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Effect of chemical and bio nitrogen fertilizer on yield and yield components of soybean under intercropping with maize

Yaghoub Raei[1], Amin Bagheri-Pirouz[1], Jalil Shafagh-Kolvanagh[1], Safar Nasrollahzadeh[1], Parisa Aghaei-Gharachorlou*[2]

[1]*Department of Plant Eco-Physiology, Faculty of Agriculture, University of Tabriz, Iran*

[2]*Young Researchers and Elite Club, Tabriz Branch, Islamic Azad University, Tabriz, Iran*

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Key words: Grain yield, Intercropping, Nitrogen fertilizer, Yield components

Abstract

In order to study the effect of chemical and bio nitrogen fertilizer on yield and yield components of soybean at intercropping system of maize, an experiment was conducted at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran in 2012. The factorial set of treatments was arranged in a Randomized Complete Block Design, with three replications and two factors. The factors were represented by the following; different planting patterns factor: pure stand of maize (7plant/m^2), pure stand of soybean (40plant/m^2) and additive intercropping of optimal density of maize + 100% of optimum density of soybean. Second factor included: five levels of N fertilizers; control, 50 and 100Kg/ha urea chemical fertilizer, 50 Kg/ha urea + Bio-super bio-fertilizer and Bio-super bio-fertilizer. Results showed that sole soybean produced the highest grain and biological yield. Among the intercropping systems, sole soybean recorded the highest mean pod per plant and grain number per plant. Significant increase was observed in all characters in combined use of N fertilizer and Bio-super bio-fertilizer. Considering the experimental findings, sole cropping and combined use of Bio-super bio-fertilizer with 50Kg/ha N chemical fertilizer recommended for soybean grain yield.

***Corresponding Author:** Parisa Aghaei Gharachorlou ✉ p.aghaei_90@yahoo.com

Introduction

In recent years, a trend in agricultural production systems has changed towards achieving high productivity and promotes sustainability over time. Farmers are developing different crop production systems to increase productivity and sustainability since ancient times. This includes crop rotation, relay cropping and intercropping of major crops with other crops. Intercropping, the agricultural practice of cultivating two or more crops in the same space at the same time is an old and commonly used cropping practice which aims to match efficiently crop demands to the available growth resources and labor. The most common advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of the available growth resources using a mixture of crops of different rooting ability, canopy structure, height, and nutrient requirements based on the complementary utilization of growth resources by the crops (Andrew and Kassam, 1976). Nitrogen fixing legumes generally do not need nitrogen fertilizer, whereas, the non-legumes requires additional mineral nitrogen for optimum growth. Besides its own nitrogen requirement, legumes may contribute additional nitrogen to the soil, which can be used by the other crop in the intercrop or the succeeding crops. These include risk of crop loss due to adverse environmental conditions, need for balanced diet, and the desire to optimize the use of labor and to optimize the use of land (Jaynes *et al*., 2001).

Maize (*Zea mays* L.) is the world's most widely grown cereal, and it is ranked third among major cereal crops (Ayisi and Poswell, 1997). In developed countries maize is mainly grown for animal feed, industrial products such as glucose, dextrose, and starch and specialized foods (Malvar *et al*., 2008). Soybean (*Glycine max* L.) is considered one of the most important grains for human alimentation and is worldwide planted on approximately 79 million hectares (FAO, 2014). Maize and soybean intercropping system is one of the cropping systems practiced by most of the farmers (Wortmann *et al*., 1991).

This is due to the fact that the two crops are compatible with one another and do not compete each other (Wortmann *et al*., 1991; Norman *et al*.,1996) for nutrient especially for light. Nutrient use in intercropping system has received a considerable attention despite difficulties in quantifying its beneficial competitive effects. The competition for nutrients is important and begins early in the growth of component crops in a cereal intercropping system. In cereal/legume intercropping systems, the combination of a tall cereal with an adventitious root system and a short-statured legume with a deep tap root utilizes space and time more efficiently than a sole cereal crop. Additionally, the leguminous component often has the ability to fix atmospheric nitrogen, thus avoiding competition with the cereals for this nutrient (Hiebsch and Mc Collum, 1987). Additionally, such multiple combinations tend to be more stable in terms of system productivity than sole crops (Rao and Willey, 1980).

