BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, December 2014. Vol. **11**(3), 1531-1538

Studying the Morphological Traits and The Quantitative and Qualitative Yield of 6 Different Soybean Cultivars under Different Seed Density Conditions in Mazandaran

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doi: http://dx.doi.org/10.13005/bbra/1549

(Received: 28 July 2014; accepted: 16 September 2014)

To study the effect of different cultivars of seed on morphological traits and quality-quantity yield of oil rate of soybean cultivars, an experiment was conducted as split plots in a completely randomized block design with four replications at Mazandaran province in 2013. Seeding rates of 55, 70 and 85 kg per hectare as the main factor and soybean cultivars including Sari (JK), Telar (BP), Caspian (033), Nekador (032), Katul (DPX) and Sahar (Pershing) were considered as secondary factors. The results showed that seed rate has a significant effect on all traits except seed rate per pod. In this regard features such as plant height, and the distance of first pod from ground level increased by increasing the seeding rate. Average yield for the three seed genotypes of 55, 70 and 85 kg were respectively 2999, 3246 and 2700 kg per hectare, which were statistically in two groups. Among cultivars under study Nekador having the highest yield components had the highest seed yield. The yield rate of these three cultivars in three seed rate of 55 , 70 and 85 kg per hectare were respectively 3766 , 3643 and 3469 kg per hectare, that the amounts of 55 and 70 kg has been addressed in a statistics class. Sahar and Katul cultivars were with 135.5 and 156.9 days respectively considered among the earliest and most delayed genotypes. The correlation between seed yield and number of pods per plant and 1000 seed weight was manifested as a significantly positive indicating the prominent role of these two yield components on the seed yield.

Key words: Yield Components, Oil, Morphological Traits, Soybean, Seed Yield, Seed Rates.

Oil as a primary source of protein and energy, has an important role in human's nutrition so that today oilseed crops are considered as the second most important source of energy supply[12,21,24]. Also vegetable oils are of a better quality compared to animal fats, because of the low amount of saturated fatty acids [3]. Oilseeds, are considered as the essential food for human that with different products not only provide a part of the human food needs, but also have industrial and pharmaceutical uses and that is why they are considered as important agricultural products [4]. Past researches indicate that only about 9% of the country's oil needs are domestically produced and the rest that is 91.7 percent should be imported from abroad, and to amend the severe shortage, the researchers found that a lot of work is needed to increase oil production in the country, which is possible to achieve both through an increase in

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area under cultivation and the increased yield per unit area, among which the second option seems more logical [29]. According to the World Food Organization (FAO) in 2000, the cultivation area of soybeans in the world was 74,367,965 hectares from which 161,290,488 tons of soybeans were harvested. The average soybean yield of 1128.6 kg/hectare (the minimum) in 1961 has reached 2436.9 kg/hectare (the maximum), which was achieved in 2007, has been different that the yield in 2009 was 2243 kg/hectare in the world[13,15].

From the habit of growth, soybean is divided into three types of indeterminate growth, determinate growth, and semi-determinate growth. Indeterminate types begin to flower when they have only half the main stem nodes, therefore, development of vegetative and reproductive organs of plants mostly starts with its life cycle .In this type, pod and seed formation starts from the lower part of plant, and simultaneously continues upward with the formation of new nodes. But this type as well as the other types of all beans grows at the same time. In the determinate growth, flowering starts once the end node of the main stem is formed or begins to be formed [2], In these circumstances, the necessary measures should be taken to improve the environment for plant growth [18]. Soybean cultivation has some advantages. Including symbiotic nitrogen-fixing bacteria in the roots of soybean that fixes the nitrogen in the air, and as a result the plant will require less nitrogen during growth stages. Also some of the fixed nitrogen by symbiotic bacteria remains in the soil and the subsequent crops will require less nitrogen. Soybean cultivation has led to reduced incidence of pests and diseases and weeds in the field [7].

