Investigating the Effect of Various Seed Rates on Phenological Characteristics, Yield Components and Seed and Oil Yields in Soybean Cultivars in Mazandaran Province

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To investigate the impact of various amounts of seed rates on phenological characteristics, yield components, seed and oil yields for soybean cultivars, this experiment has been conducted in split plots in the form of randomized complete blocks with four replications in a farming field in 2013. The seed rates of 55, 70, 85 kg/ha were considered as the main factor and the soybean cultivars as the sub factor in Sari (JK), Telar (BP), Caspian (033), Nekador (032), Katul (D.P.X), and Sahar (Pershing).The results have shown that the seed rates can influence significantly all the characteristics except the number of seed in pod. In this regard, the traits like the distance of first pod from the earth surface and the number of pods in main stem increase as the rate of consumed seed increases. As a result, the number of pods in plant and 1000-seed weight decreases. Since interaction effect of seed rate and cultivar was not significant for all characteristics except the height of first pod from surface and the pods' number in main stem, it means that changes in these characteristics have a similar progress except characteristics at the given seed level. Average seed yield of genotypes for three seed levels of 55, 70 and 85kg/ha are respectively 2999, 3246 and 2700 kg/ha which are statistically divided in two groups. Among the genotypes, the cultivar of Nekador performs a better the highest seed yield due to its seed yield components. The seed yield amount of this value in three seed levels in 55, 70, and 85 kg/ha are respectively 3766, 3643, and 3496 kg/ha which its value was in the same class for 55 and 70 kg/ha seed rates. Seed rates had not significant effects on days to maturity. Sahar and Katul with 135.3 and 156.9 days to maturity, respectively which were considered as early and late maturity genotypes. Significant positive correlation of seed yield with the characteristics including pods per plant and 1000-seed weight, indicating the important role of these two yield components for seed yield increasing.

Key words: Yield Components, Oil, Soybean, Phenological Characteristics, Seed Yield.

Oil as a primary source of protein and energy, has an important role in human nutrition so that today oilseed crops are considered as the second most important source of energy in nutrition[1-3]. Vegetable oils present better quality because of their lower saturated fatty acids as compared to animal oils[4]. Oilseeds are urgently needed food for human which not only make up part of the human food needs, but also have industrial and pharmaceutical usages so that they are important agricultural products[5]. Soybean is divided into three growth types of unlimited, limited, and semi-limited according to the mode of growth. Soybean cultivation has advantages. For instance, symbiotic nitrogen-fixing bacteria

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in the roots of soybean stabilize the nitrogen in the air so that this plant needs less nitrogen in the process of its growth. The some amount of this fixed nitrogen by symbiotic bacteria remains in the soil and subsequent crops will require less nitrogen. Soybean cultivation can lead to a reduced incidence of pests and diseases and weeds on the farm[6]. Deep planting of variety seed is also not recommended genetically due to the shorter epicotyls. In some cases, deep panting of soybean seeds even increases the risk of soil diseases in greening seedlings[7]. Optimum density is important for ensuring maximum yield in soybean planting. Changing in the pattern of planting density is possible in two ways: changing the distance between rows or changing the distance on rows. The results of other investigations indicated that the higher yield is achieved by reducing the spacing between the rows. Generally, the maximum yield is achieved at high density and at checkrow planting mode[8]. Boquet *et al*. have studied four types of soybean in the growth range of different rows and times and concluded that yield increases in nearer distances for all times[9]. De Bruin and Pederson have recommenced the soybean planting in 40cm rows and observed that significant yield increase in contrast to 75cm rows[10]. Walker *et al*. have analyzed the eeffects of plant populations and row spacing on soybean maturity group III on the three types (Asgrow, Pionear, 93M90) and the distance between rows 38 and 76 cm declared. They have claimed that narrow rows can confirm greater or equal yield as compared to wider rows[11]. Parks has reported that increase of soybean yield in narrow rows is because of increase in grain production in aerial part of plant[12]. Parvez has shown that nearer rows represent a greater grain yield than wider rows[13].

Since analyzing the effect of distances of rows on yield and soybean's yield component, Torrie and Brigges have observed that constant light absorption takes place greatly in nearer rows (25 cm) than wider rows in the same leaf level. They have attributed the great light absorption due to steady distribution[14].Carpenter has researched that grain yield per plant regulates through changing the weight of dry branches. The weight of minor dry branches creates more fertile nodes and more pods in minor branches[15].

