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Influence of Biofertilizer Application Methods on Growth and Yield Performances of Green Pepper

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Abstract

Nutrient management is a crucial factor and needs consideration for better growth and high yield of green pepper. An experiment was conducted in the experimental farm of Nangarhar University Faculty of Agriculture to evaluate the influence of different methods of biofertilizer on growth and yield performances of green pepper during 2017. The experiment was conducted with randomized complete block design in five treatments and four replications. The treatments were (1) control, (2) traditional method (TM), (3) root dipping (RD), (4) soil application (SA), and (5) root dipping and soil application (RDSA). Results showed that plant length, branch number, fruit number, and fruit weight were significantly different among treatments. RDSA increased branch and fruit numbers, as well as fruit length, compared to other treatments. RDSA had a greater yield which was 5.4 ton per hectare, followed by TM, SA, RD, and control which were 5.1, 4.7, 4.3, and 3.8 ton per hectare, respectively. Economic analysis of fertilizer's expenses revealed that TM, RDSA, SA, and RD used a huge amount of chemical and biofertilizers. However, RDSA enhanced net income followed by TM, SA, and RD. This research will encourage bnbfarmers to adopt with biofertilizers and decrease the use of chemical fertilizers for eco-friendly forming.

Keywords: Green pepper, Biofertilizer, Chemical fertilizer, Eco-friendly, Capsicum annuum, Sustainable agriculture.

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Ethical: This study follows all ethical practices during writing.

1. Introduction

Green pepper (*Capsicum annuum* L.) is one of the important vegetable crops which widely cultivated in the temperate, tropical, and sub-tropical countries [1]. It is used as a spice and a source of medicines in pharmaceutical industries [2]. Pepper is considered as one of the principle sources of vitamin C and is extensively used in dishes, sauces, ketchup, pickles, etc [3, 4]. Nutrient management and fertilizers application are crucial factors affecting growth and yield performances of green pepper [1, 4]. Farmers apply a huge amount of chemical fertilizers to obtain high yield [4]. However, such fertilizers are expensive [3] and are not eco-friendly [5]. Thus, attention is needed to increase pepper productivity through nutrient use efficiency and eco-friendly strategies. Dincheva, et al. [6] suggested that the method, type, and rate of fertilizers should be considered beside crop yield. Application of chemical fertilizers alone decreased fruit quality of pepper Talukder [7]. Mondal, et al. [8] stated that continuous and inappropriate use of chemical fertilizers decline soil fertility and nutrient absorption efficiency, consequently, decrease crop productivity. Among plant nutrient sources, biofertilizers are low cost, renewable and effective. Beneficial bacteria, fungal, and blue-green alga of biofertilizers promote plants growth through producing auxins, gibberellins, cytokinins, etc and improve nutrients absorption in the soil [9]. They are eco-friendly and lead the way for high yield, quality product as well as fertilizer use efficacy [10].

Biofertilizers contain nitrogen fixation and phosphorus solubilizer bacteria, etc, which can affect seed germination, root growth and so on [1]. An integrated nutrient management system is required to maintain soil quality and obtain a high yield. The aim of the current study is to evaluate the influence of different application methods of biofertilizer combined with chemical and organic fertilizers on growth and yield performances of green pepper.

2. Materials and Methods

2.1. Site Selection And Experimental Design

An experiment was conducted at the experimental field of Nangarhar University Faculty of Agriculture in 2017. The experiment was conducted with randomized complete block design in five treatments and four replications. The treatments were control, a traditional method (TM), and three methods of biofertilizer including (1) rood dipping (RD), soil application (SA), and root dipping and soil application (RDSA). Biofertilizer was a manufacturer of Green Life Bioscience, Bogor, Indonesia. It contained nitrogen fixation, phosphorus solubilizer, and plant growth promoter bacteria with 40×109 colony-forming unit. Biofertilizer was diluted with distilled water in a 1:100 (v/v) combination based on the recommendation from the manufacturer.

The experimental field was plowed with a chisel plow and raised beds were prepared. Soil properties of the experimental field at 30 cm depth are illustrated in Table 1 as reported by Abdiani and Kakar [11]. Hydrometer method by soil triangle was conducted to determine soil texture particles. Soil pH was recorded by a pH meter (6173 pH meter, Jenco Co., Taiwan). Electroconductivity was measured using an EC meter (3251 COND/SAL/TEMP meter, Jenco Co., Taiwan). Soil phosphorus was quantified by spectrophotometer (SP-300, spectrophotometer, Optima, Co., Japan), and potassium was quantified with a flame photometer (PFP 7, flame photometer, Jenway Co., UK). Finally, the calcium carbonate was tested with the method described by Rowell [12].

