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THE EFFECTS OF TWIN-ROW PLANTING PATTERN AND PLANT POPULATION ON SEED YIELD AND YIELD COMPONENTS OF SOYBEAN AT LATE DOUBLE-CROPPED PLANTING IN CUKUROVA REGION

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ABSTRACT

This study was conducted at the experimental area of Department of Field Crops, Faculty of Agriculture, Cukurova University in 2013 and 2014. The objective of this study was to determine the influence of planting pattern and plant population on seed yield and yield components of soybean at late double-cropped (after 15th of July) planting in Cukurova region, Turkey. The experimental design was a Randomized Complete Block Design with three replications. The Atakisi (maturity group III) variety was used as a plant material in this research. The planting pattern was used as twin-row and conventional single-row. The row spacing was 70 x 25 x 70 cm, 75 x 25 x 75 cm and 80 x 25 x 80 cm for twin-row and 70 cm for single-row pattern. Intra-row spacing of 3, 4, 5 and 6 cm was arranged for different plants population. In this research, the plant populations varied between 31.6 and 69.9 plants m^{-2}. According to a two-year average, the highest seed yield (4906 kg ha^{-1}) was obtained from 80 x 25 x 80 x 3 cm (63.2 plants m^{-1}) twin-row planting pattern while the yield was 3940 kg ha^{-1} in single-row planting pattern as 70 x 4 cm (35.7 plants m^{-1}). The yield increase was 24.5% more than conventional single-row planting pattern (standard).

Key words: Double-cropped, Plant population, Planting pattern, Soybean, Twin-row

INTRODUCTION

Soybean [*Glycine max* (L.) Merr.] seed contains 21% oil, 40% protein, 34% carbohydrates and 5% ash on a dry matter basis. For this reason, it is an important source of edible vegetable oil and protein for both human nutrition and animal feeding. It uses for vegetable oil production and livestock feed in the world. Soybean is a legume crop and it improves soil fertility by fixing atmospheric nitrogen (Gulluoglu et al., 2010 and Arioglu, 2014).

Soybean has been grown mainly as a double-cropped after a small grain harvest in the Cukurova region in Turkey. The share of the double-cropped was 70% in the total Turkey soybean planting area of 34.000 ha. Cukurova is the major soybean production area in Turkey with 90% production share (Anonymous, 2014a).

The main competition factors can be identified as light, water and nutrients for plants. The competition between the plants can be regulated by the optimum plant number per unit area. Planting density is an important factor for soybean growth and seed yield. When planting density is high, the branching of each plant is depressed and the number of the lateral stem decrease. In addition, under high planting density the competition for photosynthesis and nutrient absorption among plants become severe and the stem grows tall and thin. Generally, soybean grown in high plant density produces a higher yield than of those grown in low density (Egli, 1988; Aslam et al., 1993; Hosseini et al., 2001; Calışkan et al., 2007; Liu et al., 2010; Cox and Cherney, 2011; Worku and Astatkie, 2011; Rahman and Hossain, 2011; Zhou et al., 2011; Bruns, 2011; Shamsi and Kobraee, 2011 and Akond et al., 2013).

The seed planting starts first week of June and continues to mid of July in double-cropped soybean farming in Turkey. Soybean is classified as short day plant because short days initiate the flowering process. Soybeans will flower very soon after emerge if the day length is short. For this reason, when the planting delayed after June 21, the vegetative growth stage of plants shortened and plants start to flowering due to short day conditions. Other side, in this conditions the plants can not grow tall and the number of the lateral stem decrease. As a result, pod number per plant was decreased and the seed yield was lowered. Two agronomic traits of average seed size and number of seeds per unit area directly affect of the yield (Ohyama et al., 2013). In soybean crop, these parameters can be described in terms of average number of seeds per pod, average number of pods per plant, and number of plants per unit area Soybean seed yield is calculated by multiplying the plant number per unit area x pod number per plant x seed number per pod x one average seed weight (Aslam et al., 1993). It is necessary to increase the plant number per unit area to compensate to reduction of pod number per plant at late planting double crop soybean farming. Increasing the plant number per unit area, it is necessary to reduce the plant space on the rows. The plants grow thin and weak for competition and the pod number per plant is decreases. It is possible to increase the number of plant per unit area by the Twin-row planting pattern.

