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Variability of Grain Yield and Yield Components of White Bean (*Phaseolus vulgaris* L.) Cultivars as Affected by Different Plant Density in Western Iran

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Abstract: In order to study the effect of plant density on yield and yield components of white bean cultivars an experiment was conducted as split plot in randomized complete block design with four replications in Agricultural and Natural Resources Research Center of Ilam, Iran during 2009-2010. The main and sub plots included cultivars (Shokofa and Danshekadeh) and plant density (13, 16 and 22 plant/m^2), respectively. The results of variance analysis showed that cultivar had significant effect on plant height, number of grains per plant, grain yield and harvest index. Shokofa cultivar had the highest plant height (188.5 cm), number of grains per plant (173.6 grains), grain yield (2591.8 kg ha^{-1}) and harvest index (45.5 %). Plant density had significant effect on number of branches, number of pods per plant, grain yield, biological yield and harvest index. The plant density of 13 plants per m^2 had the highest number of branches (28.5 branches), 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%). The interaction between cultivar × plant density was significant on number of branches, number of pods per plant, grain yield, biological yield and harvest index. The highest and lowest grain yield was obtained from Shokofa cultivar by 13 plants per m^2 and Danshekadeh cultivar by 16 and number of plants per m^2, respectively.

Key words: Plant density · White bean · Yield and yield components

INTRODUCTION

White bean (*Phaseolus vulgaris* L.) is one of the most important agriculture crops which consumed as nutrition matter. Absorbed sunlight efficiency by crop needed to enough leaf area to distributing equally, this aim done by changing row spacing and distributing plants over soil [1]. Black Show *et al*. [2] contributed that plant density effect on bean yield to differences in photosynthetically activated radiation uptake during growth season by canopy. In high densities, plant competing with other plants to uptake CO_2, water, light and nutrients. Also, plants exposed stress due to high density. This stress has affect crop yield and quality and plant lodging. High density induced more shadowing and reducing in photosynthesis and finally to increasing in flower and pod drop-off during reproductive stages [3]. Grain yield is affected by competition to produce maximum grain yield. Plant distribution is very important and plant pattern affected positively the distributing sunlight among plants. Main role of planting pattern on plant growth is due to differences in distributing and dispersion energy and light quality and quantity among plants which induced improving grain yield and biological yield with increasing radiation uptake [4]. Mohamadzadeh *et al*. [5] stated that the highest grain yield for 15, 30, 45 and 60 cm rows were obtained for narrow row of 30cm. Bord and Harville [6] indicated that high yield of soybean which obtained using narrow row spacing and thicker plant density was due to more radiation and growth rate of plant at the beginning of reproductive stage. Dhanjal *et al*. [7] reported that the highest plant height and number of grains per pod obtained using wide row spacing. Enyi [8] suggested that thickening density of soybean caused to increasing plant height and to reducing nodule number on stem and it is due to low radiation. Thus in decreasing plant height in thin densities is due to increasing nodule number, whereas it is due to

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increasing middle nodules spacing in thick densities caused by reducing in sunlight penetrating into canopy. Under such conditions, gibberellins photo oxidation reduced and thus middle nodules spacing increase. It is obvious that plant height would increase and branches number would reduce under such conditions. Koli and Akashe [9] observed that pods per plant was higher in 30 cm row spacing that in 25cm row spacing. Ayaz *et al*. [10] reported that grains per pod changed with changing plant density and thickening density caused to reducing in grains per pod. Pulse is one of the important agricultural crops in Ilam (western Iran) and it planting as crop rotation after wheat and barely. Therefore, this study conducted to investigating better cultivar and suitable plant density in this region.

