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Exchanging amount of sink and source affect on soybean yield and yield components

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ABSTRACT

Drastic reduction of light in cloudy days in the northern part of Iran and the presence of pod eater pests are two main reasons for the recognition of source and sink relation. The effect of source and sink on vegetative and storage organs of plant is a path for recognition of limiting factors in producing soybean plant. This experiment was conducted in order to study effect of source to sink on yield, yield components, harvest index and some agronomical characteristics of soybean. The experiment was laid out factorial in randomized complete blocks design (RCBD) with four replications. Factor A included changing of source in five levels: a_1- defoliated of 25%, a_2- defoliate of 50% , a_3- defoliate of 75%, a_4- open canopy, and a_5- control (without defoliation); and factor B included changing of sink in three levels: b_1- cut 25% of pods, b_2- cut 50% pods, b_3- cut 75% pods. Analysis of variance showed that the source and sink ratio had a significant difference on grain yield ($p<0/01$). The open canopy (a_4) and 75% defoliate (a_3) had maximum (790.4 gm^{-1}) and minimum (458.7 gm^{-1}) of grain yield, respectively. The grain yield of a_1, a_2 and a_3 treatments decreased 15.1, 25, and 35% compared to the control (a_5), respectively. The treatment of open canopy (a_4) increased 12% yields in comparison with the control. Factor A was significant for some traits such as the number of pods, number of grain, 100 grains weight, number of lateral branches and plant height. Harvest index influenced the changes in source and sink ratio and showed significant diversity ($p<0/01$). The maximum and minimum of harvest index were obtained in defoliate of 75% and open canopy, respectively. Results showed that factor B had significant effect on the number of pod, 100 grain weight, seed weight in lateral branch, pods weight and the number of pod. Investigations also showed that the open canopy increased the light penetration in canopy, photosynthesis and yield. Factor B decreased the yield in order to increase in the cut of pods.

Key word: source, sink, soybean, yield, agronomy trait.

INTRODUCTION

Golestan province located in the north part of Iran and has been the important area for cultivation of soybean within the 50 years ago. Higher performance of soybean and new cultivars in comparison with old cultivars is because of the increase of genetic potential via breeding and genetic advances through breeding and agricultural technology progresses used in agricultural producing systems. Developments occurred in recent years, was promising for agricultural technology and its high capability in the increase of food production. One of the most important methods is the maximum use of solar energy to produce more dry and usable materials. Effective factors on photosynthesis systems were divided to two categories; environmental and inter-plant factors. Effective environmental factors consist of light, carbon dioxide, temperature, food and water and inter-plant factors include solar respiration, leaf age, hormones, control of photosynthetic material, diseases and etc [1]. Performance of a plant is final result of assimilate by leaves (source) and transfer of this material to growing seed (sink), the place that is

applied for synthesis of starch, protein and lipid. Shade cover decreases growth rate and indicates that production is limited in intended plants [15]. In farming plants, the movement of photosynthetic materials from source to sink is based on the production capacity of synthesis materials (source) on the one hand and the storage capacity of synthesis materials on the other hand. If imbalance decreases between these, it means that proper balance between source and sink is an important factor for achieving desired performance [18]. Source limitation means that plant is notable for making photosynthesis materials for economic purposes. Versus the concept of destination limitation means that plant might to be able for making sufficient photosynthesis materials, but the economic purposes of plant miss full use of photosynthesis materials. The production of assimilate by photosynthesis, translocation of assimilate to reproductive sinks, and utilization of assimilate by the developing seeds to produce the storage materials is the function of yield in a grain crop [6- 7]. Thus, the concept of photosynthetic source and sink is fundamental to yield of a grain crop [11]. Sever reduction of light by the increase of cloudy days in Golestan province climate and also pod eater and phyllophagous pests are reasons of the recognition of source and sink relation. The effect of increase and decrease of resource and sink on vegetative and storage organs in the plant is the path for achieving desired performance and recognition of limiting factors in soybean plant in this region [16]. For this aim, present research was conducted for evaluation of changes in the source and sink on the light penetration in canopy and final performance of soybean.

