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Research Article

A study on the impact of Plant Growth Promoting Fungus (PGPF) and Plant Growth Promoting Rhizobacteria (PGPR) as biofertilizers for *Abelmoschus esculentus* (L.) Moench.

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ABSTRACT

In this study, the effectiveness of plant growth promoting fungus (PGPF) and plant growth promoting rhizobacteria (PGPR) on Bhendi (*Abelmoschus esculentus* (L.) Moench) was estimated. Germination study was conducted with Bhendi seeds treated in different PGPR and PGPF. The growth indices like vigour index, seedling growth, shoot length, root length, total leaf area, fresh weight and dry weight and yield parameters were taken into consideration for this experiment. All these morphological growth parameters gradually increased with PGPF and PGPR when compared to control. On the basis of germination study data, the best growth of bhendi seedling was recorded in PGPF followed by PGPR when compare with control.

INTRODUCTION

One of India's most significant year-round vegetable crops is bhendi (*Abelmoschus esculentus* (L.) Moench), often known as okra or lady's fingers. It is an annual plant in the Malvaceae family [1]. Due to its excellent palatability and numerous culinary applications, it is a widely used vegetable in subtropical and tropical areas [2]. Its immature, young, green seed pods are consumed as a vegetable, while the fruit's essence is used in many dishes to thicken stews, soups, and sauces to give them more firmness [3]. Okra is a crop with many uses because it has fresh leaves, buds, flowers, pods, stems, and seeds [4]. Bhendi leaves help reduce proteinuria and enhance renal function by removing oxygen free radicals that cause the condition [5,6]. The seeds have been used on a modest scale for oil production and are a source of protein and oil. It can also be used as a caffeine-free alternative to coffee. You may roast and grind okra seeds to make a coffee alternative without any caffeine [7]. Okra also has industrial applications and is used in confectionary [8]. Okra contains a significant level of folic acid, which is essential for the formation of the neural tube in the baby between the fourth and the 12th week of pregnancy [9]. Amazing okra provides a ton of benefits, but remember to choose natural vegetables rather than processed ones [10]. India is the second-largest vegetable grower in the world, producing around 10% of all vegetables grown worldwide [11].

Now days, various chemical fertilizers, pesticides are being used to enhance the productivity of food crops and to avoid losses by different pest, herbs, insects and harmful microorganisms, respectively [12]. The basic idea or thought of farmers in using chemical was to achieve better performances and more productivity of crops [13]. But, in spite of different improvements in food grain production with arrival of green revolt loss of these chemicals in the atmosphere, its persistence in the soil and leaching in ground deteriorated the most essential natural assets i.e. air, water and soil causing serious threat to the mankind [14]. Application of bio-fertilizers have emerged as an effective alternative to accomplish these requirements without causing severe ill effects onto the environment [15].

The fungi known as Trichoderma species are found in almost all soils and other environments. The species of *Trichoderma* include *T. viride, T. koningii, T. hamatum*, and others [16]. Trichoderma differs from the control in terms of plant height, grain weight and number per panicle, grain yield, biological yield, and biomass yield. Farmyard manure was added along with *T. viride* and NPK, and the majority of the growth and yield parameters displayed the greatest values [17]. Trichodermal fungi have become the most effective bio-protectants for managing soil-borne plant diseases. Trichoderma are well-known as bio-control agents for plant diseases and have grown to be an important component of the fight against agricultural disease. Studies on the compatibility of biocontrol agents with chemicals and botanicals have been done in the past [18]. The direct effects of biofertilizers aid in the absorption of nitrogen, the solubilization of phosphorus, the generation of plant hormones, and ultimately the promotion of plant development [19,20]. From farmer fields to industry, Trichoderma is one of the economically significant bacteria [21].

A genus of bacteria called Plant development Promoting Rhizobacteria (PGPR) uses biofertilizers and other substances to promote plant development and increase plant yield. Plant growth regulators (PGRs) and plant growth promoting rhizobacteria (PGPR) have the potential to be utilized to genetically increase drought tolerance while enhancing plant growth and output. The findings demonstrated that when compared to irrigated and drought

circumstances, chickpea plants treated with a consortium of PGPR dramatically increased the chlorophyll, protein, and sugar contents [22]. To minimize heavy metals in contaminated farmed fields for agricultural advantage, separation of such PGPR is extremely challenging. In addition to preventing environmental contamination, using biofertilizer as a biocontrol agent reduces the input of chemical pesticides [23].

