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Effect of different sowing dates on growth, yield and quality of soybean cultivars

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Abstract

Pakistan is spending lion share of its foreign exchange for the import of edible oil to meet the requirements of ever increasing population. Being rich source of protein and oil, soybean (*Glycine max* L.) crop can play significant role in this regard. Time of sowing is one of the most critical factors which greatly influence the growth, yield and quality of soybean crop. In order to determine the response of two soybean varieties on different planting dates, an experiment was conducted at Agronomic Research Area, University of Agriculture Faisalabad during spring season 2016. Two soybean varieties Malakand-96 and Kharif-93 were sown on three sowing dates; 15th March, 25th March and 04th April. The experiment was laid out in split plot design replicated three times keeping sowing dates in main plot and varieties in subplots using net plot size of 6.0 m x 1.8 m. The data related to quality, yield and yield components and growth parameters were recorded and analyzed statistically by applying Fisher's analysis of variance technique. Least significant difference (LSD) test at 5% probability level was applied to compare the treatment means. The final yield and yield parameters were compared by t-test as early two sowing dates resulted in complete mortality of plant. Statistical analyzed data showed that germination count was better in 4th April planting (54 plants m^{2}) than 15th and 25th March. At 4th April sowing Kharif-93 gave higher grains per pod (2.8), 1000 grains weight (160.67 g), grain yield (1.15 t ha^{-1}), harvest index (31.96%), and oil contents (18.13%) than soybean variety Malakand-96. It is concluded that March planted crop did not reach to its potential ability due to unfavorable environmental conditions. Hence 4th April planting recommended for planting soybean and among two varieties Kharif-93 performed better under Faisalabad conditions.

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Introduction

Pakistan imported 1.98 million tons of edible oil worth Rs. 152.514 billion (US$ 1.457 billion) to fulfill the domestic requirement of 2.045 million tons during the year 2016-17 whereas, the local production contributed 0.446 million tons only (14 percent of the requirement) (Govt. of Pakistan, 2016-17). This is sufficient to indicate the poor condition of oilseeds cultivation and production in the country. Due to ever increasing population especially in developing countries, including Pakistan the supplication of edible oil especially from animal source is becoming scarce and expensive (Amiri *et al.*, 2012). Being rich source of protein and oil, soybean (*Glycine max* L. Merrill) crop can play significant role in this regard.

In Pakistan improved varieties of soybean were introduced from USA during early sixties while its commercial cultivation was started in early seventies, since then its cultivation has been unstable in Pakistan and never attained a large yield (MINFAL, 2006). Low production of soybean in Pakistan might attributed to lack of précised information regarding its production technology, high temperature, poor stand establishment, poor varietal adoptability and poor marketing (MINFAL, 2006). Among these time of sowing is one of the most critical factors which greatly influence the yield of soybean crop (Ahmad *et al.*, 2010). It has been observed that sowing time greatly affects the seed germination (Andric *et al.*, 2007) vegetative and reproductive performance (Bastidas *et al.*, 2008) and grain yield (Egli and Cornelius, 2009). Moreover, soil moisture is vital from seed germination to maturity for high yield potential of soybean (Mengistu and Heatherly, 2006). Sowing date generally determines the yield potential of a cultivar in an agro-ecological zone. Optimal utilization of the climatic factors such as temperature, humidity, moisture, day length etc. is achieved through appropriate planting dates (Hashemi, 2001). For every agronomic produce selection of appropriate sowing date is very important in order to get maximum yield. The objective of selecting appropriate planting date is the determination of proper time at which all environmental factors are effective for different phonological stages of the plant (Azari and Khajepour, 2003).

In one study it was observed that higher temperature and radiations shifted the reproductive phase towards less favorable conditions (Egli and Burdening, 2000). High temperature due to delayed cultivation of soybean caused more respiration in pods as a result less storage of assimilates took place. Because of this reason seed yield reduced, plant height also reduced, less oil percentage and smaller seed produced (Whitfield, 1992).