MATERIALS AND METHODS

This experience was done to study the impact of changes of source and sink on yield and yield components of soybean crop in Gorgan agricultural research station of Golestan province, northern part of Iran in 45º and 25′ of east 39° and 45′ of north with 400 to 450 mm of average annual rainfall. Before cultivation deep plowing after wheat harvest, 3 times disk with trowel, 2.5 L of Terfelan herbicide per acre, 50 kg/ha urea and a 1 L of complete fertilizer of Taftan dissolved in water was sprayed. The experience conducted in factorial completed randomized design with four replications. The first factor (A) was the source changes in five levels consisting; a_1: the removal of 25% leaves, a_2: the removal of 50% leaves, a_3: the removal of 75% leaves, a_4: open canopy (increase of source with the increase of light penetration into canopy), and a_5: care index (no change of source). In control treatment, there is no any change in canopy. Second factor (B), the changes of sink, consisting three levels; b_1: deletion of 25% of pod, b_2: deletion of 50% of pod, and b_3: deletion of 70% of pod. Unit plot consists of three rows with 50cm lines distance and bushes of 8 cm. Soybean cv. DPX were collected from second row with length of 170cm. Seed, plant height, the number of lateral branches, number of pod, number of seeds per pod, pod weight, weight of 100 seeds, and harvest index were calculated. Also, in order to estimate the total performance of seed after remove of two lateral lines (1 and 3 rows) and the remove of half meter from two sides as margin to length 3.5 m (two square meter) was cultivated and economic and biologic performance and also harvest index for all experimental units was computed.

RESULTS AND DISCUSSION

Data showed that the soybean yield and yield components were influenced by intact source and sink removal. Entire source had more significantly effect on yield properties, weight of 100 seeds, height, the number of lateral branches, and average of pod weight, average of seed number in pod and harvest index. Also, Entire source had significant effect on total biomass properties. Protection of source from removing had significant influence on yield properties, weight of 100 seeds, height, the number of lateral branches, average of pod weight and average of seed number in pod. The open canopy and control 3950 and 3529 Kg/ha had highest yield, respectively (Fig. 1). The yield of open canopy has been increased 11% than control and yield in defoliation treatments of 25%, 50% and 75%, had decrease of 16%, 25% and 31% than control, respectively (Fig. 2). Soybean yield decreased when the sink or pod deletion increased (Fig. 2). It indicates that because of enjoying efficient light, intact sources have more photosynthesis and finally more number of pod, lateral branch and weight of 100 seeds. Whereas, defoliation have lower economic performance because of limitation in source and resource, reduction of photosynthesis, assimilate and disorder in balance of hormones. Yield characteristics are controlled by many genes and are influenced strongly by environment. This trait is the result of many properties that alone or together affect on it [2]. The result is similar to reports of Pettigrew [15]. In his study about the proportions of source to sink on three different genotypes of cotton concluded that the cotton boll yield was more open canopy (17%). Pettigrew [15] also reported that in shadow, cotton boll yield has declined 20% than to control treatment. Sink deletion has significant effect on total biomass ($p<0.01$). Increase in treatment compared to the control source, had increased 11% in biomass (Fig. 3). In present research with increasing light and its absorption by open canopy lead to faster expansion of leaf area, provide assimilate, biologic yield and also biomass or dry matter production than other treatments. Because of the lack of light on the lower floors and dense canopy, reduction of photosynthesis, aging of lower leaves, the control treatment on the lower floors have produced less dry matter and biologic weight. Defoliation result was reduction in photosynthesis and dry matter and finally the weight of the biological plant is reduced per unit area. Highest plant