High plant populations provide a way to optimize grain yield in short-season production systems. Twin-row planting pattern is very important at late planting double-cropped soybean production. Several experiments conducted on twin-row planting pattern and plant population under different soil and climatic conditions indicated that yield is higher in twin-row planting than single-row planting (Ikeda, 1992; Bell, 2005; Koger, 2007; Mascagni et al., 2008; Stalcup, 2009 and Bruns, 2011).

Usually single-row planting pattern and 135.142 plant ha^{-1} (70x4 cm) plant density were applying in double-cropped soybean production in Cukurova region, Turkey. Twin-row planting pattern was not used so far in soybean production in Cukurova region.

The objective of this study was to determine the influence of twin-row planting pattern and plant population on seed yield and yield components of soybean at late double-cropped planting in Cukurova region, Turkey.

MATERIALS AND METHODS

Materials

Field experiments were conducted in 2013 and 2014 as a second crop after wheat harvesting, between July and October at the Cukurova University research farm in Adana, Turkey (Southern Turkey, 36º59 N, 35º18 E; 23 elevation). The Atakisi variety was used as a plant material in this research. Atakisi is medium early (maturity group III) and high-yielding indeterminate soybean variety.

The texture of the soil was clay loam. The salt content of the soil was low. The soil tests in both years indicated a pH of 7.7 with high concentrations of K_2O and low concentrations of P_2O_5. In addition, the organic matter and nitrogen content of the soil was very low. The lime content was 24.13 % in the upper layers with increased levels in lower layers.

In the Adana province of Turkey, winters are mild and rainy, whereas summers are dry and warm, which is a typical of a Mediterranean climate. The average monthly air temperature during the research period (July-October) was 19.5 to 28.6 ºC in 2013, whereas it was in 21.0 to 29.1 ºC range in 2014. The total rainfall was 31.5 mm and 148.8 mm during the growing periods in 2013 and 2014, respectively. The average relative humidity was ranged from 47.9% to 69.0% in 2013 and 62.9% to 72.6% in 2014 (Table 1).

Table 1. The average monthly temperature, monthly precipitation and relative humidity at Adana-Turkey, during the 2013 and 2014 growing seasons (Anonymous, 2014b)

Months	Avg. temperature (ºC)		Precipitation (mm)		Relative humidity (%)	
	2013	2014	2013	2014	2013	2014
July	28.2	28.2	0.0	0.3	65.2	72.6
August	28.6	29.1	0.0	0.3	69.0	70.3
September	25.3	25.9	15.0	80.4	63.1	64.1
October	19.5	21.0	16.5	67.8	47.9	62.9

Method

The experimental design used in this study was a Randomized Complete Block replicated three times. The experimental site was cultivated deeply by the disked-harrowed after wheat harvesting in both years. Before planting, 200 kg ha^{-1} of DAP (36 kg ha^{-1} N, 92 kg ha^{-1} P) fertilizers were applied. Mineral fertilizer rates were determined based the nutritional requirements of soybean and soil nutrient availability. Weed control was accomplished at both years with a pre-plant application of Treflan (trifluralin) at amount of 1.5 L ha^{-1}. The plot size was varied from 14.0 m^2 to 21.0 m^2 according to planting pattern and row distance. Twin-row and single-row planting patterns were sown in Figure 1. Plots were planted by hand in the 17th of July in both years. Before planting, all seeds were inoculated with *Bradyrhizobium japonicum* bacteria.