Under field conditions temperature fluctuate greatly and affect the growth of plants. During the growing season of soybean when temperature increased from optimum, it caused stress conditions and had destructive effect on blooming, pod development, seed formation and full maturity of crop (Khan *et al.*, 2011). Quality parameters include protein and oil contents of seed, are greatly influenced by inherited factors such as choice of cultivar and maturity group, climatic factors for example, temperature and moisture (Robinson *et al.*, 2009) at the time of seed formation.

The variations in quality of seed are primarily due to the effect of temperature on the enzymes that contribute in the biosynthesis of fatty acids present in soybean seed particularly during the period of seed development (Bachlava and Cardinal, 2009). Keeping in view this discussion, the present study was planned to evaluate the potential and adaptability of approved soybean cultivars under Faisalabad conditions and also to determine the effect of sowing dates on the growth, yield and quality parameters of soybean cultivars.

Materials and methods

Experimental site and soil

The proposed study was conducted at student farm, Agronomic Research Area, University of Agriculture, Faisalabad to examine the performance of two soybean cultivars sown at various sowing dates under Faisalabad conditions. The climate of this region is from semiarid to subtropical. Soil testing before the experiment was done to check the pH and nutrient status in the soil.

Design and treatments

The experiment was laid out in split plot design with three replications. The sowing dates (15th March, 25th March and 04th April) were considered as main factors and soybean varieties (Malakand-96 and Kharif-93) as sub factors. The net plot size was 6.0 m x 1.8 m.

Crop husbandry

Seed bed Preparation

Seed bed was prepared by applying soaking irrigation (rouni). After that the field was cultivated two times with the help of cultivator followed by the same number of planking.

Sowing date and Seed rate

The crop was sown at respective dates each of 10 days interval with the help of hand drill at 30 cm spaced rows with seed rate of 100 kg ha^{-1}.

Fertilizer application

Fertilizer was applied at the rate of 25 kg N, 50 kg P and 50 kg K ha^{-1}. All nutrients were applied at the time of sowing in the form of urea, diammonium phosphate and sulfate of potash respectively.

Irrigation

Total six irrigations were applied during the whole growth period of crop till maturity. 1st irrigation was applied 7 days after emergence, 2nd at three to four leaf stages, 3rd after thinning, 4th during flower initiation, 5th during pod formation and 6th during seed development.

Intercultural practices

Hoeing was done by manual method. Two hoeing were given to ensure optimum control of weeds in crop 20 and 40 days after sowing.

Harvesting

Harvesting was done manually with the help of sickle. Harvested crop was tied into bundles and allowed to dry in the field for 10 days to lower the moisture level up to 12%.

Data collection

In this experiment, the parameters of seed yield and its components, the qualitative parameters such as seed protein and oil contents were recorded.

At the end of growth season, ten randomly sampled plants were taken from the central rows of each plot and measured yield attributes and morphological characteristics. The weight of 100 seeds was recorded as the average of three 100-seed samples and calculated 1000-grain weight by unit method. Also, to determine biological yield, whole plant dry weight was considered as biological yield. Harvest index was calculated by following formula;

$$Harvest\ index = \frac{Grain\ Yield}{Biological\ Yield} X\ 100$$

Oil content was determined by Soxhlet Fat Extraction method (A.O.A.C., 1990).Percent oil content was calculated using the following equation;

$$Oil\ Contents\ (\%) = \frac{Weight\ of\ flask + oil - Weight\ of\ flask}{Weight\ of\ flask + seed - Weight\ of\ flask} X100$$

Protein in seed was determined according to Kjeldhal method (Bremner, 1964). Percent crude protein was calculated using the formula;

$$(Crude\ Protein\%) = \frac{(V1 - V2)N}{100\ W} X\ 14X\ 6.25X\ 100$$

Statistical analysis

Data collected on all parameters was analyzed statistically by using Fisher's analysis of variance technique and least significant difference (LSD) test at 5% probability level was applied to compare the treatments' means (Steel *et al.*, 1997) using the computer statistical program MSTATC. Final data of yield and quality parameters were recorded in 4th April planting only. So there were only two varieties sown at that sowing hence t-test was applied to compare the significance level of these varieties.