Deep planting of seed cultivars that genetically, have a shorter hypocotyl are also not recommended. Deep cultivation of soybean seeds in some cases even increased the risk of soil diseases is the greening seedlings [26]. Characteristics of soybean vegetative and reproductive growth stages has been prepared by Fehr and Caviness (1977) [16]. Many factors, including weather conditions, planting design, seeding rate, management of farm operations and food can cause a variety of performance and other characteristics of soybean [11]. Akond and colleagues in the study of the effect of row spacing on agronomic characteristics of soybean reported that yield is affected by changes in plant population and row spacing [1]. Parvez et al., (1989) through some studies showed that with increasing density, main stem height, number of pods per unit area and seed yield increased while the number of nodes on main stem and number of pods per plant decreased [22]. Carpenter and Board's (1997) study showed that by density increase, the number of pods per unit area and seed yield of main stem increased, while seed yield decreased in secondary branches and harvest index [10]. Boeurlein (1988) examined effect of removing the branches in soybean yield. The results showed that with increasing distance in normal plants the average seed yield increases, while the wingless plants small distance was more desirable[6]. Domingues and Hume (1973) after examining the three types of soybean growth (restricted and semi- restricted and unrestricted growth) reported that with increasing density, height of cultivars had indeterminate reduction [14]. With increasing density, light intensity on vegetation was reduced and it reduced the number of tributaries and biomass. His research showed that absorbing photo-synthetically active radiation to achieve maximum performance was influenced by morphological and physiological characteristics[28]. Isik through applying different densities on bean reported that with increasing plant density the weight of each only bush decreases, but with increasing the number of bushes per unit area, biological yield increases [19]. Biological yield has been confirmed as one of the best indicators of selection in many studies [9].The researchers concluded that soy density per unit area can reduce the yield per unit area due to increased competition for water and nutrients [8, 20]. Optimum plant density of soybean cultivars changes according to varieties and geographic location[23]. Boeurlein concluded that increased density in late planting can reduce crop damage caused by delay. Quantities of low seed consumption may also lead to poor posture bushes at the farm level, as a result there can be non-uniformity in the green field, especially if there is a possibility of crust forming on the soil surface [5].

In studying the physiological response of soybean genotypes to plant densities it was found that in all studied genotypes yield of product was higher in high density compared to low density. There is a relationship between the reduction in

seed yield at low density and reduced number of pods or seed per unit area[17].Suhre and Davis stated that yield is the result of increase in the number of pods and seed. Although higher seed rate, provides more functionality, low seed rate causes increase in plant yield. This increase is due to new varieties and higher abilities of cultivars to head higher in low seeding situations, while heading is highly reduced in comparison to seeding rates. New cultivars can better compensate lower plant population through producing more seed on the branches than older cultivars[27]. In this study we investigated the effects of different cultivars on agronomic characteristics and yield of soybean cultivars and also by determining the appropriate values for the cultivars in Mazandaran climate, we determined the effect of seeding rate on morphologic characteristics of yield components and specified the correlation rate of traits and the most effective rates on the yield of desired seed cultivars.

EXPERIMENTAL

This scheme was done in the crop year of 2013 in a region with 36 degrees longitude, 42 minutes east and with 53 degrees latitude, 13 minutes North and a height of 16 meters above sea level, with warm summers and cold and humid winters and the annual rainfall of 560 mm.

Soil properties of the testing site

To determine the soil characteristics (texture and chemical characteristics of the soil) sampling was done prior to testing, for this project the site was sampled at several points at the depth of 0-30 cm. Table 1 shows the results of soil samples prior to the plant.

Treatments of the test and the statistical characteristics of the design

The experiment was conducted in small plots (split plots) in a randomized complete block design with four replications which had 2 factors of density (the amount of the consumed seed), and cultivar. The amount of the seeds were 55, 70 and 85 kg/hectare were considered as the main factors and soybean cultivars including Sari (JK), Telar (BP), Caspian (033) , Nekador (032), Katul (D.P.X) and Sahar (Pershing) were considered as minor factors.