Just as providing enough nitrogen optimizes the yield potential, disregarding proper management like applying excessive amount of N fertilizer proves disagreeable outcome, so determining proper nitrogen fertilizer rate in order to produce more grain and to reduce environmental hazard must be taken into consideration (Jaynes *et al*., 2001).

Cropping systems and N fertilizer are important factors affecting crop production. However, information is lacking on how they affect grain yield and yield components. The objective of the study was to determine the effects of N fertilizer levels on soybean yield and yield components under intercropping system of maize.

Material and methods

Site description and experimental design

The field experiment was conducted in 2011 at the Research Farm of the University of Tabriz, Iran (latitude 38°05_N, longitude 46°17_E, altitude 1360m above sea level). The climate of research area is characterized by mean annual precipitation of 285 mm, mean annual temperature of 10°C, mean annual maximum temperature of 16.6°C and mean annual minimum temperature of 4.2°C.

The experimental design was a factorial in a Randomized Complete Block Design, with three replications and two treatments. The treatments were represented by the following; different planting patterns treatment: pure stand of maize (7plant/m²), pure stand of soybean (40plant/m²) and additive intercropping of optimal density of maize + 100% of optimum density of soybean. Second treatment included: five levels of N fertilizers; control, 50 and 100Kg/ha urea chemical fertilizer, 50Kg/ha urea + Bio-super bio-fertilizer and Bio-super bio-fertilizer.

Measurement of traits

To specify yield components of soybean, ten plants were selected from the middle of the plots and then, they were measured. Also to determine of grain yield and biological yield an area equal to 1 m² was harvested from middle part of each plot considering marginal effect and dried in an oven at 75° for 48hours.Subsequently, biological yield and grain yield per unit area were determined. Harvest index was calculated by the following equation:

Harvest index = (Grain yield/Biological yield) × 100

Statistical analysis

Statistical analysis of the data was performed with MSTAT-C software. Duncan multiple range test was applied to compare means of each trait at 5% probability.

Result and discussion

Fertilizer treatments, intercropping of maize and soybean and interaction significantly affected pod per plant of soybean at 1% probability level (Table 1). The highest pod per plant (31.7) of soybean was obtained in soybean sole cropping under Bio-super bio-fertilizer. The lowest pod per plant (19.8) was recorded under control treatment (Fig.1). Wright (1981) reported higher pod per plant under sole cropping than intercropping conditions. However, a non-significant difference in pod per plant between sole and intercropped crops was reported by El-Karmany (2001). Studies of Moradi *et al.* (2011) on wheat showed that the using effective microorganisms as a bio-fertilizer and N fertilizer increased all studied vegetative growth characters.

Table 1. Analysis of variance of yield and yield components of soybean affected by intercropping and N fertilizer treatments.

SOV	df	Mean square					
		Pod per plant	Grain per plant	100-grain weight	Biological yield	Grain yield	Harvest index
Block	2	7.5 **	79.7 **	0.19 **	35453.2 **	5864.1 **	0.0002
N fertilizer	4	136.34 **	861.02 **	1.54 **	135305.7 **	23155.4 **	0.005 **
Intercropping	1	458.5 **	2480.1 **	6.94 **	289439.6 **	60032.1 **	0.00005
Interaction	4	8.21 **	57.19 **	0.506 **	79792.2 **	4195.1 **	0.002 **
Error	18	0.437	3.06	0.019	15569.5	263.2	0.00006

* and ** = Significant at 5% and 1% probability level, respectively.