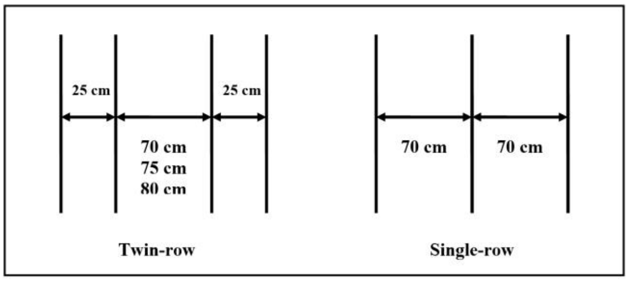

Figure 1. Twin-row and single-row planting patterns

During the growing period, recommended pesticides were applied to control insects and diseases. Plots at both years were furrow irrigated beginning at R1 (beginning flowering) and continuing to R6 (full seed). Approximately 30 mm of water was applied at about 15 day intervals. During the growing period, other standard cultural practices were applied at proper time intervals.

The soybean seeds were planted at a high density at planting and then plant distance (plant density) was regulated by pulling out plants (thinning) at the V2 growth stage (two trifoliolate leaf nodes). The planned of planting patterns and plant populations are given in Table 2.

Table 2. The planned planting patterns and plant populations in experiment

Planting patterns	Row spacing (cm)	Plant spacing (cm)	Plant numbers (plant m^{-1})	Seeding rate* (kg ha^{-1})
Twin-row	70 x 25	3	69.9	108.7
Twin-row	70 x 25	4	52.6	81.9
Twin-row	70 x 25	5	42.1	65.4
Twin-row	70 x 25	6	34.9	54.3
Twin-row	75 x 25	3	66.4	103.3
Twin-row	75 x 25	4	50.0	77.8
Twin-row	75 x 25	5	40.0	62.2
Twin-row	75 x 25	6	33.2	51.7
Twin-row	80 x 25	3	63.2	98.7
Twin-row	80 x 25	4	47.6	74.1
Twin-row	80 x 25	5	38.1	59.2
Twin-row	80 x 25	6	31.6	49.2
Single-row**	70	4	35.7	55.6

*100 seed weight was 14.0 g and seed germination was 90%. ** Single-row (70x4 cm) is a conventional planting pattern in Cukurova

Measurement of characteristics

Data was measured from the 10 pants which were randomly selected from the central rows of each plot and then cut from the ground just before harvest. Average plant height (cm), the lowest pod height (cm), branch number (no.plant^{-1}) and pod number (no. plant^{-1}) were calculated as the quotient of their respective values and the number of sampled plants (n=10). Yield data per plot was measured in a similar way from all remaining plants excluding the very end on each side of the two central rows. 100-seed weight (g), oil content (%) and crude oil yield (kg ha^{-1}) data were obtained after harvest (Zaimoglu et al., 2004).

The data were statistically analyzed by using MSTAT-C package program with Randomized Complete Block Design. The Least Significant Differences (LSD) test was used to compare the treatments at 0.05 level.

RESULTS AND DISCUSSION

The Plant Height and Lowest Pod Height

The data belonging to plant height and the lowest pod height at different planting pattern and plant densities at late planting double cropped soybean production are presented in Table 3.

Table 3. The effect of planting pattern and plant density on plant height (cm) and the lowest pod height (cm) at the late planting double cropped soybean production

Row spacing (cm)	Plant numbers (plant m^{-1})	Plant height (cm)			Lowest pod height(cm)		
		2013	2014	Mean	2013	2014	Mean
70 x 25-3*	69.9	86.6	103.4	95.0	19.6	22.5	21.1
70 x 25-4*	52.6	88.1	103.2	95.7	18.0	21.2	19.6
70 x 25-5*	42.1	83.7	98.8	91.3	14.6	20.3	17.5
70 x 25-6*	34.9	80.8	96.9	88.8	14.2	19.4	16.8
75 x 25-3*	66.4	90.2	98.4	94.3	17.9	22.0	19.9
75 x 25-4*	50.0	82.1	98.8	90.5	17.2	21.6	19.4
75 x 25-5*	40.0	86.9	98.9	92.9	16.5	21.8	19.2
75 x 25-6*	33.2	83.8	96.9	90.4	16.9	19.6	18.3
80 x 25-3*	63.2	83.9	98.0	90.9	14.9	22.6	18.8
80 x 25-4*	47.6	81.1	97.7	89.4	16.2	21.7	18.9
80 x 25-5*	38.1	83.5	96.8	90.1	17.4	21.2	19.3
80 x 25-6*	31.6	84.5	95.3	89.9	16.5	19.6	18.0
70x4**	35.7	82.1	95.5	88.8	15.0	18.4	16.7
LSD (5%)	-	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**