Table-1.
Soil characteristics of Nangarhar University faculty of agriculture research farm.

Soil properties	**Description and quantity**
Texture Class	Sandy clay loam
Clay texture	25.02%
Silt texture	27.30%
Sand texture	47.68%
pH	7.8
Electroconductivity	0.045 dS/ m
Total Nitrogen	1.20%
Phosphorus	3.3 mg/ kg
Potassium	118 mg/ kg
Calcium carbonates	23.00%

Each treatment received an equal amount of farmyard manure (FYM) and Diammonium phosphate (DAP) except of the control; however, urea and biofertilizer were used based on treatments application as shown in Table 2. The plot size was 12 m^2 and contained two raised beds. FYM and DAP were applied as a basal dressing during land preparation. Urea was used at three growing stages (as a basal dress at land preparation, as a top dress after transplanting and at flowering stages). Seedlings of RD treatment were treated with biofertilizer before transplanting.

Table-2.
Sources and amounts of fertilizers applied in each plot of treatments

Treatments	**FYM (kg)**	**DAP (g)**	**Urea (g)**	**Biofertilizer (mL)**
Control	0	0	0	0
TM	30	130	260	0
RD	30	130	0	5
SA	30	130	0	15
RDSA	30	130	0	20

Note: The presented values are per plot during all growing period. RDSA mean RD (5) and SA (15).

2.2. Plant Materials and Measurements

Green pepper (*Capsicum annum* L.) cv. Sindhi, the most cultivated variety of green pepper in the eastern region of Afghanistan was selected as a test crop. Seeds were sown in nursery boxes and 30 days old seedlings were transplanted to the prepared raised beds. 30 cm space between crops and 50 cm between rows were considered as a planting density. During the productive stage, fruits were collected 8 times from each treatment at weekly interval and the yield was calculated. Weeds were controlled three times manually by hands and irrigation was conducted based on weather condition and plant requirement. Growth and yield parameters including plant length, branch and fruit number, fruit length, weight, and diameter as well as yield were recorded. Plant length was randomly recorded on 10 plants with a common ruler from the surface of the soil to the tip of the plant. 20 fruits were randomly selected to evaluate fruit length, diameter, and weight. Economic analysis was also conducted among treatments. SPSS 13.0 statistical software (Prentice Hall, New Jersey, USA) was used to analyze the data. Analysis of variance (ANOVA) was conducted to express the differences among treatments, followed by tukey's multi-comparison test. Significant differences were defined at $p < 0.05$ probability level.

3. Results and Discussion

3.1. Growth and Yield Performances

Growth and yield performances in terms of plant length, branch number, fruit number, and weight were significantly different ($p<0.05$) among treatments; however, fruit length and diameter did not differ Table 3.

Table-3.
Growth parameters influenced by biofertilizer and other treatments

Treatments	Plant length (cm)	Branch number	Fruit number	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
Control	34.5 d	14.9 d	16.8 d	8.6	1.4	1.7 b
TM	37.8 a	19.8 a	25.0 a	8.9	1.5	1.9 a
RD	35.3 d	15.2 d	17.5 d	8.7	1.4	1.7 b
SA	36.9 b	18.6 b	22.3 b	8.9	1.5	1.9 a
RDSA	37.6 a	20.1 a	26.7 a	9.1	1.5	1.9 a

Note: Data are presented as mean of replications. Different letters in a column indicant significant differences at 0.05 level.

RDSA treatment increased branch number (20.1), fruit number (26.7), and fruit length (9.1) compared to the other treatments; however, TM treatment obtained a higher plant length which was 37.8. Control treatment decreased all growth parameters and showed lower performances. Based on the growth characteristics, RDSA recorded the highest followed by TM, SA, RD, and control, respectively. Biofertilizers promote plant growth and nutrient absorption from the soil, as well as strengthen crops against biotic and abiotic stress [13]. They have nitrogen fixation and phosphorus solubilizing bacteria beside plant growth promoters Pariari and Khan [14]. Khan, et al. [15] reported that biofertilizers can positively affect seed germination, root growth, and nutrient absorption in several crops. Therefore, in this study, the growth performance of RDSA was higher than that in TM which might be due to enhanced uptake of nutrients by the plants.