The aim of present study was to evaluate the PGPF and PGPR induced variations on growth and plant metabolism in *Abelmoschus esculentus* (L.) Moench., with the following objectives.

- To find out the proficiency of plant growth promoting rhizobacteria and plant growth promoting fungus on the germination and growth tendency of Bhendi.
- To carry out the response in growth parameters of Bhendi in *Rhizobium*, *Azospirillum* & Phosphobacteria (PGPR) and *Tricoderma viride* (PGPF) inoculations.
- To analyses the response in increased yield of Bhendi in various plant growth biofertilizers.

MATERIALS AND METHODS

The present research work was carried to find out the effect of Plant Growth Promoting Rhizobacteria (PGPR) on germination, growth, pigments and yield of *Abelmoschus esculentus* (L.) Moench.

Biological materials

The dry and dormant seeds of the Bhendi variety 'Super Green' were obtained from VNR Seeds Pvt Ltd, Raipur, Chhattisgarh, India (Fig. 1A).

Experimental area

The present study on PGPR and PGPF in Bhendi. was carried out in the Botanical Garden, Department of Botany, A.V.C. College (Autonomous), Tamil Nadu, India.

Plant Growth Promoting Rhizobacteria (PGPR) and Plant Growth Promoting fungus (PGPF)

PGPR and PGPF) were given by Faculty of Agriculture, Annamalai University, Annamalainagar, Tamil Nadu.

Seed treatments

The groundnut seeds were surface sterilized with 80% ethanol and 0.1% mercuric chloride and then rinsed three to four times with distilled water. The seeds were combined with rhizobacteria that either work alone or in groups to promote plant growth, and then they were dried in the shade for 30 minutes. The seeds were sowed after drying in the shade (Fig. 1B).

Treatments	PGPR and PGPF
T0	Seeds without treatments
T1	Rhizobium
T2	*Azospirillum*
T3	Phosphobacteria
T4	*Tricoderma*

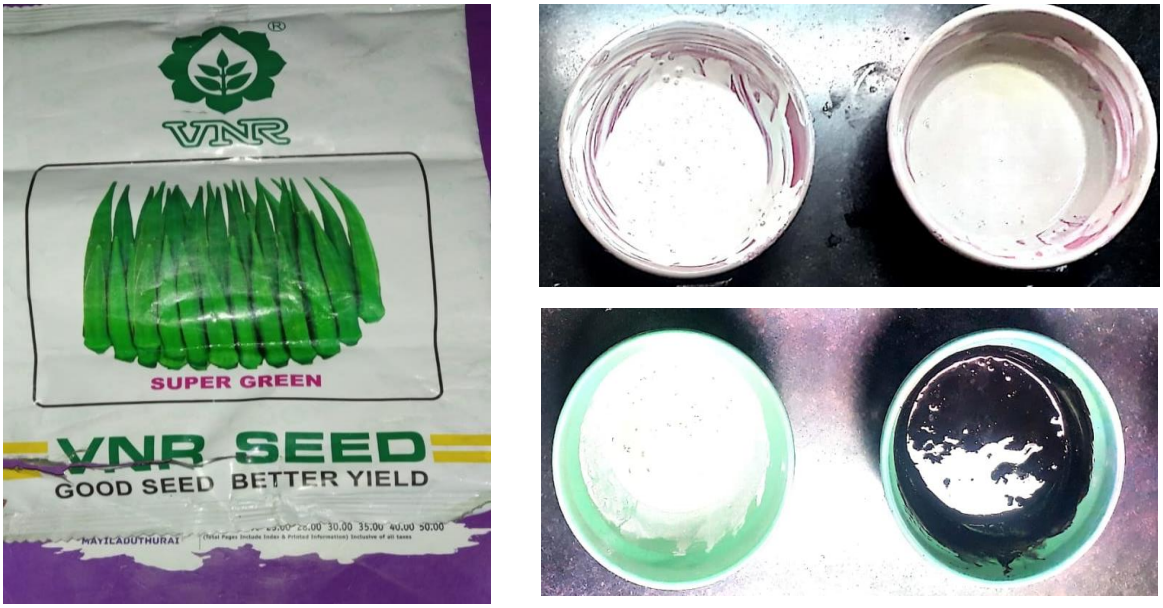
Non-treated dry seeds of Bhendi were pre-soaked in distilled water for 6 hours were used as control.

