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Influence of Planting Dates and Plant Population on Soybean Yield and Yield Components under Peshawar Conditions

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Abstract: Field trials were conducted to evaluate the influence of planting dates and density on yield and yield components of two soybean cultivars under Peshawar conditions during 1997-1998. All the yield and yield components were significantly affected by planting dates and plant density. Maximum number of pods per plant, seeds per pod, seed yield, biological yield and seed weight were obtained from early planted crop. A steady decrease in all the yield and yield components was observed with delay in planting of soybean. Though the lowest density of 20 thousand plants ha^{-1} gave significantly greater number of pods per plant and seeds per pod than higher plant densities of 40 and 60 thousand plants ha^{-1}. Yet biological and seed yields increased with increase in plant density from 20 to 60 thousand plant ha^{-1}. Epps produced significantly higher biological yield than William-82 which produced higher seed yield, however the differences in seed yield and yield components between the two varieties did not reach significant level.

Key words: Planting dates, density, varieties and yield

Introduction

Soybean [Glycine max (L.) Merr.] is one of the important oil and protein crop of the world, and has great potential both as oilseed crop and as a crop that can be used as rich source of proteins for animal production and for human beings. The supplies of proteins and oils especially from animal sources (meat and fish) are becoming expensive and scarce particularly in developing countries (Jimenez *et al.*, 1991). New sources of proteins and oils have been explored in the developed countries. As an inexpensive source of proteins, soybean can play a major role in elevating nutritional standards of foods in developing nations, where human beings are facing protein deficiencies (Chaudhry, 1985). Soybean can possibly play a major role in narrowing the gap between the production and consumption of proteins and oils in Pakistan, provided it can be fitted into the cropping husbandry (Sher *et al.*, 1999 and Beg, 1985). Soybean is a legume and thus has the ability to fix atmospheric nitrogen through symbiosis with proper strain of *Rhizobium japanicum*. Soybean, in suitable cropping pattern, can be used not only to decrease N-fertilizer use on a particular farm but it can trips off excess N applied to previous crop and thus can prevent ground water pollution. One of the reasons for lesser area, lower yield, smaller returns and nominal production of soybean in Pakistan is the erratic and poor emergence of the crop in field due to poor seedling establishment. For producing a bumper crop of soybean, seed germination, and its subsequent establishment in the field are important events for uniform plant stand. Appropriate date of sowing and plant density 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. Though it is deemed that conditions in NWFP are more favorable for production of soybean crop. The effects of environmental conditions during seed filling period on yield and yield components have not been fully explored under agro-climatic conditions of the North West Frontier Province in autumn. Therefore, the present experiment was designed to study the influence of planting date and plant density on yield and yield components of soybean.

Materials and Methods

The experiment was carried out at the Agriculture Research Farm of the NWFP Agricultural University Peshawar, during 1997 and 1998. The site is located at 34° N latitude, 71.3° longitude and an altitude of 450 meters above sea level. Peshawar 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 (0.7-0.8%) and alkaline in reaction with a pH of 8.0-8.2. A basal dose of 36 kg N and 92 Kg P_2O_5 Kg ha^{-1} in the form of Diammonium phosphate (D.A.P) fertilizer was applied at sowing. Determinate variety Epps (MG-V) and Indeterminate variety William-82 (MG-III) were planted on May 2, June 2, July 2 and August 2, at the planting density levels of 20, 40 and 60 plants/m^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 varieties were allotted to sub plots. A sub plot size of 4m x 5m, 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. Two to five seeds per hill were planted and thinning was done to leave 1, 2, 3, plants/hill corresponding to 20, 40 and 60 plants/m^2 at V2 stage (2nd node with fully developed trifoliate leaf at node above the unifoliate nodes). Normal cultural practices for raising a successful crop were followed uniformly for all the experimental units. The plots were hand weeded at different vegetative stages. Irrigation was applied at weekly interval. The following data were recorded on yield and yield components:

(a) Number of Pods $plant^{-1}$ (b) Number of seeds pod^{-1}
© Seed yield (kg ha^{-1}) (d). Seed weight(g/1000)
(e) Biological yield (kg ha^{-1})

Number of pods per plant were estimated by counting the number of pods (>2cm) in four plants per treatment at

each sampling date till physiological maturity. For number of grains per pod, 20 pods at each sampling date were randomly selected. Seeds were separated by hand and were counted to record the number of grains per pod. A sub plot size of 4m x 5m was harvested by hand, cleaned, dry and seed yield (kg) per plot were recorded. For the determination of 1000 seed weight, thousand seeds from each treatment was randomly selected and weighed. Data were statistically analyzed using Fisher's analysis of variance techniques appropriate for randomized complete block design with varieties split on combinations of dates of sowing and plant densities. For quantifying the effect of planting dates and plant density on yield and yield components, LSD at 0.05 level was carried out if the F test indicate significance.

