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Original Article

Effect of Bacteria and Vermicompost on Phenology and Growth of Soybean (Glycine Max L.) in Sustainable Agricultural Systems

Mona Kazemi Moghadam[1], Hossain Hassanpour Darvishi[1*], Mohsen Javaheri[2]

[1]Department of Agronomy, College of Agriculture, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran
[2] Department of Agronomy, College of Agriculture, Sanandaj Branch , Islamic Azad University, Sanandaj, Iran

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ABSTRACT

Objective: To evaluate the effects of bacteria and vermicompost on phenology and growth of soybean trial an experiment was conducted as split plot in a completely randomized block design with three replications. **Methods:** Main plots of experiment at two levels included the non-use and the use of bacteria and the subplots at three levels included the non-use of vermicompost (control), the use of 5 tons of vermicompost per acre and the use of 10 tons of vermicompost per acre. **Results:** The results showed that the treatment including 10 tons of vermicompost had the highest amount of the days to full maturity with the amount of 153 days and the treatment of non-use of vermicompost had the lowest amount of the days to full maturity. Also, the highest amount of SFP was obtained from the treatment including the use of vermicompost at the rate of 10 tons per acre that increasing the seed growing and filling period led to obtain the highest amount of seed yield with the amount of 1699 kg ha while the lowest amount of seed yield was obtained from the treatment including non-use of vermicompost with the amount of 1419 kg ha. The use of bacteria compared with non-use of it led to obtain the highest amount of seed yield with the amount of 1636 kg ha while non-use of bacteria had the lowest amount of seed yield with the amount of 1443 kg ha. Also, the results obtained from the analysis of variance showed that the effects of using vermicompost on the stem diameter, plant height, and days to pod at the level of 1% and on the days to flowering, days to full maturity and seed yield at the 5% level were significant.

1. INTRODUCTION

Sustainable agriculture is a biological process that tries to implement the key characteristics of a natural ecosystem. In this approach, the main objective is the long-term strengthening and increase of soil fertility, biological control of pests and diseases, reducing or eliminating chemical fertilizers and fertilizer materials. In recent years, the need to study the biological characteristics of root growth area is significantly considered for the sustainable agriculture in order to improve the nutrition and growth of the plant. Safar Zadeh et al (2007) reported that the world's attention to modern agriculture and applying the new sciences and technologies is considered to minimize the damage to resources and maximize the utilization of them; however, using the growth regulators has attracted many researchers to improve the crop growth and increase their production. The importance of biological nitrogen fixation in soybean and Rhizobium Japonicum bacteria is known by a number of researchers who examine various aspects of this relationship. After infection of soybean roots by Rhizobium Japonicum, the node is made in the outer shell of the root and the bacteria lead to the

*Corresponding Author: Hossain Hassanpour Darvishi, Department of Agronomy, College of Agriculture, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran (hhassanpour87@gmail.com)

creation and growth of the node by producing auxin and cytokinin. Asadi Rahmani, et al (2000) reported that for the plants like soybeans that can have the highest yield by the symbiosis dependence to molecular nitrogen-fixing bacteria without need to the use of synthetic fertilizers. Using this substantial ability is considered as an inevitable necessity in terms of its helpful economic and environmental aspects. Today, the use of organic fertilizers is not very common for various reasons, while according to the reports, using it increase the plant stability in the soil, in addition to maintain the nutrient cycle, reduce the pollution and modify the physico-chemical properties of soil and in this regard, the effect of organic fertilizers is beyond the pure chemical fertilizers (Magdof and weil, 2004).

Tejada and Gonzalez (2008) reported the decrease of soil bulk density and increase of soil porosity by the use of organic fertilizers of compost, vermicompost and livestock manure in the soil and the highest effect was attributed to Compost. During an experiment by using vermicompost in soil, Mirzaee et al (2009) also stated that this type of fertilizer makes the soil spongy and increases the percentage of pores and ultimately reduces the soil bulk density. The use of bio-fertilizers like vermicompost, microorganisms solubilizing phosphate and Azotobacter in a system based on organic farming enhances the quality and stability of the yield while maintaining environmental health (Sharma, 2002). The organic matter is the main cause of soil productivity and fertility and for maintaining the fertility and productivity of soil the organic matter level must be maintained at an appropriate level.