*Twin-row, **Single-row

The plant height values varied between 80.8-90.2 cm in 2013, and between 95.3-103.4 cm in 2014 (Table 3). The differences between the plant densities were not statistically significant in 2013 and 2014. The plant height in 2014 was higher when compared to 2013, because of the rainy weather after the emergence of the plants to the soil surface in 2014. This rainfall stimulated vegetative growth of the soybean plants and the plant height increased. The plant height varied between 88.8 cm and 103.4 cm in the two-year study (Table 3). As the plant density was increased in per unit area, plant height increased substantially. The competition between the plants increased to use more solar energy at high plant density. Similar results were reported by other researchers (Cox and Cherney, 2011; Rahman and Hossain, 2011 and Akond et al., 2013).

The lowest pod height is an important plant parameter to reduce harvest loss in soybean farming. Pods too close to the soil surface increase harvest losses since some combine harvester heads are unable to pick up the bottom pods.

The lowest pod height values varied between 14.2 and 19.6 cm in 2013; between 18.4 and 22.6 cm in 2014 (Table 3). The differences between the plant densities were not statically important in 2013 and 2014. Plants were significantly podded higher up the stem in 2014 than in 2013. The rainfall just after emergence stimulated vegetative growth of the soybean plants and it delayed flowering. For this reason, the bottom pod height was increased. According to two-year average, bottom pod height was varied between 16.7 cm and 21.1 cm. While the bottom pod height was 16.7 cm at standard planting pattern (plant density 35.7 plant m^{-1}), it increased up to 21.1 cm at twin-row planting pattern (plant density 69.9 plant m^{-1}). As the plant density increased in per unit area, plant height and bottom pod height increased substantially. As a result; the differences between the plant densities were not statically important. Similar results were supported by the findings by Aslam et al. (1993).

Branches Number and Pods Number

The data belonging to branches number and pods number per plant at different planting pattern and plant densities at late planting double cropped soybean production are presented in Table 4.

It can be seen in Table 4, the differences between the plant densities were not significant for number of branches in 2013, but it was significant in 2014. The branch number varied from 2.10 to 2.98 in a two-year average. Soybean produced more branches per plant at low plant densities (31.6 plant m^{-1}) compared with the high plant densities (69.9 plant m^{-1}). At low plant density, existing plants developed more branches because of reduced in competition. When planting density is high, the branching of each plant is depressed and the number of the lateral stem decrease. These results are in agreement with the findings of Hosseini et al. (2001); Dapaah et al. (2005); Cox and Cherney (2011); Worku and Astatkie (2011); Rahman and Hossain (2011) and Shamsi and Kobraee (2011).

Table 4. The effect of planting pattern and plant density on branches number per plant (no. $plant^{-1}$) and pods number per plant (no. $plant^{-1}$) at the late planting double cropped soybean production

Row spacing (cm)	Plant numbers (plant m^{-1})	Branches per plant (no. $plant^{-1}$)			Pods per plant (no. $plant^{-1}$)		
		2013	2014	Mean	2013	2014	Mean
70 x 25-3*	69.9	2.33	2.03 bc	2.18	45.4 e	46.0 f	45.7 h
70 x 25-4*	52.6	2.63	2.43 abc	2.53	49.4 de	50.0 ef	49.7 fgh
70 x 25-5*	42.1	2.77	2.30 abc	2.53	55.7 bcde	56.2 cde	56.0 def
70 x 25-6*	34.9	2.87	2.60 ab	2.73	58.7 abcd	61.0 bc	59.9 bcd
75 x 25-3*	66.4	2.63	1.67 c	2.15	48.1 de	49.9 ef	49.0 gh
75 x 25-4*	50.0	2.53	1.67 c	2.10	52.3 cde	53.6 de	53.0 efg
75 x 25-5*	40.0	2.93	2.40 abc	2.67	60.7 abc	60.0 bcd	60.4 bcd
75 x 25-6*	33.2	2.73	2.67 ab	2.70	66.3 ab	64.7 ab	65.5 ab
80 x 25-3*	63.2	2.63	1.63 c	2.13	55.7 bcde	55.2 cde	55.5 def
80 x 25-4*	47.6	2.83	2.67 ab	2.75	58.0 abcd	59.5 bcd	58.8 cde
80 x 25-5*	38.1	2.70	2.97 a	2.83	62.2 abc	64.9 ab	63.6 abc
80 x 25-6*	31.6	2.93	3.03 a	2.98	67.4 a	69.0 a	68.2 a
70x4**	35.7	3.13	2.67 ab	2.90	60.8 abc	61.3 bc	61.1 bcd
LSD (5%)	**-**	**N.S**	**0.820**	**N.S**	**10.87**	**6.818**	**5.238**

