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Seed Developmental Profile of Soybean as Influenced by Planting Date and Cultivar under Temperate Environment

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Abstract: The aim of present study were to characterize the pattern of seed development in precociously mature soybean seeds planted on different dates during its progression from germination to seedling growth and maturation and its effect on yield under temperate environment. Changes in seed quality (Viability and Germination) were monitored from developmental to maturation (growth stage R5 to R7) of soybean (*Glycine max* (L.) Merr.) in different planting dates. Information on the effect of planting date on seed fresh and dry weight, moisture content and germination of soybean is meager. A field experiment was conducted with four planting dates and two soybean cultivars to study the influence of planting dates on seed developmental traits for 2 years. Determinate cultivars (Epps, maturity group [MG] V) and indeterminate cultivar, Williams 82 [MG] 111) were planted on May 1st to August 1st at one month interval at the Agriculture Research Farm of the NWFP Agricultural University Peshawar, during 2000 and 2001. Seeds were harvested at 10-days interval from 35 to 75 days after anthesis (DAA) in all planting dates. Epps planted in early May gave maximum fresh, dry seed weight and moisture content. A steady decrease in fresh and dry weight and moisture content were observed with delay in sowing of soybean. An inverse relationship was noted in Williams 82 regarding fresh, dry weight and moisture content in all planting dates. Water per seed increased up to 100% DAA, after which no further increase occurred. Moisture content declined for the whole seed, respectively, from above 75 and 65% at 95 DAA to 65 and 50% at 140 DAA in both cultivars. Decrease in seed moisture content during development was accompanied by increase in desiccation tolerance and germination, reaching maximum at physiological maturity in both cultivars. Fresh and dry seed germination increased linearly in both varieties. Mean rate of change in germination was more pronounce in Epps as compared to Williams 82. Immature seeds in both cultivars during early developmental stage did not germinate in all planting dates.

Key words: Seed development, soybean varieties, planting dates, attributes

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) have long been the world's most economically important grain legume and the total area sown to the crop continues to increase rapidly, particularly in the tropics and sub-tropics (Summerfield and Roberts, 1983). Most genotypes are extremely sensitive to variations in climate, particularly in terms of their developmental responses to photoperiod and temperature (Major and Johnson, 1987). Rates of phenological development and also the areas of adaptation of

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genotypes are said to be dictated largely by photoperiod, so that crop durations are either extended or curtailed and seed yields are reduced when they are cultivated outside the range of latitudes to which they are adapted (Shanmugasundaram, 1981). Temperature and photoperiod are the two major environmental variables that affect the length of the preflowering period (PFP) in many crops. Unlike photoperiod, which affect the duration of the photo-induction phase in photoperiod sensitive cultivars (Collinson *et al*., 1992; Yin *et al*., 1997) whereas, temperature affects the duration of the entire PFP in all cultivars of rice (Yoshida, 1981). Temperature is the primary environmental factor controlling developmental rate and often determines the rate of seed germination, seedling establishment, flowering, fruit maturation and plant growth. Temperature could affect seed growth rate directly by affecting seed metabolism or by affecting the supply of assimilate to the seed (Egli and Wardlaw, 1980; Jones *et al*., 1981; Donovan *et al*., 1983). High temperature reduce seed growth rate in many crops, reduce plant growth and yield in many environments. Unfavorable environmental conditions (temperature, photoperiod, rainfall and relative humidity) during seed growth and development in the field can reduce germination and reduce yield subsequently. Length of photoperiod strongly influences the morphology of soybean plant by causing changes in the time of flowering, maturity and dry matter production. Soybean cultivars do not have the same critical day length and usually experience gradually warming temperatures and lengthening days during vegetative and reproductive periods when grown as summer crop. The timing of reproductive events in the crop and specially the duration of the preflowering period are modulated strongly by photoperiod and air temperature (Summerfield *et al*., 1986). Significant differences in dry matter accumulation were found between determinate and indeterminate soybean (Beaver and Cooper, 1982) and between soybean isolines (Wilcox, 1985).Germination in developing soybean seed has been an important topic of investigation, because germination and development are distinct physiological stages in the life cycle of the plant. It is apparent from these studies that time from anthesis and the degree of desiccation play a crucial role in determining the ability of seeds to germinate and its subsequent growth. Appropriate date of sowing is not only important for proper emergence but also important to have the crop in the field when environmental conditions are conducive for proper growth and development. The aim of the present investigation were to characterize the pattern of seed development in precociously mature soybean seeds planted on different dates during its progression from germination to seedling growth and maturation and its effect on yield under temperate environment.

