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Effect of Planting Time and Cultivar on Soybean Performance in Semi-Arid Punjab, Pakistan

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I. Introduction

Soybean is classified more as an oil seed crop than as a pulse. It contains 40-42% of proteins and 18-20% of oil (Devi et al., 2012). Due to its high nutritional value there is an increasing demand of soy food e.g. soymilk, soybean sprouts, soy nuts, several types of tofu, cottage cheese and curd (Rao et al., 2002). In Pakistan, seed yield of soybean is very low as compared with its yield potential and the average of world. Despite numerous uses, its low yield at field level has lessened its popularity among Pakistani farmers because there is a lack of interest for growing the edible oilseed crops among the growers. There are many factors limiting soybean production at farmers farm. Among these factors improper planting time, climatic variability, low germination percantage poor quality seed irrigation shortage. Exploring the soybean varietal and agronomic flaws can help us to bridge this gap. Quick germination and even crop stands are essential for obtaining higher yield levels (Yari et al., 2010). Another possible reason of low production is the non-adoption of new developed cultivars with higher nutrition requirements. The sowing of soybean cultivars of high yield potential at optimum planting time is considered as a hopeful approach to increase soybean production. Choices of cultivar play a great role in increasing soybean production. Generally, the planting time varies depending on the climatic condition of the region and the cultivar to be grown. Different cultivars of soybean are sensitive to change in environmental conditions where the crop is being planted. Therefore, it is also necessary to study the genotype × environment interaction to identify the varieties which are stable in different environments (Calvino et al., 2003a). The previous studies showed that the early or late planting significantly decreased the crop yield (Rehan, 2002). Sowing date is the variable with the largest effect on crop yield (Calvino et al., 2003a, b). Proper management of soybean by planting date is an excellent approach to increase both crop yield and economic benefit. Effects of planting time on soybean yield and other traits varied at locations (Naeve et al., 2004). Environmental conditions associated with late planting affect crop features related to the capture of radiation and portioning of crop resources. These include less vegetative growth (Board et al., 1992), shorter stems (Boquet, 1990); lower reproductive nodes (Board et al., 1999), and shortening of the reproductive phases (Kantolic & Slafer, 2001). In spring-sown single crops of soybean, yield is most susceptible to nutritional and water deficits during late flowering and grain filling, and grain number is the main yield component involved in this response (Andriani et al., 1991). Delayed planting generally shifts reproductive growth into less favorable conditions with shorter days and lower radiation and temperature (Egli & Bruening, 2000). In a simulation study, Egli and Bruening (1992) found that reduced radiation and temperature accounted for most of the reduction in yield associated with late planting in well watered soybean crops reaching maturity in late season. CROPGRO-soybean model can be used to simulate the growth and development of soybean. So for determining the best planting time of spring soybean, CROPGRO-soybean model from the DSSAT (Decision Support

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System for Agro-technology Transfer) of United States could be calibrated. The objective of present study was to evaluate the effect of planting times and cultivars on yield and quality attributes of soybean in agro-ecological conditions of Faisalabad, Pakistan.

II. Materials and Methods

In order to evaluate the effects of planting date and cultivar on various yield and quality attributes of soybean, a split plot experiment based on randomize complete block design with three replications was conducted at Agronomy Research Farm, University of Agriculture, Faisalabad, Pakistan (31.25° N, 73.09° E, and 184 m above sea level) during the spring 2012. Due to high evapotranspiration, Faisalabad features a semi-arid climate with mean annual rainfall of about 200 mm. The soil of the experimental site was a sandy clay loam with proportion of sand, silt and clay as 51.15, 22.50 and 26.35%. Soil pH and EC was 7.7 and 0.94 dSm^{-1}, respectively. The organic matter, total nitrogen, available phosphorus and potassium were 0.68%, 0.062%, 14 mg kg^{-1} and 188 mg kg^{-1}, respectively. The Bulk density and cation exchange capacity was 1.44 g CC^{-1} and 4.3 $cmol_c$ kg^{-1}.

