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Row Spacing and Inter Row Spacing Effects on Some Agro-Physiological Traits of Two Common Bean (*Phaseolous vulgaris* L.) Cultivars

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Abstract: An experiment was conducted to evaluate the effects of row spacing (RS) and inter row spacing (IRS) on some agro-physiological traits of 2 common bean (*Phaseolous vulgaris* L.) cultivars, at the agricultural research area, Faculty of Agriculture, University of Urmia, Iran during 2003. Experimental design was a factorial split-plot based on randomized complete block design with 3 replications. The 30, 45 and 60 cm of RSs constituted the main plots and IRSs of 5, 10 and 15 cm and cultivars of Derakhshan and Naz (determinate and indeterminate, respectively) were allocated to the sub plots. Obtained results showed that different RSs and IRSs affected the Grain Yield (GY). The highest GY was recorded at 30 cm RS (4.191 t ha^{-1}) and 5 cm IRS (3.926 t ha^{-1}). The number of pods $plant^{-1}$ (NPP), the number of grains $plant^{-1}$ (NGP) and grain weight $plant^{-1}$ (GWP) increased as a result of a decrease in the RS and IRS. In addition, it was observed that by increasing the RS and IRS the first pod trait had higher height. However, the Grain Protein Content (GPC) was not affected by the IRS and RS changes. On the other hand, Naz (indeterminate) had higher capability for the grain yield than Derakhshan (determinate) cultivar.

Key words: Row spacing, inter row spacing, grain yield, grain protein content, common bean

INTRODUCTION

Common bean (*Phaseolous vulgaris* L.) is one of the most important crops in legume family (Leguminosae) which is considered one of the most major protein and calorie resources in the world for human food. About 1145000 ha planted area (10.39% of Iran's total field area) are allocated to legume cultivation in Iran, 80150 ha of which is particularly allotted to common bean farming and yields about 144.7 t ha^{-1} grain (Anonymous, 2002). Plant distribution pattern and plant density affect the utilization of environmental resources which influence inter and intra plant competition. As a result, plant density is considered a vital factor in getting higher GY (Board and Harville, 1996). Plant density can be regulated through the manipulation of the RS and IRS (Koocheki and Sarmadnia, 1999). As the IR increases, more light penetrate in crop canopy and reach the lower leaves during the grain formation; therefore, grain yield $plant^{-1}$ level increases in wider RSs (Ayaz *et al*., 1999). On the other hand, due to a decrease in number of plant m^{-2} in wider RSs GY decreases. As a result, the highest grain yield m^{-2} is obtained at lower RSs and higher plant density. Besides, higher plant density can cause a reduction in CO_2 concentration and an increase in moisture amount in crops canopy, resulting in fungi diseases (Boyak *et al*., 2004). Xu and Pierre (1998) by imposing different RSs considering a constant IRS demonstrated that a decrease in RS results in an increase in the GY. Hang *et al*. (1993) used IRSs of 5, 7.5 and 10 cm in their studies and demonstrated that GY was increased by decreasing IRS.

The objective of this investigation is to determine the effects of row spacing and inter row spacing on grain yield and some agro-physiological traits of determinate and indeterminate cultivars of common bean (*Phaseolous vulgaris* L.).

MATERIALS AND METHODS

The experiment was conducted at the agricultural research area, Faculty of Agriculture, University of Urmia, Iran during 2003. The soil properties are a clay loam texture, pH of 7.8 and soil saturation percentage of 54%. The experimental design was a factorial split-plot based on randomized complete block design with 3 replications. 30, 45 and 60 cm RSs constituted the main plots and cultivars of Derakhshan and Naz (determinate and indeterminate growth, respectively) and 5, 10 and

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15 cm IRSs were used as the sub plots. Before sowing, the field was prepared by a plough (20-25 cm) in autumn and disk harrowing and rolling in spring. It was irrigated and sown in depth of 2.0-2.5 cm in the moist soil using hand line sowing in spring after the cold weather disappeared. Hand weeding was applied two times. After the maturity, two rows with the 1 m lengthened were removed from each plot due to the border effects. To evaluate of the traits including the height of the first pod (HFP), number of pods plant^{-1} (NPP), number of grains plant^{-1} (NGP) and grain weight plant^{-1} (GWP) totally, 5 plants were randomly selected from each plot. Similarly, to be able to determine of the Grain Yield (GY), one of the middle rows in each plot was hand harvested after removing 1 m from each side of plots. The Grain Protein Content (GPC) was found by Kjeldahl method and to determine the Crop Growth Rate (CGR) and Total Dry Matter (TDM), ratios were calculated on Growth Days Degree (GDD) basis during the growth season. All obtained data were subjected to statistical analyze with SAS statistical software and Duncan's Multiple Range Tests (DMRT) were used for means comparison ($p<0.05$).

