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The Effects of Seed Rate on Yield and Yield Components of Soybean (*Glycine max* L. Merrill)

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Abstract: This study was carried out to investigate the effects of sowing densities on yield and yield components. Seed rates were planted in 40, 50 and 60 cm row spaces and into 5, 10 and 15 cm intra row spaces. Seed rates did not affect the height of plant, number of seed per pod and 100 seeds weight but affected its branch height, the first pod height and side branches number, number of pod per plant and grain yield. Seed rates increased side branches height and grain yield but decreased side branch number of pod per plant.

Key words: Soybean, seed rates, yield components

Introduction

Soybean is considered as the plant of the century due to its high nutritional value. It is the most important plant in terms of both protein and fat content, containing 18-25% fat, around 40% protein. 60-65% of soybean consists of pulp. Soybean pulp is the main source of protein for farm animals on a worldwide scale. 30-35% of plant oil consumed on a global scale is extracted from the soybean plant (Mounts *et al.*, 1987).

There is a gap between vegetable oil supply and demand in Turkey (Arslan *et al.*, 1993). In order to close this gap in plant oil supply, the soybean plant introduced to Turkey has not been efficiently produced due to several reasons. For a success full an agricultural produced on, it must have both a market value and high productivity. Productivity depends on the genetic structure of the plant, processes of cultivation and environmental conditions. Important factors influencing the processes of cultivation include the row inter and intra spacing and the mechanization of agriculture.

There is research indicating that soybean productivity increases with the decrease in the row and width distances (Cordonnier and Johnston, 1983; Piggot and Farrel, 1983), indicate that soybean productivity decrease with the decrease in the row and width distances between seeding of soybean plants (Gary, 1983; Emiroglu *et al.*, 1986). Interestingly, scientific research has also concluded that variations in sowing distances of seeding do not influence the productivity and yield of the soybean plant (Cordonnier and Johnston, 1983; Piggot and Farrel, 1983; Tunio *et al.*, 1984; Yilmaz, 1999).

The objective of this experiment was to determine the effects of row and width seeding of the soybean plant and to expand the production of soybean in the same region.

Materials and Methods

The experiments were carried out in 1998 and 1999 in the province of Ordu. The data on temperature and annual precipitation was given for the experimental period and long term (50 years) average.

The clay and loamy soil of the experimentation area is also pH neutral (7.05). Salt content of the soil is 0.05% and contains low levels of phosphoric acid (5.496 kg da⁻¹). Potassium levels are high (199.410 kg da⁻¹) and organic matter of the soil is average (2.92%).

Seeding was done in to three row variations (30, 40 and 50 cm). Another group consisted of three width variations of 10, 15 and 20 cm within each group given above. The experiment was set up in the completely randomized design with three replication for two years (1998 and 1999). The plot's area was 7.2 m².

The data were made on the length of the plant, height of side branches, height of first pod, number of pods per plant, number of seeds per pod, weight of 100 seeds and productivity of seeds. The data collected was statistically analyzed in according to experimental plan and means were separated by Duncan's multiple range test.

Results and Discussion

In almost all the variables discrepancies are observed for the different years (Table 2 and 3). Probably is due to variations in annual precipitation. In the first year, when precipitation level was 405.9 mm, in the second year, this value was 625.6 mm (Table 1). As can be seen from the results, precipitation in the second year took place mostly during the months of June, July and August, which are the crucial months for the growth of the soybean plant. This has, in turn, revealed itself in the increase in elements of productivity during the second year.

