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Evaluation of Sink-source Relationship of Soybean Cultivars at Different Dates of Sowing

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Abstract: In order to evaluate the relationship of sink and source on seed yield and yield components of soybean (*Glycine max* (L.) Merrill) cultivars in Mazandaran province at different dates of sowing a split plot factorial design based on completely randomized block design was carried out in Dasht-e-Naz Sari area during summer 2008. Date of sowing at two levels (22 June and 6 July) was as the main plot and different cultivars at four levels (BP and JK cultivars and 032 and 033 promising lines) and different treatments of sink and source limitation (elimination of the leaves at one third plant height at different surfaces of canopy and one third flower elimination) were as sub plots. Analysis of variation showed that delayed cropping reduced the seed yield whereas seed yield was maximum at 22 June (58.62 $g.m^{-2}$) comparing to the second date of sowing 6 July (53.65 $g.m^{-2}$). Maximum seed yield obtained from BP cultivar (83.99 $g.m^{-2}$) which rather than 1000 seed weight, was related to more number of seed per pod (2.48), number of pods in main branch (17.38) and number of pods per plant (20.59). The JK cultivar produced the second highest seed yield (56.63 $g.m^{-2}$), after BP, having more 1000 seed weight (174.2 g), more number of pods per plant (20.38). Sink and source limitation showed that at control (without leaf or flower elimination) maximum seed yield (75.82$g.m^{-2}$) was obtained, after which leaves elimination from the lower part of the canopy had the second highest seed yield (66.18 $g.m^{-2}$). The results also showed that flower elimination at flowering stage resulted in 56.74 $g.m^{-2}$ seed yield, showing the ability of soybean plants in compensating the seed yield via producing higher 1000 seed weight (175.1 g) and higher number of seed per plant (2.35).

Key words: *Date of sowing, Soy bean. Sink- Source relationship. Seed yield.*

INTRODUCTION

Oilseeds production consisting of vegetable edible oil and protein containing meal after oil extraction are important part of human daily consumption and livestock [29]. Considering some 70 millions population of Iran, more than 1.100 million tones of vegetable edible oil is required to meet the annual needs from which merely 14 % is produced inside the country and the rest is imported [30].

Soybean (*Glycine max* (L.)Merrill) is one of the most important oilseed crops in the country playing inevitable role in vegetable edible oil production. In crop rotation pattern, soybean accommodates after wheat and other winter crops. It produces acceptable percentage of oil (18 to 25 %) and considerable amount vegetative protein (30 to 50%) more so nitrogen fixing symbiosis bacteria with soybean plant causes in soil fertility, improvement of soil structure and enhancement of the proceeding crop in rotation after soybean [18].

Agronomical and environmental factors, directly or indirectly, affect seed and oil production of oilseed crops [15]. Selecting an appropriate date of sowing is very curtail and is effective parameter for gaining the highest seed yield for soybean like other crop [21]. Therefore the more diversion from suitable date of sowing, the lesser seed and oil yield for soybean crop [27]. Delaying in soybean cultivation causes usually in coincidence of crop maturity with autumn heavy rains and causing decreases the seed yield and increases harvesting losses [25] with consequence of smaller seed having less weight. Soybean seed yield has positive correlation with crop vegetative growth and number and surface of leaves during summer in order to more exposure to the sun radiation, hence more photosynthetic activity. Whitfield [28] reported that delaying in soybean cultivation caused in coinciding the crop maturity with higher temperature causing itself in more pods respiration therefore decrease in assimilate storage and producing smaller seeds, shorter plant height, limited seed yield and oil percentage. Christmas [7] showed that the interaction effects of cultivars x date of sowing for seed oil percentage, 1000 seed weight and seed yield was significant. Taking proper action at plant different growth stages is