Five planting dates including 21st January, 28th January, 4th February, 11th February and 18th February (T_1, T_2, T_3, T_4 and T_5, respectively) were considered as main plots and the cultivars including SA 72-60 and Faisal soybean (V_1, and V_2, respectively) were also considered as sub- plots. Each sub plot was consisted of six rows 6 m long and 30 cm apart. While, the distance between plants on each row was 5 cm. Crop management factors like land preparation, fertilizer, and weed control were followed as recommended for local area. All the plant protection measures were adopted to make the crop free from insects. The data were recorded on ten randomly selected plants of each entry of each replication for number of pods per plant, number of seeds per plant, plant height, 1000- seed weight, seed yield and biological yield was recorded. The protein and oil contents of soybean seeds were obtained by using Kjeldhal's method and Rooskhvisky's method, respectively. The analyzed statistically by using Fisher's Analysis of Variance Technique and least significant difference (LSD) test at 5% probability level (Steel et al., 1997).

III. Results and Discussion

Analysis of data revealed that all the yield and quality related attributes were significantly ($p \leq 0.05$) affected by various planting times. However, response of different cultivars varied only for number of pods per plant, number of seeds per plant, plant height and seed yield. The interaction between these two factors was also non-significant for all parameters recorded.

a) Number of Pods Per Plant

Data (Table 1) regarding number of pods per plant revealed a decrease with delay in planting time. Maximum number of pods per plant (29.53) was produced by 28th January planting. Regarding different cultivars, Faisal soybean produced significantly more number of pods per plant (21.79) as compared to SA 72-60 (20.19).These results are matched with the findings of Ahmed et al. (2010) on soybean pods. In another experiment Ahmed et al. (2008) also recorded the similar results. Number of pods per plant was affected significantly by genotype (Hwang, 1998).

b) Number of seeds Per Plant

Analysis of data revealed that maximum number of seeds per plant (81.23) was recorded for those plots grown on 28th January. These results are quite similar to the findings of Calvino et al. (2003b) who reported higher number of seeds per plant in early planting as compared to late planting. In cultivar, maximum number of seeds per plant 58.72 was recorded in Faisal soybean. There was also lot of difference between the size and weight of seeds during early and delayed planting. These results are quite in line with the findings of Lee and Hwang (1998) who reported that number of seeds per plant was significantly affected by genotype.

c) Plant Height (cm)

Plant height represents the phenology and growth of crop. The plant height was affected significantly by different planting times (Table-1). 28th January planting produced significantly taller plants 96.23 cm than all other treatments. Likewise, among the two varieties Faisal soybean produced statistically taller plants 80.83 cm against significantly the lowest plant height of 76.16 cm for SA 72-60. The greater plant height recorded in 28th January was probably due to comparatively longer growing period along with the optimum environmental conditions. These results are in line with those of reported by Wade and Johnston (1975) who stated that photoperiod sensitivity had marked reduction in growth period due to delayed seeding might account for decrease in plant height.

d) 1000-Seed Weight (g)

Planting time treatments showed that maximum 1000-seed weight of (74.79 g) soybean was recorded in T_2 (28th January), which was statistically at par with T_1 (71.85), when planting was done on 21st January. These two treatments were statistically at par with each other against the minimum 1000-seed weight (65.97 g) was observed in T5 (18th February). This might be due to the short vegetative growth period and long reproductive and grain filling period, that significantly raised the 1000-seed weight. These results are similar with Pedersen and Lauer (2004), in case of soybean, who stated that average seed weight from early sowing was higher than that from late sowing. Early planted varieties got more

time and growth period to accumulate more photo-assimilates. Furthermore, high temperature caused shrinking of seeds during late planting. There was statistically similar behavior of two varieties Faisal soybean and SA 72-60 with 1000-seed weight of (70.96 g) and (70.63 g), respectively. The delaying of planting time than 28th January caused decrease in seed weight. Seed yield is affected by the seed weight. These results are matched with the findings of Adeniyan and Ayoola (2007). However, the interactive effect of varieties and planting time was non-significant.

