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JPSP JOURNAL OF PLANT SCIENCE AND PHYTOPATHOLOGY
ISSN 2575-0135

Research Article

Impact of Biofertilizers & Different doses of NPK on Growth and Photosynthetic Pigments of Okra Plant (*Abelmoschus Esculentus* L. Moench)

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Submitted: August 21, 2023
Approved: August 31, 2023
Published: September 01, 2023

How to cite this article: Kujur R, Khan HI, Lal EP, Verma LK. Impact of Biofertilizers & Different doses of NPK on Growth and Photosynthetic Pigments of Okra Plant (*Abelmoschus Esculentus* L. Moench). J Plant Sci Phytopathol. 2023; 7: 092-096.

DOI: 10.29328/journal.jpsp.1001112

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Keywords: Azotobacter; Bacillus; Okra; Chlorophyll

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Abstract

Okra is an herbaceous hairy annual plant that belongs to the family Malvaceae. It is cultivated in tropical, subtropical, and warm temperate regions around the world. The present work was carried out to study the effect of biofertilizers (Azotobacter + Bacillus) and different concentrations of Nitrogen, Phosphorus, and Potassium i.e.NPK on growth and photosynthetic pigments of okra (*Abelmoschus esculentus* L. Moench). Okra can be named a multipurpose crop as its various parts such as leaves, buds, flowers, pods, stems and seeds can be used for different purposes [1]. Okra is rich in dietary fiber, vitamins, oils, etc. Application of hazardous fertilizers causes a nutrient imbalance in soil, With respect to reducing the causes due to chemical fertilizers, biofertilizers are suited best to maintain higher productivity and yield of crops. Random block design (RBD) was selected as an experimental design. The treatments combination taken are T_0- Control, T_1- *Azotobacter* + 50% NPK, T_2- *Azotobacter* (2.5 kg/ha) + 100% NPK, T_3- *Bacillus* (2.5 kg/ha) + 50% NPK, T_4- *Bacillus* (2.5 kg/ha) + 100% NPK, and T_5 with NPK 100%. The final result revealed, that the treatment combination with *Azotobacter* + 100% NPK (T_2) showed the highest value of plant height (65.60 cm), number of leaves per plant(62.36), number of flowers per plant (27.40), and also carotenoid content (2.82 mg/g), chlorophyll a(2.47 mg/g) and chlorophyll b(3.25 mg/g) were observed maximum. So, it can be concluded through this paper that the combination of Azotobacter 2.5 kg/ha + 100% NPK (T_2) is suitable for the okra plant for better growth and enhancement of photosynthetic potential in-field practices.

Introduction

All over India, the estimated production of okra is about 6371 million metric tonnes, under an area covering 519 million hectares [2]. According to the current data Uttar Pradesh produces a total of 335.86 million metric tonnes of okra with a share of 5.23 [2]. Okra pods are rich in nutrients like dietary fiber, vitamins, oils, polysaccharides, and polyphenols which makes them have antioxidant, anti-inflammatory, and other functions [3-6]. Okra is a tropical crop. Its optimal temperature for germination, growth, and fruit setting is between 25 °C to 30 °C. However indiscriminate use of inorganic fertilizers, besides being expensive, leads to a nutrient imbalance in soil causing ill effects on soil health and microflora. Therefore, in order to reduce the consumption of harmful and intensive chemical fertilizers, there is an urgent need to encourage the use of organic and biofertilizers to the maximum possible extent [7] which will not only maintain higher productivity but also provide greater stability to the crop production [8].

Okra yield responses to organic and inorganic fertilizers have been reported by several workers [9-11] Integrated Nutrient Management practices have created suitable conditions for proper growth and development of plants and for soil health. The requirements of suitable fertilizers are important for the early growth and total production of fruit yield in okra. Integrated management of fertilizers can advance crop productivity [12] and also gain attention to fulfill the farmer's economic requirements as well as to manage ecological conditions on a long-term basis [13]. Photosynthesis is the most important source of energy for plant growth [14]. The amount of chlorophyll present in the chloroplasts of mesophyll cells of the leaf is a key indicator of the photosynthetic capacity. Application of both nitrogen and phosphorus from inorganic fertilizer, accelerate the synthesis of chlorophyll and amino acid that are involved in the major plant processes.