MATERIALS AND METHODS

In order to investigate the effect of plant density on yield and yield components of white bean cultivars, an experiment conducted in Agricultural and Natural Resources Research center Ilam, Iran during 2009-2010, with 46° 36′ E longitude and 33° 476 N altitude and 975 m height above sea in western. Experiment conducted as split plot as randomized complete block design in four replications. Cultivar (Shekofa and Daneshkae) selected as main plot and plant density in three levels (22, 16 and 13 plant/m^2) sub plot. Tested farm planted wheat last year. Before planting, one thirds nitrogen (150-100 kg ha^{-1}), 100 kg ha^{-1} phosphate and 100 kg ha^{-1} potash fertilizers were used and added to soil using disk harrow and two-thirds nitrogen fertilizer manure to soil before flowering stage. Any plot included 5m 5 lines and 1 line didn, 8 plants between two sub lines and main plots spaced 1m. Desirable density regulated during four leaves stage and by root out additional plants. Weeds controls by hoeing. Farm irrigated once per week as flooding. 10 plants selected randomize from any plot and attributes such as plant height, grains per pod, number of branch, pod per plant, grains per plant, 1000-grains weight were measured. In order to measuring grain yield, plants per plots calculated. To calculating biological yield, all plant weight measured after harvesting plants per plot and then biological yield determined. Harvest index given by dividing grain yield biological yield. Statically analysis was conducted using MSTAT-c software. Mean comparison was also conducted with Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Plant Height: Analysis of variance indicated significant difference in cultivar plant density and interaction effects of cultivar and plant density at $p<0.01$ on plant height (Table 1). Table 2 showed that Shekofe cultivar had significant different with Danshekadeh cultivar and it obtained 188.59 cm plant height. Shokofa cultivar had indeterminate growth compared with Danshekadeh cultivar, thus it obtained high plant height. As shown in Table 2, plant density had significant differences, the highest height, 159.9cm was obtained at 22 plants per m^2 densities, while the lowest plant 149.2 cm height was obtained at 13 plants per m^2 densities. The interaction effects between cultivars and plant density also indicated significant difference. As shown in Table 3, Shokofa cultivar had significant difference in all plant densities with Danshekadeh cultivar. The highest and lowest plant height was obtained in Shokofa cultivar x 22 plants per m^2 densities and in Danshekadeh cultivar x 13 plants per m^2 density, respectively. Enyi [8] reported that plant height increased with increasing plant density and nodule number on stem reduced. Thus increasing height in high densities is due to increasing nodule spacing affected by reducing sunlight penetrating into canopy. Under this conditions, gibberellins oxidation reduces and nodule spacing increases. It is obvious that under such conditions, plant height was increased, while branches number was reduced. In other study, Silim and Saxena [11] reported that branch numbers was decreased at early season while increased with late season of bean crop at 22 and 44 plant/m^2 densities. Also increasing density decreased branches number and increased plant height.

Number of Branches: Variance analysis showed a significant difference in branches number under different plant densities, while was not affected by the interaction between cultivars and plant densities (Table 1). In spite of lack of cultivar effect on branch numbers, it observed that Shokofa cultivar had more number of branches than Danshekadeh cultivar (Table 2). Data in Table 2 indicated the a significant difference was observed between plant density and low plant density, which resulted in an increasing number of branchs. The highest and lowest number of branchs was obtained at 13 and 22 plant/m^2 densities, respectively. Das *et al*. [12] reported that increasing density significantly reduced branches number. Wells *et al*. [13] on soybean indicated that radiation penetrating in to canopy was decreased with high plant density and reduced branches number.

Table 1: Analysis of Variance of grain yield and agronomic traits in cultivar and plant density

