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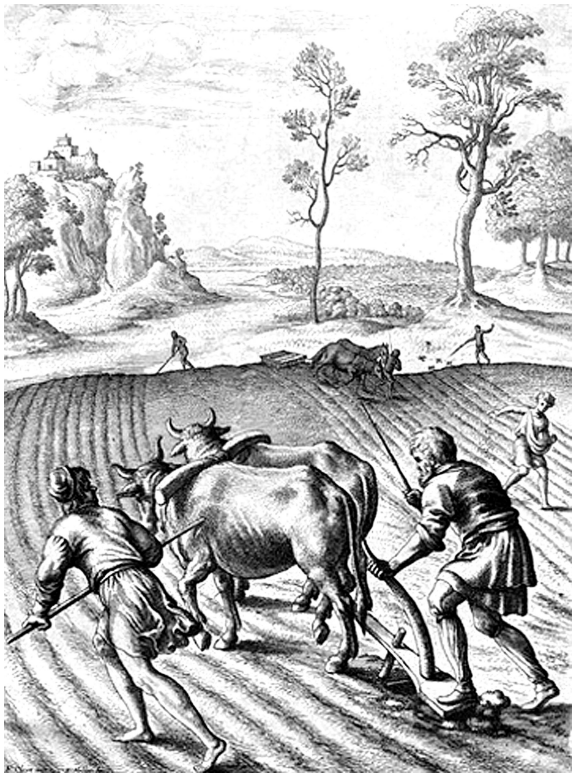

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Influence of Planting Date and Plant Density on Morphological Traits of Determinate and Indeterminate Soybean Cultivars under Temperate Environment

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Abstract: Determinate and indeterminate soybean types [*Glycine max* (L) Merrill] have different growth habits. One determinate (Epps, MG V) and one indeterminate (Williams 82, MG 111) cultivars were planted from May to August at one month interval using plant densities of 20, 40 and 60 plants m^{-2} to determine the growth behavior of cultivars. Number of days to emergence, unifoliate and 6th trifoliate leaf formation were reduced in both cultivars with delay in sowing. Early planted crop in May attained more plant height than delayed planted crop. Highest plant density of 60 plants m^{-2} attained maximum plant height as compared with the lowest plant densities. Epps produced the tallest plants as compared with Williams 82. The number of days to maturity declined with each successive planting date for both cultivars. The maturity date of Williams 82 was affected more by planting date than that of Epps.

Key words: Planting date, plant densities, determinate and indeterminate cultivars, morphological traits

Introduction

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. Therefore the effect of planting date and plant density on vegetative and reproductive periods may not be similar for different cultivars. Significant differences in dry matter accumulation and morphological features were found (Beaver ***et al.***, 1985) between determinate and indeterminate soybean and between soybean isolines (Wilcox, 1985). Average dry matter yields of 1902 Kg ha^{-1} (Hanway and Weber, 1971a); 10220 Kg ha^{-1} (Hanway and Weber, 1971b); 8512 Kg ha^{-1} (Henderson and Kamprath, 1970) have been reported from different cultivars. Zeyada ***et al.*** (1981) stated that May planting decreased dry matter yield. Green ***et al.*** (1977) reported that yield from indeterminate cultivars was more than semi-determinate and matured five days later and have six days longer reproductive period. Parvez ***et al.*** (1989) reported that node and pod numbers, leaf area index, crop growth rate, total biomass, and seed yields were significantly increased with increasing plant density up to a certain population density depending on spatial arrangement. They further stated that seed yield of both Determinate and Indeterminate soybean in subtropical latitudes is optimized by May seeding, high PPD (40 plants m^{-2}) and use of square planting patterns as approximated by narrow-

row culture. This study was undertaken to determine the influence of planting date and plant density on morphological traits of determinate and indeterminate soybean cultivars under temperate conditions.