Yield performance was also significantly different ($p<0.05$) among treatments Figure 1. RDSA treatment obtained a high yield compared to other treatments which was 5.4 ton per hectare. The lowest yield was recorded in control treatment and was 3.8 ton per hectare. TM, SA, and RD produced 5.1, 4.7, and 4.3 ton per hectare, respectively. Mishra, et al. [16] mentioned that biofertilizer can increase crop yield up to 10-30% and can decrease the application rate of chemical fertilizer up to 30-40%. Our study also clarified that biofertilizer especially RDSA treatment obtained the highest yield and is a good alternative for chemical fertilizer.

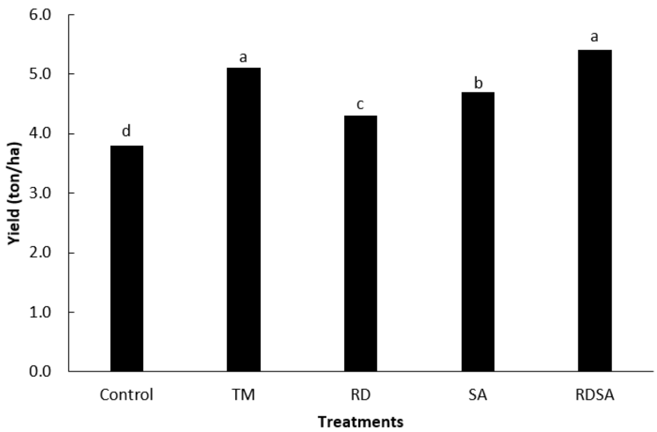

Figure-1.
Yield performance among treatments. TM (traditional method), RD (root dipping), SA (soil application), and RDSA (root dipping and soil application). Similar letters indicate not significant differences.

Application of phosphorus solubilizing biofertilizer has been declared as a yield improver in several crops [1]. The increased yield in RDSA treatment might be due to improved vegetative growth, maximum fruit number, and fruit length. A similar finding was reported by Ghoname and Shafeek [17]. In addition, the applied chemical fertilizers are not totally absorbed by the plants and will run away from root zones. Such condition will seriously affect the economy of farmers as well as pave the way for pollution of several types particularly groundwater contamination. Consequently, soil fertility will be decreased, and the living organism of the soil and water will face dangerous [18].

3.2. Economic Analysis

As mentioned above, RDSA and TM obtained a high yield in contrast to remaining treatments, but TM received a huge amount of chemical fertilizer. Based on the chemical and biofertilizers expenses, TM was an expensive treatment followed by RDSA, SA, RD, and control, respectively.

Table-4.
Economic analysis among treatments based on fertilizer expenses per hectare

Treatments	Fertilizer expenses	Price of 1kg GP	Yield (ton/ha)	Gross income	Net income
Control	0	35	3.8	133000	133000
TM	7584	35	5.1	178500	170916
RD	1875	35	4.3	150500	148625
SA	5625	35	4.7	164500	158875
RDSA	7500	35	5.4	189000	181500

Note: Economic analysis was conducted only for urea and biofertilizer, the other parameters were not considered. Value are presented in Afghan currency (AFN) (1 AFN = 0.013 US $). GP indicates green pepper.

According to the market prices, if 1 kg of urea calculates at 35 AFN, 1 kg of green pepper at 35 AFN, and 1 L of biofertilizer at 450 AFN, the gross and net income will be the same as illustrated in Table 4. The comparative economic analysis among different treatments revealed that RDSA is the most profitable treatment followed by TM, SA, RD, and control. Thus, it is clear that RDSA obtained higher net income followed by TM, SA, RD, and control. The uses of chemical fertilizers were enhanced with the green revolution. A few decades ago, it revealed that such fertilizers can hazardous environment for the living organisms. They are not economic and can reduce soil productivity and quality [18].

4. Conclusion

In modern agriculture, nutrient management and fertilizers application are the most crucial factors which affecting plant growth, yield, and quality performances. Fertilizers application particularly the use of chemical fertilizers must be considered to prevent environmental problems. The current study revealed that the application of biofertilizer as a root dipping and soil application (RDSA) can compensate for the use of chemical fertilizer. It means that the applied amount of chemical fertilizer might not be absorbed by the plants and might lead the way for environmental pollution caused by chemicals. Further research should be undertaken to point out new application methods and an appropriate amount of fertilizer application based on crop type, soil and region condition.

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