		MS								
S. O. V	df	Plant height	Number of branch	Pod per plant	Grains per pod	Grains per plant	1000-grain weight	Grain yield	Biological yield	Harvest index
Replication	3	91.4	30.3	82.05	0.4	590	58.7	94714.8	14568	9.2
Cultivar (C)	1	2748.1**	22.4ns	50.7ns	1.04ns	15595.8*	92.9ns	2211908.1**	1761500.1ns	294.3**
Error a	3	16.8	24.5	82.1	0.21	678.9	22.7	49524.6	451185.8	0.97
Plant density (PD)	2	394.4*	57.1*	512.1**	0.18*	11805.8**	1.3ns	237262.5*	20026290.5**	32.01**
C× PD	2	701.6**	25.2ns	339.1**	0.25ns	2883.5**	9.3ns	748846.1**	1803659.5**	29.2**
Error b	12	100.3	12.9	10.9	0.16	127.9	10.8	34862.5	152975.8	2.5
C.V%	-	7.4	13.8	9.8	12.2	7.6	10.4	8.1	7.2	7.8

*: Significant at 0.05 level, **: Significant at 0.01 level

Table 2: Mean comparison of agronomic traits in cultivar and plant density

Main effect	Plant height (cm)	Number of branches	Pods per plant	Grains per pod	Grains per plant	1000-grain weight (g)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Cultivar									
Shokofa	188.5a	26.9a	35.11a	3.6a	173a	33.3a	2591.8a	5681.3a	45.5a
Danshekadeh	120.9b	24.05a	31.2a	3.4a	122.6b	29.4a	1984.6b	5139.5a	38.5b
Plant density (plant/m^2)									
22	159.9a	23.2b	26.2c	3.3a	104.8b	30.9a	2010b	5050b	39.9b
16	154.9b	26.7ab	32.6b	3.2a	161.3a	31.6a	2280a	5595b	40.9b
13	149.3c	28.5a	42.1a	3.2a	178.2a	31.5a	2393a	5761a	41.6a

Mean which have at least once common letter are nit significant different at the 5% level using (DMRT)

Table 3: Mean comparison of interaction effect of cultivar × plant density on grain yield and agronomic traits

Treatment		Plant height (cm)	Number of branches	Pods per plant	Grains per pod	Grains per plant	1000-grain weight (g)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
	22	202.8b	22.5b	26.8c	3.9b	115.5d	32.3ab	2329b	5789b	40.2c
Shokofa	16	181.2b	27ab	28c	3.2ab	180.2b	34.8a	2428b	5186c	46.9b
	13	180.3a	31.4a	50.5a	3.06ab	225.1a	32.8ab	3018a	6133a	49.7a
	22	130.7c	23.9b	25.6c	3.7a	94.1e	29.4ab	1745.5c	5286b	33.1d
Danshekadeh	16	116.9c	25.5ab	37.2b	3.3ab	142.4e	28.4b	1850c	5589b	33.2d
	13	115.1c	25.7ab	33.8b	3.4ab	131.3cd	30.3ab	2358b	6067ab	38.9cd

Mean which have at least once common letter are nit significant different at the 5%level using (DMRT)

Number of Pods Per Plant: Number of pods per plant had not significant effect by cultivar, but it showed significant difference in plant density and interaction between cultivar and plant density. In spite of no difference in pods per plant between cultivars, it observed that Shokofa cultivar had higher pods per plant than Danshekadeh cultivar (Table 2). The increase in pods number may be due to the increase of brances numbers in Shokofa cultivar than of Danshekadeh cultivar. Plant density showed significant difference in pods per plant. Number of branches was increased with low plant density. The highest and lowest pods per plant was obtained at 13, 22 plant/m^2 densities, respectively (Table 2). There was negative relation between pods per plant density, so that high plant density decreased number of pods per plant. Koli and Akashe [9] indicated that higher pods per plant was obtained by using 30 cm row spacing than that of 25 cm row spacing. Ikeda [14] reported that pods per plant was increased significantly with increasing row spacing. The interaction between cultivar ×plant density also indicated significant difference in pods per plant. Data presented in Table 3 showed that Shokofa cultivar had more pods per plant that that Danshekadeh cultivar. In both cultivars low plant density increased pods per plant. The highest and lowest pods per plant was obtained by Shokofa cultivar with 13 plant/m^2 density and Danshekadeh cultivar with 22 plant/m^2 densities, respectively. Other studies showed that high plant density reduced sunlight penetrating in to canopy and as a result buds form was also reduced. Decreasing branches lead to reducing pods per plant [15]. Leech *et al*. [3] also indicated that pods per branches were decreased with high plant density due to low micro climate space.