Materials and Methods

The experiment was carried out at the Agricultural Research Farm of the NWFP Agricultural University Peshawar, during 1997 and 1998. The site is located at 34^0 N latitude, 71.3^0 longitude and an altitude of 450 meters above sea level. The experimental site is located about 1600 km north of the Indian Ocean and thus has a continental climate. The soil of the experimental site was silty clay loam with a clay type montmorillonite, low in nitrogen (0.03-0.04%), low in organic matter (0.8-0.9%) and alkaline in reaction with a pH of 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 (D.A.P) fertilizer was applied at sowing. Indeterminate cultivar Williams 82 (MG-III) and determinate cultivar Epps (MG-V) were planted on May 2, June 2, July 2 and August 2. The experiment was laid out in randomized complete block design with split plot arrangement having four replications. Twelve combinations of the four planting dates and three plant densities were allotted to main plots and cultivars were allotted to sub plots. A sub plot size of $4 \times 5m^2$, having 8 rows five meters long was used. Sowing was done in hills and row to row distance of 50 cm and hill to hill distance of 10 cm were used. Irrigation and all other agronomic practices were carried out uniformly for all the experimental units. Data were recorded on:

(a) Days to emergence
(b) Days to unifoliate leaf formation
(c) Days to 6th trifoliate leaf formation
(d) Plant height
(e) Days to maturity

Data on days to emergence was recorded, when more than 80% of the plants emerged in each sub plot. The data regarding plant height was recorded on eight plants averaged at time of maturity. Data were statistically analyzed using analysis of variance techniques appropriate for randomized complete block design with varieties split on dates of sowing. Main and interaction effects were separated by LSD test at 0.05 level of probability, if the F-values were significant.

Results and Discussion

Days to emergence

Speed of emergence measured as days to emergence in the field is important for proper crop stand especially under cold seedbed conditions in early spring planting. Days to emergence of the two soybean cultivars planted on the four dates and thinned to the three plant densities indicated that May planted crop took 7 days to emergence during both years (Table 1). June and July planted crop took the minimum number of days to emergence respectively. However, August planting took slightly more time to emergence. Maximum days to emergence in early planting dates may be due to low soil temperature in May. Whereas the minimum number of days to

Table 1: Days to emergence of determinate and indeterminate soybean cultivars as affected by planting date and plant density

		Plants ha^{-1} (000)			
Date of sowing	Varieties	200	400	600	Means
		-- Two years average --			
		-------- D × V × P ----------			
May 2	Epps	7.0	7.0	7.0	7.0
	Williams 82	7.0	7.0	7.0	7.0
June 2	Epps	4.5	4.5	4.5	4.5
	Williams 82	4.0	4.0	4.0	4.0
July 2	Epps	4.0	4.0	4.0	4.0
	Williams 82	4.0	4.0	4.0	4.0
August 2	Epps	5.0	5.0	5.0	5.0
	Williams 82	4.5	4.5	4.5	4.5
		---------- D × P ------------			
May 2		7.0	7.0	7.0	7.0
June 2		4.3	4.3	4.3	4.3
July 2		4.0	4.0	4.0	4.0
August 2		4.8	4.8	4.8	4.8
		---------- P × V ----------			
	Epps	5.1	5.1	5.1	5.1
	Williams 82	4.9	4.9	4.9	4.9
Means		5.0	5.0	5.0	

Table 2: Days to unifoliate leaf formation of determinate and indeterminate soybean cultivars as affected by planting date and plant density

		Plants ha^{-1} (000)			
Date of sowing	Varieties	200	400	600	Means
		--------- D × V × P ---------			
May 2	Epps	10.0	10.0	10.0	10.0
	Williams 82	11.0	11.0	11.0	11.0
June 2	Epps	7.5	7.5	7.5	7.5
	Williams 82	8.0	8.0	8.0	8.0
July 2	Epps	6.0	6.0	6.0	6.0
	Williams 82	6.0	6.0	6.0	6.0
August 2	Epps	5.0	5.0	5.0	5.0
	Williams 82	5.5	5.5	5.5	5.5
		---------- D × P ------------			
May 2		10.50	10.50	10.50	10.50a
June 2		7.75	7.75	7.75	7.75b
July 2		6.00	6.00	6.00	6.00bc
August 2		5.25	5.25	5.25	5.25c
		---------- P × V ----------			
	Epps	7.5	7.5	7.5	7.5
	Williams 82	7.62	7.62	7.62	7.62
Means		7.56	7.56	7.56	

* Means of the same category followed by different letters are significantly different at 0.05 % level of probability using LSD test.