e) Seed Yield kg ha $^{-1}$

Data (Table 1) depicted that seed yield of soybean was significantly ($p \leq 0.05$) affected by different sowing dates and cultivars. Maximum seed yield 1530.2 kg ha^{-1} was recorded in 28th January planting which was statistically at par with the yield of 21st January, but significantly higher than rest of planting dates. Higher seed yield in T_2 might be due to greater leaf area closely related to Kumudini et al., (2001) reported that Greater leaf area enhanced the grain yield due to increased interception of solar radiation and healthier carbon exchange rate. Among cultivars Faisal soybean produced significantly higher seed yield of 1228 kg ha^{-1} as compared to 1121.9 kg ha^{-1} produced by SA 72-60. These results are in line with the results of Evans (1996), who concluded that genotypes had a significant effect on the seed yield. Results revealed that with the delayed planting of spring soybean after January its yield lost drastically over time because it results decrease in vegetative and reproductive growth. Late planting due to the loss of suitable time for the growth, the plant was not achieved its potential ability because light interception and crop simulates partitioning were severely affected and consequently lead to yield decline. In case of early planting there was more time for plant growth in optimum temperature and moisture, so seed yield increasing is rational. With late planting the growth period becomes short. High temperature during flowering decreases the seed yield and yield components of soybeans. In another studies, the delayed planting decrease the yield (Kane et al., 1997; Board et al., 1999; Egli & Bruening, 2000; Kantolic and Slafer, 2001). Similar results were recorded with late planting by Ahmed et al. (2010), Calvino et al. (2003) and Ngalamu et al. (2012).

f) Biological Yield kg ha $^{-1}$

Analysis of data revealed that biological yield of soybean was significantly influenced by different planting dates. Late planting of spring soybean after January resulted in drastic biomass reduction over time. Among five planting dates, spring soybean produced significantly higher biological yield of 4431 kg ha^{-1} and 4308 kg ha^{-1} with T_2, and T_1 respectively, against the lowest T5 (3949.3 kg ha^{-1}). However, No meaningful difference between cultivar SA 72-60 and Faisal soybean with respect to biological yield was recorded (Table 1). Same results were recorded with the late planting by Ngalamu et al. (2012), Ahmed et al. (2010) and Calvino et al. (2003) in their experiments.

g) Protein Contents (%)

Analysis of data (Table 1) revealed that protein concentration of soybean seeds was significantly affected by planting times. Early planted soybean (T_1: 21st January) produced seeds with lower protein percentage of 31.65 %. However, the protein percentage was increased with delayed planting as late planted (T_4) crop gave maximum protein percentage of 33.53 % which was comparable with T_5 (33.32 %). This maximum protein percentage might be due the optimum temperature during the seed development and maturity. While, the lower percentage with early planted crop was due to the effect of environmental factors, such as high temperature and photoperiod at maturation. No significant difference was recorded between cultivars regarding protein percent. These results are in line with those of reported by Khan et al., (2001) who stated that protein contents in late planted crop were higher than the early planted crop. The results are also matched with the findings of Moosavi et al., (2011).

h) Oil contents (%)

Results regarding percentage of oil in soybean seeds showed that there was meaningful difference between effects of different planting times on this trait. While, no significant variation was recorded in different cultivars. Interactive influence of these two factors was also non-significant (Table 1). Highest oil percentage was recorded in T_1 (20.90 %) followed by T_2, T_3 and T_4 which were statistically at par with each other. Delay in sowing decreased concentration of oil and seeds harvested from T_5 gave minimum oil percentage of 18.92 % statistically similar with T_4. The seeds harvested from early sowing developed and matured at high temperature which resulted in maximum oil percentage as compared to late planted crop. Suryavashi et al. (1993) and Wolf et al. (1982) reported more oil contents from seeds matured at high temperature than the seeds matured at low temperature. Nishioka and Okumura (2008) also concluded similar results and suggested that the increased oil contents with early planting. Hu and Waitrak (2012) reported that high temperature associated with delayed planting can have a negative effect on yield and quality of soybean seeds by changing the protein and oil contents. Planting methods affected the oil percentage and highest oil percent was found in early planting Calvino et al. (2003a).