Characteristics of soybean cultivars

1 - Sari (JK): semi-limited growth mode (Semi-determinate), 2 - Telar (BP): Semi-limited growth mode (Semi-determinate), 3 - Caspian (033): semi-limited growth mode (Semi-determinate), 4- Nekador (032): semi-limited growth mode (Semi-determinate), 5 - Sahar (Pershing): semi-limited growth mode (Semi-determinate), 6 - Katul (DPX): semi-limited growth mode (Semi-determinate).

Research Stages

The field was planted for wheat in the last year. The used herbicide is Trifluralin before planting 2.5 liter per hectare. The disc is used for mixing the poison to the soil. According to soil testing, used fertilizers are 120 kg/ha phosphate triple, 150 kg/ha sulfate potassium, 50 kg/ha urea, 50 kg/ha manganese sulfate, and 20 kg/ha sulfate. The experiment map is implemented after fertilizing and mixing them with soil. When planting, *Rhizobium japonicum* (a bacterium) is used to inseminate the seed. The planting operations are, according to treatments of consumed seed rates, with four replications in plots. Each replication contains 18 plots; each plot includes 6 rows with 5m longitude at a distance of 40cm. Distances of plants on row planting are different according to seed rates and 1000-seed weight, i.e. about 4cm to 8cm.

Sampling method for the studied traits

Pod's height from surface

The distance of first plot from earth surface for 10 randomly shrubs in each plot.

Pod's numbers in main stem

In 10 randomly selected plants, number of pods of each main stem was counted and the average was calculated for each plant.

Total pods per plant

Number of pods per 10 randomly selected plants from each plot was measured and the average was used as this trait.

Seeds per pod

in 10 randomly selected plants, the numbers of seeds per pod on main stem were counted and the average was calculated for each pod.

1000-seed weight: Five hundred seeds from each plot was weighed and then doubled, so the weight of 1000 seeds was measured in grams.

Seed yield: The marginal effect was calculated on a kg scale with respect to weighing the seed of each plot in 4.8 square meters after correction with

12% moisture per kg and then was extended to kilograms per hectare.

Harvest Index

The harvest index for each plot is obtained through obtaining economic yield and biological yield and through the following equation.

Oil Content

By soxhlet was measured by the oil content. In this context the mill to 5 grams of The samples, solvent extraction using petroleum ether with a boiling range of 40 to 60 ° C was performed. After extraction, solvent oil was isolated by vacuum evaporation. After measuring the sample weight and oil content was calculated.

Oil Yield

Multiplying the oil content and seed yield for each treatment was calculated as kilograms per hectare.

Statistical analysis

Data obtained was analyzed by SAS and MSTAT-C statistical software were compared through the comparisons of Duncan's multi-domain mean. In each group of comparing the mean, the means that have at least one letter in common are not statistically significant.

RESULTS AND DISCUSSION

The effects of different seed rates on morphological traits of soybean varieties

Mean squares of seed amount for the characteristics of plant height was significant at the five percent level, which indicates a significant difference of this characteristic in the amount of consumed seed (Table 3).

Comparing the mean of this characteristic in Duncan's method is shown in (Table 2). With increasing the amount of consumed seed, the height of the plant has increased, the degree of this characteristic in the consumed seed levels was variable from 75.5 to 82.8 cm respectively related to the amount of the consumed seed for 55 and 85 kg/ha (Table 2). Significance of the mean squares of this characteristic for the studied cultivars has had a significant difference regarding the plant height (table 3). Also among the studied cultivars, the degree of this characteristic has been variable from 54.6 to 103.2 cm respectively in Telar and Katul cultivars. In this study, the long height cultivars

Table 1. Physical and chemical properties of the soil of the testing place before planting

Type of the texture	Soil texture			Potassium of the soil (P.P.M)	Soil Phosphor (P.P.M)	Organic carbon (O.C)	Organic material (O.M)	Neutral materials percentage	Electrical Conductivity percentage	Saturation percentage %T.N.V	Soil pH EC×10^3	The depth (S.P) of the soil (Cm)
	clay	Silica	sand									
Loamy	20	30	50	180	13.6	1.2	2.2	30	0.68	50	7.6	0-30

often had high 1000-seed weight, so that the correlation of plant height and 1000-seed weight is shown to be significant and positive (Table 4).

