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Yield and yield components of red bean cultivars in different planting pattern as a second cropping in Kermanshah climate, Iran

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Abstract

To evaluate the effect of planting pattern on yield and yield components of different bean cultivars as second cropping in Kermamanshah province, this experiment carried out based on split plot arrangment in randomized compplet block design with three replications. Planting Pattern as 15 × 12 cm, 30 × 6 cm, 45 × 4 cm, respectively, so that the density of 55.5 plants.m^{-2} were observed and considered as main plots. Main plots consisted of three planting patterns with 15, 30 and 45 cm as row spacing and 4, 6 and 12 cm as plant spacing. Six bean cultivars including Akhtar, Goli, Pak, Shokofeh, Dorsa and Daneshkadeh were assigned sub-plots. After harvesting canola as main crop in this field, bean cultivars were cultivated as second crop in summer of 2013. Analysis of variance showed that planting pattern on grain yield, biological yield and harvest index were significant at the 1% level. 100-grain weight and number of pods per plant were significant at the 5% level, but had no significant effect on number of grains per pod. Cultivar had a signifcent affect on the number of pods per plant, grain per pod, grain yield, biological yield and harvest index at the 1% level. Protein content was affected by cultivar at the 5% level. Interaction effect between planting pattern and cultivar were significant on grain yield, biological yield and harvest index at the 1% level, but pods per plant, grain per pod and 100-grain weight were no significant by plantig pattern and cultivar. The heghest grain yield with mean of 445 g.m^{-2} was observed in planting pattern of 45 cm and Dorsa cultivar and the lowest grain yield with mean of 10 g.m^{-2} was bserved in planting pattern of 15 cm and Akhtar cultivar, respectively.

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Introduction

Legumes are an important source of protein and energy for humans. Legumes after wheat and rice are the main agricultural crops that feed the world's people, especially the developing countries. Pulses with 17 to 40% protein, plays an important role in the production of protein and calories that are require foe human. Protein content of seed is 2 to 3 times higher than the protein found in grain of cereal and 10 to 20 times more protein of starch and glandular plants (Bagheri, 2007). Legumes increase soil stability and productivity and reduce the chance of diseases, pests and weeds for the next crop, especially when the ceraels are roatation frequently. Bean is one of the most important crops in the world and Iran that belongs to Fabaceae family. Given the importance and nutritional value of pulses and bean, the production of theses crops, particularly in developing countries, are more attention in the world. Therefore, understanding the various aspects of its varieties such as morphological characteristics, physiological, resistance to pests, diseases and weeds are at the forefront of the research programs (Jafari, 2003). Thus main effect of planting pattern and plant density on crop is mainly due to difference how sunlight would distribute across canopy and increasing sunlight absorption would cause to improving grain yield (Naseri *et al.,* 2010). Proper selection of crop varieties for a particular place of management decisions is important and can have a great effect in agricultural production project. Arrangement of plants within a given plant density is important so that the appropriate density of healthy plants at the best planting pattern is based on succsful crop production systems. The geometric arrangement of plants or planting pattern by changing the width of the row and plant spacing in the row changed. Theoretically, the choice of narrow row and plant spacing to increase the efficient use of resources and delay in the start of the interplant competition. Optimum plant density for maximum economic yield depending on the type of crop, variety and cultivation conditions. Thus, in recent years a lot of research on the regulation of plant populations based on the availability of production factors and the effect of plant density on yield, and it is done (Kochaki and Banyan Aval, 1993). To achieve the highest yield, in addition to optimum density, consistent distribution of plants and consequently the structure of plant canopy are great importance (Mohamadzadeh *et al.,* 2011). Nazaralizadeh *et al.* (2012) found studing row spacing and plant density effect on safflower that improving yield using shorter row spacing was result from increasing LAI and CGR in vegetative growth stage.