Pot culture experiment

Plastic pots with measurements of 40 cm in diameter and 45 cm in height were used in this study. Red soil, sand, and farmyard manure were combined in a 1:1:1 ratio in each pot, which held 10 kg of soil mixture. The pots were arranged in a completely random block design (CRBD). For the PGPR and PGPF treatments, four sets of pots were used, with one set acting as the control. From five initial seeds, three bhendi plants per pot were thinned on the tenth day after sowing (DAS).

Irrigation schedule

To promote equal germination, irrigation was administered prior to sowing. At 3 DAS, irrigation was administered carefully to prevent overflooding. Twice a week, uniform irrigation was performed.



(A) **(B)**

Fig 1. (A). Seeds of *Abelmoschus esculentus* (L.) Moench., Bhendi variety 'Super Green' were obtained from VNR Seeds Pvt Ltd, Raipur, Chhattisgarh, India. (B). Seed treatments of *Abelmoschus esculentus* (L.) Moench., using various biofertilisers (from left – Row 1. *Rhizobium*, *Azospirillum*. Row 2. Phosphobacteria and *Trichoderma viride*

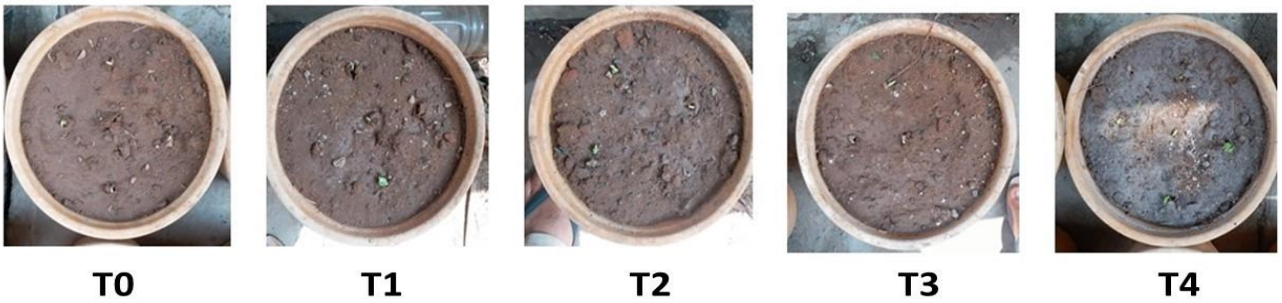


Fig. 2. Seedling growth stages (3 DAS) of *Abelmoschus esculentus* (L.) Moench., using various biofertilisers.

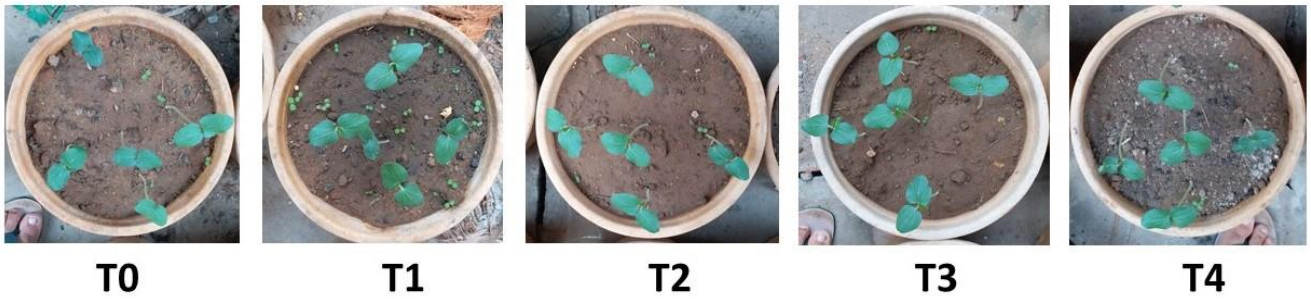


Fig. 3. Seedling growth stages (7 DAS) of *Abelmoschus esculentus* (L.) Moench., using various biofertilisers.

Germination percentage

On the seventh day following sowing, the number of seeds that germinated in each treatment was counted. For each treatment, three replicas were kept. The following formula was used to get the overall germination percentage.

$$\text{Germination \%} = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

Seedling growth (cm/seedlings)

From each treatment, ten seedlings were chosen at random in order to track their growth. Using a centimeter scale, the growth of the groundnut seedlings was measured, and the results were recorded.