Table 1: Climatic data at the experimental site

| Months | Average temperature (°C) | | | Precipitation (mm) | | |
|-----------|--------------------------|------|------|--------------------|-------|-------|
| | L.T. | 1998 | 1999 | L.T. | 1998 | 1999 |
| April | 11.3 | 14.4 | 12.0 | 76.4 | 50.2 | 61.3 |
| May | 15.3 | 16.4 | 15.6 | 55.8 | 90.9 | 62.4 |
| June | 17.8 | 21.2 | 21.2 | 73.3 | 21.9 | 119.9 |
| July | 22.2 | 23.6 | 24.7 | 80.2 | 44.3 | 62.2 |
| August | 22.1 | 24.5 | 24.3 | 75.6 | 20.4 | 177.4 |
| September | 19.0 | 20.6 | 20.3 | 102.0 | 34.6 | 36.5 |
| October | 15.3 | 16.8 | 16.4 | 123.6 | 143.6 | 105.9 |
| Ave./Tot. | 17.6 | 19.6 | 19.2 | 586.9 | 405.9 | 625.6 |

Table 2: The average values of the research factors

| Row | 1998 Width (cm) | | | | 1999 Width (cm) | | | | Yearly average width (cm) | | | |
|------------------------------------|-----------------|--------|--------|------|-----------------|--------|-------|--------|---------------------------|--------|-------|------|
| | 5 | 10 | 15 | Ave. | 5 | 10 | 15 | Ave. | 5 | 10 | 15 | Ave. |
| Height of the plant (cm) | | | | | | | | | | | | |
| 40 | 60.7 | 60.9 | 65.2 | 62.3 | 130.8 | 136.3 | 122.6 | 129.9 | 95.8 | 98.6 | 93.9 | 96.1 |
| 50 | 66.1 | 60.6 | 62.5 | 63.1 | 135.5 | 129.4 | 140.5 | 135.1 | 101.6 | 95.0 | 101.5 | 99.4 |
| 60 | 63.9 | 58.3 | 62.9 | 61.7 | 131.8 | 129.3 | 124.9 | 128.7 | 97.9 | 93.8 | 93.9 | 95.2 |
| Ave. | 63.6 | 59.9 | 63.5 | | 132.7 | 131.7 | 129.3 | | 98.4 | 95.8 | 96.4 | |
| Side branch height (cm) | | | | | | | | | | | | |
| 40 | 8.0 | 7.1 | 5.8 | 7.0 | 21.3 | 15.5 | 15.2 | 17.3 | 14.6 | 11.3 | 10.5 | 12.1 |
| 50 | 8.5 | 5.7 | 7.7 | 7.3 | 19.0 | 14.1 | 16.5 | 16.5 | 13.7 | 9.9 | 12.1 | 11.9 |
| 60 | 8.5 | 5.9 | 6.6 | 7.0 | 13.9 | 19.8 | 12.5 | 15.4 | 11.2 | 13.2 | 9.6 | 11.3 |
| Ave. | 8.3a | 6.3b | 6.7b | | 18.0a | 16.4ab | 14.7b | | 13.2a | 11.5ab | 10.7b | |
| Fist pod height (cm) | | | | | | | | | | | | |
| 40 | 14.5 | 12.9 | 12.9 | 13.4 | 26.3 | 27.7 | 26.6 | 26.8 | 20.4 | 20.3 | 19.8 | 20.1 |
| 50 | 16.1 | 14.0 | 14.6 | 14.9 | 29.1 | 27.5 | 28.1 | 28.2 | 22.6 | 20.8 | 21.4 | 21.6 |
| 60 | 16.5 | 12.7 | 13.8 | 14.3 | 26.5 | 31.0 | 24.9 | 27.5 | 21.5 | 21.9 | 19.4 | 20.9 |
| Ave. | 15.7a | 13.2b | 13.8b | | 27.3 | 28.7 | 26.5 | | 21.5 | 21.0 | 20.2 | |