Table 3: Days to 6th trifoliate leaf formation of determinate and indeterminate soybean cultivars as affected by planting date and plant density

		Plants ha^{-1} (000)			
Date of sowing	Varieties	200	400	600	Means
		--- Two years average ----			
		---------- D × V × P ----------			
May 2	Epps	34.0	33.30	32.70	33.33
	Williams 82	33.33	33.21	30.25	32.26
June 2	Epps	33.12	32.45	31.29	32.28
	Williams 82	33.34	32.12	31.34	32.26
July 2	Epps	31.89	30.53	30.56	30.99
	Williams 82	31.89	30.11	30.00	30.66
August 2	Epps	31.15	30.00	29.32	30.15
	Williams 82	30.00	30.00	30.00	30.00
		---------- D × P ----------			
May 2		33.66	33.25	31.47	32.79a
June 2		33.23	32.28	31.31	32.26a
July 2		31.89	30.32	30.28	30.83b
August 2		30.57	30.00	29.66	30.07b
		---------- P × V ----------			
	Epps	32.54	31.57	30.96	31.69
	Williams 82	32.14	31.10	30.39	31.21
Means		32.34	31.33	30.67	

Table 4: Plant height (cm) of determinate and indeterminate soybean cultivars as affected by planting date and plant density

		Plants ha^{-1} (000)			
Date of sowing	Varieties	200	400	600	Means
		--------- D × V × P ----------			
May 2	Epps	114.4	115.8	122.2	117.5a
	Williams 82	87.1	90.9	98.1	92.0c
June 2	Epps	102.1	105.9	113.8	107.3b
	Williams 82	83.3	84.7	91.0	86.3d
July 2	Epps	90.0	95.1	100.3	95.2c
	Williams 82	81.4	83.7	89.2	84.8d
August 2	Epps	37.5	42.1	43.3	41.0e
	Williams 82	35.4	37.2	39.4	37.3e
		---------- D × P ----------			
May 2		100.8	103.3	110.1	104.7a
June 2		92.7	95.3	102.4	96.8b
July 2		85.7	89.4	94.8	90.0c
August 2		36.5	39.7	41.4	39.2d
		---------- P × V ----------			
Epps		86.0	89.8	94.9	90.2a
Williams 82		71.8	74.1	79.4	75.1b
Means		78.9b	81.9b	87.2a	

* Means of the same category followed by different letters are significantly different at 0.05 % level of probability using LSD test.

Table 5: Days to maturity of determinate and indeterminate soybean cultivars as affected by planting date and plant density in 1997 and 1998

Date of sowing	Varieties	Plants ha^{-1} (000) 200	400	600	Means
		-- Two years average --			
		--------- D × V × P ---------			
May 2	Epps	174.0	174.0	174.0	174.0a
	Williams 82	120.0	120.0	120.0	120.0b
June 2	Epps	131.0	131.0	131.0	131.0b
	Williams 82	109.0	109.0	109.0	109.0bc
July 2	Epps	114.0	114.0	114.0	114.0b
	Williams 82	84.0	84.0	84.0	84.0c
August 2	Epps	78.0	78.0	78.0	78.0d
	Williams 82	69.0	69.0	69.0	69.0e
		---------- D × P ----------			
May 2		147.0	147.0	147.0	147.0a
June 2		120.0	120.0	120.0	120.0b
July 2		99.0	99.0	99.0	99.0c
August 2		72.5	72.5	72.5	72.5d
		---------- P × V ----------			
	Epps	124.25	124.25	124.25	124.25a
	Williams 82	95.50	95.50	95.50	95.50b
Means		109.87	109.87	109.87	

* Means of the same category followed by different letters are significantly different at 0.05 % level of probability using LSD test

emergence in June and July planting may be due to high soil temperature because germination is the result of many processes which involved enzymes. The activation of these enzymes mainly depend upon temperature. The average of both years indicated that both varieties took the same days to emergence. The possible reason for difference in days to emergence in both years is due to variation in air and soil temperature, relative humidity and rainfall.