height was observed in the control treatment (156.9 cm), defoliation of 25% (139.7 cm), defoliation of 50% (137.1 cm), defoliation of 75% (126.6 cm) and open canopy (123.4 cm), respectively (Fig. 4). Obtained results shows light appropriate passage into canopy, because of high density of plant and numerous leaves. Plants compete to absorb light and thus plant height increased. The result of defoliation was decrease in light penetration into plant population and then reduction in plant competition that leads to shorten height of plant. Similar to Board and Harville [2] reports, because of efficient space between plants and no competition for light, the source treatments had lowest plant height. At the same line in soybean plants, Khadem Hamzeh et al. [9] concluded that in higher plant density and lower light penetration, plant height will be increased. The open canopy had the highest number of lateral branches (8.4) and control had the least number of lateral branches number (5.8). This indicate the influence of light and thus the red and infrared light lead to further development of branches in soybean because of proper space and light penetration to lower layers canopy (Fig. 5). Open canopy treatment had higher pod weight (Fig. 6), 23% higher than control. Pod weight decreased in defoliation of 25% and 50% treatments without significant different with the control. Minimum pod weight was observed in defoliation 75%, 28% lower than control. Former studies indicated that when equilibrium is broken between sources and sinks in individual soybean plant through pods or leaf removal, the direction of assimilate transport is changed [2]. More sink deletion treatments more declined the pod weight (Fig. 7). This indicates that light penetration increase photosynthesis and provide more assimilate leads to pod weight. The greatest number of seed per pod (Fig. 8) and 100 seed weight (Fig. 10) was observed in open canopy treatment and decreased with increasing of deletion percent of pod (Figs. 9 and 11). Increase in source number and receiving more light cause to produce and transport more photosynthetic and sugar materials into pods cause to increase seed number and their weight. Wang et al. [17] stated that pods gained assimilate not only from the attached leaf but also from the leaves at the adjacent nodes (above or below). They found a strong adjacent compensation in assimilate distribution process, because pods weight at the nodes with leaf removal was 60% of the same nodes with leaf attached. Charles-Edwards et al. [3] stated that the assimilate requirement of an individual seed plays an important role in determining total seed number because the total assimilate requirement of all of the seeds on the plant must be in balance with the available assimilate supply. Equilibrium, therefore, will be maintained between source and sink during plant growth and development [12]. Pod deletion provides conditions for uptake photosynthetic materials and their accumulation in a smaller number of sinks increased seed weight. More removed sink number caused more seed number in pod. 100 seeds weight in open canopy treatment was 31.09 g and minimum weight of 100 seeds in 75% defoliation treatment of source was 24.7 g (Fig. 10). The above results are consistent with experiments of Egli [5] and Board and Harville [2] results. A positive correlation between leaf area and seed weight across the main axis in soybean was reported, and was defined as source-sink parallelism [4]. The highest harvest index was shown in control treatment (29.5%) and the lowest harvest index were in defoliation of 50% and 75% (both 21%) (Fig. 12). Harvest index is the percent ratio between total bio mass and economic yield. Legumes generally exhibit low harvest index as compared with cereals. Park [14] that traits like biological yield and harvest index are closely related to sink size, source activity and sink source ratio. Olsen [13] reported that photosynthesis, light independent reactions and the partitioning of assimilates are the essential pre-requisite for increased and stable plant productivity. Khan et al. [10] reported a significant positive correlation between harvest index and economic yield and negative correlation between harvest index and biological yield in chickpea.

