

EFFECT OF TILLAGE AND PLANT DENSITY ON YIELD AND COMPONENTS OF YIELD IN THE COMMON BEAN

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ABSTRACT

In order to examine the effect of plant density and the use of Mulch on the growth and yield of common bean, an experiment was conducted using the experimentation of crushed plots with random complete basic block design in the crop season in 2014 for one crop season length in Lakan of Rasht City's terrarium and watershed of natural resources placed in Gilan province. The first factor was at two levels (including, a: doing tillage, b: not doing tillage) and the second factor had various plant densities (including 4 plant densities of 33, 12, 18, and 9 in each square meter). The characteristics under investigation were: the height of bush, the number of green pod in each square meter, the number of green seeds in each square meter, green pod yield, and the number of green seeds in pod. The results revealed that tillage did not have any significant effect on any of the characteristics. The effect of density was very significant on all the aforementioned characteristics. The results of mean comparison showed that the density of 33 bushes in each square meter has the most yield and components of yield in common bean.

Keywords: *Common Bean, Yield, Tillage, Plant Density*

INTRODUCTION

Common bean is considered as one of the most important members of cereals. And as it possesses approximately 12 to 32 percent protein, it takes the first place of cereal production in the world. This plant covers half of the areas under cereal cultivation in Iran. Common bean plant is very sensitive to climate and soil conditions; its yield is damaged even during very short periods of water shortage. Furthermore, common bean plant is cultivated by dry farming in most fields of the province; its watering is not done even during the growth period. Hence, reduction in the amount of soil's water and the increase of the ambient temperature leads to the creation of drought in common beans' bushes. The effects of tillage methods on the growth and yield of the plant are, to a great extent, related to disorders of the moisture regime and it is in turn achieved as the result of the improvement of permeability and retention of soil moisture. The aim of tillage and improvement of soil health is the incorporation of crop residues, weeds, and wild plants, with soil; and, consequently, the redistribution of pathogenic organisms around weeds and insect larva from the upper parts of the soil (they gather on those parts) to the deeper parts and their disposal to the depth that they can no longer erupt the crops. Access to resources used by a plant such as solar radiation, usable water, and food has a great relationship with plant density; adjustment of plant density, to increase the yield per unit, will be based on the degree of the availability of resources and other factors of production. Plant density is one of the factors that affect the morphological and physiological characteristics, yield, and yield components of crops. Nowadays, it is recommended that plant spacing should be reduced as much as possible. It helps agricultural plants' bushes quickly fill the space and provide shade. In Guilan, the density of common bean planting is very different; farmers do not use a specific density in planting. The density of planting, with respect to the dry farming of common bean in the province, can be very important and the appropriate planting density can help in better production of this plant. Due to early spring rainfall, the opportunities for the preparation of the land are low and if planting can be done without tillage, the growth stages of this plant will improve (Koochaki and Soltani, 1988).

The objectives of tillage in semi-arid environments are short-term, among them it is possible to name the preparation of land for planting, improvement of soil moisture regime, nutrient status of its components, soil health, and weed control; or they are long term of which, prevention of erosion and maintenance of

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soil fertility can be named. Some of these objectives overlap; for example, improving moisture regime and the status of the nutrient components. Some of the objectives may be in conflict with each other, for example, improving the soil permeability to increase water conservation, and reducing evaporation to prevent water loss on the other hand, can be named. Most of the beneficial effects of tillage are very temporary and can be lost once the soil is wet (Koochaki and Soltani, 1988). Plant density per unit has great effects on the yield of products and like other agricultural inputs; it is important (Torabi, 2005). Plant density is one of the most important factors in determining the level of competition between plants (Khajepour, 1987). Optimum plant density is the one that as a result of which all the environmental factors (water, air, light, and soil) have been fully used and at the same time the competition within the plant is at its least degree to obtain maximum yield with desired quality. On the other hand, this density should provide enough space for the operations of harvesting (Khajepour, 1987). Optimal density depends on various factors such as the characteristics of the plant, plant height, growth period, the time and method of planting, soil fertility, plant size, available moisture, solar radiation, planting pattern, and weed status (Shirtliffe *et al.*, 2002).

