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Effects of Time of Sowing on the Quality of Pea Seed

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Abstract: An experiment was conducted to identify the effect of time of sowing on the quality of pea seeds. Eight sowing dates from 01.03.99 to 07.06.99 with an interval of fifteen days were tested for covering a wide range of environmental variations. Seed quality was determined by using germination percentage, emergence percentage, controlled determination test (ageing test) and electrical conductivity test. Starch, protein, water soluble carbohydrate and fat percentages of seeds from four selected sowings were also determined. Germination percentage of unaged seeds obtained from sowing 1 to 5 i.e., from 1-3-99 to 26-4-99 was high and similar and then decreased. This decrease was only significantly lower of seeds obtained from last sowing date (07.06.99). Vigour of aged seeds was markedly lower in 1, it then increased and was relatively constant between 2 and 5 (15.03.99 and 26.4.99) and after that it decreased to 8%. In all treatments emergence percentage of unaged seeds was over 70%, but in aged seeds, emergence percentage was decreased markedly after 5.

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

Introduction

Pea is a large seeded grain legume with high protein content. The seed of pea is borne in a fruit called pod. Peas require cool and moist climate. The seeds germinate and grow vigorously at lower temperatures than do many other pulses (Arnon, 1972). The environmental conditions required for germination of different species are different. A water requirement for germination is common to all seeds (USDA, 1961). In peas there are no special requirements for germination such as exposure to light or fluctuating temperature and there is no hard seed coat to remove for peas (Suteliffe and Bryant, 1977).

Qualitative parameters of seed are largely controlled by genetically. But these genetical potentials are always expressive under appropriate environmental and technological conditions leaving behind a scope for adjustment and manipulations (Blum and Pnuel, 1990). There are many production factors which can easily modify to enhance the quality of seeds harvested. These are row width, seeding rate, fertilization regime, tillage practice, irrigation, sowing date, harvesting date etc. Time of sowing is known to influence the establishment of the pea crop, growth and development of seeds and also the environment experienced during seed development, both with in and above the crop canopy (Castillo *et al.*, 1993a). Adam *et al.* (1989) reported that soybean seed obtained from delayed sown plants decreased germination percentage in the field. Late planting presumably delayed seed maturation and influenced on seed quality.

Castillo *et al.* (1994) found that time of sowing of the seed crop had no effect on the germination of the pea seeds produced, but did affect seed vigour as both conductivity and hollow heart were greater in seeds from a November sown crop compared to a December sown crop, and as a consequence, expected field emergence was significantly lower (Halligan, 1986). Bockstacle and Vulsteke (1969) reported that mid March is the traditional sowing time, earlier and late March sowings were compared. More rapid germination resulted from later sowings. Therefore, the experiment was conducted with following objectives:

- To determine the effects of sowing dates on seed viability and vigour of pea seed.
- To determine the effects of sowing dates on the chemical composition of seeds and its relationship with viability and vigour of pea 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	S8 = 07.06.99

A randomised complete blocks design was used. The pea variety was Baccara, which is a normal leaved 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. Initially 24 seeds were sown in each pot, with 2 seeds at each position. When the seeds emerged the seedlings were counted and then thinned to twelve per pot, which is equivalent to 79 plants per m^2. Twelve plants were established in each pot, and arranged in a grid pattern, with approximately 8 cm between plants. Phosphorus and potassium fertilizer were applied as a basal dose @ of 50kg P_2O_5 and 50 kg 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 pods 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 boxes 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, emergence percentage and electrical conductivity tests were made on samples

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of seed. These tests were also repeated on samples of seed that had undergone controlled deterioration (ageing).

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 hours at 25°C temperature in a growth chamber of Heanfaes Research Centre, University of Wales, Bangor. 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 8 days and germination, emergence and electrical conductivity 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. These 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 to 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.