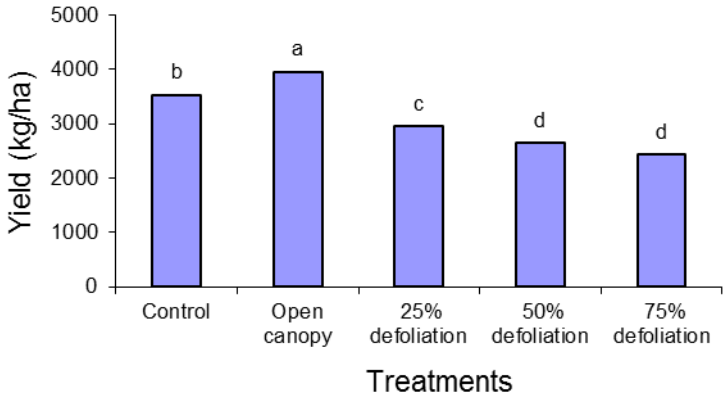

Fig. 1: The effect of source changes on the soybean yield

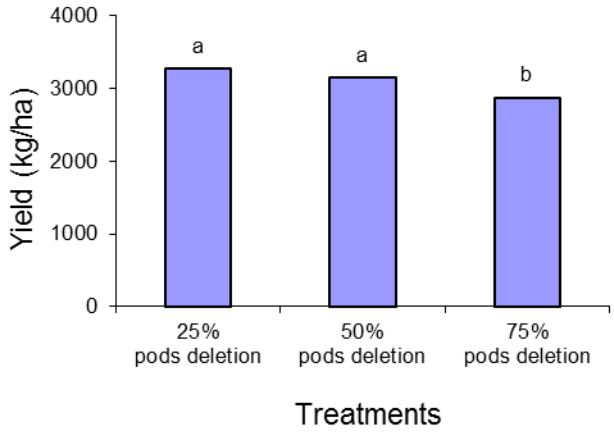

Fig. 2: The effect of sink changes on the soybean yield

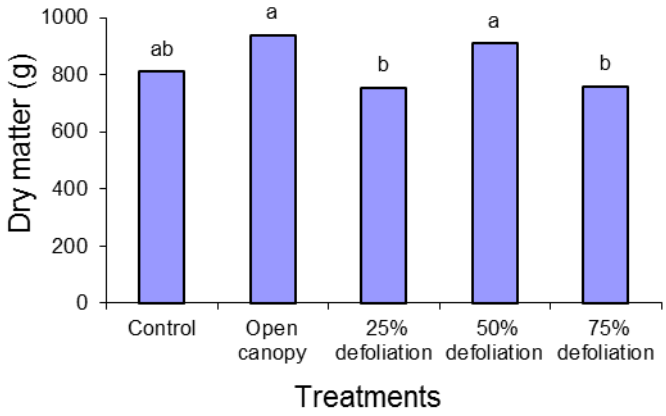

Fig. 3: The effect of source changes on the soybean dry matter

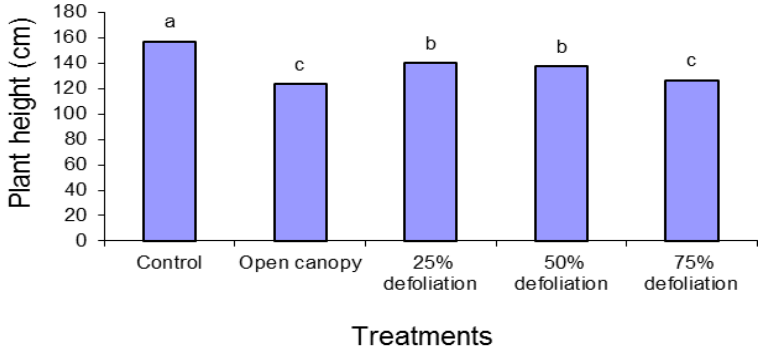

Fig. 4: The effect of source changes on the soybean plant height

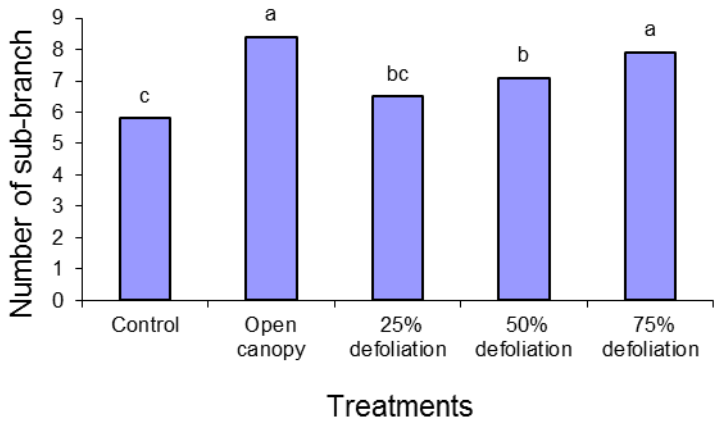