Apart from providing nutrients, the organic matters have the different effects on the soil properties, especially its physical properties (Pedra, et al, 2006). In an experiment on the pea, it is found that the use of 3 t ha of vermicompost significantly increased the seed yield and biological yield compared with the control (jat and Ahlawat, 2004). By investigating the combined use of organic fertilizers on soybean, Maheshbabu et al (2008) found that the seed yield with the combined use of vermicompost + livestock manure (50 per cent) was significantly increased compared to carbide of either alone (100%). Also the study of Manna et al (2003) about vermicompost showed that the soil biological activities including soil respiration, microbial carbon biomass and dehydrogenase activities in vermicompost treatments were much more than treatments containing chemical fertilizers.

2. MATERIALS AND METHODS

The research was conducted in 2012-2013 in the agricultural research farm, located at 2 km from the city of Sanandaj with the geographical position of 46 degrees, 29 minutes longitude and 35 degrees, 16 minutes latitude, with the altitude of 1393 meters above sea level as split plot in a completely randomized block design with three replications. The main plots of experiment included the non-use and the use of bacteria in three levels and the subplots included the use of vermicompost (control), the use of 5 tons of vermicompost per acre and the use of 10 tons of vermicompost per acre. The bacterium used was Bradyrhizobium Japonicum, the vermicompost used contained the worms called Eisenia foetida and also the cultivar used was Safiabad cultivar. Every experimental plot had 6 plant lines with the long of 3 m, the distance between the rows was 50 cm and the distance between the plants on the row was 10 cm. For moistening the seed, a solution of 10% sucrose and the bacteria was used for the seed in the shade and immediately after that the planting was done. Also for analyzing the physical and chemical properties of experiment area soil before preparing the ground, some points from zero to thirty-cm depth were sampled (Table 1). During the period of growth and development of plant the phenological characteristics measured included the days to flowering, days to pod, the seed filling period, flowering period, and the days to full maturity, the morphological characteristics included plant height and stem diameter and the seed yield was also evaluated. The statistical calculations related to the Analysis of variance and the mean comparison was conducted by using my software MSTAT- C and mean comparisons of the characteristics were plotted by Duncan's multiple range test and the graphs were plotted by using software Excel.

Table 1.
Physicochemical test results of soil of experiment area

Electrical Conductivity	Acidity	Sand	Silt	Clay	Organic carbon	Total nitrogen	Absorbable phosphorous	absorbable Potash
EC*104	(PH)	(%)					(ppm)	(ppm)
1.283	7.5	64.6	26	9.4	1.07	0.107	11.7	120

3. RESULTS AND DISCUSSION

Results obtained from analysis of variance showed that there was a significant difference in the days to pod, stem diameter and plant height at the level of 1% of vermicompost treatment so that the mean comparisons of characteristics by Duncan's test at the level of 5% showed that the highest amount of days to pod was obtained from the treatment including the use of 10 tons of vermicompost per hectare with the amount of 95 days and the lowest amount was obtained with the amount of 91 days from the treatment including the non-use of vermicompost (Table 3).