Significance of mean squares of the seed amount for the characteristic of Pod's Height from surface at the probability level of one percent indicates significant difference of this characteristic is applicable in the levels of the seed amount (Table 3). With increasing the consumed seed rate, the height of the first pod from the surface increases (Table 2). The degree of this characteristic on seed levels of 55, 70 and 85 kg/ha have been respectively equal to 11.8, 17.3 and 21.1 cm, which have statistically been classified in three distinct classes.

Significance of the mean squares of these characteristics for the studied species also indicate that the studied cultivars have had a significant difference regarding the height of the first pod from ground (Table 3). Also, among the amount of data the degree of this characteristic has been variable between 12.9 to 20.3 cm in Sahar and Nekador variables, respectively (Table 2). Considering that the high levels of this characteristic will lead to facilitation in harvest and less waste in the harvest time, therefore the Caspian and Nekador cultivars will have priority having high levels of this characteristic. Negative and significant correlation of this characteristic with the number of pods per shrub indicates that cultivars with high levels of this characteristic have less number of pods per plant (Table 4).

Average amount of the seeds used for the characteristic of Pod's Number in Shrub was significant at the one percent level, which indicates a significant difference of this characteristic in the levels of this level of the seeds (Table 3). With increasing the amount of the consumed seed, the number of pods per plant decreased. The amount of this characteristic in the levels of the consumed seed was variable from 50.5 to 64.2 numbers for 55 and 85 kg/ha consumed seed. Also, the degree of this characteristic for the seed amount of 70 and 85 kg per hectare are in a statistical group. The significance of mean squares of this characteristic for the studied cultivars indicates that the studied cultivars have had a significant difference regarding the pods per shrub (Table 3). Among the varieties studied, the amount of this characteristic was variable from 46.8 to 63.7 in Telar and Sari cultivars, respectively (Table 2). Positive and significant correlation of this characteristic with the harvest index indicates that the increase in the grain yield have an effective role in increasing the harvesting index (Table 4).

3-2 The effects of different seed rates on yield components and seed and oil yields of soybean varieties

mean comparison of number of seeds per pod characteristic shows that (Table 2) with increasing the used seed amount number of seeds per pod does not follow a specific process and amount of this for all 3 levels of seed in places in one statistical group, and indicates that number of seeds per pod

Table 2. Mean comparison of the effect of seed rates, soybean cultivars and their interaction effects on Morphological Characteristics, Yield Components and Seed and Oil Yields

Traits Factor	Plant Height	Pod's Height from surface	Pod's Number in Shrub	Seeds per pod	1000-seed Weight (gr)	Seed Yield (Kg.ha)	HI (%)	Oil content (%)	Oil Yield (Kg.ha)
55 kg.ha	75.5b	11.8c	64.2a	2.22a	196.1a	2999ab	43.4a	23.08	694.7a
70 kg.ha	77.8ab	17.3b	53.6b	2.27a	187.2b	3246a	36.9b	21.5b	698.2a
85 kg.ha	82.8a	21.1a	50.5b	2.19a	177.0c	2700b	32.2c	19.36c	532.4b
Sari(JK)	75.0c	15.9bc	63.7a	1.62d	185.8bc	3024bc	40.4b	21.52b	658.9b
Telar(BP)	54.6e	17.4bc	46.8d	2.86a	178.3c	2855bcd	43.4a	21.79b	621.2bc
Caspian(033)	96.9b	18.3ab	58.5ab	2.41b	196.0ab	3141b	36.7c	20.63b	648.7b
Nekador(032)	75.4c	20.3a	60.3ab	2.42b	199.3a	3626a	39.0bc	22.68a	822.6a
Katul(DPX)	103.2a	15.5c	55.5bc	2.13c	202.0a	2690cd	31.7d	20.79b	564.9bc
Sahar(Pershing)	67.1d	12.9d	51.6cd	1.93c	159.2d	2536d	33.8d	20.03b	534.5c