Plant density can influnce on growth indices, therefore, the analysis and identification of growth indices factors on yield and yield components are important. Desired plant density depends on several factors including plant characteristics, growth period, the time and method of planting, soil fertility, plant size, available moisture, solar radiation, planting patterns and weeds status (David *et al.,* 1994). Planting pattern and plant spacing, determines the development of usable space per plant and thus yield can be achieved (Kochaki, 1993). Naseri *et al.* (2012) indicated that seed yield canola increased due to increase in plant density to 60 plants.m^{-2}. Indicated, the number of grains per plant was influenced by both the spacing between the rows and rows, respectively, So that, with increasing row spacing, increasing the number of grains per plant and grain per plant increased with the decrease in density is due to the increased number of pods per plant, So that a direct relationship between the number of grain and number of pods per plant (Torabi Jefrodi *et al.*, 2005). Determinate crops show a better response to the changing of planting pattern and plant density and indeterminta crops show better response to high densities in narrow row spacing (Mesut *et al.*, 1986). Kazemi *et al.* (2012) in their study on yield and yield components of different densities were white bean varieties they found plant density had significant effect on lateral branches, pod per plant, grain weight, biological yield and harvest index and density of 13 plants.m^{-2} had the highest number of branches (2805 branchs), number of pods per plant (42.1 pods), grain yield (2393 kg.ha^{-1}), biological yield (5761 kg.ha^{-1}) and harvest index (41.6%) to other plant densites. In their syudy interaction effect between plant density and cultivar were significant on number of branches, number of pods per plant, grain weight, biological yield and harvest index. The highest and lowest grain yield from the Shokofeh cultivar with plant density of 13 plants.m^{-2} and Daneshkadeh cultivar with 16 plants.m^{-2}, respectively. Grain yield has direct correlation with pods per plant so that with incresing plant density individual pod per plant decresed but pod per plant per.m^{-2} increased (Aghamiri, 1993).

This research was done to determine the best and most compatible and determine the best planting pattern and row spacing on bean as a second cropping in Kermanshah province, Iran.

Materials and methods

Study side and *Experimental design and treatments*

This study was conducted to evaluate the effect of planting pattern on yield and yield components of bean varieties as second crop in Kermamanshah province at Agricultaral Research Center of Kermanshah (37⁄ 8' E, 33⁄ 40'N), Iran during 2012-2013 cropping season based on split plot arrangment in randomized compplet block design with three replications. Pattern arranged as 15 × 12 cm, 30 × 6 cm, 45 × 4 cm, respectively, so that the density of 55.5 plants.m^{-2} were observed and considered as main plots. Main plots consisted of three planting patterns with 15, 30 and 45 cm as row spacing and 4, 6 and 12 cm as plant spacing. Six bean cultivars including Akhtar, Goli, Pak, Shokofeh, Dorsa and Daneshkadeh were assigned sub-plots. The average annual temperature was 13.82. The results of the physical and chemical analyses of the soils for experiment are shown in Table 1.

Table 1. Physical and chemical of properties of soil in the experimental area.

soli depth	Texture	Silt (%)	Clay (%)	Loam (%)	K (ppm)	P (ppm)	N (%)	OM (%)	PH
0-30	Silt, Clay, Loam	8/8	36	55.2	250	8.4	11	1/12	7.5

Plant analysis

Number of pods per plant, number of grains per pod, 1000-grain weight, grain yield, biological yield, harvest index and protein content were calculated. 5 plants measured manually in each plot after omitting side lines and 50 cm from end and begging of plot and plants sent to labratory. Protein content was determined using the **kedjeldal** procedure. All field observations and plant samples were obtained from the central two rows of each four row plot. In addition, the central two rows were harvested for grain yield. The harvest index (HI) was determined as the ratio of grain weight to total biological yield (weight of grains, pods, leaves, branches and stem).

Statistical analysis

The data were analyzed statically by SAS and MSTAT programs and the data means were compared by Duncan's Multiple Range Test.

Result and discussion

Number of pods per plant

Number of pods per plant is the most important components of grain yield. The ability of legumes to formation of flower buds and pods are very high that depends on the conditions interior the plant and the environment. Inappropriate conditions during the flowering period, and increase loss flowers during pod formation, loss of reproductive organs, especially the young pods of the plant occurs (Kochaki, 1985). In the present experiments, according to analysis of variance (Table 2), the effect of planting pattern at the 5% level was significant on number of pods per plant. Cultivar effect on this trait was significant at 5% level. According to the simple comparison the highest number of pods per plant with mean of 17.2 pods beloged to 45 cm planting pattern. The lowest number of pods per plant witrh mean of 15.3 observed in 30 cm planting pattern (Table 3). The highest number of pods per plant with mean of 19.5 pods showed Dorsa cultivar (Table 3). Torabi Jefrodi *et al.* (2005) in their study on planting pattern, planting density and some vegetative traitsin red bean cultivar indicated that the increase in yield per plant in closer planting pattern and plant density is due to these circumstances, plants and sunlight utilization of available resources. As a result, the plant becomes more established and more material enters the sheath. Number of pods per plant is on of most variable trait among other yield components. Legume potential for the formation of flower buds, flowers and pods are very high, but achive to this potential depends on genetic plant and environmental conditions (external).