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possible by awareness of different plant organs share in photosynthetic assimilate production. [11]. Mature leaves produce more assimilates than their need and therefore export the extra carbohydrates to other organs. They are called source and the destination of photosynthetic products are called sink [12]. The rates of assimilates transportation from source to sink depends upon the rate of assimilates production in source on one hand, and the rate of up-loading the products at sink on the other hand [14]. Reports are available on the effect of leaf elimination on seed yield for different crops such as wheat [32], triticale and durum wheat [6], sunflower [1], rice [19], tomato [2], cotton [8], Chinese pine saplings [20] and maize [22]. Singh and Nair [26] believed that the effect of leaf elimination on maize seed yield differs depending on time, method and severity of the treatment. It is possible that leaf elimination affect seed yield via changing in gas exchange pattern [32] or by allocation of more photosynthetic assimilates or changing in seed development pattern, hence changing seed weight [17]. There is not a well established research work on the effect of leaf elimination on high yielding soybean cultivars in Iran. Therefore the present study was carried out to evaluation of sink-source relationship of soybean cultivars at different dates of sowing in Mazandaran province of northern Iran.

MATERIALS AND METHODS

A split plot experimental design based on randomized complete block design was carried out in Dasht-e-Naz, Sari to evaluate the effects of changing in sink- source ration on different soybean cultivars at two dates of sowing. Date of sowing with two levels (22 June and 6 July) was as the main plot and different cultivars and sink-source elimination treatments were as sub plots. There were four cultivars viz BP, JK, 032 and 033 and five levels of leaf and flower elimination: three of which were leaf elimination of the one-third length of upper, middle and lower part of the plant height, one treatment as elimination of one-third total flower of plant at full flowering stage and one control plot. Each plot was of five meters length with 7 rows of plants with a distance of 45 cm from each other. Mineral nutrients were added to the soil based on results of physico-chemical properties test. Center-piot sprinkler irrigation was the method of watering. Leaf and flower limitation was done at complete flowering. Data were analyzed based on ANOVA and the mean comparison were adjudged following Duncan's multiple test range using MSTAT C statistical soft ware.

RESULTS AND DISCUSSION

Plant Height: Analysis of variation showed that the effects of cultivars and sink-source limitation for plant height were significant at 0.01 level (Table 1), the interaction effects of date of sowing x cultivars x sink-source limitation were significant at 0.05 level and effects of date of sowing and interaction effects of date of sowing x cultivars, date of sowing x sink-source limitation and cultivar x sink-source limitation were not significant for plant height.

Mean comparison showed that average plant height at first date of sowing (22 June) with 50.27 cm height was more than that of the second date of sowing (6 July) with 40.78 cm showing 23% increase. Among the different cultivars the maximum plant height (52.77 cm) obtained for the cultivar 033, which statistically was different from the rest of the cultivars. Plant height for the other cultivars were recorded as 46.18 cm, 41.89 cm and 41.28 cm for 032, JK and BP cultivars, respectively (Table 2). Sink-source elimination treatments showed that maximum plant height (47.46 cm) obtained at which the leaves of one-third height of lower part of the plant were eliminated. This record was not statistically different from those obtained at control (46.79 cm) and elimination of the leaves at the middle part of the plant height (47.16 cm). The minimum plant height (41.35 cm), observed at which the leaves of upper part of the plant were cut.

Number of Pods per Plant: The effects of sink-source limitation, interaction effects of sink-source limitation for number of pods per plant were significant at 0.01 level and the effects of cultivars and interaction effects of sink-source limitation x cultivars were significant at 0.05 level (Table 1). Effects of date of sowing and its interaction x cultivar and triple interaction of cultivar x date of sowing x sink-source limitation were not significant.

Mean comparison showed that number of pods per plant was less at the first date of sowing (19.28) comparing to the second date of sowing (21.24).