RESULTS AND DISCUSSION

Height of the first pod (HFP): The results demonstrated that the HFP decreased due to an increase in RS. In 30 cm RS, the first pod height was realized at the height of 19.19 cm. Also, different IRSs showed the same effect for this trait (Table 1). As RS and IRS increase inter plant competition increases. Consequently, less light penetrates in crop canopy and internodes become longer and cause the first pod to appear at higher height. Bashtani (1997), Dadkhah *et al*. (1998) and Boyak *et al*. (2004) separately reported similar results in their studies. Lower RSs and IRSs would bring about mechanized harvesting possibility due to the appearance of first pod in higher height. Therefore, following the results obtained from this study, 30 cm row spacing and 5 cm inter row spacing are reasonable to reach a mechanized agronomy.

Number of the pods plant^{-1} (NPP): It was increased as a result of an increase in RS in this study. The highest number of it was 19.48 in 60 cm RS (Table 1). These results agree with those of Adam and Weaver (1998) and Board *et al*. (1990). An increase in IRS resulted in an increase in the NPP (Table 1). Hashemijazi *et al*. (2005) used 3 different IRSs in their study. Their results demonstrated an increase in NPP and in NGP due to an increase in IRS.

Number of the grains plant^{-1} (NGP): An increase in RS resulted in an increase in this trait. The highest value was 55.24 in 60 cm RS (Table 1). These results agree with those of Rezaee and Hasanzadeh (1996) due to RS changes. IRS changes also, affected this trait. An increase in IRS resulted in an increase in NGP (Table 1). Hashemijazi *et al*. (2005) by using 3 RSs (35, 50 and 60 cm) and 3 IRSs (5, 10 and 15 cm) in their studies, reported similar results.

Grain weight plant^{-1} (GWP): It was increased as a result of an increase in the RS. The highest value was 24.09 g recorded in 60 cm RS (Table 1). Obtained results agree with those of Board *et al*. (1990) and Xu and Pierre (1998) for this trait. In addition, an increase in IRS resulted in an increase in GWP (Table 1). Bashtani (1997) by investigating the effects of 4 RSs (30, 40, 50 and 60 cm) and 4 IRSs (5, 10, 15 and 20 cm) on common bean reported that an increase in RS and IRS resulted in an increase in GWP and some other traits including NGP, NPP and pod weight plant^{-1} (PWP). These results, could be attributed to this fact that in wider RSs and IRSs each plant can better utilize accessible resources and take the sunlight, accordingly, more nutrition and energy are allocated to each plant resulting in better growth and higher GWP, NGP, NPP and PWP.

Grain Protein Content (GPC): Evaluating the effects of RSs and IRSs demonstrated that these factors had no significant effect on this trait (Table 1). Habibzadeh *et al*. (2002) by using 4 IRSs (15, 20, 25 and 30 cm) and Singh *et al*. (1971) by using 2 RSs (75 and 100 cm),

Table 1: Means comparison of the agro-physiological traits for 3 row spacing and 3 inter row spacing using for 2 common bean cultivars

Parameters (cm)	Grain yield (t ha^{-1})	First pod height (cm)	Pods plant^{-1}	Grains plant^{-1}	Grain weight plant^{-1} (g)	CGR (g m^{-2} GDD)	TDM (g m^{-2})	Grain protein (%)
RSs								
30	4.191^{a}	19.19^{a}	10.64^{b}	33.04^{c}	8.44^{c}	2.68^{a}	1044.63^{a}	25.83^{a}
45	3.912^{a}	14.27^{b}	15.77^{ab}	45.83^{b}	15.60^{b}	2.56^{a}	921.45^{b}	25.68^{a}
60	3.121^{b}	12.42^{c}	19.48^{a}	55.24^{a}	24.09^{a}	2.49^{a}	749.96^{c}	25.70^{a}
IRSs								
5	3.926^{a}	17.72^{a}	7.97^{c}	25.44^{c}	12.53^{b}	3.17^{a}	1038.90^{a}	24.70^{a}
10	3.576^{b}	15.36^{ab}	15.05^{b}	37.86^{b}	17.31^{a}	2.55^{ab}	912.33^{b}	25.46^{a}
15	3.723^{b}	12.90^{b}	22.87^{a}	70.82^{a}	18.28^{a}	2.01^{b}	764.80^{c}	26.58^{a}