Results and discussion

Germination count

The data for germination count is presented in the Table 2. A perusal of table showed that various sowing dates significantly differed from one another in case of germination count. Among three sowing dates 4th April sowing performed better as compared to 15thand 25th March sowing. In case of varieties germination count was not affected significantly. Interaction of sowing dates and varieties was found significant. Low germination count of 15th March might be due to low metabolic activities of

germination enzymes within the seeds because of low temperature (17.5°C) than optimum (20°C-30°C) required for soybean germination as compared to 4th April planting (27°C). Our findings are also confirmed by Asim (2008) who found that average minimum temperature from 15°C to 19°C caused the reduction in germination as compared to temperature from 22°C to 27°C. Similarly Chamandi *et al.* (2012) recorded same results, according to them early sowing (low temperature) often reduced the emergence of soybean than that in late sowing.

Table 1. Physiochemical analysis of experimental soil.

Characteristics	Unit	Value
Texture	Sandy loam	
pH		8.00
EC	dS m^{-1}	0.16
Organic matter	%	0.31
Nitrogen (N)	%	0.019
Phosphorus (P)	Ppm	5.66
Potassium (K)	Ppm	102

Plant height (cm)

April sowing had positive effect on plant height when compared with March sowing. Table 2 showed that there was no significant effect of varieties on plant height and interaction of sowing dates and varieties was also non-significant. An increase in plant height at 4th April planting might be because of long time period for vegetative growth, more rainfall which affects positively and induced more water availability as compared to March planting. Relatively high temperature caused the reduction in vegetative period of crop in case of March sowing.

These findings seem to be supported by the findings of Asim (2008) and Taghavi *et al.* (2012) who found the maximum plant height in April planting that was gradually decreased with delay sowing dates due to discrepancy in climatic conditions of a region. Bastidas *et al.* (2008) also in accordance to our findings that late planting in June caused increase in plant height due to greater inter-nodal distance and less number of nodes than May planting.

Days to flower initiation

The data presented in table 2 revealed that sowing dates have significant difference in days taken to flower initiation. Both varieties Malakand-96 and Kharif-93 showed non-significant effect on days to flower initiation.

The interactive effect of sowing dates and varieties was also found to be non-significant. Early flowering in March sowing might be attributed to mean maximum temperature of 41°C with no rainfall during vegetative stage which hastened the initiation of reproductive stage (flower formation) compared with the temperature 37°C with rainfall in case of April planting (65.33 days after planting). These results are in agreement with Asim (2008) who found that high temperature boosted the reproductive development of soybean and relatively low temperature slow down these processes. Similarly Pedersen and Lauer (2003, 2004a, 2004b) after their experiments concluded that all reproductive stages of soybean from flowering to seed formation were delayed with three week delay in sowing.

Days to pod formation

Statistical analysis of data revealed that various sowing dates significantly differed from one another in case of days taken to pod formation (Table 2). No significant effect of varieties on days to pod formation was found. The interaction between sowing dates and varieties was also found to be non-significant. Minimum days from planting to pod formation in March sowing might be due to temperature stress.

In March planting very high temperature (43 to 45°C) during the month of June reduced the duration of flowering and pod formation started earlier in contrast to April planting pod formation started almost in mid-July with mean maximum temperature of 35 to 37°C. Heavy rainfall during the month of July also reduced the temperature and low temperature delayed the pod formation in April planting. These findings are in accordance with Pedersen and Lauer (2003, 2004a, 2004b) they observed that all reproductive stages of soybean from the flowering to seed formation were delay with three week delay in sowing.

Table 2. Effect of different sowing dates on growth parameters of soybean cultivars.

Treatments		Germination count	Plant height (cm)	Days to Flower initiation	Days to Pod formation	Flower per plant
15th March	Malakand-96	39 b	41.21 b	56.67 b	87.00 b	57 b
	Kharif-93	39 b	40.00 b	56.00 b	85.00 b	52 b
25th March	Malakand-96	52 a	39.55 b	53.66 b	82.00 b	49 b
	Kharif-93	42 b	36.89 b	57.67 b	83.00 b	51 b
04th April	Malakand-96	49 a	56.77 a	64.66 a	99.33 a	78 a
	Kharif-93	54 a	50.99 a	66.00 a	101.67 a	81 a
Sowing time		N/A	5.714	5.937	8.326	13.892
Variety		N/A	NS	NS	NS	NS
Sowing time × Variety		6.154	NS	NS	NS	NS

Flowers per plant

Flowering is an important agronomic trait that determines crop yield. No significant difference was observed between varieties and the interaction of cultivars and planting dates (Table 2).