Fig. 5: The effect of source changes on the number of the soybean sub-branches

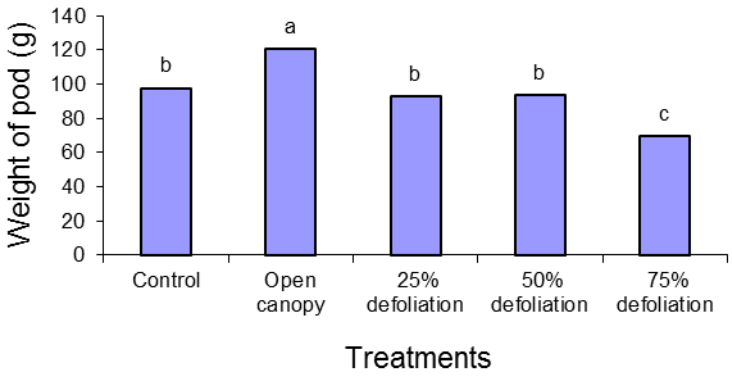

Fig. 6: The effect of source changes on the soybean pod weight

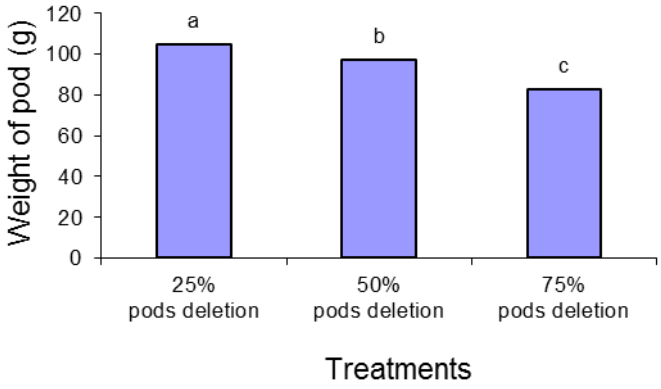

Fig. 7: The effect of sink changes on the soybean pod weight

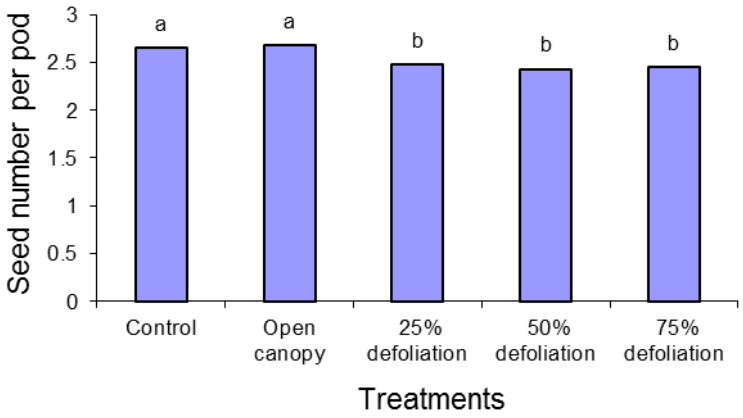

Fig. 8: The effect of source changes on the soybean seed number per pod

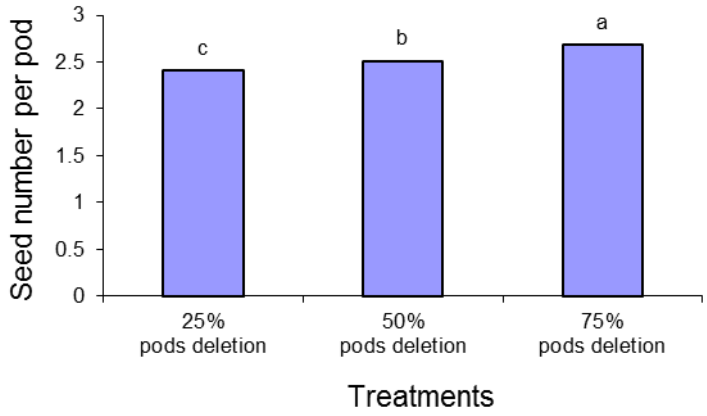