Aissyk *et al.*, in an experiment stated that with the increase of plant density, in spite of the loss of plant weight and weight of seed in plant due to the increased number of plants per unit, plant yield and biological yield is increased. Maximum utilization of the factors required for plant growth can only be achieved when the plant community puts the maximum pressure on these factors (Donald, 1963). As a result, because of the plant competition, each of the plants is under relatively severe stress (Koochaki and Soltani, 1988). Hence, this research is conducted with the aim of examining the effect of tillage and planting density on the Common Bean's Yield in Guilan province.

MATERIALS AND METHODS

This experiment was conducted to examine the effect of plant density and tillage on the growth and yield of common bean in the crop season in 2014 for one crop season length in Lakan of Rasht City's terrarium and watershed of natural resources placed in Gilan province. To this end, the study utilized the experimentation of crushed plots with random complete basic block design in triplicate. The first factor was at two levels (including, a: doing tillage, b: not doing tillage) and the second factor had various plant densities (including 4 plant densities of 33, 12, 18, and 9 in each square meter). To achieve this plant density, the researcher planted common bean seeds with row spacing of 40 cm on the rows of 10, 20, 30, and 40 cm. To implement the scheme, plot designs were created in dimensions of 5×1 m plots at a distance of 50 cm from the adjacent experimental units. Among the repetitions the distance of one square meter was considered as well. In each repetition, eight plots were created; therefore, 24 plots were created as a result of the three repetitions. Land preparation operations were done in April 2014. To prepare the seedbed in the tillage part rotivator using the Taylor machine was utilized, and in the parts without tillage, hand weeding was done, and rivers, streams, drains, and distances were accurately determined. Planting operations were done on 22 April. During the planting period, all crop cares such as irrigation (three stages due to lack of rainfall and the potential of plants drying), weeding (in several stages), and fertilization were done. 5 kg N, 4 kg of potash fertilizer at the beginning of the vegetative period and before flowering were added to soil of the experimentation place. Moreover, due to the yellowing of the tips of the leaves and the possibility of nitrogen deficiency in plants, nitrogen was sprayed in R7 and R8 stages. In this experiment, crop was harvested in two stages. The first harvest was done after 65 days of planting and the second harvest was done after 77 days of planting. The first harvest was done to examine the yield of wet bush and the second one was done to examine the yield of dry bush. In the harvesting stage, the present number of bushes in 50 square meter with the distances of 10-20-30-40 cm in the row, was randomly harvested from each testing unit, and was measured under investigation characteristics. In order to eliminate the side effects, bushes in the adjacent rows as well as bushes located at the beginning and at the end of plots were removed. Characteristics examined in this study were plant height, number of green pods per square meter, number of green seeds per square meter, green pod yield, and the number of green seeds per pod that were measured to determine the height from ground level to the highest point of

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the plant; their mean was calculated for individual plants. Five plants were sampled to determine the number and yields and then counting and weighting were started. Then their mean for each experimentation unit, as the under investigation characteristic, was calculated. Statistical calculations and data analyses were performed using SAS software. Moreover, Duncan's test at the 5 % level was used to compare the means. Graphs were, also, plotted using Excel software, version 2010.

RESULTS AND DISCUSSION

The Height of Common Bean Bush

The results of the analysis of variance for the effect of mulch and plant density on plant height are shown in Table 1. As the aforementioned table shows, tillage does not have any significant effect on the height of common bean bush. This insignificant effect of tillage reveals that land preparation operations does not have any noticeable effect on absorbing water and minerals from the soil and their use to increase the plant height. As the soil texture of the field is loamy, full tillage operations can provide the conditions for less plant growth by reducing the amount of soil moisture. Plant density had significant effect on the height of common bean plant (Table1-4) and by increasing the plant density from 9 bushes per square meter to 33 bushes per square meter, the height of common bean bushes significantly increased; hence, the highest plant height in plant density was 33 plants per square meter and the lowest plant height in plant density was 9 plants per square meter. Increased plant competition for light absorption at high density is one of the major factors in increasing the plant height in plant density of 33 plants per square meter. Moreover, it seems that reduction of the photo oxidation of auxin in the main stem of the common bean in densities of 18 and 33 plants per square meter provides the conditions for increasing the height of common bean. Plant density in tillage did not have significant effect on the height of common bean plant. The obtained results correspond with the findings of Lucas and Milbourn (1976), Hougaard *et al.*, (1978), and Dominiguez and Hume (1978). In the low density, the production of subsidiary stems from the angle between the leaves and main stem of common bean is stimulated; and, although with the increase of density, the number of subsidiary branches in plant reduces, the total number of produced subsidiary branches per unit increases. Moreover, in spite of no increase in the number of nodes in high density, due to the elongation of internodes, plant height increases (Lucas and Milbourn, 1976).