Method for electrical conductivity: Following the procedures described by PGRO (1981) for measuring electrical conductivity 50 seeds per replicate were used. The base diameter of the container was 80 mm. The seeds were placed in 250 ml de-ionised water and then the containers were covered to prevent evaporation loss and entry of foreign matter. A separate container of de-ionised water was prepared at the beginning of each test. All containers were kept at 20°C for 24 hours and then electrical conductivity was determined using an analytical conductivity meter (Model Ch-8603, Schwerzenbach, Switzerland).

Chemical analysis: Chemical analysis were performed on samples of seeds from four selected sowings (S1, S3, S5 and S8) using all four replicates of each treatment. 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; 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

Effects of sowing date on viability and vigour of pea seeds: By the end of the germination test at 7 days, germination percentage of unaged seeds ranged from 90-99% (Fig.1). Raising seed moisture content followed by ageing at 50 °C for 8 days decreased germination percentage markedly. In unaged seeds germination was high and similar from S1 to S5, and then decreased. This decrease was only significantly lower at the last sowing date (Table 1). However in aged seeds germination was markedly lower in S1, it then increased, and was relatively constant between S2 and S5, and after that it decreased to 8%.

In all treatments emergence percentage of unaged seeds was over 70%. By the end of the test at 21 days, emergence percentage of unaged seeds ranged from 73-92%. Raising seed moisture content followed by ageing at 50 °C for 8 days decreased emergence percentage markedly. In unaged seeds emergence was high and similar from S 5 to S7 but was relatively smaller in S 1 and 8. This decrease was significant in S1 and S8. In aged seeds emergence was lower in S1, it then increased in S2 and decreased markedly after S5.

Differences in germination and emergence percentage between sowing date treatments were greater for aged seeds than unaged seeds. Also with aged seeds the differences between germination and emergence were similar at all sowing dates (Fig. 1) but with unaged seeds differences between germination and emergence are not constant across sowing dates (larger differences at the early and the final sowing dates).

During the controlled deterioration test the seeds had a moisture content ranging from 17.23-23.20% after humidification (Table 1). Although the procedures and conditions used during the controlled deterioration process were identical for all sowings, seeds from the last two sowings took up more moisture, and had a higher moisture content after humidification, than seeds from the other sowings. This decreased slightly during the ageing at high temperature. These differences of moisture content between treatments might be because the seeds were produced in different environmental conditions through the sowing date treatments. The unaged seeds germinated rapidly and achieved a germination of over 90% in 3 days. A few unaged seeds had emerged by the first count at 7 days but no aged seeds had emerged by that time. The electrical conductivity of unaged seeds was similar in S1 toS7, but was higher in S8. However, the electrical conductivity of aged seeds showed a much wider variation. It slightly decreased from S1 to S4, but markedly increased after S6.

Seed nutrient analysis: The percentages of fat were low and similar in all the sowing date treatments. The ranges of fat percentages were 1.4-1.5. The protein percentage was significantly higher in S8 than in S1, S3 and S5. The percentage of water soluble carbohydrate was similar in all the treatments. The percentage of starch increased as sowing was delayed up to 26.04.99 and thereafter it decreased (Table 1).

Discussion

The environment during seed development is a major determinant of seed vigour (Delouche, 1980). Sowing dates exhibit their effects on plants by affecting various physiological process. In this

Table 1: Effect of data of sowing on seed quality (viability and vigour) and fat percentage, protein percentage, water soluble carbohydrate percentage and starch percentage of pea seeds