Variation in number of flowers was due to the effect of temperature and moisture. High temperature and no rainfall in late May caused the shedding of flowers in March planting compared with April planting whose flowering period was started in the month of June. Rainfall in June lowered the soil temperature and provided favorable environment which resulted in more number of flowers in April planting.

These findings are in line with the results of Staton (2012), who stated that high temperature and moisture stress reduced the flower production by aborting the flower blossom. So it is concluded that flower production reduced in early sowing (March planting) as compared to late sowing (April planting).

Pods per plant

The productive potential of an oil seed crop is finally determined by the number of pods produced per plant, which is main yield component.

The data regarding the number of pods per plant shows significant difference among three sowing dates but both varieties produced similar number of pods per plant. Interactive effect of cultivars and planting dates was also non-significant (Table 3). Reduce fruit set in March planting might be due to higher temperature (45°C) during flowering and pod formation as compare to April planting. High temperature caused the flower abortion and reduced the fertilization of flowers which resulted in decreased number of pod set. Increased pod formation in April sowing might be due to long reproductive stage and more time to reach the full maturity. These results are in agreement with Taghavi *et al.* (2012), Asim (2008), Sadeghi and Niyaki (2013) who observed highest number of pods per plant in April sowing due to favorable environmental conditions as compared to other sowing dates. Similarly Sincik *et al.* (2009) found 15.1% more number of pods per plant from April planting than May planting. These findings supported our study because we also recorded the maximum number of pods per plant in April sowing when compared with March sowing.

Unfertile pods per plant

Data regarding the unfertile pods is summarized in (Table 3) which shows significant differences among

the sowing dates. No significant difference had been recorded for two varieties. The interaction effect of cultivars and planting dates on unfertile pods per plant was also found to be non-significant. Khan *et al.* (2011) also observed that temperature stress in the range of 35-43°C at the time of pod development and seed formation severely affected the seed filling resulted in unproductive pods. Similarly Thomas *et al.* (2003) concluded that reproductive growth of soybean was depressed due to very high temperature; particularly above 40°C seed development was reduced.

Table 3. Effect of different sowing dates on yield attributes of soybean cultivars.

Treatments		Pods per plant	Unfertile pods per plant	Fertile pods per plant	Productive plants
15th March	Malakand-96	7 b	6 a	1 b	4 b
	Kharif-93	7 b	6 a	1 b	5 b
25th March	Malakand-96	6 b	5 a	1 b	4 b
	Kharif-93	8 b	6 a	2 b	4 b
04th April	Malakand-96	24 a	3 b	21 a	30 a
	Kharif-93	27 a	4 b	23 a	32 a
Sowing time		6.312	1.274	9.157	12.576
Variety		NS	NS	NS	NS
Sowing time × Variety		NS	NS	NS	NS

Fertile pods per plant

There was no seed formation in March planting because of high temperature stress during flowering and pod formation. Therefore maximum number of unfertile pods was produced during March planting. Number of fertile pods was only produced in 4th April planting (Table 3). A measurable seed setting was found in 15th and 25th March sowing due to less pollen viability, less number of flowers per plant (Table 2) and reduced fertilization under high temperature stress. Hence no. of fertile pods was extremely negligible in early plantings of 15th and 25th March.

Productive plants

Number of plants per unit area is an imperative constituent contributing to yield. Number of productive plants at harvest is given in the Table 3.The results showed that maximum number of productive plants was recorded in 4th April sowing as compare to 15th and 25th of March. Oplinger and Philbrook (1992) found that number of productive plants at harvest increased in June planting as compared to May planting because of high temperature and optimum moisture. Similarly Bastidas *et al.* (2008) recorded highest number of plants at harvest in late planting than that in early planting during first year of study.

Grains per pod

Table 4 shows that number of grains per pod was significantly different between two varieties at 4th April planting. Asim (2008), Shamsi and Kobraee (2012) and Ahmad *et al.* (2010), they reported that number of grains per pod was significantly different in different cultivars in case of late planting.