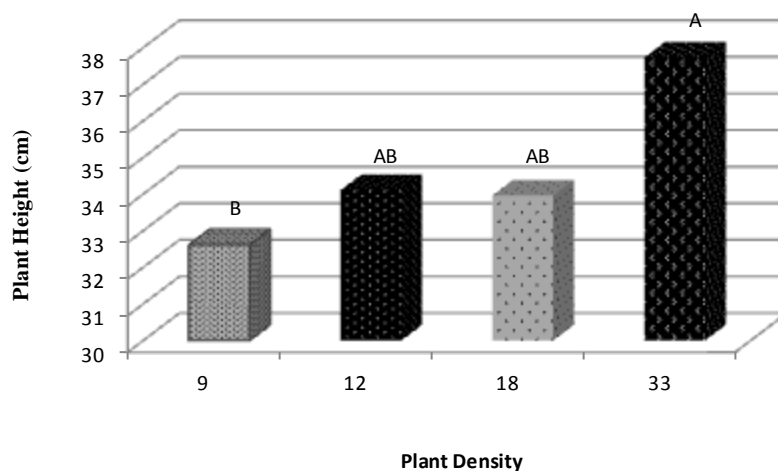


Figure 1: The effect of plant density on the height of Common Beans

Number of Pods in Green Common Beans

The results of analysis of variance for the effect of tillage and plant density on the number of pods in green common beans are shown in Table 1. As can be seen, tillage system does not make significant differences in the number of green pods in common bean plants. In other words, number of formed pods in no-till system and number of formed pods in a complete tillage system were equal. This implied a very

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good adaptation of common bean plants with lightweight soil conditions, especially loam soils. Therefore, as grains demonstrate a little reaction to soil conditions and agricultural inputs, it can partially be concluded that planting common beans is successful in lightweight soils with minimal ground preparation works. Moreover, since a large fraction of moisture in the soil exit by intense evaporation during land preparation, reducing tillage yields can better control leaving of water from soil, through quickly cutting off the capillary pores of soil, which will help reserving soil moisture for a longer time, under the field condition. This is due to the fact that common beans are planted dry land in Gilan Province. And in the years that there is lack of rainfall in spring, by reducing tillage yields, it is possible to greatly supply common bean plants' need of water. Effect of plant density was significant on the number of green pods; and, number of green pods significantly increased by increasing density to 33 plants per square meter that had a statistically significant difference with number of green pods in other plant densities. It seems that due to the low volume of common bean plants, increasing density would be one of the ways to increase yield per area unit. Because, as can be seen in Figure 2-4, despite the number of green pods per area unit, by increasing plant density from 9 to 18 plants per square meter, the difference of this attribute between the density of 9 to 18 plants per square meter was not significant. Also, the interaction of plant density in tillage on the number of green common bean pods was not significant. The obtained results are consistent with findings of Custer *et al.*, (1989). Custer *et al.*, (1989) observed that in lower plant density, the amount of dry matter accumulation in pods, stems, and leaves, in the same number of days after harvest, was mostly more than the amount in higher plant density. In addition, the accumulation rate of substances in the pod was more than the stem and leaf. And, by beginning of pod filling, the accumulation rate of the substances in this organism increases, since, pod is a strong destination.