Fig. 9: The effect of sink changes on the soybean seed number per pod

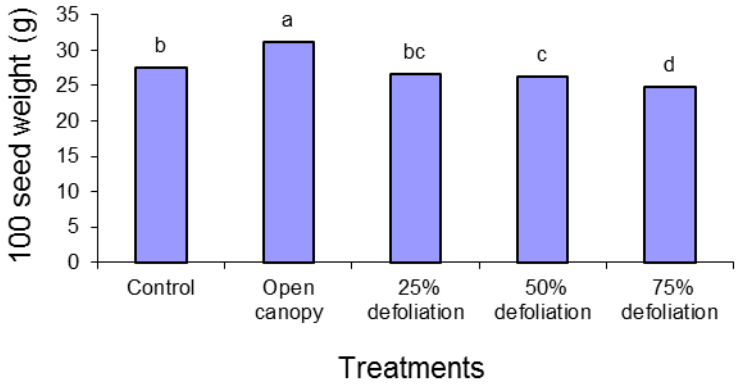

Fig. 10: The effect of source changes on the soybean 100 seed weight

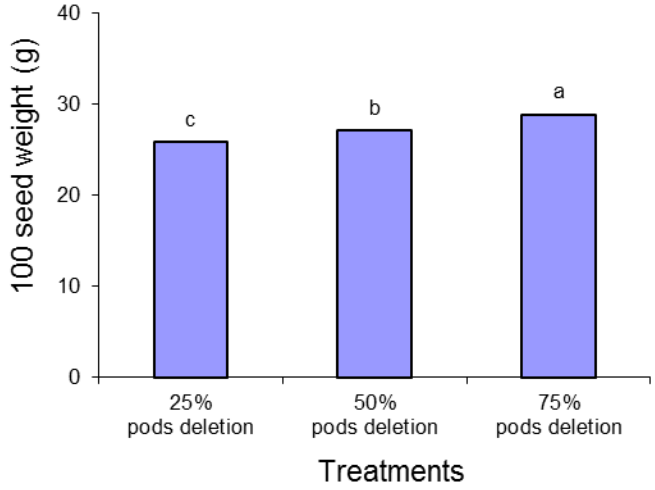

Fig. 11: The effect of sink changes on the soybean 100 seed weight

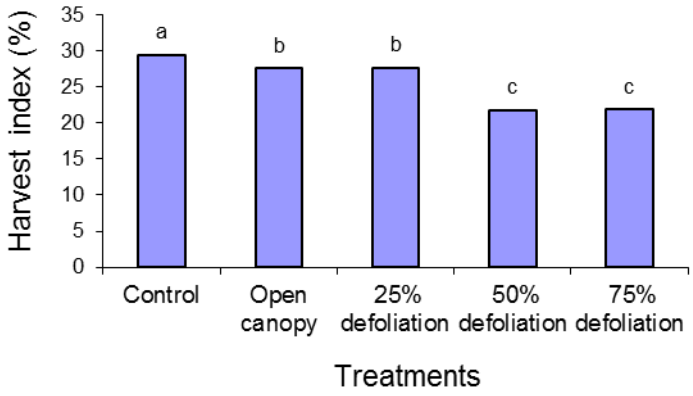

Fig. 12: The effect of source changes on the soybean harvest index

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