Number of grains per pod

The results showed that there was no significant on number of grains per pod by planting pattern, but cultivar had a significant effect on this trait at the 1% level (Table 2). Recording the simle comparision, Shokoofeh cultivar with mean of 6.08 grains had the higest number of grains per pod to othe cultivars (Table 2). Obviously, with increasing planting pattern decreased interplant and intraspecific competition result in better food didtrubition to sink. Hashemi Jazi *et al.* (2003) found that with increasing plant density and planting pattern number of grains per pod is slightly reduced. Incresing in number of grains per pod with increasing inter row pacing and intra row spacing reported by Ranjbar *et al.* (1995).

Table 2. Analysis of variance (Mean Square) for some studid traits.

S.O.V	d.f	Number of pods per plant	Number of grains per pod	100 - grain weight	Grain yield	Biological yield	Harvest index
Replication	2	16.83 *	2.54 **	100.91**	82.91 **	172.02	0.64
Planting pattern	4	17.03*	0.44	30.01 *	244172.7 **	3500763.63 **	306.3**
Main Error	5	0.048	0.035	8.04	6.16	165.82	0.034
Cultivar	4	37.41 **	2.87 *	78.52 **	32824.83 **	1126957.14 **	501.16 **
Planting pattern × cultivar	10	0.88	0.056	10.90	3498.76 **	185510.66**	89.69 **
Sub Error	30	4.63	0.202	6.19	6.74	166.04	0.19
C.V (%)	-	13.2	8.75	9.01	1.35	1.28	2.22

ns, *, ** Non significant and significant at the 5 and 1% level, respectively.

100-grain weight

100-grain weight was significantly affected by planting pattern and cultivar (Table 2). According to simple coparioson table the highest 100-grain weigh with mean of 29.02 g was obtain from 45 cm planting pattern, statistically there was no significant differences between 15 and 30 cm a planting pattern and were the same group (Table 3). Also, the simple coparioson indicated that the highest 100-grain weight with mean of 31.5 g belonged to Dorsa cultivar. Interaction effect between planting pattern and cultivar indicated that 45 cm planting pattern and Dorsa cultivar with mean of 34.1 g had the heihest 100-grain weight and 45 cm planting pattern and Goli cultivar with mean of 21.6 g ha the lowest 100-grain weight (Table 3). Hashemi Jazi (2003), during his research on pinto beans stated that the 100-grain weight was influenced by planting pattern and plant density.

Grain yield

Analysis of variance showed that the planting pattern of cultivar and their interactions were significant on yield at the 1% level (Table 2), so that the highest grain yield was obtained from 45 cm planting pattern with mean of 326.6 $g.m^{-2}$ ant the lowest grain yiels belonged to 15 cm planting pattern thad was due to decrese in number of pod per plant and 100-grain weight (Table 3). It can be concluded, that by reducing the planting pattern and increasing in plant density, light penetration into the canopy would be inadequate and, therefore, the construction of photosynthesis is reduced result in incresing of unfilled grains per plant d, resulting in it leads to a reduction in grain yield. These findings are consistence with results of Kahraryan (2002). Dorsa cultivar with mean of 302.5 $g.m^{-2}$ had the heighest grain yield and the lowest grain yield belonged to Shokofeh cultivar with mean of 127.1 $g.m^{-2}$ (Table 3).

This matter is indication of genetic difference among studid cultivars. The reson of having the highest grain yield in Dorsa cultivar is due to the higher number of pods per plant. Interaction effect between planting pattern and cultivar stated that the 45 cm planting pattern and Dorsa cultivar with mean of 445 $g.m^{-2}$ had the higest grain yield (Table 3). Tghdiry *et al.* (2012) concluded that grain yield of pinto beans with increasing row spacing incresed. It can be concluded that, increasing the space between the rows, thus reducing competition between them has resulted in increased grain yield. It appeared that, by reducing the light radiation received by each plant row spacing decreased.

Harvest index (HI)

HI was affected by planting pattern and cultivar ant their interaction effect at the at the 1% level (Table 2). HI indicate relationship between economic yield and biological yield, the maximum HI was obtained from 45 cm planting pattern and Dorsa cultivar wth mean of 38.08% ant the lowest HI belonged to from 15 cm planting pattern and Goli cultivar wth mean of 30.9% (Table 3). Babayan *et al.* (2012) stated that the planting pattern and planting datewas significantly decreased HI. With increasing pattern of HI increased.