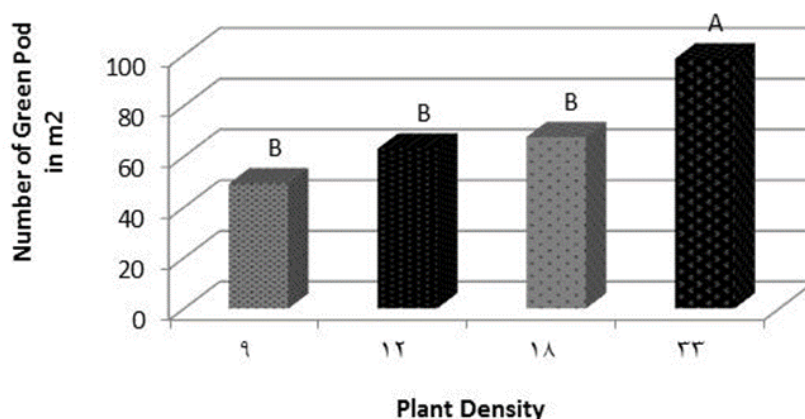


Figure 2: Effect of plant density on the number of green common bean pods

Number of Green Grains in Common Beans

The results of analysis of variance for the effects of tillage and plant density on the number of green grains in common beans are shown in Table 1. As can be seen, there isn't any statistically significant difference between the effects of complete tillage of land and lack of tillage on the number of green seeds that are able to be harvested per area unit. Since the number of formed seeds in plants of common beans are under the influence of weather conditions and the fertilization of ovum, tillage yields can't have tangible effect on the number of the formed pods in common beans; it is due to the fact that during flowers formation and their fertilization, the air temperature was almost perfect for fertilization, and the soil moisture content amount was, also, in a good condition.

However, the effect of plant density on the number of formed green seeds in area unit was significant, which is mainly due to increasing number of plants per area unit. In other words, the increasing number of pods, due to increasing plant density of field, provided the condition to increase the number of harvestable green seeds per area unit. According to above chart, it can be understand that plant density of common beans, would be more appropriate regarding the chosen plant distances. In other words, if plant density

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increases, it seems that the number of grains will increase per area unit; because, in three plant densities, namely 9, 12, and 18 plants per square meter, there is not much statistical difference in terms of the number of harvestable green seeds per area unit. Also, the interaction of density and tillage, regarding the number of harvestable green seeds per area unit, was not significant. This represents the independent effect of each considered factor on the number of harvested green seeds. The obtained results correspond with the findings of Ikeda (1992), Ishag (1973), Westerman and Crothers (1977). The results related to the reaction of number of seeds per pod is not similar to density changes in beans. However, some researchers believe that plant density has no effect on the number of seeds per pod (Ikeda, 1992; Ishag, 1973). There are, also, some reports indicating that increasing plant density in beans decreases seed number per pod (8, 20) or increases it (22 and 27). Mostly, the number of seeds per pod reduced by increasing unlimited growth of common beans, but remained constant in limited growth numbers due to less competition in the same density (Westerman and Crothers, 1977).

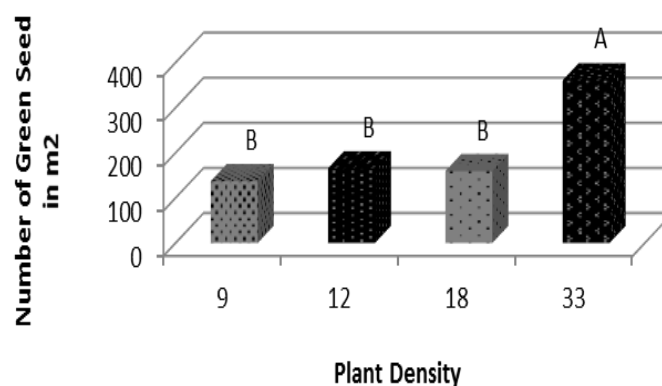


Figure 3: Effect of plant density on the number of green seeds of common beans

Yield of Green Pods of Common Bean

The results of analysis of variance for the effect of tillage and plant density on the number of green seeds of common bean are shown in Table 1. As can be seen, the effect of tillage on yield of green pods of common bean was not significant. In other words, tillage yield did not have any significant effect in increasing the yield of green pods of common bean. Thus, by reducing tillage yield, it is possible to reduce a large part of initial costs in the production of common bean. But the Effect of plant density became significant on yield of green pods in common bean; since, the yield of green pods in common beans increased with gradual increasing of plant density. And, the highest yield of green pods was, again, obtained from density of 33 plants per square meter that had a statistically significant difference with other plant densities.