Number of Grains Per Pod: Number of grains per pod was not significantly affected by treatment used (Table 1). It is obvious that grains per pod is one of the most constant grain yield components and was not affected by density. Similar results were reported by Hang *et al*. [16] and Danna [17] reported that grains per pods didn't affected by row spacing and planting pattern.

Number of Grains Per Plant: Number of grains per plant had significant differences by cultivar, plant density and also interaction effects between cultivar × plant density at $p<0.01$ (Table 1). Results in Table 2 showed that Shokofa cultivar had more grains per plant (173.6) than Danshekadeh. On the other hand the highest grains per plant was obtained using 13 plant/m^2 density, while no significant difference was observed between 22 and 16 plant/m^2 densities (Table 2). There is various evidence that grains per plant was decreased with increasing plant density [18]. Wahab *et al*. [19] reported that increasing grains per plant with decreasing plant density was resulted from increasing pods per plant so that there was direct relation between grains per plant and pods per plant. Increasing grains per plant is proportionate with high plant density. Data in Table 3 showed that Danshekadeh cultivar had significant difference in plant density. Low plant density increased grains per plant in Shokofa so that, the highest grains per plant was obtained using 13 plants/m^2 density whereas the lowest was obtained by 22 plant/m^2 density.

1000-Grains Weight: This attribute didn't affect significantly by none experimental factors (Table 1). As shown, no significant difference observed between cultivars. Table 2 show that Shokofa cultivar obtained highest 1000-grains weight 33.3g. As shown in Table 2, plant density hadn't significant difference in this trait, but thinning density caused to increasing 1000-grains weight. 16 plant/m^2 density obtained highest 1000- grains weight and lowest 1000- grains weight is one of the most constant yield components and isn't affected by density [20-21. Shirtliffe and Johnston [22] reported that 1000-grain weight didn't change with changing in plant density.

Grain Yield: Grain yield affected significantly by cultivar, plant density and interaction between cultivar ×plant density (Table 1). Results in Table 2 showed that Shokofa cultivar had higher grain yield (258.8 kg ha^{-1}) than Danshekadeh. Data also indicated that Shokofa cultivar had higher yield than Danshekadeh due to higher number of pods per plant, number of grains per plant and more 1000 grains weight. It is obvious that low plant density improved grain yield so that the highest grain yield was obtained with 13 plant/m^2 density. But no significant difference was observed between 13 and 16 plant/m^2 density (Table 2). Larry *et al*. [23] on soybean indicated that grain yield was reduced with decreasing plant density. The interaction between cultivar×plant density also showed significant difference in grain yield. As shown in Table 3, Shokofa cultivar in all density showed significant difference with Danshekadeh cultivar. The highest and lowest grains was obtained in Shokofa cultivar and 13 plant/m^2 density or Danshekadeh and 22 plant/m^2 density, respectively. Ablett *et al*. [24] reported that grain yield of soybean was increased significantly with high plant density, while grain yield was reduced occasionally with increasing plant density due to lodging and plants mortality.

Biological Yield: Data presented in Table 1 showed that biological yield was not significantly affected by cultivar but plant density and their interaction effects had significant difference. Data in Table 2 showed that Shokofa cultivar had the highest biological yield (5681.3 kg ha^{-1}). It is obvious that low plant density increased biological yield so that the highest biological yield was obtained using 13 plant/m^2 density, while 13 and 16 plant/m^2 densities had no significant difference (Table 2). The interaction effects between cultivars and plant density also indicated significant difference in biological yield. Shokofa cultivar had significant difference with Danshekadeh. The highest and lowest biological yield was obtained with Shokofa and 13 plant/m^2 density or Deneshkade cultivar and 22 plant/m^2 density, respectively (Table 3).