The results also showed that maximum number of pods per plant (25.59) obtained at BP cultivar which was statistically different from the other cultivars except with JK (20.38). The cultivars 032 and 033 produced less number of pods per plant (13.95 and 17.14, respectively). The results obtained from the exposing the plant to leaf (source) and flower (sink) elimination showed that maximum number of pods (25.25) produced at control plots statistically different from the rest of the treatments. Leaf elimination from the lower part of the canopy retained more number of pods per plant (22.29), more than those obtained from the elimination of leaves from middle (16.92) or upper (15.82) part of the plant. The results therefore showed that leaves from the lower part of the canopy have least effect on providing and translocation of photosynthetic assimilates as compared with the leaves from middle and upper parts of the canopy. Similar observation also was made by Abbaspour *et al.*, [1] in their study on sunflower. The results showed that leaf elimination from middle and upper parts of the plant faced soybean plants to decrease more number of pods per plants i.e. exposing the source limitation. Likewise Egli, [9] reported similar reduction in soybean seed yield by shading over half of the plots from approximately growth stage R6 (early seed filling) to maturity and suggested that shade always significantly reduced the individual seed growth rate (by 9-32 %) indicating that the plants were source limited.

The results obtained for the present study also showed that elimination of one-third number of flowers at flowering stage resulted in 21.07 number of pods per plant which was statistically similar with those obtained from the leaf elimination from lower part of the plant. The plants were sink limited, i.e., the seeds could not use all of the available assimilate which was seen by the earlier workers Bunker, *et al.*, [5] and Board and Harville, [4]. This results however, showed the ability of soybean plant in compensation the decreased number of flowers by allocating more photosynthetic assimilated to the remaining flowers on the plant which is reflected in more number of seed per pod (2.358), more weight of 1000 seed (175.1 g) and more seed yield (56.74 $g.m^{-2}$) (Table 2).

Number of Seed per Pod: The results showed that effects of cultivars, sink-source limitation and interaction effects of date of sowing x sink-source for number of seed per pod were significant at 0.01 level (Table 1) whereas the interaction effects of cultivar x sink-source was significant at 0.05 level and the rest of treatments were not significant for number of seeds per pod.

The mean comparison showed that there wasn't significant difference between number of seeds at two dates of sowing. The difference between cultivars was significant and the maximum number of seed per pod (2.48) observed at BP cultivar after which at 032 cultivar (2.39). The sink-source elimination showed that minimum number of seed per pod (2.16) obtained at leaves elimination from the upper part of the canopy, similar to what was observed for number of pods per plant, showing the vital role played by flag leaves in provision assimilates for seeds and pods at higher surfaces of the plant canopy. Similarly Egli and Bruening [10] suggested that the soybean plants are source limited if photosynthesis is reduced. The results of the present study also interestingly showed that elimination of one-third flowers provided maximum number of seeds per pod (2.358) even more than that at control (2.299). It showed that soybean were source limited. Increasing the amount of assimilates for allocation to the existing number of sinks resulted in producing more number of seed per pod and more 1000 seed weight.

1000 Seed Weight: The results of analysis of variation showed that effects of cultivars, sink-source limitation and interaction effects of date of sowing x cultivars for 1000 seed weight was significant at 0.01 level (Table1) and effects of interaction between cultivar x sink-source limitation was significant at 0.05 level. The results however showed that date of sowing and its interaction x sink-source limitation and the triple interaction of date of sowing x cultivars x sink-source limitation was not significant for 1000 seed weight.

The mean comparison showed that average 1000 seed weight at the first date of sowing (167.01 g) was more than the second date of sowing (163.61 g). This result showed that determination of proper date of sowing provided enough time to the plants for filling seeds properly. Among the cultivars the maximum 1000 seed weight observed for JK cultivar (174. 2g) which statistically was different from the other cultivars except with BP (149 g) (Table 2).