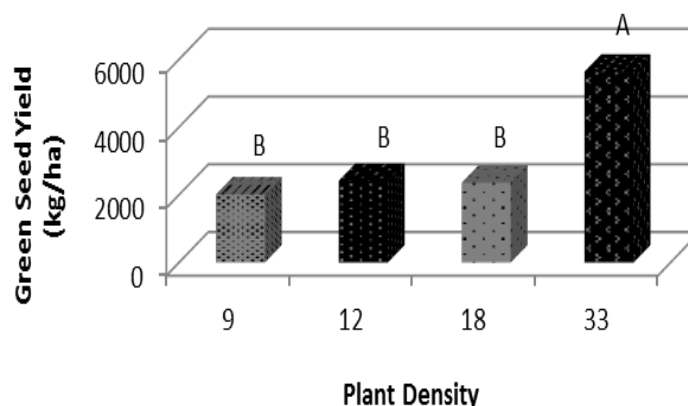


Figure 4: Effect of plant density on yield of green pods in common bean

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It seems that a greater number of common bean plants increases leaf area index, and consequently causes more production of dry matter per area unit. Thus, even when common bean plants had reached their maximum growth, there was space among plant rows. And, plants didn't have a significant competition in terms of light absorption in this density (33 plants per square meter). Moreover, increase in the number of pods per plant provided a groundwork for increasing pod yield. Also, interaction of tillage system in plant density didn't become significant on yield of green pods.

Number of Green Seeds per Pod

Variance analysis results of the tillage and plant density effect on green seed in common bean pod have been shown in chart 1. As can be seen, the tillage and plant density effect as well as the mutual effect of the tillage on plant density to the number of green seeds, were not significant. Since planted common bean is among limited growth numbers, it is reported that in these types, typically, the number of seeds per pod, due to increasing competition among pods of a plant, remains nearly identical, and plant density has no effect on the number of green seeds per pod. Moreover, interaction effect of tillage system in plant density on the number of green seeds of pods in common bean was not significant. The obtained results correspond with findings of Ikeda (1992) and Ishag (1973). Results related to the reaction of number of seeds per pod are not similar to density changes in beans. However, some researchers believe that plant density has no effect on the number of green seeds per pod (Ikeda, 1992; Ishag, 1973).

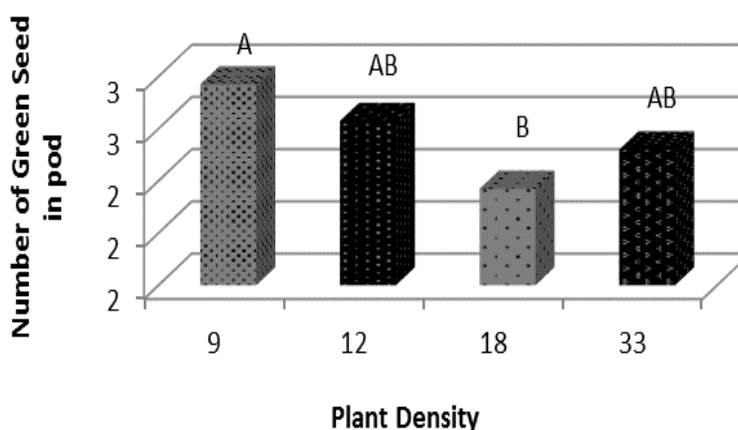


Figure 5: Effect of plant density on the number of green seeds in pods of common beans

Table 1: ANOVA for Effect of Tillage and Plant Density on green yield in Bean

S.O.V	df	Green seed yield (Kg/ha)	Green pod yield (Kg/ha)	Number of seed pods in m ²	Number of Green pods in m ²	Plant height (cm)
Replication	2	0.35 *	213644.83 ^{ns}	528.29 ^{ns}	87.11 ^{ns}	1.18 ^{ns}
Tillage	1	0.24 ^{ns}	2414418.57 ^{ns}	11662.25 ^{ns}	669.29 ^{ns}	0.54 ^{ns}
Main Error	2	0.02	2345558	7943.12	864.74	13.9
Plant Density	3	0.51 ^{ns}	17325889.98 ^{**}	64771.05 ^{**}	10610.23 ^{**}	29.36 [*]
Plant Density × Tillage	3	0.04 ^{ns}	151431.35 ^{ns}	187.03 ^{ns}	9.8 ^{ns}	1.5 ^{ns}
Sub Error	10	0.07	817597.6	2590.69	358.92	9.11
CV (%)		10.16	29.12	24.74	23.5	8.72

^{ns} Non significant, * significant at $P < 0.05$ and ** significant at $P < 0.01$

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