Boquet has observed that increase in density can decrease the yield of major stem. In this study, although the length of main stem increases as the density increases, all parts of main stem including the number of fertile node, pod number, grain number, and grain weight decreases[9]. In studying the yield and yield components of Soybean, Goli and Olsen have shown that increase in density causes the decrease in the grain yield in minor branches, pod numbers, and grain yield in a plant[16].Akind *et al*. have reported that grown plants in 50 cm rows have larger pods and more grains than grown plants in 25 cm row spacing (distance)[17].

In relation to the effect of density on yield and yield components of soybean, Pandy and Torrie have confirmed that number of minor branches, pod numbers, and node numbers are significantly under the influence of density. In lower densities, the above three parameters increase but yield in various densities remain constant[18]. Basent *et al*. have surveyed the effect of 46 am and 92 cm row spacing and 3.8 cm and 6.4 cm inter-row spacing on the yield of soybean. The results have shown the greater yield of 46 cm rows than 96 cm rows. Increase in density has not a significant effect on yield by means of regulating distances and in some cases leads to decrease in yield. As reducing the density, the number of pods per minor and main branches and the number of grain per plant, seed weight are increased but the density has no any effect on 1000-kernel weight[19].

Mayers *et al*. have claimed the existence of mutual significant interaction among planting date, genotype, and density. The average maximum yield in all dates and genotypes are approximately above 60 plants per m^2 in high densities. For above mentioned reason, the seed yield in delayed plants typically reaches maximum densities of 40 or 60 plants per m^2, but in early types, the maximum yield is obtained at densities above 80 plants per m^2. Given that the effects of treatments are different and depend on crop planting dates of latitude and longitude, and altitude above sea level. However, the numbers of seed and resulting density depend on the determined seed, the type's genetic potential from the view of compressibility and freshness[20]. Cober and Voldeng have expressed that density increment can decrease the amount of oil and increase the grain's protean. In this connection, many researchers have reported existence of reverse relationship between protean amount and grain oil as the relation is negative among them[21]. On the other hand, Tabatabayi (1995) has claimed that density has not any effect on the oil's percentage and soybean's protean.

Boeurlein has accounted that lodging is one of the affects of high density. Genetic features and factors like wind, rain, irrigation, and blight attack effectively control the number of lodging[22]. Cooper believes that severe decrease of yield in high densities may be due to early lodging. Plant height to stem's diameter is an index that defines response of a plant in the competition conditions[23]. Johnson and Harris have reported that dye-weed increases as density increases but harvesting soybean with combine harvester has not created much casualty in high densities[24]. There is a claim that lodging grows due to its long height, decrease in stem's diameter, or the combination of these two[25]. Changes in node's numbers in main stem are different as a consequent of density increment proportional to growth mode. In Fykobi type (limited Growth), node's rate was not under the influence of density but in type 903-52 (semi-limited growth), node decreases as density increases. As density increase, the first pod's height increases from the earth surface consequently. In unlimited type, as height increases in high density, the main stem's diameter decreases and causes the increase in lodging. In limited growth, high density does not face dye-weed[26]. Beuerlein and Ryder (1981) have reported that as density increases, the casualty in the 26-plant density moves from 1% into 16% in 64-plant density in m^2. Plants become weaker as a result of density increase. These plants consume water and food but do not have salient effect on yield. Researchers have said that extra density increase causes decrease in yield; and factors such as type, lodging, early maturity and bad environmental conditions have influence on yield[27]. In this study, we try to survey the effects of various seed rates on crop characteristics and on types of soybean yield as well as determining the proper seed rates for instances in Mazandaran climate in order to establish effects of seed rates on phenologic features, yield components, seed yield, and various types of soybean. As a result, we are able to determine the rate of traits' correlation and the most effective characteristics on seed yield.

MATERIALS AND METHODS

The study is performed in 2013 in a field with the coordinates of 36° longitude, 42° E, 53° latitude, 13° N, and 16 m above sea level, with the climate of hot summer and cold and damp winters, 560 mm annual rain rate.

Soil of the Field

Before conducting the experiment, we have sampled soil of the field to determine its features like bed and chemical traits. To do this, the sample is gathered from 0-30 cm deepness. Table 1 shows the result of sample before planting.