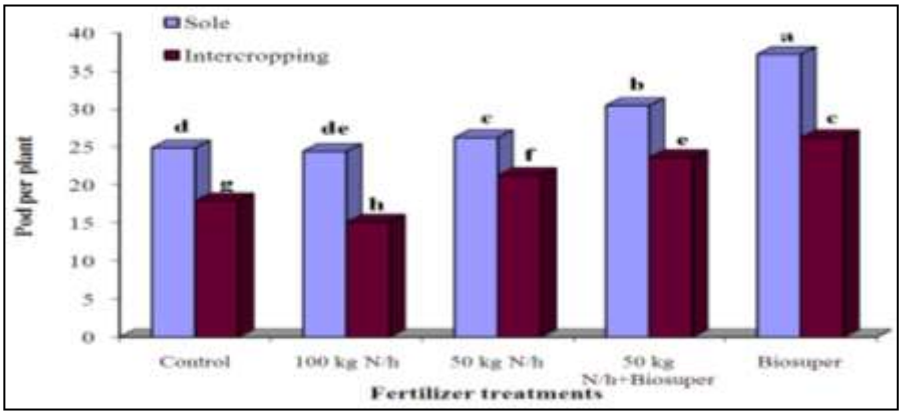

Fig. 1. Pod per plant of soybean as influenced by cropping patterns and fertilizer treatments (Different letters indicate significant difference at p≤ 0.05).

Statistical analysis of the data indicated that different intercropping patterns and fertilizer treatments had significant effect on grain per plant of soybean (Table 1). Maximum grain number per plant (80.2) was obtained in sole cropping of soybean under Bio-super bio-fertilizer treatment (Fig. 2). This result is similar with finding of Silwana and Lucas (2002) who reported that yield components of maize intercropped with both beans and pumpkin were adversely affected by intercropping conditions. In other results, (Thwala and Ossom, 2004) did not find any significant difference in yield components between mono cropping and intercropping of maize with sugar bean and ground nuts. Soleimanzadeh (2011) showed the positive effect of combined application of bio-fertilizers and N fertilizer on the most plant growth parameters of sunflower. 100-grain weight of soybean significantly affected by intercropping patterns and fertilizer treatments (Table 1).

Soybean plants in the sole cropping system and 100Kg/ha urea fertilizer treatment produced the highest 100-grain weight (15.61). Intercropping of maize and soybean under control fertilizer treatment produced the least 100-grain weight (Fig.3). Possible reason for higher 100-grain weight in sole soybean might be attributed to no inter-specific competition. Similar results are reported by Azim Khan *et al.* (2012). Hamidi *et al.* (2007) reported that 100 grain weight increased by inoculation of grain with bio-fertilizers compared to no inoculation.

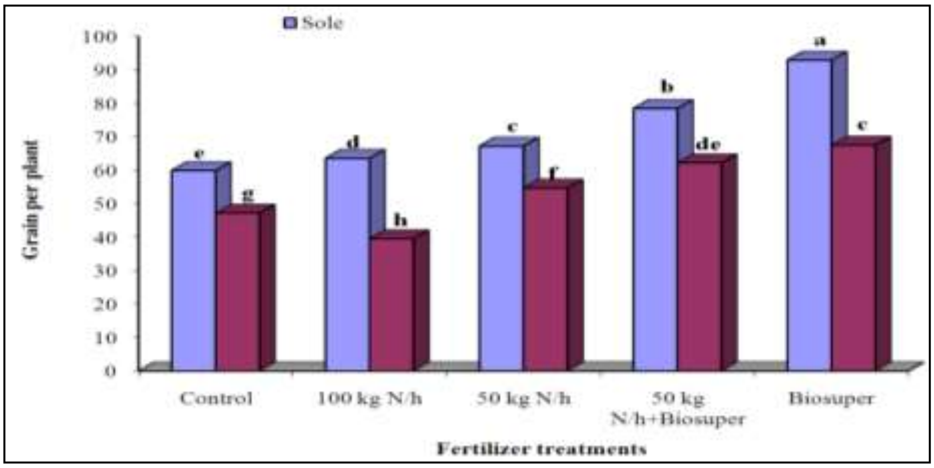

Fig. 2. Grain number per plant of soybean as influenced by cropping system and fertilizer treatments (Different letters indicate significant difference at p≤ 0.05).