*Twin-row, **Single-row

There was a statistically significant difference in pod number per plant between plant densities in different planting pattern in both years. The pod number per plant values varied between 45.4 and 67.4 in 2013, and between 46.0-69.0 in 2014 (Table 4). There was a significant effect of plant density on pod number per plant.

The differences between the plant densities were statistically significant in a two-year average. The number of pods per plant varied from 45.7 to 68.2 in 2013 and 2014 years average. By increasing intra-row spacing at the same row spacing in twin-row planting pattern, the number of pods per plant was significantly increased in both years (Table 4). The pod number increase in the low plant density was a result of extra branching. At low density, existing plants developed more branches and pods because of reduced in competition. The number of pods and branches per plant tended to decrease with increased population density. These findings are supported by Aslam et al. (1993); Hosseini et al. (2001); Dapaah et al. (2005); Liu et al. (2010); Cox and Cherney (2011); Shamsi and Kobraee (2011); Bruns (2011) and Akond et al. (2013).

100-Seed Weight and Seed Yield

The data belonging to 100-seed weight and seed yield at different planting pattern and plant densities at late planting double cropped soybean production are presented in Table 5.

Table 5. The effect of planting pattern and plant density on 100-seed weight (g) and seed yield (kg ha^{-1}) at the late planting double cropped soybean production

Row spacing	Plant numbers	100-Seed weight (g)			Seed yield (kg ha^{-1})		
(cm)	(plant m^{-1})	2013	2014	Mean	2013	2014	Mean
70 x 25-3*	69.9	13.61	14.16	13.89	4530 ab	4558 bcd	4544 ab
70 x 25-4*	52.6	13.67	14.35	14.01	4390 abcd	4330 bcde	4360 bcd
70 x 25-5*	42.1	13.64	14.45	14.05	4007 bcde	4193 de	4100 def
70 x 25-6*	34.9	13.62	14.76	14.19	3625 e	4042 e	3833 f
75 x 25-3*	66.4	13.65	14.35	14.00	4623 ab	4654 bc	4639 ab
75 x 25-4*	50.0	13.59	14.60	14.10	4347 abcd	4635 bc	4491 bc
75 x 25-5*	40.0	13.58	14.71	14.14	4137 abcde	4397 bcde	4267 bcde
75 x 25-6*	33.2	13.55	14.84	14.20	3933 bcde	4330 bcde	4132 cdef
80 x 25-3*	63.2	13.69	14.70	14.15	4755 a	5057 a	4906 a
80 x 25-4*	47.6	13.68	14.72	14.20	4434 abc	4710 ab	4572 ab
80 x 25-5*	38.1	13.65	14.76	14.20	4045 bcde	4617 bc	4331 bcd
80 x 25-6*	31.6	13.62	14.77	14.20	3727 de	4297 cde	4012 def
70x4**	35.7	13.66	14.48	14.07	3814 cde	4067 e	3940 ef
LSD (5%)	**-**	**N.S**	**N.S**	**N.S**	**696.00**	**380.37**	**323.81**

*Twin-row, **Single-row

The 100 seed weight values varied between 13.55-13.69 g in 2013, between 14.16-14.84 g in 2014 and between 13.89 g-14.20 g in two years average (Table 5). The 100 seeds weight in 2014 was heavier when compared to 2013. There was no statistically significant difference between the plant population densities in both years. These figures show that plant population densities were not affected on 100 seed weight at different planting pattern in soybean. Similar results were reported by other researchers (Dapaah et al., 2005; Liu et al., 2010; Rahman and Hossain, 2011; Worku and Astatkie, 2011 and Akond et al., 2013).

