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Full Length Research Paper

Cultivar and density effects on yield of soybean in double cropping

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Double cropping is a kind of multiple cropping system in which a second crop is planted after the first has been harvested. In order to study the yield of soybean (*Glycine max* L.) cultivars in double cropping with different densities, an experiment was conducted at Gonbad College of Agricultural Research Field of Gonbad High Educational Center (Iran). The treatments were factorial of cultivars (Williams, Gorgan 3 and Pershing) and three plant densities of 66.66, 40 and 28.75 plants m^{-2} that were carried out with three replications. Plant height, pod number per plant, seed number per pod and seed yield was measured. Overall, the lowest plant density provided the greatest yield. However interaction between cultivars and densities was significant and maximum yield was obtained with the Pershing cultivar at the medium plant density (3232.02 kg ha^{-1}). The maximum yield was obtained by using low density.

Key words: Density, double cropping, soybean, yield.

INTRODUCTION

Multiple cropping is the practice of growing two or more crops in the same place during a single growing season (Mazaheri, 1994; Francis, 1986). The practice of consecutively producing two crops of either like or unlike commodities on the same land within the same year is double cropping. An example of double cropping might be to harvest a wheat crop by early summer and then plant corn or soybeans on that acreage for harvest in the fall. This practice is only possible in regions with long growing seasons. With crop mixtures, farmers can take advantage of the ability of cropping systems to reuse their own stored nutrients and the tendency of certain crops to enrich the soil with organic matter (Francis, 1986). Farmers in the Golestan region in Iran have an opportunity to increase their productivity by double cropping after harvesting their wheat, barley and colza. There is enough growing season that remains after wheat, barley and colza harvest to grow a second crop of soybean. Most farmers in the research area cultivate rice via double cropping. If crops needing less water like soybean were grown instead of rice, more area could be cultivated after harvesting wheat, barley and colza; moreover farmers' profit could increase. Soybean also can increase nitrogen content within the soil as a result of biological nitrogen fixation. Soybeans have been planted as a double crop after the harvest of small grain crops such as winter wheat, barley and colza in many regions.

Soybean is a major source of inexpensive high quality protein, oil and vitamin B. Soybean is one of the most important oilseed crops in the world. It contains 18 - 22% oil and 40 - 42% protein (Mounts et al., 1987). Soybean is grown on an area of 84,084 ha with an annual production of 207,476 tones given an average yield of 2467 kg/ ha in Iran (FAO/STAT, 2009). Soybean is grown on an area of 55,000 ha with an annual production of 120,000 tons in Golestan province (Iran). It also plays an important role in soil fertility, as it adds nitrogen to the soil through biological nitrogen fixation. Soybean cultivar producers are continually searching for methods that will help increase yields and reduce costs. The planting of soybean in double cropping will increase the income of farmers who employ this tactic. The soybean cultivar and density are critical in determining the productivity of the system. Adjusting planting density is an important tool to optimize crop growth and maximize seed yield. Within double cropped soybeans, growers frequently employ

Table 1. Analysis of yield, pod number per plant, seed number per pod and plant height.

Characteristics	Cultivar		Density		Interaction	
	MS	F-value	MS	F Value	MS	F-value
Yield	2177626.9	6.54 **	39456.9	0.11 ns	1731.54	5.2 **
Pod number per plant	396.07	2.1 ns	507.82	2.7 ns	62.56	0.33 ns
Seed number per pod	0.48	18.4 **	0.1557	5.9 **	0.0278	1.07 ns
Height	509.6	2.93 ns	118.84	0.68 ns	256.22	1.47 ns

*, ** significant at the 0.05 and 0.01 probability levels, respectively; ns = not significant (p > 0.05); M.S. = Mean square.

high plant densities rather than standard density per unit area to minimize yield loss due to late planting (Ball et al., 2000) In a soybean double-cropping system, optimum plant density could vary with the chosen variety.

There have been many studies of planting density of soybean. The optimum plant density varies among studies, locations and conditions. Grichar (2007) studied on the effect of row spacing, plant population and cultivars on soybean production along the planting Texas gulf coast who reported 20 seeds per m^{-2} had the highest return in twin-row. All cultivars had positive yield response to the twin-row system. Cho et al. (2010) reported that seed yield was increased with increasing seeding density in delayed seedling time. They also observed maximum yield in plant densities of 30 × 15 cm, and reported that the double cropping system might be possible under an appropriate seed density. Bin et al. (2010) reported seed yield and pod numbers per plant were declined with increasing density. Arslan et al. (2006) studied maturity, growth and yield of 18 cultivars of double cropped soybean and reported that cultivars in maturity group IV were best adapted and best suited for a wheat-soybean double cropping system in the eastern Mediterranean region of Turkey. Sevgi et al. (2007) studied the effect of row spacing on yield and yield components in double-cropped soybean with row spaces of 30, 50 and 70 cm, who found that the with maximum yield was obtained by using 30 cm rows. Oz (2008) tested four plant densities (70 × 5, 70 × 10, 70 × 15 and 70 × 20 cm) and observed that an increase in plant density brought increased plant height and decreased seed yield. Board et al. (1992) studied different planting row spacing (25, 50, and 75 cm) on yield and yield components of soybean and reported that the highest yield was obtained with 50 cm row spacing.

This experiment was done to evaluate the productivity of three soybeans cultivars in three densities in double cropping.