Results and Discussion

The data recorded on yield and yield components of soybean varieties planted in autumn are reported and discussed below.

Number of pods plant^{-1}: Data regarding number of pods per plant are reported in Table 1. Statistical analysis of the data indicate that planting dates significantly affected the number of pods per plant of the soybean varieties on average of both the years. Maximum number of pods (165.23) per plant was obtained from early crop planted in early May. Number of pods per plant decreased with delay in planting and minimum number of pods per plant (17.26) was obtained from late crop planted in early August. Maximum number of pods from early planted crop may be due to longer crop growth duration from sowing to maturity and greater partitioning to reproductive sink in early planting dates resulting in maximum number of pods. These findings are in conformity with those of Mayhew and Caviness (1994) and Heatherly (1988), who found that early planted soybean produced maximum number of pods plant^{-1}. Number of pods per plant decreased with increase in plant population from 20 plants m^{-2} to 60 plants m^{-2} and maximum number of pods (115.52) was obtained from 20 plants m^{-2}. The decrease in pods per plant with increase in population may be due to greater interplant competition for light, water and nutrient leading to smaller plants with less branching in denser population. No significant difference was observed between pods per plant of the two varieties, however William-82 gave slightly higher number of pods than Epps. Interaction between the planting dates x varieties reveal that in early May planting William-82 performed well and produced significantly more number of pods per plant than Epps, while at later planting dates, Epps showed its superiority over William-82 and produced 15.7, 7.06 and 2.36 more pods per plant than William-82 planted in June, July and August respectively.

Number of seed pod^{-1}: Data recorded on number of seeds per pod are reported in Table 2. Statistical analysis of the data show that the number of seeds per pod were significantly affected by planting dates. Maximum number of seeds per pod (2.64) was obtained from crop planted in early May. A steady decrease in number of seeds per pod occurred with delay in sowing and minimum number of seeds per pod (2.25) was obtained from last planting. Maximum number of seeds per pod from early planted crop may be due to greater vegetative growth of the early planting and longer crop growth period from sowing to maturity and greater partitioning to reproductive sink in early planting dates resulting in maximum number of pods. These results are similar to those of Mayhew and Caviness (1994) and Heatherly (1988), who reported that early planted soybean produced maximum number of seeds per pod. Number of seeds per pod decreased with increase in plant population from 20 to 60 plants m^{-2} and maximum number of seeds per pod (2.72) was obtained from 20 plants m^{-2}. Significant difference was observed between seeds per pod of the two varieties and William-82 gave more number of seeds per pod than Epps. Interaction between the planting dates x varieties reveal that in early May and June planting William-82 performed well and produced significantly higher number of seeds per pod than Epps. There was no significant difference between seeds per pod of the two varieties planted in July and August.

Seed yield(Kg ha^{-1}): The statistical analysis of the data indicate that planting dates significantly affected the seed yield of the two soybean varieties during both the years (Table 3). Maximum seed yield of 6658 kg ha^{-1} was obtained from early crop planted in May. Seed yield decreased with delay in planting and minimum seed yield of 445 kg ha^{-1} was obtained from late crop planted in August. Maximum seed yield from early planted crop may be due to longer crop growth duration from sowing to maturity, which lead to great crop phytomass and greater partitioning to reproductive sink in early planting dates resulting in maximum seed yield. These findings are in conformity with those of Mayhew and Caviness (1994) and Heatherly (1988), who found that early planted soybean produced about 16% higher yield than late planted soybean crop due to maximum number of pods plant^{-1}, number of seeds/pod and maximum seed weight. Effects of planting date on yield were related to changes in plant architecture like lower leaf area index, lesser branching, lower number of leaves, lesser plant height in late planted crop. These changes resulted in smaller plants, reduction in branch stem, yield plant^{-1}, and to a lesser extent main stem yield plant^{-1}. Large reduction in branch stem vegetative and reproductive development resulted from late planting. Seed yield increased with increase in plant density from 20 plants m^{-2} to 60 plants m^{-2} and maximum seed yield of 4626 kg ha^{-1} was obtained from 60 plants m^{-2} (Pervez *et al.*, 1989). No significant difference was observed between varieties, however William-82 gave higher seed yield than Epps. Interaction between date of sowing x plant population were significant indicate that seed yield decreased with delay in planting but the extent of reduction in yield was greater in plots having 200 thousands plants ha^{-1}, lesser in plots having 400 thousands ha^{-1} and least in the plots having the highest plant density. These findings are in agreement with those of Boquet (1990) who reported significant interaction between planting dates x plant population and stated that yield losses occurred with delay in planting but the yield of soybean were increased at late planting dates by using plant density of 51 plants m^{-2}. Interaction between dates x varieties show that both varieties performed well at early planting dates and William-82 produced significantly higher seed yield of 2024 kg ha^{-1} than Epps, while at later planting dates, Epps showed its superiority over William-82 and produced 255, 709 and 74 kg ha^{-1} more seed yield than William-82 planted in June, July and August