MATERIALS AND METHODS

Plant Material

A field experiment was conducted with four planting dates and two soybean cultivars to study the influence of planting dates on seed developmental traits of soybean for 2 years. Determinate cultivar (Epps, maturity group [MG] V) and indeterminate cultivar, Williams 82 [MG] 111) were planted on May 1st to August 1st at one month interval at the Agriculture Research Farm of the NWFP Agricultural University Peshawar, during 2000 and 2001. The site is located at 34° N latitude, 71.3° longitudes and an altitude of 450 m above sea level and thus has a continental climate. The experiment was laid out in a randomized complete block design with split plot arrangement having four replications. Planting dates were allotted to main plots and cultivars to sub plots. The sub plot measures 4×5 m were established to accommodate 8 rows 50 cm apart. Sowing was done in hills and row to row distance of 50 cm and hill to hill distance of 10 cm were used. The soil of the experimental site was silty clay loam with a clay type montmorillonite, low in nitrogen (0.03-0.04%), organic matter (0.8-0.9%) and alkaline in reaction with a pH 8.0-8.2 (Shah *et al*., 1993). A basal dose of 36 kg N and 92 kg P_2O_5 in the form of diammonium phosphate (DAP) fertilizer was applied at sowing. Normal cultural practices for raising a successful crop were followed uniformly for all the experimental units. Irrigation was applied at weekly intervals or as when needed. The plots were hand weeded at different growth stages. Four plants per treatment were sampled at 10 days interval starting at R5 (Beginning seed 3 mm long in the pod at one of the four uppermost nodes on the main stem) to R7 (Beginning Maturity when one major pod has changed to brown color on the main stem). The following observations were recorded on seed samples harvested at 10 days interval after anthesis (DAA).

- Fresh seed weight (mg)
- Fresh seed moisture content (%)
- Fresh seed germination (%)
- Dry seed weight (mg)
- Dry seed moisture content (%)
- Dry seed germination (%)

Determination of Fresh Seed Weight (mg)

With in 6 h of pod collection at each sampling date, 25 fresh seeds per treatment were obtained by hand removal from randomly selected pods and were used to determine seed fresh weight on wet basis.

Fresh Seed Moisture Content Determination (%)

Seed moisture content was determined by loss in weight of the seeds using the air oven method at 105°C for 24 h on a fresh weight basis. Twenty-five seeds replicated four times from each treatment at every sampling date were placed in a weighed container and weighed before and after drying. Calculation was made up to 2 decimal using the following formula:

Percent Moisture: $[(W2-W3)]/[(W2-W1)]\times 100$

Where W_1= Weight of the empty container

W_2 = Weight of the container plus wet seed

W_3 = Weight of the container plus dry seed

Fresh and Dry Seed Germination (%)

Standard germination test were made in accordance with the method prescribed in the Rules for Testing Seeds (AOSA, 2002). Four replications of 25 fresh and dry seeds from each treatment were placed on two sheets of standard germination paper and covered with an additional sheet and was folded 2.50 cm from the bottom and rolled loosely and secured with a rubber band. Each group of rolls was placed upright in wire basket covered with a plastic bag. The rolls were then placed in a germinator at 25°C. Seeds samples were evaluated at 7th day after incubation and germination were described as radicle protrusion through the testa of the seed.

Dry Seed Weight (mg)

Determination of dry seed weight were made on 50 randomly selected pods treatment^{-1}, kept in paper bags and were placed in the drier at 35-40°C until a seed moisture content of 12-15% were obtained and after that the seeds were removed by hand from the pods and weighed.