	Sowing datas									
	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**	**SED**
Moisture % after humidification	17.30	18.59	17.56	18.58	19.15	18.80	21.01	23.20	0.585	1.208***
Moisture % after controlled deterioation	17.03	17.52	17.02	17.38	17.44	17.33	19.25	20.67	0.532	1.099***
First count germination (%) (after 3 days)										
Unaged seeds	62.00	70.00	62.00	79.00	95.50	79.00	72.00	79.50	4.919	10.154***
Aged seeds	41.00	56.50	54.00	48.25	50.50	35.75	7.75	4.50	11.662	24.070***
First count germination (%) (trans. data)										
Unaged seeds	0.67	0.79	0.67	0.91	1.28	0.91	0.82	0.92	0.076	0.158***
Aged seeds	0.42	0.61	0.58	0.51	0.54	0.39	0.08	0.05	0.136	0.280***
Final germination (%) (trans. data)										
Unaged seeds	9.92	9.95	9.77	9.95	9.95	9.82	9.80	9.45	0.095	0.195***
Aged seeds	0.48	0.70	0.65	0.57	0.60	0.45	0.12	0.08	0.021	0.044***
First count emergence (%) (after1 week)										
Unaged seeds	0.50	0.50	0.00	0.00	0.50	1.00	0.50	0.00	0.577	NS
Aged seeds	0	0	0	0	0	0	0	0	--	--
First count emergence (%) (trans. data)										
Unaged seeds	0.35	0.35	0.00	0.00	0.35	0.71	0.35	0.00	0.408	NS
Aged seeds	0	0	0	0	0	0	0	0	--	--
Final emergence (%) (trans. Data)										
Unaged seeds	8.65	9.25	9.22	9.32	9.97	9.43	9.48	8.54	0.191	0.394***
Aged seeds	0.40	0.60	0.56	0.49	0.51	0.36	0.05	0.02	0.135	0.279***
Fat %	1.5	--	1.4	--	1.5	--	--	1.4	0.111	NS
Protein %	18.6	--	18.9	--	19.0	--	--	22.5	0.851	1.757
Water soluble carbohydrate %	8.7	--	8.7	--	9.0	--	--	8.4	0.123	0.254***
Starch %	22.9	--	32.5	--	40.3	--	--	33.84	0.572	NS
Electrical conductivity/seed (μ S/)										
Unaged seeds	15.66	15.50	15.28	15.00	15.47	15.62	15.87	18.96	1.037	NS
Aged seeds	22.13	21.49	20.93	20.29	20.66	20.71	33.76	45.79	2.674	5.520***

*** = 0.1% significant level

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 peas

		Temperature (°C)				
Sowing dates	Seed filling period (days)	max	min	Rainfall (mm)	Sunshine (h)	Total sunshine (h)
01.03.99	26.May-21 July	17.8	11.7	1.9	6.3	361.7
15.03.99	01 June-26 July	18.3	11.8	1.8	7.0	390.3
29.03.99	07 June-27 July	18.7	12.0	1.5	7.2	367.5
12.04.99	15 June-02 August	19.9	12.6	1.8	7.8	357.7
26.04.99	22 June-06 August	20.1	13.0	2.1	7.2	331.0
10.05.99	02 July-17 August	20.0	13.4	1.8	7.0	328.6
24.05.99	12 July-27 August	19.4	12.9	2.0	6.7	315.4
07.06.99	22 July-08 September	19.8	12.8	2.8	6.7	329.1

Table 3: Values of the linear correlation coefficient between germination, emergence and electrical conductivity of pea seeds. Values within brackets are the corresponding probability levels

	Aged	Unaged
Emergence x germination	r = 1.00*	r = 0.519***
Emergence x conductivity	r = -0.888**	r = -0.667***
Conductivity xgGermination	r = -0.891**	r = -0.883**

*=P<0.001;**=P<0.01; ***= P>.05

experiment sowing dates had a significant effect on the quality of pea seed.

Potential causes of differences in seed vigour between sowing dates: In these 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. In pea seeds, thousand seed weight was significantly lower in the last sowing. The lowest seed vigour was also obtained from the last sowing. This is conflicting evidence with the findings of Castillo *et al*. (1992), who found that in peas thousand seed weight was not related to germination or conductivity. Their results confirm that among seed lots, thousand seed weight is usually a poor vigour determinant (Wang and Hampton, 1991; Castillo *et al*., 1994).