Experiment Treatments and Statistical Features of Design

The experiment is established through designs of in split plots in the form of randomized complete block design with four replications which contains two factors of density (consumed seed rates) and soybean cultivars. The amounts of seeds are 55, 70, 85 kg/ha are considered as the main factor and the soybean cultivars as the sub factor in Sari (JK), Telar (BP), Caspian (033), Nekador (032), Katul (D.P.X), and Sahar (Pershing).

Characteristics of Types

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: semi-limited Growth Mode (Semi-determinate)
6 Katul (D.P.X): 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 are different according to seed rate and 1000-kernel weight, i.e. about 4cm to 8cm.

Sampling Models

Days to flowering

The time after planting stage depends on day numbers after planting in each plot until first flowering.

Plant height in flowering stage

10 shrubs randomly selected from each plot and then height is measured for each 10-shrub plot.

Day to maturity

The time after planting stage until physiological finishing time for each plot.

Pod numbers in main stem

Pods are enumerated and average is obtained for each shrub.

Total pods per plant

The number of 10-shrub pods is measured and its average is set for this trait.

1000-seed weight

In 10 shrubs, the number of seeds in the pod of main stem is counted and its averaged is obtained for each pod. 500 seeds are weighed from each plot. As doubling the weight, the 1000-seed weight is quantified.

Seed yield

The yield is calculated after weighing the seeds of each plot considering the marginal effect of the threemidfieldarea,8/4m2 after correction with 12% moisture and generalized to kilogram per hectare.

Harvest Index

Harvest index is calculated after obtaining economic yield and biological yield for each plot from the following equation.

HI=(Agricultural yield)/(Plant total dry matter)×100

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

Table 1. Physical and Chemical Traits of soil before Planting

Bed Deep	Soil Bed (%)				Soil	Soil	Organic	Organic	Neutralized	Electric	Saturated	Soil
Type	clay	Silica	sand	Potassium (P.P.M)	Phosphor (P.P.M)	Carbon (o.c) (%)	Material (%)(O.M)	Material (%)(T.N.V)	conducting EC×10^3	Percent	pH (s.p)	(Cm)
Loamy	20	30	50	180	13.6	1.2	2.2	30	0.68	50	7.6	0-30

for each treatment was calculated as kilograms per hectare.

$$HI = \frac{economic\ performance}{biological\ performance} \times 100$$

Statistical Calculations

Data analyzed statistically by SAS and MSTAT-C software and then through comparisons of the average are compared again through Duncan's new multiple range test. From each group of comparison, the means which have at least one letter in common don not have statistically significant difference.

RESULTS AND DISCUSSION

The Effects of Different Seed Rates on Phenological Traits of Soybean Varieties

The results of means comparison(Table 2) for days to maturity show that Sahar cultivars is the most early maturity and the Katul cultivars is the most late maturity cultivars among the studied cultivars and the amount of this characteristic in the used seeding levels is different from 144.8 to 148.4 days, respectively, related to used seeding levels of 85 and 55 kg per ha. In addition, the amount of this characteristic for 55 and 70 kg seed per ha statistically is placed in one group. Correlation of this characteristic with the positive seed yield was not significant (Table 4), which indicates that late maturity cultivars mainly have higher seed yield. Significant and positive correlation of this characteristic with 1000-seed Weight also indicates the positive impact of this characteristic was mainly through increased 1000-seed weight. The comparison of average number of days to start of flowering in the used seed levels were different from of 56.4 to 60 days for used seed per ha were respectively 55 and 70 kg (Table 2). The correlation of this characteristic was not significant with seed yield (Table 4), which shows that changes of the characteristic did not have a significant impact on studied cultivars. Positive and significant correlation of this characteristic

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

Soybean Types (Places) Various Seed Values	Sari (JK)	Tellar (BP)	Caspian (033)	Nekador (032)	Katoul (DPX)	Sahar	Average of HI
55 Kg per Ha	46.4ab	49.7a	42.5bc	51.1b	37.7de	39.0cd	43.4a
70 Kg per Ha	4.2cd	42.7bc	34.2ef	39.8cd	31.2fg	33.5ef	36.9b
85 Kg per Ha	34.5ef	37.7de	33.4ef	32.0fg	26.3h	29.0gh	32.2c
Average of HIfor Places	40.4b	43.4a	36.7c	39.0bc	31.7d	33.8d	

Table 3. Analysis of variance for Phenological Characteristics, yield components , oil content, seed and oil yield in soybean cultivars