Yazdani and colleagues (2008) reported that using the different organic matters has not made a significant difference in the length and weight of stem. The seedling weight and number of nodes significantly increased affected by the application of trash compost and livestock

manure compared to the control and vermicompost. Then the results showed that the highest and the lowest amount of stem diameter and plant height were obtained from the treatments including the non-use of vermicompost and the use of 10 tons of vermicompost for stem diameter and plant height, respectively, that it shows the effects of the treatment including use of vermicompost for reducing the growth of lateral shoot and plant height in order to increase the economic output or seed yield as the highest amount of seed yield was obtained with the amount of 1699 kg ha from the treatment including the use of 10 tons per hectare of vermicompost while the lowest amount of seed yield was obtained with the amount of 1419 kg ha from the treatment including the non-use of vermicompost that was consistent with the results of Malakooti and Homaei (2004) who stated that the use of organic fertilizer leads to increase the soybean yield by providing phosphorus and most micronutrients that resolving the micronutrients deficiency by organic matters is presented due to the complexing strength of the material. The use of bacteria led to achieve the highest seed yield with the amount 1636 kg ha compared with lack of using bacteria while the lack of using bacteria had the lowest amount of seed yield with the amount of 1443 kg ha. Ghorbani Nasr Abadi et al (2002) reported that the mean comparison of treatments inoculated and non-inoculated by Bradyrhizobium Japonicum bacterium shows that inoculation with this bacterium has significantly increased the indices of soybean growth and the number of the root system and nitrogen-fixing nodes. Also, the characteristics of the days to flowering, days to full maturity and seed yield had a statistically significant difference at 5% level under the influence of the treatment with use of vermicompost. In the interactions the bacteria and vermicompost were located in the same statistical group so that the highest amount of seed yield was obtained with the amount of 1731 kg ha from the treatment of interaction between the use of bacteria and vermicompost with the amount of 10 tons while the lowest amount of seed yield was obtained with the amount of 1311 kg from the interaction between control treatments (non-use of bacteria and vermicompost) that shows the effects of using vermicompost and bacteria as a factor enhancing economic yield in order to achieve the stability in the soybean nutrition. Also, the bacteria used have provided the optimum plant growth conditions by nitrogen-fixing to the extent required. Then, the results of analysis of variance showed that there was a significant difference in stem diameter of the treatment of interactions between bacteria and vermicompost at the level of 5% so that the highest amount of stem diameter was obtained from the interactions between the non-use of bacteria (control) and the use of 5 tons ha of vermicompost. The highest amount of seed filling period was obtained from the treatment including the use of 10 tons ha of vermicompost with the amount of 58 days and the lowest amount was obtained from the treatment including non-use of vermicompost that the use of vermicompost in this regard could have the significant effects on the seed filling period and increasing the seed yield.

Table 2.
Variance analysis of the characteristics

Sources of changes	Degree of freedom	Mean squares							
		Days to flowering	Days to pod	Seed filling period	Flowering period	Days to full maturity	Stem diameter	Plant height	Seed yield
Repetition	2	20.222ns	32.167 ns	7.167 ns	0389 ns	60.667 ns	0.053 ns	98.838 ns	8448.222 ns
Bacterium	1	0.889 ns	2.722 ns	0.056 ns	0.222 ns	1.389 ns	14.293 **	307.024 ns	172480.222 ns
Error	2	6.689 ns	5.389 ns	2.722 ns	0.056 ns	21.556 ns	0.174 ns	655.359 ns	233798.222 ns
Vermicompost	2	16.889*	26.167 **	4.667 ns	0.056 ns	44.667 *	10.538 **	445.665**	220438.389 *
Bacterium*vermicompost	2	3.556 ns	5.389 ns	0.222 ns	0.056 ns	5.556 ns	1.766*	12.53 ns	72287.056 ns
error	8	2.556 ns	2.694 ns	1.861 ns	0.222 ns	9.778 ns	0.266 ns	53.648 ns	47164.556 ns
Coefficient of variations (%)		2.24	1.75	2.39	2.12	2.07	7.73	11.12	13.10

Ns, * and ** indicate the lack of significant difference and the significant difference at the level of 5% and 1%, respectively

In the interactions, the highest and lowest amount of seed filling period were obtained from the interactions between non-use of bacteria and the use of 10 ton of vermicompost with the amount of 153 days and the effect of treatment including non-use of bacteria with the amount of 147 days, respectively. Also, in the interactions, the highest amount of days to full maturity was obtained from the interactions between the treatment including non-use of bacteria and the use of 10 ton ha of vermicompost and the lowest amount was obtained from the effect of treatment including non-use of vermicompost with the amount of 147 days and in the interactions between the treatment including non-use of bacteria and vermicompost.