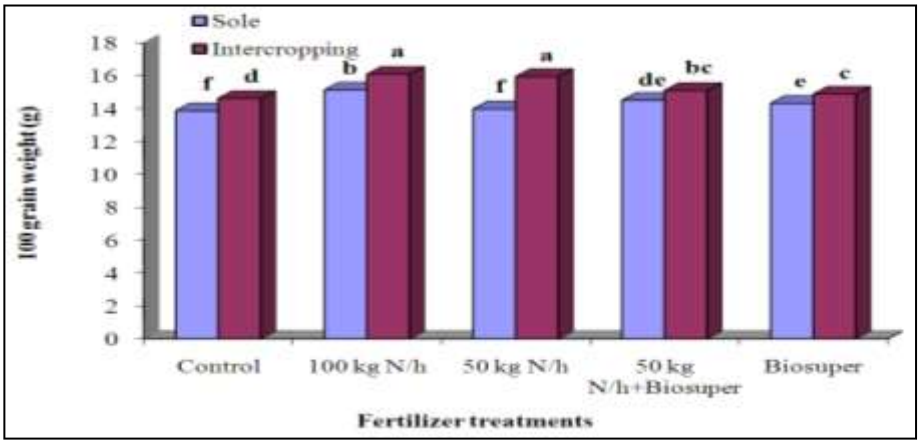

Fig. 3. 100-grain weight of soybean as influenced by cropping patterns and fertilizer treatments (Different letters indicate significant difference at p≤ 0.05).

Intercropping patterns and fertilizer treatment significantly affected grain and biological yield of soybean (Table 1). Soybean mono crop produced significantly higher grain yield (452.1 gr/m²) than intercropping treatments under Bio-super bio-fertilizer and also highest biological yield (972.7 gr/m²) was obtained in sole cropping patterns of soybean under Bio-super bio-fertilizer (Fig. 4 & 5). In agreement to this research, the general trend in most intercropping experiments is that the grain yield of a given crop in a mixture are less than the yield of the same crop grown alone, but in total productivity per unit of land is usually greater than for sole crop (Natarajan and willy, 1981). Competition for soil moisture and nutrients could have been high and might have caused the yields of soybean to drop significantly. N fertilizer in this study had a significant effect on soybean grain yield. Study on the effect of N fertilization on growth and yield components showed increase in canola grain yield (Ahmadi and Bahrani, 2009). This finding was supported by Lin *et al.* (1983) who reported that application of *Azotobacter* and *Azospirillum* increased grain yield.

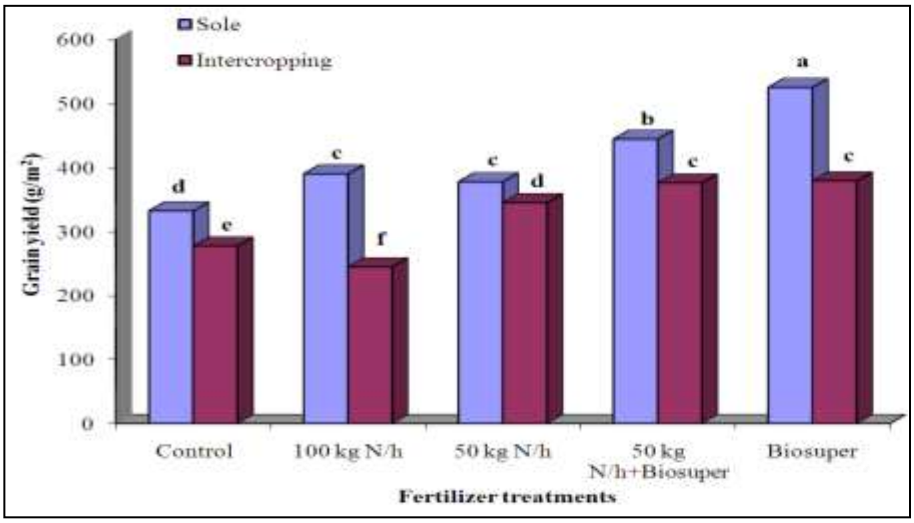

Fig. 4. Grain yield of soybean as influenced by cropping patterns and fertilizer treatments (Different letters indicate significant difference at p≤ 0.05).