The comparison of different levels of leaf and flower elimination at flowering stage of the plant also showed that 33 % of flower elimination resulted in maximum 1000 seed weight (175. 1g). The one-third leaves at lower and middle part of the canopy also showed less 1000 seed weight, producing 169.1 and 163 g, respectively. The minimum 1000 seed weight (149.2g) obtained with one-third leaves elimination from the upper part of the canopy (Table 2). Similar to what was observed for the number of pods per plant and the number of seed per pod the leaves of upper surface of the canopy played important role in assimilates provision required for seed filling without which plants were not able to take enhanced weight. On the other hand the flowers (source) elimination caused in more allocation of assimilates from sources to the remaining sinks, producing therefore more 1000 seed weight and number of seed per pod. Similar observation was made by Egli and Bruening [11] by imposing the soybean plants to the sink-source elimination by girdling soybean stem nodes.

Seed Yield: The result obtained showed that effects of cultivars, sink-source limitation and their interaction effects on seed yield were significant at 0.01 level (Table 1). The interaction effects of date of sowing x sink-source limitation was significant at 0.05 level, but the effects of date of sowing, interaction effects of date of sowing x sink-source limitation and triple interaction of date of sowing x cultivars x sink-source limitation were not significant for soybean seed yield. Mean comparison showed that seed yield was higher at first date of sowing (58.62 $g.m^{-2}$) comparing to that obtained at the second date of sowing (53.65 $g.m^{-2}$) (Table 2). It indicated that delayed cropping resulted in 9.26 % decreased in soybean seed yield. Similar observation was made by Shariati, *et al*., [26] suggesting that delaying in soybean cultivation caused in decrease in number of pods per plant, hence seed yield. The decrease in seed yield due to delaying in sowing date could be attributing to the less vigorous plant because of limited time for dry-matter accumulation. Results also showed that BP cultivar produced maximum seed yield (83.99 $g.m^{-2}$), statistically different from those obtained for the other cultivars. The higher seed yield for BP cultivar coincided with more number of pods per plant (25.59) and more number of seeds per pod (2.48). Minimum seed yield (38.29 $g.m^{-2}$) obtained for the cultivar 032 which could be an account of minimum number of pods per plant (13.95) (Table 2).

The results of sink-source elimination also showed that maximum seed yield obtained at control (75.82 $g.m^{-2}$) which statistically was different from the rest of the treatments (Table 2). The leaves of one-third length of lower part of the plant had limited effects of seed yield augmentation comparing to the middle or upper part of the plant. Since the treatment of leaves elimination of the one-third length of lower part of plant has retained more seed yield (66.18 $g.m^{-2}$) comparing those obtained at the treatment of leaves elimination of the one-third length of middle part of the plants (44.69 $g.m^{-2}$) and upper part of the plants (37.28 $g.m^{-2}$). This result was in conformity with those reported by Blum *et al*., [3] in their study on wheat. The results also showed that the treatment of elimination of one-third of flowers at flowering stage resulted in 56.74 $g.m^{-2}$ seed yield. Although showed 33% decrease when compared with control, still showing 52% compensation when was compared with leaf elimination of one-third of upper part of the plant height. It showed the reaction of soybean plant in compensation of seed yield at situation which one-third of flowers were omitted. The results indicate that any

Table1: Analysis of variation for seed yield and attributing characters at different for different cultivars, dates of sowing and different levels of sink-source limitation.

Source of variation	Plant Height	No. Pods per plant	No. Seeds per pod	1000 seed weight	Seed yield
Date of Sowing (D)	ns	ns	ns	ns	ns
Cultivar (C)	**	*	**	**	**
Sink-Source elimination (S)	**	**	**	**	**
D´C	ns	ns	ns	**	ns
D´S	ns	*	**	ns	ns
C´S	ns	**	ns	*	**
D´C´S	*	**	*	ns	*
Coefficient variation (%)	8.43	6.74	4.23	3.59	6.13

**, Significant at 0.01 level *, Significant at 0.05 level n.s, non significant

Table 2: Mean comparison different soybean cultivars at different dates of sowing and different levels of sink-source limitation.