Harvest Index: Harvest index was significantly affected by cultivar, plant density and also interaction effects of cultivar on density (Table 1). It is obvious that Shokofa cultivar had higher harvest index than Danshekadeh (Table 3). It is seem in Shokofa that it can preserved more photosynthetic matter and thus can delivered more photosynthetic matters to grain because all organs acted as source at late growth period due to it's high yield and more yield components and more dry matter. It is also shown that low plant density increased harvest index so that highest harvest index obtained in 13 plant/m^2 densities and the lowest obtained at 22 plant/m^2 densities (Table 2). Higher harvest index at 13 plant/m^2 density is indicated equal distributing plants effects on improving environmental growth factors by plant and also creating

more canopies. Harvest index was decreased with increasing plant density and remobilization efficiency of photosynthetic reduction. As increasing in competition among plants caused to severing intra specific competition in vegetative and reproductive organs to receiving photosynthetic matters, because vegetative sink will build later than reproductive sink, vegetative sink would first affected by competition branches and more pod per branch caused to more yield at 13 plant/m^2 density. The interaction between cultivar ×plant density also indicated significant difference in harvest index. As shown in Table 3, Shokofa cultivar had significant difference compared with Danshekadeh cultivar in all plant densities. The highest and lowest grain yield were obtained in Shokofa cultivar at 13 plant/m^2 density or with Danshekadeh cultivar at 22 plant/m^2 density, respectively. Crothers and Westerman [25] indicated that harvest index was reduced with increasing plant density.

CONCLUSION

Results indicated that Shokofa cultivar had the highest yield in comparison with Danshekadeh cultivar. Different densities Effect was significant on yield, yield components, plant height, grains per plant and harvest index. The 13 plant/m^2 densities take advantage from these factors due to using environmental conditions and equal distributing sunlight over canopy and these factors lead to increasing grain yield and its components. In a study on interaction effects of cultivar ×plant density, the highest grain yield was obtained with Shokofa cultivar at 13 plant/m^2 density with 3018 kg ha^{-1} and lowest grain yield in Danshekadeh cultivar and 22 plant/m^2 density with 1745 kg ha^{-1}. Interaction effect of cultivar × plant density was significant on number of branches, number of pods per plant, grain yield, biological yield and harvest index. The highest and lowest grain yield was obtained from Shokofa cultivar by 13 plants per m^2 and Danshekadeh cultivar by 16 and number of plants per m^2, respectively.