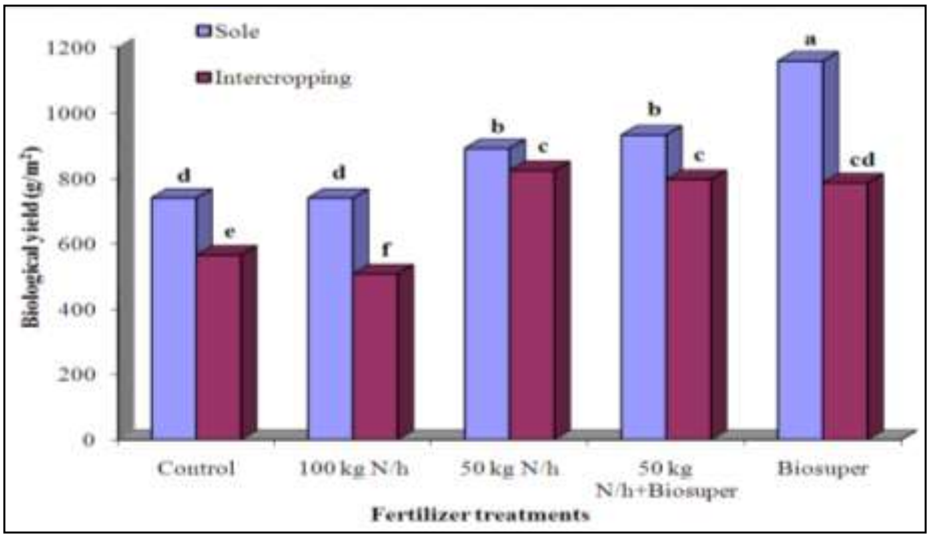

Fig. 5. Biological yield of soybean as influenced by cropping patterns and fertilizer treatments (Different letters indicate significant difference at p≤ 0.05).

According to the results showed, fertilizer treatments, intercropping of maize and soybean and interaction significantly affected harvest index of soybean at 1% probability level (Table 1). Highest harvest index (51.6%) was obtained in soybean sole cropping under 100Kg/ha urea fertilizer (Fig. 6).

Possible reason for higher harvest index in sole soybean might be attributed to no inter-specific competition. Similar results are reported by Azim Khan *et al.*, (2012). Similarly, Daneshvar *et al.* (2008) reported that combined use of N and bio-fertilizer increased harvest index of canola.

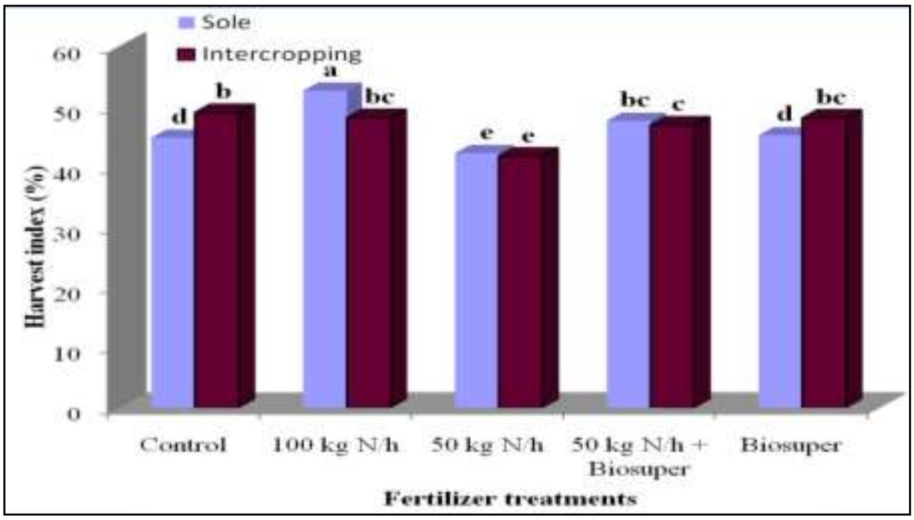

Fig. 6. Harvest index of soybean as influenced by cropping patterns and fertilizer treatments (Different letters indicate significant difference at p≤ 0.05).

Conclusion

The yield of soybean in sole system was generally greater than those of intercropping system. It can be concluded that N fertilizer increased grain yield of soybean in sole and intercropping system. In order to have a higher grain yield, sole cropping system and combined use of N fertilizer and bio-fertilizer should be taken into consideration so that without disturbing the biological function of legumes, the objectives can be achieved.

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