RSs: Row Spacings; IRSs: Inter Row Spacings; CGR: Crop Growth Rate; GDD: Growth Day Degree; TDM: Total Dry Matter; The means with at least one same letter(s) do not have statistically significant

Table 2: Means comparison of the agro-physiological traits for 2 determinate and indeterminate (Derakhshan and Naz, respectively) cultivars of common bean

Cultivars and agro-physiological traits	First pod height (cm)	Pods plant^{-1}	Grains plant^{-1}	Grains weight plant^{-1} (g)	CGR (g m^{-2} GDD)	TDM (g m^{-2})	Grain protein (%)
Derakhshan	12.12^{b}	10.61^{b}	31.10^{b}	14.19^{b}	2.38^{a}	822.35^{b}	26.42^{a}
Naz	18.53^{a}	19.98^{a}	58.30^{a}	17.89^{a}	2.77^{a}	988.33^{a}	25.05^{b}

CGR: Crop Growth Rate; GDD: Growth Day Degree; TDM: Total Dry Matter; The means with at least one same letter(s) do not have statistically significant

separately showed similar results in their studies. Sadeghipour *et al.* (2005) also, reported that GPC was not influenced by different plant densities in used common bean cultivars. However, in comparison between cultivars it was observed that Naz (indeterminate) had higher GPC (Table 2).

Grain Yield (GY) (t ha^{-1}): The highest value was obtained at the lowest RS and IRS. Using 30 cm RS and 5 cm IRS resulted in 4.191 and 3.926 t ha^{-1} GY, respectively (Table 1). Frederick *et al.* (1998), Xu and Pierre (1998) and Holshouser and Whittaker (2002) separately reported an increase in GY as a result of a decrease in the RS and IRS parameters. Dwivedi *et al.* (1994), Hayat *et al.* (2003) and Mehraj *et al.* (1996) also, reported an increase in GY due to a decrease in IRS. The results of this study imply that by decreasing RS and IRS, plant population, consequently, number of pods and grains m^{-2} increase and these changes lead to an increase in GY. Moreover, a decrease in RS and in IRS in common bean results in an increase in GY without any significant reduction in GPC. Different cultivars affected the GY (Table 2). In comparison between the cultivars; it was observed that Naz (indeterminate growth) had higher capability than Derakhshan (determinate growth) to produce more GY (Table 2). The highest GY in Naz cultivar can be attributed to the ability of indeterminate cultivars to benefit from its surrounding atmosphere and to spend less energy to create preservative and constitutive organs.

Crop Growth Rate (CGR) (g m^{-2} GDD): The process of CGR changes in this study demonstrated that different RSs had no significant effect on this trait. However, a decrease in RS resulted in an increase in CGR. The highest CGR was observed at lowest IRS, corresponding 3.17 g m^{-2} GDD (Table 1). An increase in CGR due to a decrease in IRS can be attributed to an increase in the NPP and plant population. Similar results were reported in the studies of Sirait *et al.* (1994), Mobaser *et al.* (1999) and Enyi (1973). Accordingly, an increase in CGR due to a decrease in IRS could lead to an increase in grain yield.

Total Dry Matter (TDM) (g m^{-2}): The highest TDM was obtained at the lowest RS and IRS (1044.63 and 1038.90 g m^{-2}, respectively). An increase in RS and in IRS resulted in a decrease in TDM (Table 1). These results agree with those of Ayaz *et al.* (2001) and Board *et al.* (1990). An increase in TDM due to a decrease in row spacing and inter row spacing could be attributed to an increase in plants m^{-2} and consequently an increase in dry matter weight.

To conclude, grain yield could be affected by manipulating row spacing and inter row spacing, so that to reach the highest grain yield in common bean (*Phaseolous vulgaris* L.) cultivars. By decreasing row spacing and inter row spacing resulting in an increase in plant population, we could succeed this goal. In addition, since row spacing and inter row spacing changes have no significant effect on grain protein content, this grain yield increase does not diminish the nutritional quality of common bean grain.

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