Change	Freedom	Mean Squares (MS)						
Source	Degree	Pod Number in Shrub	Grain Number in Pod	1000-Kernel Weight	Grain Yield	HI	Oil Percentage	Oil Yield
Replication	3	*3/533	0.06	31.5	537071 *	9.5	0.9	1845
Seed Rate (a)	2	**3/1234	0.04	2183.9 **	179455 **	764.6 **	71.7 **	215416 **
Error	6	Sep-47	0.04	23.5	103865	6.5	1.7	6605
Type (b)	5	**3/442	2.28 **	3142.5 **	1786088 **	6.9	122092 **	**4/221
a×b	10	Apr-53	0.03	31.8	114311	5.7	0.1	482
Error	45	Jun-35	60	107.4	108370	4.6	4.2	9201
Changes Coefficiet (%)	-	10-Jun	11.2	5.5	11.1	5.7	9.5	14.9

* shows significance in 0.05 level and ** in 0.01 level

with days to maturity indicates that cultivars which have high number of days to end of flowering are almost late maturity. The comparison of average number of days to end of flowering in the used seed levels were different from of 94.2 to 99.9 days for used seed per ha respectively 85 and 55 kg (Table 2). Mean squares of seed amount for number of days to end of flowering at one percent probability level is significant, that is indicating the significant difference of this characteristic in different amount of used seed (Table 3). Among the studied cultivars, days to end of flowering characteristic have been different from 88.9 to 106.3 days respectively for Sahar and Katul cultivars. (Table 2). Significant difference of the mean squares of this characteristic for the studied cultivars also indicates that the studied cultivars had significant differences from the view of number of days to end of flowering. (Table3). The correlation of days to end of flowering characteristic was significant with 1000-seed Weight (Table 4). It indicates that changes in this characteristic in the studies cultivars had significant impact of 1000-seed Weight on seed level. In addition, the significant and positive correlation of this characteristic with days to maturity suggests that cultivars that have higher number of days to the end of flowering, are mainly late maturity.

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 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), 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).

Indicated that the effect of the amount of seed 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

Table 4. Correlation Coefficient of the traits in Soybean cultivars in different planting densities

Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1-Day to flowering	1													
2- Day to end of Flowering	0.89**	1												
3- Flowering Period	0.67**	0.93**	1											
4- Days to maturity	0.77**	0.89**	0.86**	1										
5- Plant Height	0.53*	0.64**	0.63**	0.57*	1									
6- 1ST Pod's Height from surface	-0.36	-0.21	-0.07	-0.01	0.19	1								
7- Pod's Number in Main Stem	0.03	0.16	0.23	0.23	0.37	0.52*	1							
8- Pod's Number in Shrub	0.78**	0.59**	0.34	0.53*	0.18	-0.49*	-0.35	1						
9- seeds per pod	-0.57*	-0.43	-0.24	-0.29	-0.24	0.26	-0.06	-0.08	1					
10- 1000-seed Weight	0.63**	0.70**	0.66**	0.81**	0.51*	-0.09	-0.04	0.27	0.23	1				
11- Seed Yield	0.13	0.15	0.14	0.33	-0.02	0.16	-0.24	0.40	0.21	0.56*	1			
12- HI	0.17	0.05	-0.05	0.04	-0.56*	-0.45	-0.45	0.65**	0.26	0.31	0.50**	1		
13- Oil Percentage	0.26	0.16	0.05	0.20	-0.40	0.59**	-0.67**	0.47*	0.14	0.46*	0.54*	0.84*	1	
14- Oil Yield	0.21	0.17	0.13	0.34	-0.16	-0.09	-0.42	0.54*	0.20	0.61**	0.94**	0.60**	0.76**	1

* shows significance in 5% probability and ** in 1% probability.

the studied cultivars (Table 3). Insignificance of the interaction between the amount of seed and cultivar for the studied characteristics indicated that changes in the characteristics in the studied cultivars The results of the analysis based on the split-plot design at all seed levels have a similar trend.

CONCLUSION

Generally, this study contains the following conclusions:

a) Significance of the mean squares of seed rates shows that phenological characteristic, yield components, and seed and oil yield except seeds per pod are under the influence of significance of seed rates.

b) The mean squares are significant for all traits except oil content which in turn shows the difference of genetic types except oil content.

c) 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.

d) 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.

e) 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-kernel weight fall in reduction.

f) The mutual interaction of seed rate and type 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.

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