Biofertilizers are fertilizers that contain latent cells from the effective strains of microorganisms, which interact with the roots of the soil and help the plant to absorb various necessary nutrients (Khanna, et al. 2019).

Nowadays, biofertilizers formed from different microbes are utilized as an eco-friendly approach to embark upon biotic and abiotic stresses [15]. *Bacillus* species are competent in producing long-lived, stress-tolerant spores and secrete metabolites that are able to stimulate plant growth and prevent plants from disease infection [16]. Aasfar, et al. 2021 [17] highlighted the importance of azotobacter species as potential soil biological enhancers for maintaining the yield and providing crop nutrition. Azotobacter sp. influences plant growth, and uptake of nutrients and also protect the host plant from pathogen by the synthesis of certain plant hormones. These non-conventional nitrogen sources are cost–effective and simultaneously increase the productivity of soil [18]. The present investigation aimed to undertake the effectiveness of two biofertilizers in conjunction with NPK and to develop a suitable nutrient management strategy for okra cultivation.

Materials and methods

A pot experiment was conducted during the summer season of 2022 in the research field of the Department of Biological Sciences, SHUATS, Prayagraj. The experimental design taken was randomized block design (RBD) which consists of 6 treatments and each of them replicated thrice. The selected okra variety was *'Pankaj'*. The reason behind selecting this cultivar is because of its high-yielding and early variety type, where flowering occurs early and harvesting can be done within 50 to 60 days. Also, this variety is resistant to diseases. The treatments combination include T_0- Control (recommended only), T_1- *Azotobacter* + 50% NPK, T_2- *Azotobacter* (2.5 kg/ha) + 100% NPK, T_3- *Bacillus* (2.5 kg/ha) + 50% NPK, T_4- *Bacillus* (2.5 kg/ha) + 100% NPK, T_5- NPK 100%. The okra seed was sown in the month of March in a total of 18 pots. Parameters taken under observation are- plant height (cm.), no. of leaves per plant, no. of flowers per plant, carotenoids contents, and chlorophyll a & b contents, at 20, 40 & 60 day of intervals. The chlorophyll a, b, and carotenoids were calculated by the method of Wellburn, 1994 [19] and Vicas, et al. 2010 [20]. The chlorophyll mg/g fresh weight can be calculated by using the formula given below:

Chl a mg/g= $[\{(12.7 \times AB_{663}) - (2.96 \times AB_{645})\} \times V]$

Chl b mg/g= $[\{(22.9 \times AB_{645}) - (4.68 \times AB_{663})\} \times V]$

Where,

AB_{663} – Absorbance at 663 nm

AB_{645} – Absorbance at 645 nm

V – Volume of acetone used

Similarly, the carotenoid content was calculated by using the formula –

Carotenoid mg/g fresh weight = $1000(AB_{470}) - 3.27(\text{Chl a}) - 104(\text{Chl b}) / 227$.

The findings from this experiment were statistically analyzed by using the techniques of analysis of variance(ANOVA) and the significance of different sources of variations was tested by error mean square of Fisher Snedecor's 'F 'test at 0.05 probability level [21,22].

Results

The data presented in Table 1 and Figure 1, showed the growth parameters values under the application of different treatments. Among them the maximum plant height was shown in T_2 (Azotobacter 2.5 kg/ha + 100% NPK) at 20(35.83 cm), 40(58.76 cm), & 60 (65.60 cm) days of interval. Similarly, number of leaves per plant was found to be highest in T_2 20(36.10), 40(52.46), & 60 (62.36) days of interval. Average number of flowers per plant was observed to be maximum at 40(27.40) days.

The result observed in Table 2 and Figure 2, revealed the overall photosynthetic potential (chlorophyll & carotenoid)

Table 1: Effect of biofertilizers and different doses of NPK on growth parameters of okra.