was influenced by genetic factors and environmental factors do not have a significant impact on it. The correlation of this characteristic is positive with seed yield (Table 4), thus increasing this characteristic as one of the important components of seed can also lead to seed yield. (Table 2) indicates that with increasing the used seeding rate, 1000-seed weight decreased, which indicates increasing plant density and increasing competition between plants, eventually lead to the reduction of grain weight. Among the studied cultivars the amount of this adjective was different from 159.2 to 202 g, respectively for Sahar and Katul cultivars, which shows that 1000-seed weight is a genetic characteristic but also is affected by environmental situation. The correlation of this characteristic with phenological characteristics such as the number of days to start of flowering, days to end of flowering and days to maturity indicates that late maturity cultivars often have higher 1000-seed weight (Table 4).

The results of mean comparison shows that (Table 2), with increasing the amount of used seed, the seed yield has increased and then decreased that obtained yield for 55 and 70 kg seed per hectare is placed in one statistical group. The significant mean squares of this characteristic for the studied cultivars in one percent probability level is indicating the genetic differences between cultivars under study from the yield seed view (Table 3). The significant and positive correlation indicates of this characteristic with harvest index indicates that increasing seed yield has an effective role in increasing the harvest index (Table 4) Also positive and significant correlation with 1000-seed weight suggests that in studied cultivars these characteristics have more effective role in increasing the seed yield.

Significant mean squares of seed amount for oil content characteristic, indicates the significant effect of used seed level on this characteristic (Table 2) it seems that with increasing plant density and lower light penetration into the canopy of vegetation leads to lower oil content and amount of this characteristic in studied cultivars has not been significant which shows that there is not a significant difference between the studied cultivars from the view of oil content. The correlation of this characteristic with 1000-seed weight and seed yield is positive (Table 4),

Table 3. Analysis of variance for Morphological Characteristics, Yield components , Oil Content, Seed and oil Yield in Soybean Cultivars

Source of Vraiance	df	Mean of Squares(MS)								
		Plant Height	Pod's Height from surface	Pod's Number in Shrub	Seeds per pod	1000-Seed weight	Seed Yield	HI(%)	Oil Content (%)	Oil Yield
Replications	3	145.9*	18.7*	533.3*	0.06	31.5	537071*	9.5	0.9	1845
Seed Rates(a)	2	333.7*	511.7**	1234.3**	o.04	2183.9**	1795455**	764.6**	71.7**	215416**
Error	6	31.1	3.5	47.9	0.04	23.5	103865	6.5	1.7	6605
Cultivar (b)	5	4011.6**	75.7**	442.3**	2.28**	3142.5**	1786088**	221.4**	6.7	122092**
a×b	10	16.6	14.9**	53.4	0.03	31.8	114311	5.7	0.1	4827
Error	45	27.7	4.3	35.6	0.06	107.4	108370	4.6	4.2	9201
C.V (%)	-	6.7	12.4	10.6	11.2	5.5	11.1	5.7	9.5	14.9

*, ** Significant at p=0.05 and 0.01, respectively

Table 4. Correlation coefficient of the traits in soybean cultivars in different planting densities

Traits	1	2	3	4	5	6	7	8	9
1- Plant Height	1								
2- Pod's Height from surface	0.19	1							
3- Pod's Number in Shrub	0.18	-0.49*	1						
4- Seeds per pod	-0.24	0.26	-0.08	1					
5- 1000-seed Weight	0.51*	-0.09	0.27	0.23	1				
6- Seed Yield	-0.02	0.16	0.40	0.21	0.56*	1			
7- HI(%)	-0.56*	-0.45	0.65**	0.26	0.31	0.50**	1		
8- Oil content (%)	-0.40	0.59**	0.47*	0.14	0.46*	0.54*	0.84*	1	
9- Oil Yield	-0.16	-0.09	0.54*	0.20	0.61**	0.94**	0.60**	0.76**	1

therefore, the cultivars with potential yield and high yield components have higher oil yield in this study.