| Number of side branches of plant | | | | | | | | | | | | |
| 40 | 3.9 | 5.0 | 4.7 | 4.5 | 3.7 | 5.0 | 5.4 | 4.7 | 3.8 | 5.0 | 5.0 | 4.6 |
| 50 | 3.8 | 4.7 | 4.5 | 4.3 | 4.7 | 5.4 | 5.3 | 5.1 | 4.3 | 5.0 | 4.9 | 4.7 |
| 60 | 3.7 | 4.9 | 4.8 | 4.4 | 5.6 | 4.3 | 5.3 | 5.1 | 4.7 | 4.7 | 5.1 | 4.8 |
| Ave. | 3.8b | 4.9a | 4.7a | | 4.6 | 4.9 | 5.3 | | 4.2b | 4.9a | 5.0a | 1.0 |
| Number of pod per plant | | | | | | | | | | | | |
| 40 | 23.7 | 31.2 | 35.3 | 30.1 | 33.4 | 46.5 | 47.7 | 42.5b | 28.6 | 38.9 | 41.5 | 36.3 |
| 50 | 26.9 | 30.1 | 29.9 | 29.0 | 41.1 | 56.0 | 60.0 | 52.4a | 34.0 | 43.1 | 45.0 | 40.7 |
| 60 | 23.0 | 30.8 | 31.8 | 28.5 | 55.8 | 51.0 | 59.3 | 55.4a | 39.4 | 40.9 | 45.6 | 42.0 |
| Ave. | 24.6b | 30.7ab | 32.3a | | 43.5 | 51.2 | 55.7 | | 34.0b | 41.0ab | 44.0a | |
| Number of seed per pod | | | | | | | | | | | | |
| 40 | 2.5 | 2.7 | 2.9 | 2.7 | 2.6 | 2.1 | 2.5 | 2.4 | 2.6 | 2.4 | 2.7 | 2.6 |
| 50 | 2.7 | 2.8 | 2.8 | 2.8 | 2.1 | 2.2 | 2.2 | 2.3 | 2.4 | 2.5 | 2.5 | 2.5 |
| 60 | 3.1 | 2.8 | 2.7 | 2.9 | 2.1 | 2.6 | 2.3 | 2.3 | 2.6 | 2.7 | 2.5 | 2.6 |
| Ave. | 2.8 | 2.8 | 2.8 | | 2.3 | 2.3 | 2.3 | | 2.5 | 2.5 | 2.6 | |
| Weight of 100 seeds (grms) | | | | | | | | | | | | |
| 40 | 15.6 | 15.3 | 15.1 | 15.3 | 19.3 | 18.4 | 17.6 | 18.4 | 17.4 | 16.9 | 16.3 | 16.9 |
| 50 | 15.4 | 15.3 | 15.0 | 15.2 | 17.2 | 15.7 | 19.0 | 17.3 | 16.6 | 15.5 | 17.0 | 16.4 |
| 60 | 15.1 | 15.0 | 15.3 | 15.1 | 19.0 | 18.7 | 18.7 | 18.5 | 16.5 | 16.9 | 17.0 | 16.8 |
| Ave. | 15.3 | 15.2 | 15.1 | | 18.1 | 17.7 | 18.4 | | 16.9 | 16.4 | 16.8 | |
| Grain yield (kg da ⁻¹) | | | | | | | | | | | | |
| 40 | 45.6 | 45.4 | 50.9 | 47.3 | 114.6 | 131.8 | 135.0 | 127.1b | 80.1 | 88.6 | 93.0 | 87.2 |
| 50 | 64.3 | 43.7 | 53.1 | 53.7 | 151.6 | 147.5 | 118.6 | 139.3a | 108.0 | 95.6 | 85.9 | 96.5 |
| 60 | 71.0 | 50.8 | 73.1 | 65.0 | 153.3 | 132.2 | 105.7 | 130.4b | 112.1 | 91.5 | 89.4 | 97.7 |
| Ave. | 60.3a | 46.7b | 59.0ab | | 139.9 | 137.2 | 119.8 | | 100.1 | 91.9 | 89.4 | |

P<0.05 important.

Plant height: Plant height in the first group range from 95.2-99.4 cm, while in the second group, plant heights ranged from 95.8-98.4 cm. Statistical analysis showed that variant row and width distances of seeding do not affect the height of soybean plants.