Treatment	Av. Plant height(cm)			Av. no. of leaves/plant			Av. no. of flower/plant
	20DAT	40DAT	60DAT	20DAT	40DAT	60 DAT	40DAT
T_0	17.46	28.66	34.60	24.76	38.66	46.56	15.16
T_1	25	41.80	50.70	32.96	43.20	50.10	21.43
T_2	35.83	58.76	65.60	35.93	52.46	62.36	27.40
T_3	26.40	44.90	53.50	35.70	47.66	55.32	24.13
T_4	26.90	49.46	56.76	29.50	49.10	58.40	20.40
T_5	32.16	53.63	60.66	36.10	49.30	58.52	26.93
F - test	S	S	S	S	S	S	S
S.Ed (±)	2.443	3.3625	0.182	1.8477	2.0648	0.084	3.2363
C.D. (*p* = 0.05)	5.0683	6.973	0.405	3.8321	4.2824	0.188	6.7121

Where, DAT- Days after transplanting, S.Ed – Standard error, C.D.-Critical difference, S- significant

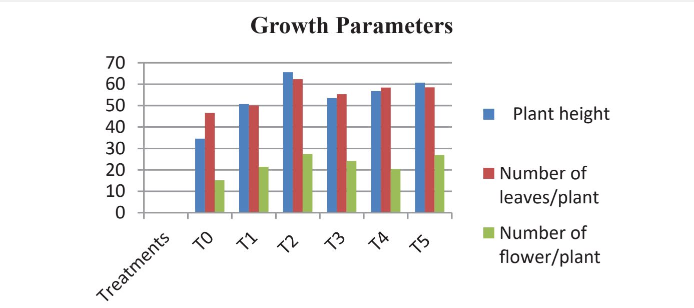

Figure 1: Showing the effect of biofertilizers and NPK doses on growth parameters of okra.

Table 2: Effect of biofertilizers and different doses of NPK on photosynthetic pigments of okra.

Treatments	Carotenoid (mg/g) fresh wt./plant			Chlorophyll a (mg/g) fresh wt./plant			Chlorophyll b (mg/g) fresh wt./plant		
	20DAT	40DAT	60DAT	20DAT	40DAT	60DAT	20DAT	40DAT	60 DAT
T_0	0.27	1.32	1.60	0.16	0.52	0.21	0.25	0.50	0.21
T_1	1.12	1.62	2.06	0.34	1.02	1.42	0.86	1.65	1.42
T_2	1.47	2.56	2.82	0.69	1.78	2.47	1.37	2.55	2.47
T_3	1.40	2.01	2.22	0.45	1.327	1.63	0.97	1.92	1.63
T_4	0.74	1.54	1.92	0.29	0.19	0.70	0.76	1.32	0.70
T_5	1.43	2.18	2.36	0.61	1.67	1.98	1.25	2.11	1.98
F- TEST	S	S	S	S	S	S	S	S	S
S.Ed (±)	0.0346	0.309	0.028	0.04794	0.0894	0.004	0.1414	0.2988	0.004
C.D. (p = 0.05)	0.0719	0.642	0.061	0.09943	0.1855	0.009	0.2933	0.6199	0.009

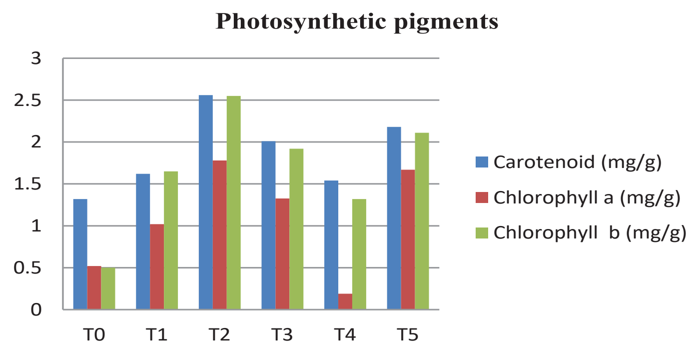

Figure 2: Showing the effect of biofertilizers and NPK doses on the carotenoid and chlorophyll content of okra.

was also found to be highest under T_2. The carotenoid content at 20(1.470 mg/g), 40(2.560 mg/g), and 60(2.82 mg/g) days of interval show maximum values. And the average chl a & chl b was also found to be maximum in T_2 i.e. at 20(0.690 mg/g), 40(1.780 mg/g), 60(2.47 mg/g) and 20(1.370 mg/g), 40(2.550 mg/g), 60(3.25 mg/g) interval of days respectively.