1000 grain weight (g)

Table 4showed that both varieties performed differently in case of 1000-grain weight. Kharif-93 gave statistically highest 1000-grain weight as compared to Malakand-96. This increase might be due to the effect of grains per pod and genetic potential of cultivar Kharif-93 to produce healthy grains. Daneshmand *et al.* (2013), Adeniyan and Ayoola (2006) and Karaaslan *et al.* (2012) found significant differences among the cultivars for 1000-grain weight.

Biological yield (tons ha^{-1})

Biological yield indicates the integrated relationship of vegetative and reproductive parts of the crop. This indicates the indirect photosynthetic efficiency of the crop. Table 4 indicates that two varieties performed equally. Biological yield was statistically at par between two varieties Malakand-96 and Kharif-93. The t-test was used to compare the level of significance of two varieties sown at 4th April sowing.

Grain yield (tons ha^{-1})

Table 4 shows that there was significant effect of varieties on grain yield. Higher grain yield was given by Kharif-93 and lower grain yield was recorded in Malakand-96.The increase in seed yield might be attributed to good genetic potential, more grains per pod and more grain weight of Kharif-93 as compared to Malakand-96. These results are in agreement with the findings of Daneshmand *et al.* (2013), Kandil *et al.* (2012), Shamsi and Kobraee (2012) and Karaaslan *et al.* (2012). They concluded that grain yield was significantly differed among various cultivars due to genetic variability. Similarly Gulluoglu *et al.* (2011) after their study on genetic adoptability also found the significant effect of varieties on grain yield. These findings supported our present study. It has been concluded from this study that Kharif-93 sown at 4th April promotes the grain yield as well as yield components such as germination per sq. meter number of grains per pod and 1000- grain weight.

Harvest index (%)

It is the physiological efficiency of a crop plant to produce certain economical yield by utilizing the stored photo-assimilates. It is the ratio of seed yield to economical yield said in percentage. The calculated value of harvest index and t-statistics table 4 depicted that effect of varieties on harvest index was significant. Kharif-93 performed best with the harvest index as compared toMalakand-96.The improvement in harvest index of Kharif-93 was due to increased grain yield of crop plants. These results are in line with Daneshmand *et al.* (2013), Shamsi and Kobraee (2012) and Asim (2008). They found that effect of varieties on harvest index was highly significant.

Oil contents (%)

Oil contents of seed are an important quality parameter which is greatly influenced by inherited factors such as choice of cultivar and climatic factors at the time of seed formation. Data recorded for oil content of seed is presented in table 4 that shows that there was significant difference among two varieties. Statistically maximum oil contents were recorded in Kharif-93and minimum was produced in Malakand-96.

The increase in oil contents in Kharif-93 might be due to more genetic potential than other variety. These results agreed with Sudaric *et al.* (2006) who reported that influence of genotype and sowing time was greater on oil contents of soybean seed as compared to protein contents.

Protein contents (%)

Protein contents of seed are an important quality parameter which is greatly influenced by inherited factors such as choice of cultivar and climatic factors at the time of seed formation. Data recorded for protein content of seed is depicted in table 4which showed that there was significant difference among two varieties. Statistically maximum protein contents were recorded in Malakand-96 and minimum was produced in Kharif-93.These results are to be supported by Dadashi and Khajehpour (2004) they observed that grain yield and percentage of protein was negatively correlated with each other. Similarly Arslanoglu *et al.* (2011), Li *et al.* (2012), Santos *et al.* (2010) and Daneshmand *et al.* (2013) recorded significant effect of cultivars on protein concentration of soybean seed.

Conclusion

Among the three sowing dates 4th April planting performed better by improving the germination, growth and yield attributes of soybean varieties under Faisalabad conditions as compared to 15th and 25thMarch sowing. Early two sowing dates 15th and 25th March sowing resulted in complete mortality of plant at pod formation stage due to unfavorable environmental conditions. Kharif-93 responded well and gave 20% more yield than Malakand-96. Kharif-93 gave 20 % more oil contents than Malakand-96 while in case of protein contents Malakand-96 performed better.

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