There was statistically significant difference in seed yields between plant population densities in both years and two years average. The seed yield values varied between 3625-4755 kg ha^{-1} in 2013, 4042-5057 kg ha^{-1} in 2014, and 3833-4906 kg ha^{-1} in two years average (Table 5). The seed yield was significantly affected by the plant population density. Over the two years average, the highest seed yield (4906 kg ha^{-1}) was obtained from 63.2 plants m^{-1} plant density in twin-row planting pattern. Generally, the seed yield was higher in twin-row planting pattern than conventional (single-row) planting pattern. The seed yield per hectare continuously increased as intra-row spacing decreased from 6 cm to 3 cm in same row spacing in twin-row planting pattern. Soybean seed yield is calculated by multiplying the plant number per unit area x pod number per plant x seed number per pod x one average seed weight. Pod and seed number per plant are the very important seed yield components, and these parameters are very respond to changes in plant density. The pod number per plant was decreased, while the plant density increased (Table 4) in the same row spacing at twin-rows planting pattern. But, the seed yield per hectare was increased. Because, while the pod number per plant was decreasing in high plant density, the total pod number of per unit area was increased. For this reason, the seed yield per hectare was increased at high plant density in twin-rows planting pattern. Planting density is an important factor for soybean growth and seed yield. When planting density is high, the branching of each plant is depressed and the lateral stem and pod number of per plant decrease.

Soybean is classified as a short day plant. Soybean planting delayed after 21 of June, the vegetative growth stage of plants shortened and plants start to flowering due to short day conditions. Other side, in this conditions the plants can not grow tall and the number of the lateral stem decrease. As a result, pod number per plant was decreased and the seed yield was lowered. It is necessary to increase the plant number per unit area to compensate to reduction of pod number per plant at late planting double crop soybean farming. Increasing the plant number per unit area, it is necessary to reduce the plant space on the rows. The plants grow thin and weak for competition and the pod number per plant decreases when the row space reduced in single-row planting pattern (Aslam et al., 1993). It is not possible to increase plant number per unit area reducing row space in conventional single-row planting pattern, but it is possible by the twin-row planting pattern.

In this research, the seed planting was done 17 of July as late double cropping. Plants started to flowering after emerging to above ground surface due to short day conditions. For this reason, plants shortened and pod number per plant was decreased. The decrease of pod number per unit area was compensated by the increasing plant number per unit area planting twin-row pattern. As a result, pod number per unit area was increased and seed yield increased (Table 5). Soybean seed yield depends mostly on pod and seed number per area. Similar results were reported by other researchers (Egli, 1988; Aslam et al., 1993; Hosseini et al., 2001; Dapaah et al., 2005; Caliskan et al., 2007; Liu et al., 2010; Bruns, 2011; Rahman and Hossain, 2011; Shamsi and Kobraee, 2011; Zhou et al., 2011; Cox and Cherney, 2011; Worku and Astatkie, 2011; Akond et al., 2013 and El-Zeadani et al., 2014).

Oil Content and Oil Yield

The data belonging to oil content and oil yield at different planting pattern and plant densities at late planting double cropped soybean production are presented in Table 6.

Table 6. The effect of planting pattern and plant density on oil content and oil yield at the late planting double cropped soybean production