Dry Seed Moisture Content Determination (%)

For the determination of dry seed moisture content, the same method was used as described earlier for fresh seed moisture content determination.

Statistical Analysis

Data were analyzed statistically according to randomized complete block design with split plot arrangement and Sigma Plot 2000 (v. 6) Regression Wizard (SPSS, Inc., Chicago, IL) was used for all regression analysis. LSD test at 0.05 level of probability was used for mean separation.

RESULTS AND DISCUSSION

Fresh Seed Weight

Data on fresh seed weight from R5 to R7 of the two soybean varieties planted on four dates are presented in Fig. 1 for 2000 and Fig. 2 for 2001. Planting date significantly affected the fresh seed weight of soybean varieties. Maximum fresh seed weight attained in both varieties decreased as sowing was delayed from May to August except in Williams 82; whereas a slight increase in the maximum fresh seed weight attained at the last sowing date in 2000. The mean fresh seed growth rates calculated from the regression equations (Table 1) shows that May planted crop of Epps has higher mean seed growth rate in 2000 and 2001. A steady decrease in means fresh seed growth rate was observed as planting was delayed and the minimum mean fresh seed growth rates were noted in plots planted in August in both year. Minimum fresh seed weight from late planted crop may be due to reduction in

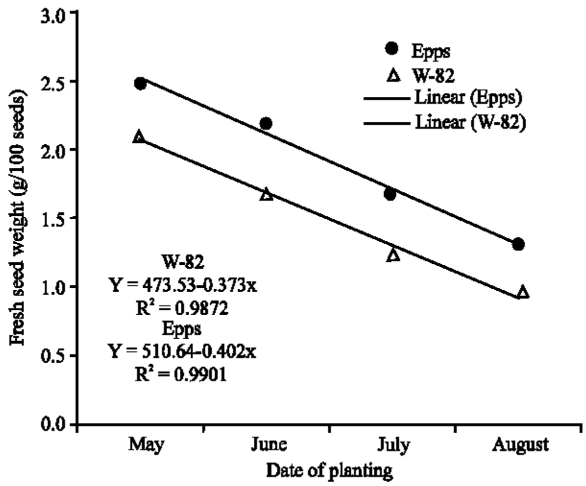

Fig. 1: Fresh seed weight development of Epps and Williams 82 varieties of soybean planted on four dates during 2000

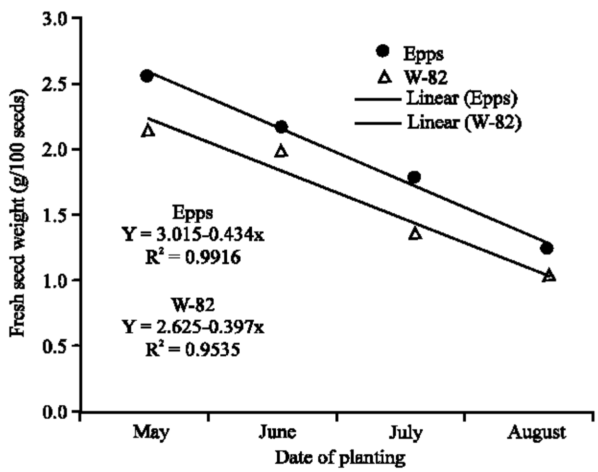

Fig. 2: Fresh seed weight development of Epps and Williams varieties of soybean planted on four dates during 2001

Table 1: Mean fresh seed growth rate (g/day/100 seeds) of soybean varieties as affected by planting dates during 2000 and 2001