Oil yield was significantly affected by the amount of the consumed seed which is resulted from the genetic difference of the seed yield of the consumed cultivars (Table 2). The significant and positive correlation of this characteristic with the seed yield and oil yield indicates that this characteristic is significantly influenced by both of the main components (Table 4).

In each group of average comparison, those averages that have at least one trait in common do not have significant difference.

The results of the analysis based on the split-plot design indicated that the effect of the seed rates was significant in all characteristics. The cultivars have had significant difference regarding all the studied characteristics except for the oil level which indicates genetic differences in all the studied cultivars (Table 3). Insignificance of the interaction between the seed rates and cultivar for the studied characteristics indicated that changes in the characteristics in the studied cultivars at all seed levels have a similar trend.

CONCLUSION

Generally, this study contains the following conclusions:

1. Significance of the mean squares of seed rates shows that Morphological characteristic, yield components, and seed and oil yield except seed's number in pod are under the influence of significance of seed rates.
2. In this regard, characteristics follow an increment progress such as shrub's height, distance of 1st pod from surface, and pod's number in main stem as the seed rate increases. Therefore, pod's number in shrub and 1000-seed weight fall in reduction.
3. The mean squares are significant for all traits except oil content which in turn shows the difference of genetic types except oil percentage.
4. The maximum seed yield is obtained from seed rate in 70 kg/ha field. Among investigated genotypes, the Nekador genotype represents the high seed yield because of its seed yield components. In investigating mutual interaction, Nekador type high yield is registered in 50 kg/ha seed rate.
5. Correlation is positive between seed yield with traits of pod's number in shrub and 1000-seed weight which shows that these two yield components have an important role in seed yield.
6. The interaction effect of seed rate and genotype is not significant for all traits (characteristics) except for 1st pod's height from surface and pod's number in main stem. Therefore, this shows that changes in most traits follow a similar progress except traits at seed levels.

REFERENCES

1. Akond, A., B. A. Ragin, l. Willshenua and K. Stella., Row spaces can effect Agronomic traits in Soybean(Glycine max L.). *Jornal Crop*

*Management.*2013; **55**(1):28-32.