Row spacing (cm)	Plant numbers (plant m^{-1})	Oil content (%)			Oil yield (kg ha^{-1})		
		2013	2014	Mean	2013	2014	Mean
70 x 25-3*	69.9	19.66	16.23	17.94	889.3 a	739.6 bcde	814.5 abc
70 x 25-4*	52.6	19.35	16.43	17.89	848.6 ab	711.5 de	780.1 bcde
70 x 25-5*	42.1	18.84	17.15	17.99	753.6 bc	719.1 cde	735.3 def
70 x 25-6*	34.9	19.13	17.47	18.30	693.5 c	706.2 de	699.9 f
75 x 25-3*	66.4	19.48	16.75	18.11	900.6 a	779.3 abc	840.0 ab
75 x 25-4*	50.0	18.05	16.81	17.43	785.3 abc	779.1 abc	782.2 bcde
75 x 25-5*	40.0	18.10	16.91	17.51	749.0 bc	743.7 bcd	746.3 def
75 x 25-6*	33.2	18.09	16.97	17.53	709.5 c	733.8 bcde	721.7 ef
80 x 25-3*	63.2	18.96	16.65	17.81	901.8 a	841.9 a	871.9 a
80 x 25-4*	47.6	18.14	16.68	17.41	803.6 abc	784.5 ab	794.1 bcd
80 x 25-5*	38.1	18.81	16.28	17.55	758.6 bc	751.6 bcd	755.1 cdef
80 x 25-6*	31.6	18.82	16.39	17.61	701.7 c	703.6 de	702.7 f
70x4**	35.7	18.76	16.66	17.71	717.8 c	677.3 e	697.6 f
LSD (5%)	**-**	**N.S**	**N.S**	**N.S**	**118.04**	**63.19**	**54.66**

*Twin-row, **Single-row

There was no statistically significant difference in oil content between plant densities in either year. The oil content values varied between 17.41 %- 18.30 % in a two-year average (Table 6). The oil content values in 2013 was higher than 2014. But, oil content was not significantly affected by the plant population densities in different planting pattern in both years. The oil content in 2013 was higher than 2014. The oil content of soybean seed was affected by air temperature at the seed filling period (Bellaloui et al., 2015). The average air temperature at the seed filling period was higher in 2014 than 2013. The high air temperature had decreased oil content of soybean seed.

The oil yield values varied between 693.5-901.8 kg ha^{-1} in 2013 and 677.3-841.9 kg ha^{-1} in 2014. There was a statistically significant difference in oil yield per hectare between plant densities in different planting pattern in both years. For two years average, the oil yield per hectare varied from 697.6 to 871.9 kg ha^{-1} (Table 6). The differences between the plant densities for the oil yield, comes from seed yield differences (Table 5). While the oil yield was 697.6 kg ha^{-1} at conventional planting pattern, it increased up to 871.9 kg ha^{-1} at twin-row planting pattern. The highest average oil yield was obtained from 3 cm intra-row spacing at twin-row planting pattern.

CONCLUSIONS

Soybean is classified as short day plant. Soybeans flowers very soon after emerge in short day conditions. For this reason, when the planting delayed after June 21, the vegetative growth stage of plants shortened and plants start to flowering due to short day conditions. Other side, in these conditions the plants can not grow tall and the number of the lateral stem was decreased. As a result, pod number per plant and seed number per unit area were decreased. Average seed size and number of seeds per unit area directly effect the yield. In soybean, these parameters can be described in terms of average number of seeds per pod, average number of pods per plant, and number of plants per unit area. It is necessary to increase the plant number per unit area to compensate to reduction of pod number per plant at late planting double crop soybean farming. Increasing the plant number per unit area, it is necessary to reduce the plant space on the rows in single-row planting pattern. The plants grow thin and weak for competition and the pod number per plant decreases in high plant density. It is possible to increase the number of plant per unit area by the twin-row planting pattern. The two years results of this study indicated that increasing plant density per unit area increased the seed yield per hectare. According to a two-year average, the highest seed yield (4906 kg ha^{-1}) was obtained from 80 x 25 x 80 x 3 cm (63.2 plants m^{-1}) twin-row planting pattern while the yield was 3940 kg ha^{-1} in conventional single-row planting pattern as 70 x 4 cm (35.7 plants m^{-1}). The yield increase was 24.5% more than conventional single-row planting pattern (standard). The seed yield per hectare continuously increased as intra row-spacing decreased from 6 cm to 3 cm in same twin-row planting pattern. Based on these results; suitable planting pattern could be suggested as twin-row planting and high plant density when the planting delayed after June 21 at double crop soybean planting in Cukurova region of Turkey.

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