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PERFORMANCE OF SOYBEAN (*GLYCINE MAX* (L.) MERRILL.) GENOTYPES UNDER MAIN AND SECOND CROPPING SYSTEMS: I. GROWTH, YIELD AND YIELD COMPONENTS

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Abstract

To determine the effects of planting date on growth, yield and yield components of soybean genotypes an experiment was conducted. The results showed that plant height, seed yield, pod number and protein content were affected significantly by planting date. Seed yield was 22.6% higher for optimal compared to late planting. Seed mass, plant height, oil and protein content were found significantly different among genotypes. Seed yield of genotypes ranged from 2443.93 to 2542.75 kg/ha, but the differences among genotypes were not statistically significant.

Introduction

Factors, such as soil type, cropping system, tillage, planting date and fertilizer application can effect growth and yield of soybean (*Glycine max* (L.) Merrill). Planting date has more influence on soybean seed **y**ield than any other production practice (Kandil *et al.* 2013). Soybean yield components (Cox *et al.* 2008, Bellaloui *et al.* 2011) and seed quality (Arslanoglu *et al.* 2011, Hu and Wiatrak 2012) can also be affected by planting dates. Early planting is a current recommendation for increasing soybean yield (De Bruin and Pedersen 2008, Robinson *et al.* 2009). Delayed planting dates often result in a suboptimal photoperiod, high temperatures, and traditionally low precipitation that can decrease the duration of vegetative and reproductive growth stages, reduce photosynthesis rate and therefore the growth and subsequent seed yield of soybean (Hu and Wiatrak 2012). Effects of planting date on soybean yield and yield parameters at various locations have been documented by several workers. De Bruin and Pedersen (2008) reported that average yield loss for delayed planting is 70 kg/ha/wk between late April and early May with a decline of 130 and 404 kg/ha/wk for the time period early May to late May and late May to early June, respectively. In spite of general yield improvement, inconsistent responses to planting date are reported in the several studies. No yield benefit to early planting was reported by Elmore (1990) and Oplinger and Philbrook (1992). Delayed planting also influences seed protein and oil, frequently resulting in increased seed protein concentration and decreased seed oil concentration (Kane *et al.* 1997, Pendleton and Hartwig 1973, Robinson *et al.* 2009).

Farmers in the southern Turkey can take advantage of a long growing season by producing two crops per year. Optimum planting date in the southern Turkey ranges from early to mid-May. When used as a second crop, soybean was planted after the harvest of previous crops such as wheat, barley, chickpea or lentil. In this practice of double cropping system, planting dates for the soybean crop are delayed until late June to early July. The objective of the present study was to quantify the impact of planting date on soybean yield, yield parameters, seed protein and oil of soybean genotypes in the southern Turkey.

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Materials and Methods

The study was conducted in the experimental field of the Department of Field Crops, University of Dicle (37°53′N, 40°16′E, 670 m a.s.l.) in south eastern of Anatolian Region of Turkey during the 2010 and 2012 growing season. Because of problem in irrigation system of the experimental field, the study cannot be carried out in 2011, as a result the study was delayed to 2012.The soil type was a clay and mid-alkaline. The long-term annual precipitation of the site is 490 mm, 18, 44, 37 and 1% of which falls in autumn, winter, spring and summer, respectively. Monthly air temperature, rainfall and humidity for 2010 and 2012 are presented in Table 1.

Table 1. Monthly temperature (°C), rainfall (mm) and humidity (%) in 2010 and 2012 growing seasons (Turkish State Meteorological Service, Diyarbakir).

Months	Temperature (°C)						Rainfall (mm)		Humidity (%)	
	Min.		Max.		Mean					
	2010	2012	2010	2012	2010	2012	2010	2012	2010	2012
May	7.0	8.6	34.1	33.0	20.5	20.8	31.6	41.0	49	58
June	11.7	9.4	42.0	41.7	26.8	25.5	11.2	7.0	29	28
July	17.7	14.5	43.3	43.7	30.5	29.1	0.0	1.6	20	21
August	17.2	17.1	42.7	41.0	29.9	29.0	0.4	0.0	21	26
September	13.8	12.8	39.7	37.9	26.7	25.3	0.0	1.8	27	23
October	3.9	7.3	31.0	35.6	17.4	21.4	63.0	107.4	56	55

The treatments were replicated three times in split plot based on randomized complete block design with two planting dates (optimal planting date as main crop, and late planting date as second crop after wheat harvest) in the main plots and four genotypes in the sub-plots. Split plots within each main plot were four genotypes: Maturity group (MG) IV genotypes HA 16-21 and HA 36-37 developed by Cukurova University; Maturity group III commercial cultivars Nova and SA 88. The size of each plot was 2.8 × 5.0 m. Row spacing (four rows) was 0.7 m and the distance between plants in the row was 0.05 m, providing a sowing density of 28 plants/m^2. At harvest the two external rows were eliminated, as well as 0.5 m from each end of the central rows, considered as borders. At harvest, 10 soybean plants from each plot were selected randomly to determine plant height (from ground level to the main stem tips) and pod number per plant. After threshing, seed mass per 100 seeds, which was determined by a random sample of 100 seeds from the harvested seed from each plot. Seed mass and seed yield were determined after correction of the seed moisture content (average 13%). The seed samples were grounded, the oil was extracted with diethyl ether using soxhlet apparatus. Protein content was measured as N×6.25 after analysis with N analyzer (Leco FP-2000, Leco Corp., St. Joseph, MI).