REFERENCES

1. Naseri, R., K.H. Fasihi, A. Hatami and M.M. Poursiahbidi, 2010. Effect of planting pattern on yield, yield components, oil and protein contents in winter safflower *cv*. Sina under rainfed conditions. Iranian J. Crops Sci., 12: 227-238.
2. Black Show, R.E., H.H. Muendel and G. Saindon, 1999. Canopy architecture, row spacing and plant density on yield of dry beans in the absence and presence of hairy night shade. Can. J. Plant Sci., 79: 663-669.
3. Leech, J., H. Stevenson and A.J. Rainbow, 1998. Effect of high plant population on the growth and yield of winter oilseed rape. Journal of Agric. Camb. Sci., 132: 173-180.
4. Orcutt, D.M. and E.T. Nilsen, 2000. The physiology of plants under stress. John willey and Sons, INC.
5. Mohamadzadeh, M., S.A. Siadat, M.S. Norof and R. Naseri, 2011. The effects of planting date and row spacing on yield, yield components and associated traits in winter safflower under rain fed conditions. American-Eurasian J. Agric. And Environ. Sci., 10(2): 200-206.
6. Bord, J.E. and. B.G. Harville, 1994. A criterion for acceptance of narrow-row culture in soybean. Argon. J., 86: 1103-1106.
7. Dhanjal, R., O.M. Prakash and I.P.S. Ahlawat, 2001. Response of French bean (*Phaseolus vulgaris* L.). Varieties to plant density and nitrogen application. Indian J. Plant Physiol., 46: 277-281.
8. Enyi, B.A.C., 1973. Effect of plant Population on growth and yield of soybean. J. Agriculture Science UK., 18: 131-138.
9. Koli, B.D. and V.B. Akashe, 1995. Dry matter production of French bean variety waghaya as influenced by row spacing, plant densities and nitrogen levels. Current Res.Univ. Agric. Sci. Banglatore, 24: 209-211.
10. Ayaz, S., D.L. Mc, Niel B.A. Mc kenzie and G.D. Hill, 2001. Population and sowing depth effects on yield component of grain legumes. 10 Australian Agronomy con ferens, Hobart.
11. Silim. S.N. and M.C. Saxena, 1992. Comparative performance of somfaba bean (*Vicia faba* L.) cult cultivars of contrastrsting plant types. 2.Growth and development inrelation to yield. J. Agric. Sci. Camb., 118: 333-342.
12. Das, S.N., A.K. Mukherjee and A.K. Nanda, 1996. Effect of dates of sowing and row spacing on yield attributing factor of different varieties of French bean (*Phaseolus vulgaris*). Agric. Digest Karnal., 16: 130-132.
13. Wells, R., J.W. Burton and T.C. Kilen, 1993. Soybean growth and light interception response to differing leaf and stem morphology. Crop Sci., 33: 520-528.

14. Ikeda, T., H. Saito, R. Matsuda and S. Sato, 1992. Soybean yield and yield components in two planting patterns. J. Agron. Crop Sci., 173: 73-78.
15. Chapman, J.E., R.W. Daniels and D.H. Scarisbrick, 1984. Field studies on C assimilation fixation and movement in oil-seed rape (*B. napus* L.). J. Agric. Sci. Camb., 102: 23-31.
16. Hang, A.N., D.C.M.C. Clary, G.C. Gilliland and T.A. Lumpkin, 1993. Plant configuration and Population effect on yield of adzuki bean in Washington. State. New crops p.588-590 In: Janik and J.E. Simon, (eds.) crops. Wiley New York.
17. Danna, F., 1983. Sowing density of dwarf beans for dry beans for dry seed production. Informatory Agrario., pp: 26687-26690.
18. Bhring, M.C., M.S. Reis, C.S. Sendiyama and M.A.S. Rade, 1991. Influence of physiological quality of seeds of soybean. Revistaceres.
19. Wahab, M.N.J., D.H. Dabbs and R.J. Baker, 1986. Effects of planting density and design on pod yield of bush snap bean (*Phaseolus vulgaris* L.). Can. J. Plant Sci., 66: 669-675.
20. Angadi, S.V., H.W. Cutforth, B.G. McConkey and Y. Gan, 2003. Yield adjustment by canola grown at different plant population under semiarid condition. Crop Sci., 43: 1356-1366.
21. Munir, M. and T. McNeilly, 1987. Dry matter accumulation, height and seed yield in spring oilseed rape as affected by fertilizer and spacing Pakistan. J. Agric. Field., 8(2): 143-149.
22. Shirtliffe, S.J. and A.M. Johnston, 2002. Yield density relationship and optimum plant Populations in tow cultivars of solid -seeding dry bean grown in Saskatchewan. Can. J. Plant Sci., 82: 521-529.
23. Larry, C.P., A.B. Rosalind, J.D. Reaper and D.V. Earl, 2002. Radiation use efficiency and biomass production in soybean at different plant population densities. Crop Sci., 42: 172-177.
24. Ablett, G., J.C. Scheihauf and A.D. Melran, 1984. Effect of row width population on soybean yield in south western Ontario. Can. J. Sic., 64: 9-150.
25. Crothers, S.E. and D.T. Westerman, 1976. Plant population effects on the seed yield of *Phaseolus vulgaris*. Agron. J., 68(6): 958-960.