	2000		2001	
Date of sowing	Epps	Williams 82	Epps	Williams 82
D1	0.80	0.57	0.67	0.41
D2	0.73	0.67	0.59	0.45
D3	0.67	0.66	0.52	0.61
D4	0.56	0.68	0.51	0.64

seed filling duration and slower seed growth rate which may be due to decrease in photoperiod and mean daily light integral. While in Williams 82, a somewhat inverse relationship was found between delay in date of sowing and mean seed growth rate as August planted crop had higher mean seed growth rate as compared to May planted crop in both years. The decrease in seed developmental rate with delay planting of Epps cultivar may be due to decrease in temperature and photoperiod. In Williams 82, the slight increase in seed development rate with delay in sowing may be due to sink capacity and sink strength of the seed due to its indeterminate nature and were differently affected by reduction in temperature in delayed planting. The differences among the seed growth rates trend of determinate and indeterminate varieties may be the patterns of seed development and its assimilates requirements. These finding are in line with those of Egli (1975), Beaver and Cooper (1982) who found that Corsoy 79 have a higher seed fill rate than Williams 79 and concluded that this advantage gave Corsoy 79 its higher yield potential, which may be due to variation in rats of dry matter accumulation in different varieties.

Fresh Seed Moisture

Data regarding fresh seed moisture (%) of the two soybean cultivars sown on four planting dates are reported in Fig. 3 for 2000 and Fig. 4 for 2001. Fresh seed moisture (%) of soybean cultivars was initially the same in all seed samples from various planting dates. Fresh seed moisture content decreased as the seed developed and the trend of decrease was about the same in all planting date. Mean rate of change in moisture (%) in fresh seed calculated from the regression equations (Table 2) reveals that Epps planted in May has higher mean rate of change in moisture (%) in both years as the crop stage advanced. A decrease in the rate of change in fresh seed moisture (%) was observed as planting was delayed up to the first week of August during both years. Slow rate of change in fresh seed moisture (%) from late planted crop may be due to slower seed growth rate which may be due to decrease in temperature and photoperiod. While during both years, a somewhat inverse relationship was found in Williams 82 as August planted crop had higher rate of change in fresh seed moisture (%) as compared to May planted crop (Egli and TeKrony, 1997; Westgate, 1994).

Fresh Seed Germination

The Figure 5 and 6 reveals that planting dates significantly affected fresh seed germination of soybean cultivars. Germination was zero in the beginning and increased steadily as the stage of seed development advanced. Maximum fresh seed germination was obtained in both varieties as sowing was delayed from May to August (Anderson and Vasilas, 1985). Mean rate of change in fresh seed germination during seed development, calculated from the regression equations (Table 3) indicates that May planted crop has lower rate of change in germination in both cultivars during 2000. A steady increase in rate of Fresh seed germination was observed with advance in stage of seed development in both cultivars with delayed planting in August. The same trend of increase in fresh seed germination was observed in both cultivars during 2001. Maximum rate of change in fresh seed germination in both cultivars from delayed planted crop may be due to optimum temperature and photoperiod during seed development and maturation (Collinson *et al*., 1992).

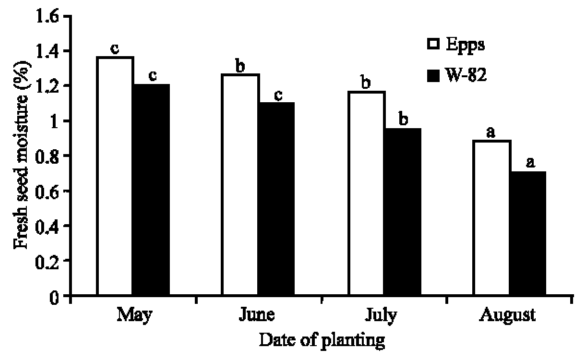

Fig. 3: Changes in fresh seed moisture percentage of Epps and Williams-82 varieties of soybean planted on four dates during 2000

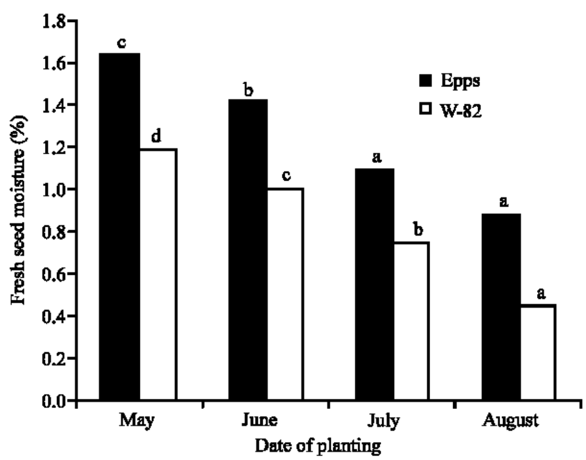

Fig. 4: Changes in fresh seed moisture percentage of Epps and Williams-82 varieties of soybean planted on four dates during 2001

