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Effect of plant density on the growth, yield and yield components of three soybean varieties under climatic conditions of Kermanshah ,Iran

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Planting density, variety, yield, yield components, growth analysis

1 SUMMARY

To study the effect of different densities on the trend of growth, yield and its components of three varieties of soybean under the climatic conditions of Kermanshah, an experiment was carried out in research fields at Mahidasht, Kermanshah in 2003. The factorial experiment had four replications arranged in random complete blocks design. Three varieties, i.e. Williams, Zan and Clark were placed in the blocks at three density levels with plants spaced at 3, 5 and 7 cm rows in the blocks. The highest dry weight was obtained from variety Clark. With increasing plant density, dry weight was observed to decrease while the leaf area index increased. At higher plant density the crop growth rate (CGR) tended to increase but was at its maximum at density D2 (medium). Comparison of changes in the relative growth rate (RGR) showed that variety Williams at density D3 (lowest) had the highest RGR of all varieties and densities. In this study density increase caused an increase in plant height, the interface of the first sub-branch from soil surface, length of inter node, number of nodes in main branch, number of grain in pod per plant, grain yield per unit area, and biological yield performance. However, increased density caused a reduction in the number of branches, node length, pods, grain yield per plant and sub branch and dry weight of grain. The percentage protein and oil content, harvest index, 100grain weight on the main and sub branch and plant, and the number of grain in pod of main and sub branch were not affected by plant density. The highest number of nodes, pods per node and 100 grain weight was obtained on cv. Clark while the highest number of grain per pod belonged to cv. Williams.

2 INTRODUCTION

Producing sufficient food stuffs is one of the most important challenges facing humankind globally. In many developing countries the food produced is not sufficient for consumption, and this will impact on social stability and development. Studies show that 90% calorie and 80% protein requirements for human beings are directly supplied by plant sources.

In this sense, oily grains are important as one of the crops with huge potential to supply part of the food requirements. Among the oily grains, soybean plays an important role in providing calories and proteins. Besides food, soybean is also important in agricultural industry as its grains contain oil (20%) and plenty of protein (40%) (Alyari & Shekari, 1998).

Based on studies previously performed, planting density seems to have significant effects on the growth process, yield components, and ultimately on the yield of different soybean cultivars (Egli, 1988; Taqizade, 1992; Majidi & Ganjali, 1997).

These researchers are of the opinion that although yield components per plant decreases with increase of planting density, reduction of yield components can be compensated for by raising the number of plants per unit area, therefore increasing the yield.

The objective of this study was to investigate how plant density affects growth, yield and yield components of three soybean varieties in Iran.

3 MATERIALS AND METHODS

This experiment was carried out at Mahidasht research field, Kermanshah, Iran, in May 2003. The experiment was of factorial design with layout as complete random blocks with 4 replications, in which cultivar factor (at 3 levels) included Williams (V1), Zan (V2) and Clark (V3) while the density factor (at 3 levels) included 3 spacings of plants on rows (D1) 3 cm, (D2) 5 cm and (D3) 7 cm. Thus, the experiment contained 9 treatments placed on 36 test plots. Routine operations were carried out on time, e.g. control of pests and diseases, fertilization, weeding and irrigation.

To investigate the growth of soybean cultivars at various densities, sampling was conducted once on every 16^{th} day starting 20 days after planting until physiological maturity (growth stage R8). Sampling area on each plot was 0.3 m^2. Plants were harvested by cutting with shears close to the soil surface.

After measuring the leaf area, different plant parts were separated and the dry weight noted for each.

In order to calculate final yield, biological yield and harvest index, an area equal to 3.6 m^2 was removed from the middle of all plots, eliminating two marginal rows and 1.5 m from ends of rows.

In order to assess the yield components at final harvesting time, 5 plants were randomly taken out from the harvesting area of each plot. Various data as well as morphological parameters were measured and recorded for each plant.

Data were subjected to analyses of variance and means separated by the Duncan's Multiple Range Test using Harvard GRAPHIC, STATG and MSTATC programs.

4 RESULTS AND DISCUSSION

To study changes of dry weight and leaf area index, mathematical equations with different degrees were used. The best equation obtained was quadratic, i.e.

$$y = Exp\ (a + bx + cx2).$$

Results showed that dry weight of plant shoots decreased with increase of density so that the minimal accumulation of total dry matter of plant was observed in plots with density D1 (3 cm spacing). On the other hand, with increasing density, leaf area index increased and the greatest leaf area index was in plots of density D1 (3 cm spacing).

Among the various cultivars, cv. Clark had the highest dry weight of shoots and leaf area index. This cultivar possesses maximum duration of leaf area. Shibles *et al.* (1975); Paruez *et al.* (1989) and Ganjali (1992) have previously reported similar results. For cultivars Zan and Wiliams, crop growth rate was nearly the same and equal, but V3 reached maximal quantity of CGR with more time lag from planting.

For all cultivars, crop growth rate became negative at the end of the growth season due to shedding of leaves and consequent reduction of dry matter accumulation. Among the different densities, D2 (5 cm) had the most while D3 had the least CGR. In this experiment, enhancement of density from D3 to D2 (7 to 5 cm) caused CGR to increase but with further increase in density caused the quantity of CGR to decrease slightly.

Comparison of changes in RGR showed that cultivar Williams and density D3 had maximum quantity of RGR. RGR quantity was lower and its reduction trend was faster for plots with density D1 (3 cm) compared to D2 (5 cm). Enyi (1973) and Shojaii Noferest (1993) also reported that with increase in density, the amount of RGR is reduced.

The experimental results also show that with increase in density the following parameters are enhanced: plant height, spacing of the formation of the first sub-branch from soil surface, the length of mid nodus, the number of gnarls on major stem, the number of grains per pod per sub-branch per plant, grain yield per unit area and physiological yield. On the converse, the following items are reduced: the number of sub-branches, the number of gnarls per sub-branch per plant, the number of pods per sub-branch per plant, the number of grains per sub-branch per plant and grain dry weight per sub-branch per plant.

In this experiment, protein and oil content (%), harvest index, 100-grain weight per major branch, or per sub-branch, and per plant, the number of grains per pod on the major- sub-branch, were all not affected significantly by variations in planting density.

These results show that some features are further affected by genetic factors rather than environmental factors. At low densities, the number of sub-branches and hence their contribution to yield are raised due to less competition. However, according to obtained equations, the most significant components of the yield in the model are the number of plants per unit area and the number of nodes per plant.

Leumman and Lambert (1960) have tested the effect of density on the yield and its components at row spacing of 50 - 100 cm and plant spacing on rows of 7.5, 3.75, 1.87, 1.25 cm and concluded that with an increase in density, higher yields are obtained while the number of sub-branches and the number of pods per plant are reduced. Ablett *et al.* (1984) suggested that soybean yield components are reduced with increase in plant density. Majidi (1997) stated that although reduction of planting density could improve grain yield per plant, it failed to compensate yield reduction caused by deficiency of plants per unit area.

5 CONCLUSION

The results of this research ultimately showed that among different treatments, cv. Williams at 3 cm plant spacing on row produces the highest yield per area unit. Williams cultivar had the largest height of formation of the first sub-branch from the soil surface, which can also facilitate its mechanized harvesting. This cultivar also had higher harvest index when compared to other cultivars. Reduction of yield components is compensated by increasing the plants per unit area, and therefore, the yield increases, although with high densities the enhancement of density leads to the reduction of yield components per plant.

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