whole is the seed. Because of this, environmental factors which influence the growth and development of the seed have a marked effect on the size of the embryo (Amlak, 1983). The quality of the seeds in linseed is very variable. In some instances seeds obtained from late developed capsules are smaller in size (Davidson and Yermanos, 1965) and it has been reported that the germination of the seeds are closely related to the seed size (Harper and Obeid, 1967).

Therefore, the experiment was conducted with the following objectives:

- To determine the effects of sowing dates on viability and vigour of flax seed.
- To determine the effects of sowing dates on the chemical composition of seeds and its relationship with viability and vigour flax seed.

Materials and Methods

Field experiment: The experiment was conducted at the Henfaes Research Centre of the University of Wales, Bangor, United Kingdom 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	and	S8 = 07.06.99.	

A randomized complete block design was used. The flax variety Tomba was used, which is a combinable 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 & Q Plc, Chandlersford, Hants, SO 53 3YX), UK and used to fill thirty two 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 m^{-2}. Phosphorus and potassium fertilizer were applied by broadcasting as a basal dose @ 50 kg each (as P_2O_5 and K_2O) 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. The plants in each pot were harvested by hand as they matured. All plants and capsules were removed and threshed by hand. The seeds were counted using an automatic seed counter, dried in trays in the air in an unheated glasshouse. The air dried seeds were placed in paper bags and stored in the laboratory at room temperature.

Methods for testing seed quality: Seed quality testing started on 02.12.99, approximately 3 months after harvest. Before starting seed quality measurement seed dormancy was tested by taking a small sample of seeds from the first and last sowings and testing germination. Seed samples from individual replicates of the pot experiment were kept separate and treated as the replicates of the seed quality tests. To determine the effects of sowing date on seed viability and vigour, germination percentage and emergence percentage were determined. These tests were also repeated on samples of seed that had undergone controlled deterioration (ageing).

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Method used for controlled deterioration (ageing): Before starting the deterioration process seed moisture content was raised to around 18% by placing the seeds on a perforated tray suspended over water for 24 h at 25 °C temperature in a growth chamber of Heanfaes Research Centre, University of Wales, Bangor, United Kingdom. The seeds were then placed in small sealable containers of 120 ml volume (Merck Ltd, Merck House, Poole, Dorset BH 15 1TD, UK). Approximately 400 seeds were placed in a container and then sealed. The containers were then placed on the shelf of an incubator, set at 50 °C. Samples of seed were removed after 36 h, germination and emergence percentage were determined. Moisture percentage of the seeds was measured before and after controlled deterioration as a check on the procedure.

Method for germination test: The seeds were allowed to germinate on sheets of Whatman no. 1 filter paper in plastic petri dishes. The filter paper was kept moist with distilled water. The petri dishes were kept at 20 °C in an incubator in the dark. There were 100 seeds per replicate of each treatment and were split between four petri dishes, each containing 25 seeds. Germination was recorded until no further seeds germinated. The first count was made after 3 days and a seed was considered germinated when its radicle protruded out about 2 mm. The final count was made at 7 days and no further germination occurred after this allocated time.

Method for emergence test: The emergence test took 21 days to complete, from sowing for taking the final recordings. It used 100 seeds per replicate of each treatment and was conducted in soil in pots in an unheated glasshouse at the same time as the germination tests. The mean soil temperature during this period was 8.26 ± 0.59 °C. The maximum daily air temperature recorded throughout this period was 13.5 °C and the minimum daily air temperature recorded was 4.1 °C. Emergence tests were conducted on all sowings. The first count of emergence was recorded at 7 days and a seed was considered emerged when its first two leaves protruded out about 2.5 cm above the soil. Final emergence was recorded on 21 days after sowing. No further emergence occurred after this time.

Chemical analysis: Chemical analysis were performed on samples of seeds from four selected sowings (1, 3, 5 and 8). Fat, protein, water soluble carbohydrate and starch percentages of the seed were determined following the procedures described by MAFF (1986).

Transformation of data: The data which were obtained from counts and expressed as percentages, were transformed according to the following rules:

Rule 1. For percentage data lying within the range of 30 to 70%, no transformation was used

Rule 2. For percentage data lying within the range of either 0 to 30 % or 70 to 100%, but not both, a square root transformation was used

Rule 3. For percentage data that did not follow the ranges specified in either rule 1 or rule 2, the arc sine transformation was used (Gomez and Gomez, 1984).

Statistical analysis: 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
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

Effects of sowing dates on viability and vigour of flax seeds: During the controlled deterioration test the seeds had a moisture content of around 22% after humidification (Table 1). This decreased slightly during the ageing at high temperature. The unaged seeds germinated rapidly and achieved a germination of 99% in 3 days. A few unaged seeds had emerged by the first count after 7 days and a very few aged seeds had also emerged by that time.