Days to unifoliate leaf formation

The statistical analysis of data indicate that planting dates had significant effect on unifoliate leaf formation of the two soybean cultivars, while the effect of plant density were non-significant (Table 2). Early planted crop took maximum number of days (10.5) to unifoliate leaf formation. Maximum days to unifoliate leaf formation in early planting dates may be due to favorable temperature for growth in May. Number of days to unifoliate leaf formation decreased significantly with delay in planting. Both cultivars took same number of days (7.50) to unifoliate leaf formation. These results are in line with those of Parvez ***et al.*** (1981) who stated that planting time affected different traits of soybean.

Days to 6th trifoliate leaf formation

The data recorded on 6th trifoliate leaf formation show that planting dates had significant effect on 6th trifoliate leaf formation of the two soybean cultivars (Table 3). Early planted crop

in May and June took maximum number of days (32.79 and 32.26) to 6th trifoliate leaf formation. Favorable temperature for growth and development during May and June may be the reason for maximum days to 6th trifoliate leaf formation. A steady decrease in number of days to 6th trifoliate leaf formation occurred with delay in planting. Both cultivars took same number of days (31.69 and 31.21) to 6th trifoliate leaf formation.

Plant height (cm)

The statistical analysis of the data indicate that planting dates had significant effect on plant height of the two soybean cultivars (Table 4). Maximum plant height of 104.7 cm was attained by early planted crop. Plant height decreased significantly with delay in planting. Reduced plant height with delay in planting may be due to quick changes in photoperiod, which accelerated development towards reproductive stages and hence less time was available for vegetative growth. Low temperature during the last week of October and early November may also be the reason for minimum plant height in delay planting. Other researchers have also found that plant height generally decreased with delayed planting (Anderson and Vasilas, 1985). Plant height increased with increase in plant population from 2,00,000 to 6,00, 000 plants ha^{-1} and maximum plant height of 87.2 cm was recorded at 6,00,000 plants ha^{-1}. These results are in agreement with those of Parvez ***et al.*** (1989) who reported that plant height increased slightly with increase in planting density. Significant differences were observed between plant heights of the two cultivars and Epps grew about 5 cm taller than Williams 82. The difference in plant heights of the two varieties may be genotypic in nature. Interaction between planting dates X cultivars was significant and both cultivars at early planting dates attained maximum plant height and a decreasing trend in plant height was observed with delayed planting. However, the rate of decrease in plant height of Epps was noted about 0.79 cm height reduction with one day delay in sowing, where as in Williams 82, the reduction in height was about 0.54 cm. This resulted in more difference in plant height at the earliest date of sowing and less difference at the last date of sowing.

Days to maturity

The statistical analysis of the data revealed that planting dates had significant effect on days to maturity of the two soybean cultivars (Table 5). Early planted crop took maximum number of days (147) to maturity. A steady decrease in number of days to maturity took place when planting were delayed to August. Minimum days to maturity with delay in planting may be due to quick changes in photoperiod and temperature as in case of plant height. Significant differences were observed between days to maturity of the two cultivars and Epps took more days to maturity than Williams 82. The difference in days to maturity among cultivars may be genetic in nature. Interaction between planting dates × cultivars was significant, both cultivars at early planting dates took maximum days to maturity and a decreasing trend in days to maturity was observed with delayed planting.

It is concluded from the present investigation that early crop planted in first week of May took maximum number of days to all morphological parameters than late crop planted in August.

Early planting dates in May and June and low plant density directly affect all morphological traits and the yield and yield components of soybean cultivars. It is recommended that for seed and oil yields, soybean should be planted in the first week of May at the rate of 2,00,000 plants ha^{-1}.

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