Studies have previously been carried out that support the findings of the current research that seeding row and

width distances did not influence the height of plants (Emiroglu *et al.*, 1986; Yilmaz, 1999). In addition, however, there were also studies indication increases in plant height (Piggot and Farrel, 1983; Tunio *et al.*, 1984) as well as decreases in plant heights (Shafshak *et al.*, 1989) depending on an increase in row and width distances. These variations probably result from the different

Table 3: The F and CV values of the research factors

| Years | Yield components | Width (W) | Row (R) | W x R | CV |
|------------|-------------------------|-----------|----------|---------|-----------|
| 1998 | Plant height | 0.142 | 2.261 | 0.871 | 10.9 |
| | Side branch height | 0.493 | 23.779** | 4.961* | 25.4 |
| | First pod height | 3.623 | 4.314* | 0.285 | 15.2 |
| | Number of side branches | 0.539 | 13.342** | 0.282 | 16.6 |
| | Number of pod Per plant | 0.330 | 6.937** | 0.700 | 27.1 |
| | Number of seed Per pod | 4.750 | 0.010 | 3.039 | 7.3 |
| | Weight of 100 seeds | 0.100 | 0.220 | 0.344 | 4.3 |
| | Grain yield | 3.410* | 2.646 | 0.753 | 34.9 |
| | Plant height | 1.216 | 0.235 | 1.062 | 9.7 |
| | Side branch height | 1.496 | 3.903* | 5.824** | 24.1 |
| 1999 | First pod height | 1.033 | 1.216 | 1.238 | 11.3 |
| | Number of side branches | 0.648 | 0.755 | 0.936 | 22.7 |
| | Number of pod Per plant | 14.877** | 2.500 | 0.704 | 24.6 |
| | Number of seed Per pod | 0.908 | 0.130 | 2.261 | 12.7 |
| | Weight of 100 seeds | 1.734 | 0.622 | 2.271 | 9.6 |
| | Grain yield | 4.118* | 2.490 | 2.299 | 16.9 |
| | Plant height | 1.210 | 0.463 | 0.822 | 220.716** |
| | Side branch height | 0.865 | 7.582 | 5.479** | 98.355* |
| | First pod height | 1.709 | 1.497 | 0.816 | 252.198** |
| | Number of side branches | 0.203 | 3.566* | 0.835 | 1.482 |
| Years Ave. | Number of pod Per plant | 2.154 | 6.436** | 0.488 | 22.413* |
| | Number of seed Per pod | 1.104 | 0.119 | 2.036 | 20.739 |
| | Weight of 100 seeds | 1.014 | 0.604 | 1.662 | 45.317* |
| | Grain yield | 1.993 | 1.892 | 2.332 | 96.959* |

* and** significantly different at 5 and 1 % probability levels, respectively.

genotype structures of different ecologies and cultivation techniques.

Height of side branches: Branches heights in the first group range from 11.3-12.1 cm. Results in the second group, however, are statistically significant, with 5 cm width values recorded as the highest. The annual average results of the heights of branches are 13.2 cm for the 5 cm width, 11.5 cm for the 10 cm width, and 10.7 cm for the 15 cm width.

Height of first pod: When planted in mass proportions, soybean harvest is done mechanically. For the loss of harvesting to be at a minimal level, the first pod should be higher from the ground. Values of the first pod height were affected by the genetic structure of the plant, precipitation levels (or irrigation) and the processes of cultivation (Yilmaz, 1999). According to the results, heights of first pod in the first group were statistically nonsignificant as the range for the three variations is from 20.1-20.9 cm (Table 2 and 3). For the second group, the results were significant for the first year but not the second year. The values for the first year are 15.7 cm height for the 5 cm width, 13.2 cm height for the 10 cm width and 13.8 cm height for the 15 cm width. Similar results have been found in previous research (Cordonnier and Johnston, 1983; Kolpak, 1992; Yilmaz, 1999).