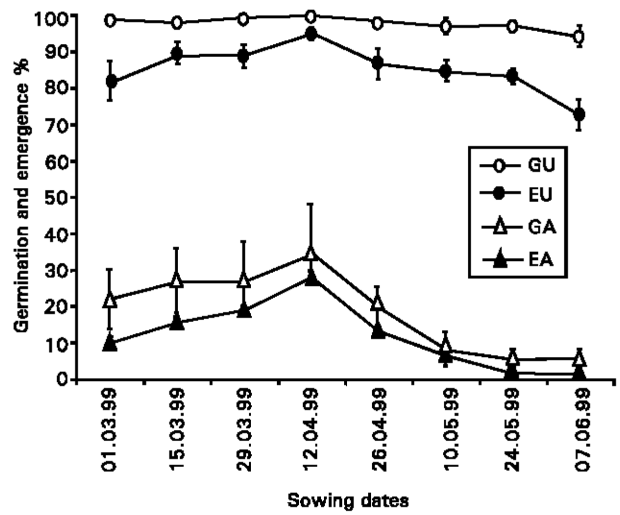

Fig. 1: Effect of sowing dates on germination (G) and emergence (E) % of aged (A) and unaged (U) seeds of flax (vertical bars are ±SE of the means)

Differences in germination and emergence percentage between sowing date treatments were greater for aged seeds than unaged seeds (Fig. 1). By the end of the germination test at 7 days, germination percentage of unaged seeds ranged from 94 to 99%. Germination percentage was slightly lower at the last sowing date but the effect was not significant. Raising seed moisture content followed by ageing at 50 °C for 36 h decreased germination percentage markedly. In aged seeds germination increased from S1 to S4 and then decreased as sowing was delayed after that.

In all treatments final emergence percentage of unaged seeds was over 70%. By the end of the test, at 21 days, emergence percentage of unaged seeds ranged from 73 to 95%. Raising seed moisture content followed by ageing at 50 °C for 36 h decreased emergence percentage. In unaged seeds emergence was higher and similar from sowings 1 to 3 and 5 to 7 respectively. S4 had the highest and S8 had the lowest emergence percentage. As sowing was delayed, germination and emergence of aged seeds increased, reached a maximum in S4 and then decreased.

Seed nutrient analysis: The percentage of fat was similar in all the sowing date treatments. The range of fat was from 35.4 to 37.2% (Table 1). The protein percentage increased as sowing was

Table 1: Effects of sowing dates on seed quality (viability and vigour) and fat percentage, protein percentage, water soluble carbohydrate percentage and starch percentage of flax seeds

	Date of sowing									
Parameters	01.3.99	15.3.99	29.3.99	12.4.99	26.4.99	10.5.99	24.5.99	07.6.99	SED	LSD
Moisture % after humidification	20.90	21.29	20.49	19.89	20.98	21.79	21.38	22.22	0.527	1.088**
Moisture % after controlled deterioration	19.69	20.19	19.41	18.62	19.95	20.78	20.40	21.09	0.574	1.184**
First count germination % (after 3 days)										
Unaged seeds	98.50	98.00	99.00	98.50	95.50	92.00	93.50	90.50	2.291	4.729**
Aged seeds	11.00	13.00	15.00	24.00	12.75	3.00	1.00	0.00	8.337	NS
First count germination % (trans data)										
Unaged seeds	9.92	9.90	9.95	9.92	9.77	9.95	9.67	9.51	0.118	0.244**
Aged seeds	0.11	0.13	0.15	0.25	0.12	0.03	0.01	0.00	0.088	NS
Final germination % (trans data)										
Unaged seeds	9.92	9.90	9.95	9.98	9.87	9.85	9.84	9.69	0.082	NS
Aged seeds	0.22	0.28	0.28	0.36	0.20	0.08	0.05	0.05	0.116	NS
First count emergence % (after 7 days)										
Unaged seeds	0.00	0.50	0.50	1.00	0.00	0.00	0.00	0.00	0.457	NS
Aged seeds	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.00	0.125	NS
First count emergence % (trans data)										
Unaged seeds	0.00	0.35	0.35	0.71	0.00	0.00	0.00	0.00	0.322	NS
Aged seeds	0.00	0.00	0.35	0.35	0.00	0.00	0.00	0.00	0.163	NS
Final emergence % (trans data)										
Unaged seeds	9.04	9.46	9.40	9.75	9.29	9.19	9.11	8.51	0.243	0.501**
Aged seeds	3.15	3.93	4.36	5.28	3.67	2.53	1.21	0.85	0.372	0.768***
Fat (%)	36.0	-------	36.50	-------	37.20	------	------	35.40	0.954	NS
Protein (%)	16.3	-------	16.50	-------	23.00	------	------	23.20	0.718	1.481***
Water soluble carbohydrate (%)	4.30	-------	4.20	-------	4.70	------	------	4.90	0.218	0.451*
Starch (%)	0.00	-------	0.00	-------	0.00	------	------	0.00	0.469	NS