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. In peas highest vigour was obtained in sowings made between 15.03.99 and 26.04.99. Vigour was lower in sowings made before or after these dates. The effects of sowing later were greater than the effects of sowing early.

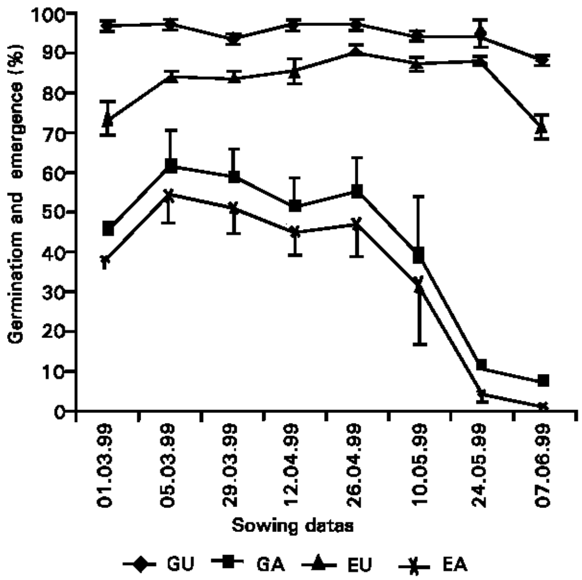

Fig.1: Effect of sowing data on germination (G) and emergence (F)% of aged (A) and unaged (U) pea seeds (vertical bars ± SE of the means)

Environmental conditions during seed filling period: Environmental conditions during crop growth and development, seed filling and maturation can affect seed size and seed vigour (Castillo *et al*., 1993b). From the data it can be seen that the earliest S1 experienced lower minimum and maximum temperatures, moderate rainfall and sunshine per hours per day and total sunshine (Table 2). The following sowing (S2) experienced moderate temperatures and rainfall but higher sunshine hours per day and the highest total sunshine. This sowing also showed the highest vigour. The later sowings had lower vigour, experienced lower sunshine hours per day and lower total sunshine. One possible cause of high vigour in the early sowings is that the plants experienced the highest total sunshine during the seed filling period. Greater photosynthesis by these plants might have created more food reserves and enzymes, which might be responsible for high seed vigour. Differences in seed vigour between sowings were not due to differences in mean temperature, which varied little between sowings, or water supply, as the plants were watered as required.

Seed nutrient concentration and seed vigour: Low seed vigour in the later sowings of peas was not due to differences in fat percentage, because there was very little fat in the seed and no differences between treatments. It was also not due to differences in protein percentage, as the final sowing had the highest protein but the lowest vigour. It was also not due to water soluble carbohydrate. Although water soluble carbohydrate was lower in the final sowing, S1 and S3 had similar water soluble carbohydrate percentage but markedly different vigour. Starch percentage was low in the first and final sowings, which had low vigour, but was also low in S3, which had high vigour. This result provided conflicting evidence with the results of (Kalpana and Rao, 1993), who reported that as seed protein content decreased vigour of seeds of pigeonpea also decreased.

Relationship between germination, emergence and electrical conductivity: In the case of unaged seeds, germination and electrical conductivity were not significantly correlated with emergence but there was a significant negative correlation between conductivity and germination (Table 3). Therefore conductivity of unaged seeds can be used to predict germination in the laboratory but neither germination nor conductivity can be used to predict emergence. However, in the case of aged seeds both germination and electrical conductivity were significantly correlated with emergence and there was also a significant negative correlation between conductivity and germination. Therefore both germination and conductivity of aged pea seeds can be used to predict field emergence. In unaged seeds the differences in germination and emergence between sowing dates were relatively small. When the seeds were aged differences between sowing dates were expressed. The results of the present studies are in good agreement with the results of other workers for peas (Matthews and Bradnock, 1967; Matthews and Whitbread, 1968; Powell and Matthews, 1981; Hampton and TeKrony, 1995) who reported that electrical conductivity values were correlated with field emergence of peas.

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