Treatment	Plant height (cm)	Pods per plant	Seeds per pod	1000 seed weight (g)	Seed yield (g.m-2)	Plant height (cm)
Date of sowing (D)						
22-Jun	50.27 A	19.28 A	2.29 A	167.01 A	58.62A	50.27 A
6-Jul	40.78 B	21.24 A	2.27 A	163.61 A	53.65A	40.78 B
(C) Cultivar						
BP	41.28 B	29.59 A	2.483 A	149.0 B	83.99 A	41.28 B
JK	41.89 B	20.38 AB	2.013 C	174.2 A	56.63 B	41.89 B
32	46.18 B	13.95 B	2.390 AB	169.8 A	38.29 B	46.18 B
33	52.77 A	17.14 B	2.242 B	168.3 A	45.65 B	52.77 A
Sink-Source limitation (S)						

Table 2: Continue

control	46.79 AB	25.25 A	2.299 A	170.2AB	75.82 A	46.79 AB
elimination of the leaves of one-third upper part of plant	41.35 C	15.82 C	2.162 B	149.2 D	37.27 E	41.35 C
elimination of the leaves of one-third lower part of plant	47.46 A	22.29 B	2.315 A	169.1 B	66.18 B	47.46 A
elimination of the leaves of one-third middle part of plant	47.16 AB	16.90 C	2.277 A	163.0 C	44.69 D	47.16 AB
elimination of the one-third flower	44.89 B	21.07 B	2.358 A	175.1 A	56.74 C	44.89 B

Figures with different letters indicate significant difference from each other at 0.05 level

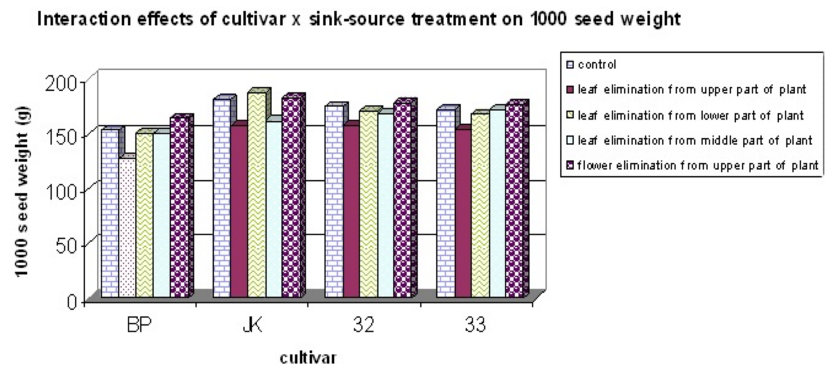

Fig. 1: Interaction effects of cultivar x sink-source treatment on 1000 seed weight.

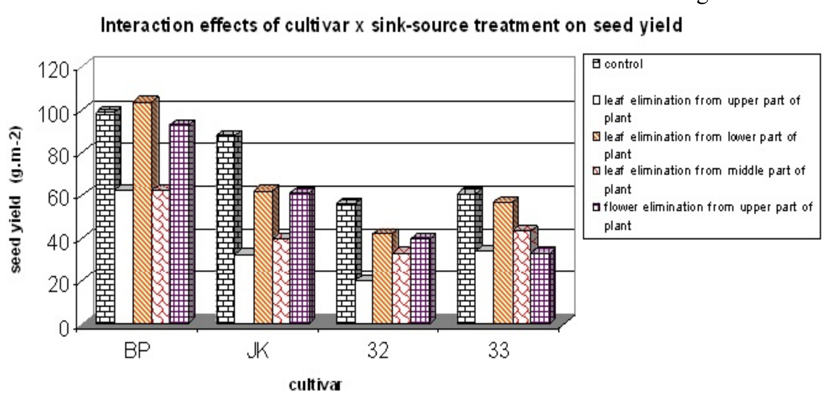

Fig. 2: Interaction effects of cultivar x sink-source treatment on seed yield.