In crux, it is concluded that early planting of soybean (21 January) is more appropriate in terms of higher yield than late-sown crop in agro-ecological conditions of Faisalabad. Under these conditions cultivar Faisal soybean seems more suitable than SA 72-60, as it outperformed regarding productivity.

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Fig. 1 : Mean Weekly Weather Data for Soybean Growing Season January - June in 2012.

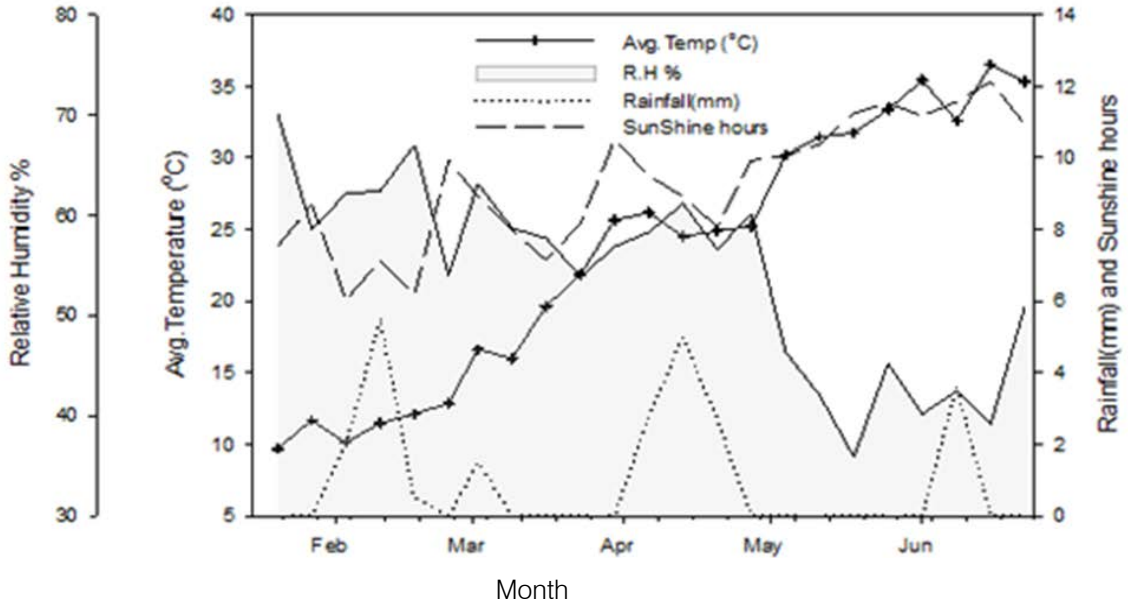

Table 1 : Effect of Various Plant Times on Yield and Quality Attributes of Different Soybean Cultivars.

Treatment	Number of pods per plant	Number of seeds per plant	Plant height (cm)	1000-seed weight (g)	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Protein percent	Oil percent
Variety								
SA 72-60	20.19 b	53.58 b	76.16 b	70.63	1121.9 b	4165.7	32.61	19.84
Faisal soybean	21.79 a	58.72 a	80.83 a	70.96	1228.0 a	4221.3	32.98	20.10
LSD	1.03	2.28	3.75	NS	103.22	NS	NS	NS
Planting time								
T_1 = 21st Jan	21.97 b	57.81 b	91.13 a	71.85 ab	1413.3 a	4308.0 ab	31.65 c	20.90 a
T_2 = 28th Jan	29.53 a	81.23 a	96.23 a	74.79 a	1530.2 a	4430.5 a	32.57 b	20.60 ab
T_3 = 4th Feb	21.43 b	57.95 b	78.77 b	71.48 b	1193.8 b	4187.0 bc	32.92 ab	20.05 bc
T_4 =11th Feb	19.10 b	50.04 c	65.83 c	69.88 b	929.8 c	4092.8 cd	33.53 a	19.37 cd
T_5 = 18th Feb	12.90 c	33.73 d	60.50 c	65.97 c	807.7 c	3949.3 d	33.32 a	18.92 d
LSD	3.44	3.97	6.44	3.14	175.69	204.90	0.64	0.77
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

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