MATERIALS AND METHOD

Experimental site

The experiment was carried out on the Research Farm at Gonbad-e-Kavoos Higher Education Center of Agriculture Collage (Iran) with latitude 37˚16' N, longitude 55˚12' E and altitude 52 m. The local climate is temperate; summers are hot and dry and winters are mild and rainy. Gonbad-e-Kavoos is located in the west Golestan province with an average annual rainfall of over 450 mm and average annual temperature of 17.7°C. The soil was loamy clay with pH 7.7.

Experimental design and treatments

The study was performed in randomized complete block design, with three replications. Treatments were a factorial of cultivars of soybean and plant densities. Cultivars were Gorgan 3 (maturity group IV), Williams (maturity group II), Pershing (maturity group IV) varieties and densities were 66.66 (high), 40 (medium) and 28.75 (low) plants m^{-2}. We planted with high density and pulled the additional plants when they had 4 - 6 leaves. Each plot contained 5 rows in each plot and each plot was 5 m long with a distance between rows of 60 cm. Tillage consisted of moldboard plowing followed by disking. Irrigation was applied during the growing season when required. We added 200 kg ha^{-1} phosphate and 50 kg ha^{-1} urea were applied to all plots. Five plants were harvested from each plot randomly to determine plant height, pod number per plant and seed number per pod.

Statistical analysis

Analysis of variance was done using Costat. Duncan's multiple range test was conducted for mean comparison with p-value 0.05.

RESULTS AND DISCUSSION

Table 1 shows the results of seed yield, pod number per plant, seed number per pod, and plant height variance analysis. The effect of cultivars was significant on seed yield and seed number per pod but it had no significant effect on pod number per plant and plant height. Gorgan 3 produced the greatest yield on average (2805.3 kg ha^{-1}) although Williams produced the greatest number of seed per plant (Table 2). The density also had significant effect on seed number per pod but it did not have a significant effect on seed yield and plant height (Table 1). The interaction between cultivar and density had a significant effect on yield but it did not have a significant effect on other characteristics (Table 1). Seed yield and seed number per plant were not significantly different between

Table 2. Mean comparisons of seed yield (Kg. ha^{-1}), pod number per plant, seed number per pod and height (cm) between cultivars.

Cultivar	Yield (Kg ha^{-1})	Pod numbers per plant	Seed numbers per pod	Height (cm)
Gorgan 3	2805.3 a*	37.95 a	1.25 b	125.55 a
Williams	2740.7 a	28.23 a	1.62 a	87.71 b
Pershing	2690.9 a	38.39 a	1.3 b	92.8 ab

Values within the same column followed by the same letters are not significantly different according to Duncan's multiple range test (p = 0.05).

Table 3. Mean comparisons of seed yield (Kg ha^{-1}), pod number per plant, seed number per pod and height (cm) between densities.

Density	Yield (Kg ha^{-1})	Pod number per plant	Seed number per pod	Height (cm)
HI	2697.9 b*	28.28 a	1.39 ab	94.65 a
MED	2345.5 b	35 ab	1.28 b	89.92 a
LOW	3193.4 a	29.41 a	1.51 a	95.88 a

Values within the same column followed by the same letters are not significantly different according to Duncan's multiple range test (p = 0.05).

Table 4. Mean comparisons of seed yield (Kg ha^{-1}), pod number per plant, seed number per pod and height (cm) between treatments.

Interaction cultivar (V) and density (D)	Yield (Kg ha^{-1})	Pod number per plant	Seed number per pod	Height (cm)
Gorgan3				
High	3055.7 a*	32.63 a	1.29 cde	104.42 a
Medium	2146 b	25.22 a	1.64 ab	87.29 ab
Low	3214.1 a	27.01 a	1.23 de	92.25 ab
Pershing				
High	3065.3 a	38.88 a	1.21 de	92.67 ab
Medium	1775.4 b	25.51 a	1.46 bcd	87.29 b
Low	3232 a	40.62 a	1.18 e	97.95 ab
Williams				
High	1972.9 b	42.36 a	1.28 cde	104.56 a
Medium	3114.1 a	33.97 a	1.28 a	96.25 ab
Low	3134.2 a	47.57 a	1.49 bc	86.35 ab

Values within the same column followed by the same letters are not significantly different according to Duncan's multiple range test (p = 0.05).

cultivars (Table 2). Arslan et al. (2006) also reported that maturity group IV, are suitable in wheat-soybean double cropping. There was a significant effect of cultivars between seed number per and height.

The greatest seed yield (3193.44 kg ha^{-1}) was obtained with low plant density treatment (Table 3). This high average seed yield shows that, we should plant at lower densities in double cropping on the farm in this area. Cho et al. (2010) observed that double cropping system might be possible under effective seed density. Also Sevgi et al. (2007) reported that the maximum seed yield was obtained from double cropping soybean. The reason for greater seed yield in low plant density was low competition between plants. Pod number per plant and seed number per pod contribute to overall yield. Pod numbers per plant and seed numbers per pod were also affected by plant density (Table 3). The maximum pod per plant was obtained in medium plant density and minimum pod number per plant was obtained in high plant density (Table 3). Table 4 shows the results of the average seed yield, pod numbers per plant, seed numbers per pod and plant height for the interaction between cultivars and plant densities. Pershing cultivar had the maximum seed yield at low plant density

(3232.02 kg ha^{-1}) and a significant effect was not observed in pod numbers per plant. The maximum plant height was observed with Williams's cultivar at high plant density (Table 4). In all varieties, the greatest yield was seen at the lowest plant density. However in Gorgan 3 and Pershing yield was similar at highest and lowest plant densities whereas in Williams yield was similar in medium and low plant densities (Table 4).

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