The statistical significance of differences in the traits between groups was analyzed with analysis of variance (ANOVA) and Tukey's HSD test using a statistical software package (JMP version 5.0.1a), $p < 0.05$ was considered to indicate a statistically significant difference.

Results and Discussion

As seen in Table 2, planting date had appreciable effect on seed yield ($p < 0.05$), pod number ($p < 0.05$), plant height ($p < 0.01$) and protein content ($p < 0.01$). Seed mass ($p < 0.01$), plant height ($p<0.01$), oil content ($p < 0.05$) and protein content ($p < 0.01$) were affected by genotype. However, there was no significant interaction between planting date and genotypes for all components.

Mean plant height was approximately 22% less for the planting on 25 July (late) as second crop than for the planting on 20 May (optimal) as main crop (Table 3). Plant height is a genetic trait that varies among soybean cultivars and can also be affected by planting date. Delayed planting reduces main stem node number (Bastidas *et al.* 2008, Pedersen and Lauer, 2004a) likely due to declining photoperiod and warmer temperatures hastening maturity (Major *et al.* 1975) and this caused shorter plant height. The effect of delayed planting on reduction of plant height agrees with previous reports by Board and Settimi (1986). However, Pedersen and Lauer (2004a) found that plants in the late May planting were 35 cm shorter than plants in the early May planting, but at R6, plants in both planting dates were nearly equal in height. Plant height in HA 16-21 (MG IV) and HA 36-37 (MG IV) were significantly ($p < 0.05$) higher than those of Nova (MG III) and SA 88 (MG III). As expected, the MG IV genotype was generally taller than the MG III due to difference of vegetative growth duration.

Table 2. Analysis of variance for plant height, seed yield, yield components, oil and protein content of soybean genotypes grown at two planting dates in 2010 and 2012.

Source of effects	df[†]	Plant height (cm)	Seed mass (g)	Pod number (no/plant)	Seed yield (kg/ha)	Oil content (%)	Protein content (%)
Planting date (PD)	1	**	NS	*	*	NS	**
Genotype (G)	3	**	**	NS	NS[‡]	*	**
PD × G	3	NS	NS	NS	NS	NS	NS

[†]df, degree of freedom. *Significant at $p < 0.05$. **Significant at $p < 0.01$. [‡]NS, not significant at $p < 0.05$.

In the present study, seed mass response did not differ appreciably by planting date, with similar seed mass recorded in both optimal and late planting for all genotypes. However, a slightly decreasing trend in seed mass was observed as the planting date was delayed. These results are in agreement with previous research suggesting that delayed planting date has little or no effect on soybean seed mass (Pedersen and Lauer 2004a), although other studies have exhibited both increased (Bastidas *et al.* 2008) and decreased (Anderson and Vasilas 1985, Elmore 1990) seed mass with delayed planting. The contradictory results of the effect of planting date on soybean seed mass can likely be attributed to the variability of seed mass among genotypes (Robinson *et al.* 2009) and the influence of location-specific environmental conditions during the mid- to late seed filling period (Table 1) on seed mass (Ball *et al.* 2000, De Bruin and Pedersen 2008, Elmore 1990). Genotypes differed in seed mass with HA 16-21 (MG IV) having 10% larger seed mass than SA 88 (MG III) (Table 4). Pedersen and Lauer (2004b) stated that yield advantages between cultivars were correlated with seed mass, partially as a result of the number of seeds available for filling, the duration of the filling period, and total photosynthate production.

Pod number was influenced by planting date, with optimal planting date producing 42% more pods per plant than late planting. Delayed planting reduces pod number likely due to declining photoperiod and warmer temperatures hastening maturity (Major *et al.* 1975) and may explain main stem node number response to planting date (Bastidas *et al.* 2008, Pedersen and Lauer 2004a). Cox *et al.* (2008) found that soybean planted in mid-May had lower plant density than those planted in late May, but produced more pods per side branch, which contributed to more pods per plant and pods per unit area. Soybeans planted in mid-June had more plants per unit area but fewer pods per side branch, pods per plant, pods per unit area, seeds per unit area, and lower seed yield compared to those planted in mid-May (Khan *et al.* 2011). Longer photoperiods cause greater node production and node fertility and lead to greater pod and seed number production (Kantolic and Slafer 2001). Pod number was in general similar among the genotypes, but HA 16-21 and HA 36-37 (MG IV) was higher than those Nova and SA 88 (MG III). Genotypes differences in pod number were related to main stem pods per reproductive node and branch reproductive node number (Board and Harville 1996).