CONCLUSION

Longer soybean growth stages due to using vermicompost shows the availability of appropriate opportunity and conditions for plant growth. The plant growth promoting bacteria also improve the plant growth by producing the hormones stimulating the plant growth and increasing the root uptake efficiency. In general, there is a kind of competition between the vegetative organs such as roots, stem and leaves during the vegetative growth for photosynthetic material but with the development of reproductive growth in indeterminate soybean cultivar used a competition was made between the vegetative and reproductive organs but in the case of low photosynthetic material the vegetative growth dominates the reproductive growth and in this case, the moisture of leaves continues. Usually the reproductive growth is the first step of plant production for achieving the economic yield. Over time, the crops whose flowers, fruits and seeds make the economic yield are selected so that the large amounts of all its dry matter transfer to the reproductive parts. The leaves and other green tissues are the main parts of producing the photosynthetic materials.

Table 3.
Comparison of the characteristics

treatment									
Effect of bacterium	**vermicompost**	**Days to flowering (day)**	**Days to pod (day)**	**Seed filling period (day)**	**Flowering period (day)**	**Days to full maturity (day)**	**Stem diameter (mm)**	**Plant height (cm)**	**Seed yield (kg ha)**
Non-use of bacterium		72a	94a	57a	22a	151a	8.85a	61.74a	1443a
use of bacterium		71b	93b	57a	22a	151a	9.33b	70b	1636 b
	Non-use of vermicompost	69.67b	91.67b	56.17a	22.33a	147.8b	9.830a	74.67a	1419a
	use of 5 tons of vermicompost	71.67ab	94a	57.50a	22.17a	151.5ab	9.722a	57.44b	1502a
	use of 10 tons of vermicompost	73a	95.83a	57.83a	22.17a	153a	7.720b	65.50ab	1699a
Bacterium*vermicompost									
Non-use of bacterium* Non-use of vermicompost		69c	91c	56a	22.33a	147b	9.053b	72ab	1311a
Non-use of bacterium* use of 5 tons of vermicompost		72.33ab	94.67ab	57.67a	22a	152.3ab	10.94a	53.22c	1352a
Non-use of bacterium* use of 10 tons of vermicompost		73.67a	97a	58a	22a	154a	6.553c	60bc	1667a
use of bacterium* Non-use of vermicompost		70.33bc	92.33bc	56.33a	.22.33a	148.7ab	10.61a	77.33a	1526a
use of bacterium* use of 5 tons of vermicompost		71abc	93.33bc	57.33a	22.33a	150.7ab	8.500b	61.66bc	1652a
use of bacterium* use of 10 tons of vermicompost		72.33ab	94.67ab	57.67a	22.33a	152.3ab	8.887b	71ab	1731a

In each column, the means that have at least one common letter are in the same statistical group with the Duncan test at 5% level

Some of these materials remain in the green tissue to maintaining the cells and if the transfer rate is low, it can be turned to starch or the other form of sugar stored. The photosynthetic material remains are transferred to the vegetative destinations for the activities such as growth, maintenance and storage. In the vegetative stage the stem and leaves compete for getting the photosynthetic material. A part of photosynthetic material that is distributed in these organs is the determinant of plant growth and its production potential. The investment of photosynthetic material for the production leads to receiving more light. Considering the results obtained the positive effects of using the bacteria restricting the growth can be considered as a factor in increasing the stimulation of vegetative and reproductive growth of soybean so that the inoculation of bacterium with the seed and using it at the flowering stages as spraying or through irrigation water increases the root growth and plant uptake as well as longer vegetative and reproductive growth of soybean that can affect the growth process.

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