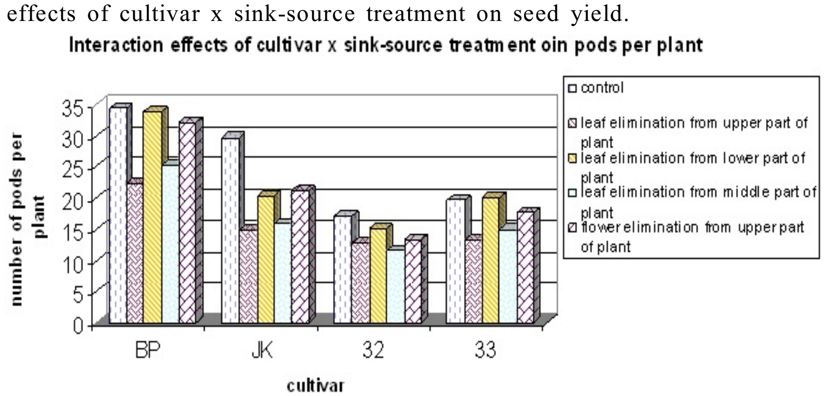

Fig. 3: Interaction effects of cultivar x sink-source treatment on number of pods per plant.

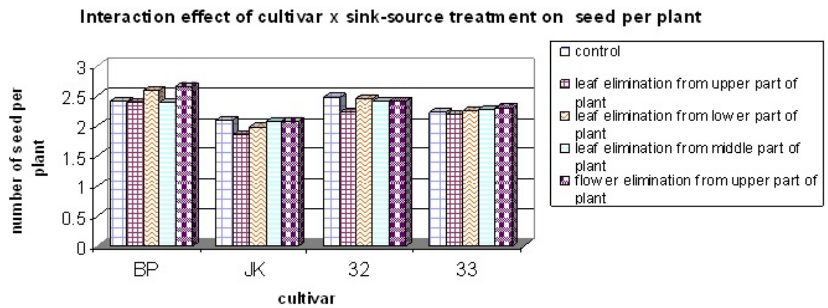

Fig. 4: Interaction effects of cultivar x sink-source treatment on number of seed per pod.

alterations in the source-sink balance will quickly cause a change in the distribution patterns to the pods which was observed also by Fellows *et al*., [13] and Seong-hyu Shin *et al*., [24]. It was done by allocation of more photosynthetic assimilates to the remaining flowers and therefore pods, hence producing maximum number of seeds per pod (2.358) and maximum 1000-seed weight (175.1 g) at this treatment. The results obtained from the interaction effects of cultivar x sink- source treatment on seed yield showed that the maximum seed yield (103.6 $g.m^{-2}$) observed at BP cultivar with leaf elimination of the lower part of the plant and the minimum seed yield (20.32 $g.m^{-2}$) obtained for cultivar 032 at which the leaf elimination of the upper part of the plant was imposed (Fig 2). It was also shown that elimination of one third amount of the flower resulted in 92.94, 61.16, 39.55 and 33.32 $g.m^{-2}$ seed yield for the cultivar BP, JK, 032 and 033, respectively. Showing the ability of the re-allocation of photosynthetic assimilates from sources to sinks during the periods when the soybean plant was imposed to sink limitation. This ability was more obvious for BP and thereafter and to lower extent for JK cultivar. These two cultivars therefore showed higher stability at stressful situation. Similar trend was also observed at interaction effects of cultivar x sink- source treatment on number of pods per plant (Fig 3) showing more number of pods per plant for BP and JK cultivars 32.18 and 21.17, respectively. The interaction effects of cultivar x sink- source on number of seeds per pod and 1000 seed weight however did not show similar trend (Fig 4 and 1). The observation therefore showed that the an increase in seed yield was mostly due to more proliferation number of pods per plant comparing to the number of seeds per pod and or 1000 seed weight. The results are supported by those reported by Cheema *et al*., and Yasari *et al*., [29] suggesting that increase in seed yield was mainly because of more number of pods per plant. Similar observations were also reported by Santonoceto *et al*., [23] and Hocking *et al*., [16] for canola and Zhaohui and Shengxiu [31] for mustard.

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