Discussion

Application of *Azotobacter* (2.5 kg/ha) with 100% NPK showed the best result in growth characters as well as in photosynthetic pigments. It might be due to azotobacter increases nutrient availability in the soil by fixing more nitrogen. The highest dose of nitrogen might have enhanced cell division and formation of more tissues resulting in luxuriant vegetative growth and thereby increasing plant height [23]. N, P and K concentrations were increased, this increase boosted the growth and productivity of hibiscus plants, this may be because microorganisms also produce substances that aid growth, resulting in a more efficient absorption of nutrients, the reason for the increase in nitrogen was attributed to the fruit, this may be because microorganisms also produce substances that aid growth, led to a more efficient absorption of nutrients [24].

Rapidly increasing plant height might be due to a more balanced C: N ratio, plentiful transfer of available nutrients from the soil with slighter retention in roots, and more translocation to aerial parts for protoplasmic proteins and synthesis of various other compounds [25]. The reason for the increase in plant height may be due to the fact effect of NPK (Nitrogen, phosphorus, and potassium) which accelerates the synthesis of chlorophyll and amino acids which are associated with major plant processes (Dar, et al. 2010).

The combined use of inorganic fertilizers and biofertilizers has also been observed similarly in the vegetative attributes by Panda, et al. [26] and Singh, et al. [27]. The application of combined fertilizers increases the nitrogen and phosphorus availability for plant uptake. Thus, an increase in nutrient level enhances the number of leaves, plant height, and number of flowers and also increases number of chlorophyll content in the okra plant. Similar results are reported by Ghuge, et al. [28].

The study concluded by Fayaz, Kh, et al. [29] and Ayemi, et al. [30] on Gerbera found that the highest NPK levels (100%) had a significant impact on total leaves. Joshi and his co-workers [31] in their study found that application of 100 kg N ha-1 recorded significantly higher plant height at 30 and 60 DAS, the number of leaves plant-1 at 30 and 60 DAS.

An average number of flowers is increased in the plot treated with biofertilizer as well as NPK due to the presence of nitrogen and it encouraged the differentiation of bud which causes earlier flowering. Similar results were also reported by Mal, et al. [12] and (Sharma, et al. 2016).

The addition of biofertilizer might supply the essential elements that cannot be fulfilled singly by NPK to plants by which plant synthesizes more chlorophyll. Similar findings observed by El Kinany, et al. [32] concluded that compost application has increasing chlorophyll amount and leaf mineral nutrition, mainly macroelements. The interaction of azotobacter with NPK promotes the synthesis of photosynthetic pigments by inducing related enzymes and resulting in the enhancement of photosynthetic activity. A larger number of leaves might have resulted in the production of more photosynthates. Ramakrishnan and Selvakumar [33] observed in their study that Azotobacter and Azospirillum-treated plants had the highest chlorophyll and protein contents.

The structural element of chlorophyll and protein molecules is nitrogen and thus its quantity affects the the formation of chloroplasts and the building up of chlorophyll. Related finding was reported by Kadlag, et al. [34]. Also, positive results of biofertilizers towards photosynthetic pigments have been observed by Hassan, et al. [35]. They inoculate roselle plants with the bio-fertilizer (Azotobacter+Azospirillum) and found an increased number of the total chlorophyll content, carotenoid, total anthocyanin (TAC), and total flavonel (TF) by 16.45, 26.10, 8.44 and 14.27%, respectively.

The chemical fertilizer enhanced the chla, chlb, and carotenoid content at lower concentrations, while biofertilizer enhanced these photosynthetic pigments almost at all the concentrations [36]. The positive result of fertilizers on the photosynthetic pigments is because of the improvement of chlorophyll formation, and photochemical efficiency of its leaf [37].

Conclusion

On the basis of the experiment performed, to study the effect of biofertilizers - Azotobacter and Bacillus and inorganic component NPK on okra, it is concluded that treatment T_2- Azotobacter + 100% NPK showed a significant and positive effect on growth and photosynthetic potential of okra.

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