*, ** and *** for 5, 1 and 0.1% probability levels, NS = Non significant

Table 2: Mean daily maximum and minimum air temperatures, mean daily rain fall and sunshine hours and total sunshine during the seed filling period of flax

		Temperature (°C)				
Sowing dates	Seed filling period (days)	Max.	Min.	Rainfall (mm)	Sunshine (h)	Total sunshine (h)
01.03.99	04 June-02 August	18.9	11.9	1.7	7.5	451.2
15.03.99	10 June-04 August	19.4	12.5	1.9	7.2	402.8
29.03.99	15 June-06 August	19.9	12.8	2.2	7.4	394.4
12.04.99	25 June-06 August	20.5	13.2	2.2	7.3	315.1
26.04.99	30 June-10 August	20.2	13.6	1.6	6.8	285.5
10.05.99	08 July-15 August	19.9	13.5	1.9	6.9	270.5
24.05.99	18 July-05 September	19.7	12.9	1.9	6.4	250.5
07.06.99	01 August-14 September	19.3	12.6	3.1	5.8	227.7

Table 3: Values of the linear correlation coefficient between germination and emergence flax seeds (n=8)

Emergence x germination	r values
Aged	r = 0.950*
Unaged	r = 0.885**

*= P< 0.001 **= P < 0.01

delayed, from 16.30% in S1 to 23.24% in S8. The percentage of water soluble carbohydrate was similar at all the treatments. It was slightly higher at 26.09.99 sowing date and ranged from 4.2 to 4.88%. Samples were also run to analyze starch, but virtually no starch was detected in flax seeds.

Discussion

Potential causes of differences in seed vigour between sowing dates: In this studies delaying sowing was associated with: lower 1000 seed weight, seed filling occurring later in the year, changes in the biochemical composition of seeds and shorter duration of the seed filling periods.

Thousand seed weight was generally lower as sowing was delayed and was significantly lower in the last sowing. Sowing date had a small effect on seed viability but a much larger effect on seed vigour. When seeds were exposed to stress, then differences in vigour became apparent. The emergence test was performed in January, under very cold and wet conditions. Significantly lower emergence was found in the first and final sowings. The differences were larger in aged seeds than unaged seeds. There was evidence that seed vigour was highest with intermediate sowings. The highest vigour obtained in the sowing on 12.04.99. Vigour was lower in sowings made before or after these dates. The effects of sowing later were greater than the effects of sowing early. The lower vigour of the later sowings of flax may be partly due to lower 1000 seed weight (Kalton *et al.*, 1959; Haskins and Gorz, 1975).

Environmental conditions during seed filling period of peas and flax: All the sowings experienced similar temperature during the seed filling period, but S4 experienced slightly higher temperatures than the other sowings (Table 2).

Flax seed vigour was low at S1 and S8 and S4 had the highest vigour. The first sowings experienced better conditions. However, the last sowing started flowering later and was harvested much, so, it experienced poorer conditions. Therefore total low sunshine hours may be a cause of lower vigour in sowings 5 to 8, but not 1 to 3.

Seed nutrient concentration and seed vigour: Fat percentage was similar in all sowings. A low protein percentage was found in earlier sowings and a high protein percentage in the last sowing, which also had lowest vigour. Low vigour was not due to variation in water soluble carbohydrate, as it was similar in all sowings. It has been reported that high oil concentration is associated with low seed vigour in linseed (Saeid and Rowland, 1999). However, in this study no significant differences of fat percentage were observed between sowings (Table 1). Hence differences in seed nutrient content between sowings did not account for the observed differences in vigour between sowings. Overall later sowings were associated with a shorter seed filling period and lower sunshine during the seed filling period, which was reflected in lower 1000 seed weight but the chemical composition of seeds was largely unaffected. Early sowings were associated with more favourable conditions but the reasons for high vigour in sowing 4 are not clear.

Relationship between germination and emergence: There was a significant correlation between germination and emergence percentage for both aged and unaged seeds (Table 3). This is an agreement with the results of Bekendam *et al.* (1987), from their study of three years under a range of environmental conditions. They concluded that for small seeded species onion, sugar beet and flax, the germination capacity of seed lots had a good correlation with their field emergence both under favourable and unfavourable field conditions.

Earlier sowings were associated with a longer seed filling period and longer sunshine during the seed filling period. Though the chemical composition of seeds was unaffected, but perhaps for more favourable environmental conditions, sowings from 01-03-99 to 12-04-99 were given vigorous flax seeds. So, from this experiment it may be concluded that, in UK condition, from 1st March to mid April would be recommended as sowing time to produce vigorous flax seed.

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