2. Ablett, G. R., W.D. Beversdorf, and V.A. Dirks., Row width and seeding rate performance of indeterminate, semi-determinate, and determinate soybean. *J. Prod. Agric*. 1991; **4**: 391-395.
3. Beaver, J .S., and R. R. Johnson., Response of determinate and indeterminate soybeans to varying cultural practices in the northern U.S.A. *Agron. J*. 1981; **73**: 833-838.
4. Bergland, D. R., Soybean production field guide for North Dakota and Northwestern Minnesota. Published in cooperative and with support from the North Dakota soybean council. 2002; 136Pp.
5. Boeurlein, J. E., Yield of indeterminate and determinate semi dwarf soybean for several planting dates, row spacing and seeding rates. *J. Prod. Agric*., 1988; **1**: 300-303.
6. Beuerlein, J. and G. Ryder., Planter beats drill for narrow-row soybeans. *Crop Soils* 1981; **33**(4): 7-8.
7. Bharati, M. P., D. K. Whigham, and R. D. Voss., Soybean response to tillage and nitrogen, phosphorus, and potassium fertilization. *Agron. J*. 1986; **78**:947–950.
8. Boquet, D. J., Plant population density and row-spacing effect on soybean at post optimal planting dates. *Agron. J*. 1990; **82**: 59-64.
9. Blum, A., Breeding crop varieties for stress environments. *CRC Critical Reviews in Plant Sciences*. 2011; **2**:199-237.
10. Carpenter, A. C., and S. Board., Growth dynamic factors controlling soybean yield stability across plant population. *Crop Sci.,* 1997; **37**: 1520-1526.
11. Dekeeijer, T. J., A.J.Debuck. G. A. A. Wossink. J. Onema. J. A. Renkema and P. C. Struik., Annual variation in weather: its implication for sustainability in the case of optimizing nitrogen input in sugar beet. *Evroup. Agron.J*. 2003; **19**: 251.
12. Delka, E., S. Oplinger, T. M. T. Eynor, D. H. P. Utman, J. D. D. Oll, K. A. Kling, B. R. Durgan and D. M. Notzel., Safflower. University of Wisconsin-Extension pub. Cooperative Plant and Animal Products and the Minnesota Extension Service. 2005; 300Pp.
13. Deviation., 1. FAO., Legume inoculants and their use. Food and Agriculture Organization(FAO) of the United Nation. Rome. Italy. FAO Statistics, 2011.
14. Domingues, C. and D. J. Hume., Flowering, abortion and yield of early maturing soybean at three densities. *Agron. J.*, 1973; **70**: 801-805.
15. FAOSTAT.., Prod stat, crop processed. Food and Agriculture Organization(FAO) of the United Nation. Room. Italy. FAO Statistics Deviation, 2011.
16. Fehr, W. R., C. E. Caviness, D. T. Burmood, and J. S. Pennington., Stage of development description for soybean. *Crop Sci.* 1971; **11**:929–931.
17. Gan, Y., H. Stulen, H., Keulen, H. and P.J. Ckuiper., Physiological response of soybean genotypes to plant density. *Field Crops Research,* 2002; 74- Iss.No. 378-4290- p 231-241.
18. Gupta, B. S.,D. E.Johnson. F. C. Hinds and H. C. Minor., Forage potential of soybean straw. *Agron. J*. 1973; **65**:538-541.
19. Isik, M., M. Tekeoglu, Z. Onceler and S. Cakir., The effect of plant population density on dry Bean (Phaseolus vulgaris l.), 1997.
20. Jason, K. N., and R. S. Emerson., Effect of row spacing and soybean genotype on main stem and branch yield. *Agron. J*. 2005; **97**:919-923.
21. Khalili, A., Position of oilseeds in the national economy vegetative oil. *Industry Magazine*. 2005; 30-31, 28-30p.(In Farsi).
22. Parvez. A. Q., F. P. Gardner, and K. J. Boote., Determinate and indeterminate-type soybean cultivars response to pattern, density and planting date. *Crop Sci*. 1989; **29**: 150-157.
23. Rahman, MD. M and MD. M. Hossain., Plant density effects on growth, yield components of two soybean varieties under equidistant planting arrangement. *Crop Sci*. 2005; **41**(1):367-373.
24. Sedaghati, H., Development of oilseeds cultivation. Vegetative Oil Industry Magazine. 2003; **8**: 6-7.
25. Shibles, R. M., I. C. Anderson and A. H. Gibson., Soybean. in L.T.E. vans(ed.). Crop Physiology. Cambridge University Press, London. 1975; 151-189Pp.
26. Singh, G., The soybean : Botany , Production and Uses. Forest stewardship council. 2010; 494 p.
27. Suhre. J and V. M .Davis., Genetic gain * Management interaction in soybean: seeding rate effect. Crop Sci. Available on line al: http//Handle. net/2142/42401/ (accessed 27 November), 2008.
28. Wells, R., Dynamics of soybean growth in variable planting pattern. *Agron. J*.1993; **85**:44-48.
29. Zaman, Q. U and M. A. Malik, Rice bean Productivity under various maize-rice bean intercropping system. Agriculture and Biology. 2002; **3**: 255-257.