Table 1: Number of Pods per plant of soybean varieties as affected by date of sowing and plant density during 1997 and 1998

Date of Sowing	Variety	Plant density(000) plants ha^{-1}			Mean
		200	400	600	
Two years average					
D x V x P					
May 2	Epps	194.22	135.34	110.78	146.78 b
	William-82	202.18	181.56	167.31	183.68 a
June 2	Epps	145.16	133.34	130.37	136.30 bc
	William-82	138.53	122.68	100.97	120.73 c
July 2	Epps	100.22	84.22	78.62	87.68 d
	William-82	101.90	82.34	59.22	81.15 d
August 2	Epps	21.16	17.43	16.75	18.44 e
	William-82	21.81	14.25	12.19	16.08 e
D x P					
May 2		198.20	158.45	139.04	165.23 a
June 2		141.84	128.01	115.67	128.51 b
July 2		100.56	83.28	68.92	84.25 c
August 2		21.48	15.84	14.47	17.26 d
P x V					
	Epps	115.18	92.58	84.13	97.30
	William-82	115.85	100.21	84.92	100.33
Mean		115.52 a	96.39 b	84.52 c	98.82

Table 2: Number of seeds per pod of soybean varieties as affected by date of sowing and plant density during 1997 and 1998

Date of Sowing	Variety	Plant density(000) plants ha^{-1}			Mean
		200	400	600	
Two years average					
D x V x P					
May 2	Epps	2.65	2.38	2.17	2.40 b
	William-82	2.96	3.00	2.69	2.88 a
June 2	Epps	2.50	2.13	2.00	2.21 e
	William-82	3.00	3.00	2.88	2.96 a
July 2	Epps	2.75	2.25	2.13	2.38 cd
	William-82	3.00	2.25	2.38	2.54 bc
August 2	Epps	2.25	2.00	1.98	2.08 de
	William-82	2.63	2.38	2.25	2.42 b
D x P					
May 2		2.81	2.69	2.43	2.64 a
June 2		2.75	2.56	2.44	2.58 b
July 2		2.88	2.25	2.25	2.46 c
August 2 2		.44	2.19	2.11	2.25 d
P x V					
	Epps	2.54	2.19	2.07	2.26
	William-82	2.90	2.66	2.55	2.70
Mean		2.72 a	2.42 a	2.31 b	2.48

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

Table 3. Seed yield (Kgha^{-1}) of soybean varieties as affected by date of sowing and plant density during 1997 and 1998

Date of Sowing	Variety	Plant density(000) plants ha^{-1}			Mean
		200	400	600	
Two years average					
D x V x P					
May 2	Epps	2925	5263	8749	5646 b
	William-82	4313	8375	10323	7670 a
June 2	Epps	1969	3823	6071	3954 c
	William-82	1988	3698	5411	3699 d
July 2	Epps	834	1838	2904	1859 e
	William-82	524	893	2034	1150 f
August 2	Epps	143	472	831	482 g
	William-82	149	387	687	408 h
D x P					
May 2		3619 e	6819 b	9536 a	6658 a
June 2		1978 g	3760 d	5741 c	3826 b
July 2		679 j	1365 h	2469 f	1504 c
August 2		146 l	429 k	759 i	445 d
P x V	Epps	1468	2849	4639	2985
	William-82	1743	3338	4614	3232
Mean		1605 c	3093 b	4626 a	3108

Table 4: Seed Weight (g/1000) of soybean varieties as affected by date of sowing and plant density during 1997 and 1998

Date of Sowing	Variety	Plant density(000) plants ha^{-1}			Mean
		200	400	600	
Two years average					
D x V x P					
May 2	Epps	148.0	154.8	143.8	148.9 c
	William-82	177.6	180.9	165.7	174.7 a
June 2	Epps	137.6	143.5	133.8	138.3 d
	William-82	168.1	170.9	160.6	166.5 b
July 2	Epps	110.0	119.6	109.2	112.9 e
William-82		130.8	137.7	132.8	133.7 d
August 2	Epps	108.1	103.7	97.9	103.2 f
	William-82	118.3	115.6	110.3	114.7 e
D x P					
May 2		162.8	167.9	154.7	161.8 a
June 2		152.9	157.2	147.2	152.4 b
July 2		120.4	128.6	121.0	123.3 c
August 2		113.2	109.7	104.1	109.0 d
P x V					
Epps		125.9	130.4	121.2	125.8
William-82		148.7	151.3	142.3	147.4
Mean		137.3 a	140.8 a	131.8 b	136.6