Table 3. Simple and interaction comparison of planting pattern and cultivar on some studied traits.

Traits	Number of pods per plant	Number of grains per pod	100-grain weight (g)	Biological yield ($g.m^{-2}$)	Grain yield ($g.m^{-2}$)	Harvest index (%)
Planting pattern						
R1) (15 cm)	16.35 b	5.22 a	26.48 b	619.22 c	113.55 c	19.69 b
R1) (30 cm)	15.30 c	4.95 b	27.37 ab	906.77 b	13.66 b	15.81 c
R1) (45 cm)	17.25 a	5.23 a	29.02 a	1485.11 a	326.66 a	24.05 a
Cultivar						
V1 (Akhtar)	13.69 d	4.8 dc	29.06 a	1075.22 d	176.55 c	15.88 c
V2 (Daneshkade)	16.11 bc	4.58 d	26.05 b	460.22 f	155.66 d	32.39 a
V3 (Shokofa)	15.13 bc	6.08 a	29.66 a	1430 a	217.11 b	14.96 d
V4 (Dorsa)	19.52 a	5.08 bc	31.55 a	1228.8 b	302.55 a	25.79 b
V5 (Pak)	17.63 ab	5.5 b	25.82 b	1110.22 c	178.7c	14.97 d
V6 (Goli)	15.6 dc	4.69 dc	23.6 b	717.66 e	127.11e	15.17 d
R1v1	13.83	4.83	26.33	801.66 c	98.33 de	12.26 d
R1v2	16.25	4.58	25	378 e	127.66 d	36.68 a
R1v3	14.83	6.08	28.66	749 c	10.d	14.42 d
R1v4	19.5	5.16	30.83	666 cd	216.66 cd	32.46 a
R1v5	17.75	5.66	25.56	621.33 cd	82.66 e	13.30 d
R1v6	15.83	5	22.5	529.33 cd	48 e	9.03 e
R2v1	13.16	4.66	28.54	623.33 cd	107 de	17.21 cd
R2v2	14.16	4.50	26.33	344.66 d	77.33 d	22.43 b
R2v3	14.08	5.91	28.83	1564.66 ab	225.33 cd	14.37 de
R2v4	18.91	4.91	29.66	1205 b	246 c	20.41 d
R2v5	16.58	5.25	24.23	1122.66 b	11.33 d	10.63 e
R2v6	14.91	4.5	26.43	590.33 cd	58 e	9.2 e
R3v1	14.08	5.16	32.33	1800.66 a	324.33 b	18.01 cd
R3v2	17.91	4.66	26.83	688 c	262 c	38.0 a
R3v3	16.5	6.25	31.5	1979.33 a	318 b	17.08 cd
R3v4	201.6	5.16	34.16	1815.66 a	445 a	24.5 bc
R3v5	18.58	5.58	27.66	1596.66 ab	335.23 b	20.99 c
R3v6	16.25	4.58	21.66	1033.33 b	275.33 c	26.68 b

Means in each column followed by similar letter(s) are not significantly different using Duncan's Multiple Range Test.

Biological yield

Biological yield was affected by planting pattern and cultivar ant their interaction effect at the at the 1% level (Table 2). The maximum biological yield belinged to 45 cm planting pattern and Shokofa cultivar with mean of **1979.3 $g.m^{-2}$** and the minimum biological yield was observed in 30 cm planting pattern and Daneshkade cultivar with mean of **344.66 g.m^{-2}** (Table 3). Increasing in produced dry matter in plants under optimum planting pattern could be due to the expansion of the leaf surface and durability, which make use of more efficient physiological source of light, dry matter production.

Protein content

Protein content was significant at the 1% level by cultivar (Table 2). Akhtar cultivar had the higest protein with mean of 25.6% and the Minimum protein content belonged to Goli cultivar with mean of 22.5%. Torabi Jefrody *et al.* (2002) found that with increasing row spacing protein content increased.

Conclusion

It can be concluded that grain yield increased with increasing row spacing. Because it increases the space between the rows, thus reducing competition between them. It appeared that, by reducing the radiation received by each plant row spacing decreased. Therefore, the plant produced less dry matter partitioning and grain decreases and the probability of transmission.

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