Number of side branches: The three row distances in the first group had no effect on the number of side branches in the soybean plant (Table 3). The average number of

side branches was 4.6 for the 40 cm width, 4.7 for the 50 cm width, and 4.8 for the 60 cm width. The results of the second group were significant. As the width distances in the second group increased from 5 to 15 cm, the number of side branches also increased. This value was recorded as 4.2 for 5 cm, 4.9 for 10 cm and 5.0 for 15 cm. The results of the current experiment showed similarities with results obtained in other research (Tunio *et al.*, 1984; Shafshak *et al.*, 1989; Kolpak, 1992; Yilmaz, 1999).

Number of pods per plant: The effect of row distances on the number of pods per plant was nonsignificant in the first year while it was statistically significant in the second year. With increasing row distances of seedings in the second year, the number of pods per plant also increased, yielding an average value of 36.3 for the 40 cm width, 40.7 for the 50 cm width and 42.0 for the 60 cm width. The same results were obtained for the second group and an increase in the number of pods was observed for an increase in width distances of seeding, yielding an average of 34.0 pods for 5 cm, 41.0 pods for 10 cm, and 44.0 pods for 15 cm. These results showed complete or partial similarities with results in other previously carried out research (Piggot and Farrel, 1983; Carrora *et al.*, 1983; Emiroglu *et al.*, 1986; Yilmaz, 1999).

Number of seeds per pod: The effect of various row distances on the number of seeds per pod was found to be statistically nonsignificant (Table 3). In the first group, with increasing row distance of seeding, the average values obtained were respectively 2.6, 2.5 and 2.6 seeds

per pod. For the second group, with increasing width distance, the average value of seeds per pod was, 2.5, 2.5 and 2.6 respectively. Row and width distances did not have any effect on the number of seeds per pod (Emiroglu *et al.*, 1986; Shahidullah and Hossain, 1989; Yilmaz, 1999).

Weight of 100 seeds: In the current experiment, the effect of row distances on the weight of 100 seeds was statistically nonsignificant (Table 3). In the first group, with increasing row distance, the average values obtained were respectively 16.9, 16.4 and 16.8 g per 100 seeds (Table 2). For the second group, with increasing width distance, the average weight of 100 seeds was 16.9, 16.4 and 16.8 grams respectively. Previous studies reported varying effects of row spacing on 100 seeds weight, due to possibly genetic and environmental factors (Pawlowski *et al.*, 1993).

Grain yield: The results obtained were statistically insignificant for the first year but significant for the second year. According to the results of the current experiment, the yield increased from 87.2 kg da⁻¹ at 40 cm row distance, to 96.5 kg da⁻¹ at 50 cm distance and 97.7 kg da⁻¹ at 60 cm distance.

The effects of various row widths on grain yield were statistically nonsignificant for both years of experimentation. Nevertheless, grain yield increased with the increase in width distances. Results indicate the productivity to be 100.1 kg da⁻¹ for 5 cm width distance, 91.9 kg da⁻¹ for 10 cm distance, and 89.4 kg da⁻¹ for 15 cm width distance. Previous results indicating no change in the grain yield with the change in row and width distances (Piggot and Farrel, 1983), there are also results which indicated an increase in productivity with an increase in seeding distances (Cordonnier and Johnston, 1983; Gary, 1983; Tunio *et al.*, 1984; Shahidullah and Hossain, 1989; Yilmaz, 1999). The results of the current research were in complete or partial accordance with some of the previously undertaken research.

In the experimentation on seeding distances undertaken during a two year period, it can be concluded that plant height, the number of seeds per pod and the weight of 100 seeds were unaffected by variations in row and width distances in the seeding of soybean plants. Variations in seeding distances, however, completely or partially affect branch height, the height of first pod, the number of branches, the number of pods per plant and grain yield. With the increase in seeding distances, an increase in branch heights and grain yield has been observed, while the number of branches and the number of pods per plant has decreased. The results of the current research show similarities with a number of other researches carried out on the yield of the soybean plant.

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