Table 2: Mean rate of change of percent moisture (% change /day) in seed of soybean varieties as affected by planting dates during 2000 and 2001

	2000		2001	
Date of sowing	Epps	Williams 82	Epps	Williams 82
D1	-1.36	-0.72	-1.51	-1.02
D2	-1.34	-0.88	-1.44	-1.07
D3	-1.24	-0.87	-1.43	-1.07
D4	-1.23	-0.90	-1.34	-1.19

Dry Seed Weight

Data on dry seed weight of Epps and Williams 82 sown on four planting dates are presented in (Table 4). The table shows that planting dates significantly affected the dry matter accumulation in soybean cultivars. Dry seed weight decreased in both varieties as sowing was delayed from May to August during both years. The mean dry seed accumulation rate indicates that May planted crop had higher dry matter accumulation rate as compared to delayed planted crop in August. A steady decrease in dry matter accumulation rate was observed as planting was delayed and the rate of decrease was more in 2001 than 2000. Minimum dry seed weight from late planted crop may be due to decrease in photoperiod and temperature which resulted in minimizing the seed filling duration and its growth.

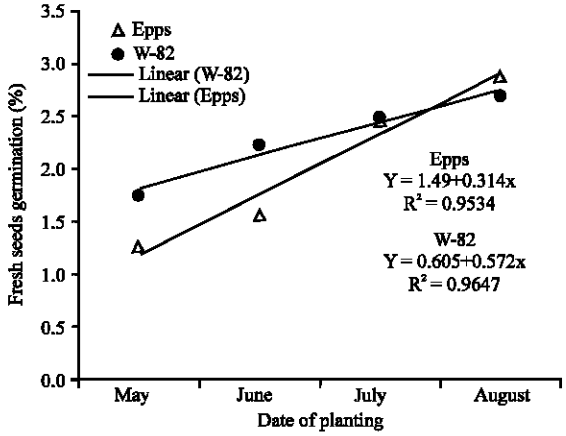

Fig. 5: Changes in fresh seed germination of Epps and 82 varieties of soybean planted on four dates during 2000

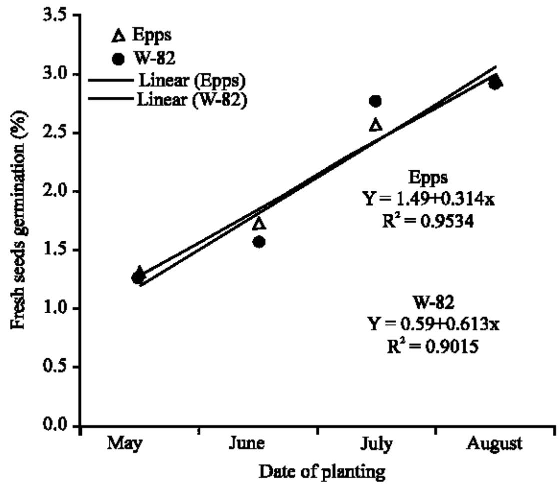

Fig. 6: Changes in fresh seed germination of Epps and varieties of soybean planted on four dates during 2001

Table 3: Mean rate of change in fresh seed germination (%/Day) of soybean varieties as affected by planting dates during 2000 and 2001

	2000		2001	
Date of sowing	Epps	Williams 82	Epps	Williams 82
D1	2.55	1.31	1.99	1.26
D2	2.64	1.74	2.22	1.56
D3	2.65	2.58	2.33	2.77
D4	2.70	2.91	2.50	2.87

Table 4: Mean dry seed accumulation rate (g/day/100 seeds) of soybean varieties as affected by planting dates during 2000 and 2001

	2000		2001	
Date of sowing	Epps	Williams 82	Epps	Williams 82
D1	0.34	0.37	0.31	0.38
D2	0.30	0.30	0.30	0.32
D3	0.28	0.28	0.23	0.24
D4	0.24	0.23	0.20	0.17