Table 3. Growth, yield, yield components, oil and protein content of soybean genotypes grown at two planting dates in 2010 and 2012.

Planting date	Genotype				
	HA 16-21	HA 36-37	Nova	SA 88	Mean
Plant height (cm)					
Optimum	115.23	109.63	94.77	95.13	103.69a
Late	91.67	91.40	81.90	74.20	84.79b
Mean	103.45a	100.52a	88.33b	84.67b	94.24
Seed mass (g)					
Optimum	16.08	14.28	15.22	14.32	14.97
Late	15.03	14.62	14.59	13.99	14.56
Mean	15.55a	14.45bc	14.90ab	14.15c	14.77
Pod number (no./plant)					
Optimum	100.67	101.83	98.27	94.90	98.92a
Late	66.03	77.63	66.47	68.87	69.75b
Mean	83.35	89.73	82.37	81.88	84.33
Seed yield (kg/ha)					
Optimum	2725.60	2766.83	2842.37	2607.07	2735.47a
Late	2166.27	2318.67	2160.20	2280.80	2231.48b
Mean	2445.33	2542.75	2501.29	2443.93	2483.47
Oil content (%)					
Optimum	21.55	20.20	19.23	19.77	20.19
Late	20.45	19.44	18.29	19.29	19.37
Mean	21.00a	19.82ab	19.53b	18.76b	19.78
Protein content (%)					
Optimum	38.82	38.81	37.65	35.65	37.73a
Late	33.63	35.57	33.71	32.03	33.73b
Mean	36.22b	37.19a	35.68b	33.84c	35.73

Means followed by the same letter are not significantly different at $p < 0.05$.

The difference between planting 20 May (optimal) and 25 June (late) was 504 kg/ha and was sufficient ($p > 0.05$) to suggest that optimal planting provided greater yield compared to late planting (Table 3). Plants that flowered earlier were exposed to a greater quantity of sunlight due to longer photoperiod and solar radiation intensity, factors associated with increased yield (Cooper 2003). Different photoperiod and temperatures during vegetative and seed filling stages at the two planting dates might have contributed to the differences in seed yield. Other studies have reported 200 kg/ha (Lueschen *et al.* 1992) and 300 kg/ha (Grau *et al.* 1994) yield loss for mid-May compared to early May planting. In contrast, Elmore (1990), Oplinger and Philbrook (1992) have also reported no positive effect on seed yield from planting dates. No difference was found in seed yield among genotypes (Table 2). However, Nova (MG III) had the highest seed yield at optimal planting date while the lowest seed yield at late planting. At the late planting, HA 36-37 (MG IV) and SA 88 showed higher seed yield than other two genotypes.

Oil concentration remained consistent across planting dates (Table 3). However, there was a trend of decreasing oil concentration as planting date was delayed. Rowntree *et al.* (2013) found that there was no evidence of an effect of planting date on seed oil concentration. Oil, on the other hand, showed no clear association with the changes in temperatures observed between planting dates. Mean oil and protein content was significantly higher in MG IV (HA 16-21 and HA 36-37) than MG III (Nova and SA 88) (Table 3). The lower oil and protein concentrations in MG III (Nova and SA 88) have been attributed to a shorter growing season (Piper and Boote 1999) when compared to MG IV (HA 16-21 and HA 36-37). Seed oil and protein concentrations are primarily dictated by genetic factors such as cultivar selection and maturity group (Kane *et al.* 1997) and environmental factors such as temperature (Robinson *et al.* 2009) during the reproductive phases of growth, particularly R5 to R6.

The soybean genotypes exhibited significantly lower protein concentration in the late planting (Table 3). Jaureguy *et al.* (2013) reported that soybean have shown a gradual decrease in protein when planted later than the second week of May in other studies. The decrease in protein concentration with planting date observed in this experiment supported the observation that cool temperatures experienced during seed-filling play a significant role in determining soybean seed protein, agreed with patterns observed in other studies (Kane *et al.* 1997, Jaureguy *et al.* 2013). Kumar *et al.* (2006) indicated that shortened duration from flowering to maturity might have contributed to reduction of protein accumulation.

Delaying planting could adversely affect the growth and development of soybean, and result in a significant reduction in seed yield and yield components. It appeared that the yield reduction was greater as the planting date was delayed. The shortened duration of vegetative growth and seed filling period probably contributed maximum to the yield decrease observed in later planted soybean. Vegetative growth, especially plant height was affected by delayed planting resulting in a fewer pods and decreased yield. High temperature conditions, which usually accompany late planting dates, could have negatively affected the growth, development and yield of soybean. The seed yield of HA 36-37and Nova genotypes (MG IV) was obtained higher than HA 16-21 and SA 88 (MG III) genotypes.

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