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

Table 5: Biological yield (kgha^{-1}) of soybean varieties as affected by date of sowing and plant density during 1997 and 1998

Date of Sowing	Variety	Plant density(000) plants ha^{-1}			Mean
		200	400	600	
Two years average					
D x V x P					
May 2	Epps	19478	30928	52453	34286 a
	William-82	18984	28225	48050	31753 b
June 2	Epps	12875	24630	33950	23818 c
	William-82	11950	20025	29150	20375 d
July 2	Epps	11175	16484	30490	19383 e
	William-82	4353	8049	12588	8330 f
August 2	Epps	4100	7312	11474	7629 h
William-82		3825	8007	11850	7894 g
D x P					
May 2		19231 f	29577 c	50252 a	33020 a
June 2		12413 g	22327 d	31550 b	22097 b
July 2		7764 j	12266 h	21539 e	13856 c
August 2		3963 l	7659 k	11662 l	7761 d
P x V					
Epps		11907	19838	32092	21279
William-82		9778	16076	25409	17088 b
Mean		10842 c	17957 b	28751 a	19183

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

respectively.

Seed Weight (g/1000): Data on seed weight of the two soybean cultivars planted on the four dates and thinned to the three plant densities are reported in Table 4. The statistical analysis of the data showed that planting dates significantly affected the seed weight of the soybean based on average of the years. Early planted crop produced seed weighing of 161.8 g/1000 seeds. A steady decrease in seed weight of soybean was observed as planting was delayed and the minimum seed weight of 109.0 g/1000 seed was recorded from late planting. Minimum seed weight from late planted crop may be due to reduction in seed filling duration. Plant density effects on seed weight showed that heavier seeds were produced at the lower plant densities. Highest plant density of 60 plants m^{-2} produced the lowest seed weight. The reason for maximum seed weight at lower densities may be that at the lower densities plants competition for water and nutrients was less and thus plants had higher photosynthetic activities which resulted in more assimilate for seed filling. Significant differences were found between cultivars with respect to seed weight. William-82 produced heavier seeds weighing 147.4 g/1000 seeds than Epps which could be due to different rate of dry matter accumulation among cultivars as reported by Egli (1975), Beaver and Cooper (1982) who found Corsoy 79 to have a higher seedfill rate than William 79 and concluded that this advantage gave Corsoy 79 its higher yield potential. Interaction between planting dates x varieties was significant and though William-82 produced heavier seeds than Epps in all planting dates, but the percent difference between the two varieties was maximum (28%) in the second planting date and minimum (11.5%) in the last planting date. This could be due to the differential response of the varieties to variation in photoperiod and temperature.

Biological Yield (Kg ha^{-1}): Biological yield of the two soybean varieties planted on the four dates and thinned to the three plant densities are reported in Table 5. The

combine statistical analysis of the data from the two years indicate that planting dates significantly affected biological yield of the two soybean varieties. The two years average yield show that maximum biological yield of 33020 kg ha^{-1} was obtained from early planted crop. Biological yield decreased with delay in planting and minimum biological yield of 7761 kg ha^{-1} was obtained from delay planted crop. The maximum biological yield from early planted crop may be due to long growth period from sowing to maturity and to longer seedfill duration, which means that crop growth continued for long time and ultimately resulted in higher biological yield. These findings are in agreement with those of Shah and Jackobs, (1988) who concluded that early sowing produced more seed and stalk yield of soybean. They further stated that delay in sowing adversely affected phytomass because of shorter days and low temperature. Plant population significantly affected biological yield of soybean. Based on the two years average biological yield increased with increase in population from 2,00,000 to 6,00,000 plants ha^{-1}, and maximum biological yield of 28751 kg ha^{-1} was obtained from 6,00,000 plants ha^{-1}. Epps produced significantly higher biological yield than William-82. The difference in biological yields of the two cultivars may be due to difference in genetic make-up that influence physiological parameters determining biological yield. These findings are in line with those of Pervez *et al.* 1989 who reported that the total dry matter production was greater in May planting and plant density of 40 plants m^{-2}. Interaction between planting dates x plant density was significant, reveal that the response of plant population varied with date of sowing.

In early sowing date, the highest plant density produced 2.5 times more biological yield than the lowest plant density, while in the last sowing date highest plant density produced about 3 times higher biological yield than lowest population. Interaction between planting dates x varieties indicate that Epps in all planting dates showed its superiority over William-82 but in last planting date William-82 produced 265 kg^{-1} more biological yield than Epps.

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