Table 5: Mean rate of change in air-dry seed moisture content (% change/Day) of soybean varieties as affected by planting dates during 2000 and 2001

	2000		2001	
Date of sowing	Epps	Williams 82	Epps	Williams 82
D1	-0.14	-0.1	-0.14	-0.11
D2	-0.14	-0.1	-0.12	-0.10
D3	-0.14	-0.1	-0.10	-0.10
D4	-0.12	-0.1	-0.10	-0.10

Table 6: Mean rate of change in air-dry seed germination (percent/Day) of soybean varieties as affected by planting dates during 2000 and 2001

	2000		2001	
Date of sowing	Epps	Williams 82	Epps	Williams 82
D1	2.70	1.54	2.01	1.10
D2	2.81	2.08	2.22	1.38
D3	2.96	2.82	2.30	2.60
D4	3.04	2.91	2.50	2.87

Dry Seed Moisture

Keeping the seed moisture content at proper level is a pre-requisite for proper storage to maintain vigor and viability of a seed lot. Data on dry seed moisture (%) of the two soybean cultivars planted on four planting dates are reported in (Table 5). The table reveals that planting date significantly affected the air dry seed moisture (%) of the soybean. Dry seed moisture decreased as sowing was delayed from May to August in both cultivars. Mean rate of change in dry seed moisture (%) indicates that May planted crop of Epps has higher rate of moisture change in dry seed in 2000 and 2001. A steady decrease in the rate of moisture (%) in dry seed was observed in both varieties as planting was delayed to August. Slow rate of change in moisture (%) in dry seed from delay planted crop may be due to differences in seed-coat characteristics. While in Williams 82, the mean rate of change in seed moisture (%) in dry seed was about the same in all planting dates during both years. The variation among the two cultivars may be due to their genetic make-up and variation in seed coat characteristics.

Dry Seed Germination

The Table 6 shows that planting date significantly affected the dry seed germination of the soybean during both years. In both cultivars, dry seed germination increased as sowing was delayed from May to August with maximum germination of seeds from delay planting. The mean rate of change in dry seed germination with advance in stage of crop shows that in both varieties, May planted crop have slower rate of change in percent dry seed germination during both years. A steady increase in rate of change in dry seed germination was observed in both varieties as planting was delayed from May to August and the rate of change in dry seed germination was more pronounced in Epps than Williams 82 during both years. Maximum dry seed germination from delay planted crop may be due to its development and maturation at optimum temperature and photoperiod and also its escape from the *Phomopsis* sp.

CONCLUSIONS AND RECOMMENDATIONS

In this study we have compared the effect of planting dates and two soybean cultivars on the seed developmental processes of viability, germination and growth, viz., premature desiccation of the intact seed. In the fresh (non-dried) developing seed, the tissue surrounding embryo inhibits germination and maintains its metabolism in a developmental mode. Following drying (which may be natural or imposed) the same seed has a promotive effect upon the switch to germination/growth processes, including the production of enzymes essential to post-germinative seedling growth. Drying appears to play a direct role in post-germinative enzyme production. Fresh (non-dried) embryo (or of the prematurely dried) hydrolytic processes resulting in the degradation of cotyledonary storage reserves in a manner similar to that observed following imbibition of the mature dry seed. Post-germinative enzyme production, essential to seedling growth, does not occur in fresh seed to the level as required for germination of the intact mature or prematurely dried seed. Desiccation does not alter the subsequent response of the immature seed. Differences in production of post-germinative enzyme between embryos of fresh and dried seeds among different planting dates and cultivars were found primarily to a period of seed detachment from the mother plant. It is further stated that high temperature stress during seed filling and maturation periods under field environment were detrimental to some physiological and physical parameters of soybean. Avoidance of hot weather during seed development by optimal planting date and other management factors that shorten the length of high temperature stress during the said period results better seed development and quality. The factors within the seed that influence high temperature deterioration requires further study because soybean seed production areas are often vary in the length and degree of high temperatures during the seed development period.

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