Vigour Index

According to the protocol, vigour index was computed after recording seedling height and germination %.

Vigour index = Germination percentage x Total length of seedling (cm)

Whole plant fresh and dry weight

The fresh weight of the plants was calculated using an electronic scale (Model - XK3190-A7M), and the results were represented in grams after the plants had been washed in tap water. The plants were dried for 24 hours at 60°C in a hot air oven after being given a fresh weight. The weight was measured after drying, and the values were given in grams.

Root and shoot length

On several DAS, the root and shoot lengths were recorded. Total root length was measured from the tap root below the root-stem transition point to the length of the lateral roots. The stem's length was measured from tip to point of root stem transition zone. Per plant, the root and stem lengths were expressed in cm.

Total leaf area

Using a LICOR Photo Electric Area Meter (Model LI-3100, Lincoln, USA) to calculate the total leaf area per plant, the measurement was expressed in cm^2.

Yield parameters

During the harvesting phase, the yield metrics including total pod and seed weight and total seeds weight were measured.

Weed management

Hand weeding was done two times at 25 and 45 days after sowing in order to remove the weeds from the field.

Plant harvesting

Well matured plants from the experimental pots were taken by hand pulling at the time of harvest.

Statistical analysis

The data pertaining to all of the researched characters were statistically analyzed using SPSS 16.0. Seven duplicates of each treatment and the control were intended for the values. computed information shown as Mean SD.

RESULTS

Germination studies

The maximum germination percentage, seedling length, vigour index (seedling length x germination percentage), fresh weight and dry weight were recorded in Bhendi seedlings grown with *Trichoderma viride*. Among PGPR biofertilizers the *Rhizobium* showed lowest germination percentage, seedling length, vigour index, seedlings fresh and dry weight. The lowest germination percentage, seedling length, vigour index (seedling length x germination percentage), fresh weight and dry weight were recorded in Bhendi seedlings grown without treatment of biofertilizers.

Morphological parameters

Pot culture experiment was conducted to find out the effect of plant growth promoting rhizobacteria and plant growth promoting fungus on morphological, photosynthetic pigment, and yield of Bhendi (Fig 2, 4).

Shoot length (cm/plant)

Table 2 and Fig. 4 and 5 present the findings of the influence of plant growth-promoting rhizobacteria and fungi on the shoot length (cm/plant) of bhendi at different phases of its growth (15, 30, 45, and 60 DAS). The maximum shoot lengths were found in bhendi cultivated with the plant growth-promoting fungus *Trichoderma viride*. The shoot length gradually increased.

The crop cultivated without the use of rhizobacteria that promote plant growth had the shortest shoot length on record. The plant growth-promoting rhizobacteria (*Rhizobium*, Phosphobacterium, and *Azospirillum*) demonstrated greater values at different phases of its growth (15, 30, 45, and 60 DAS) when compared to control. Azospirillum increased the maximum shoot length in PGPR.

Root length (cm/plant)

Table 3 and Fig. 4 and 5 present the findings of the impact of plant growth-promoting rhizobacteria and fungi on the root length of bhendi at different phases of its growth (15, 30, 45, and 60 DAS). Bhendi cultivated in *Trichoderma viride*, a fungus that promotes plant development, had the longest roots ever measured. The crops produced without PGPR and PGPF had the shortest root length at different points in their growth (15, 30, 45, and 60 DAS). The *Azospirillum* exhibited overwhelming growth, yield, and pigment content among the PGPR (*Rhizobium*, Phosphobacteria, and *Azospirillum*), but less than PGPF.

Total leaf area (cm²/plant)

Table 4 displays the findings on the impact of plant growth-promoting rhizobacteria on the total leaf area (cm2/plant) of bhendi at different growth stages (15, 30, 45, and 60 DAS). The bhendi crop treated with *Trichoderma viride* had the largest overall leaf area. At different growth stages (15, 30, 45, and 60 DAS), the crops planted without plant growth-promoting rhizobacteria and fungus had the lowest total leaf area.

Fresh weight of plant (g/plant)

The effect of plant growth promoting rhizobacteria on fresh weight (g/plant) of bhendi crop at various stages of its growth (15, 30, 45 and 60 DAS) is shown in Table 5. The highest fresh weights were recorded in igbhendi crop grown with plant growth promoting fungus *Trichoderma viride* followed by plant growth promoting rhizobacteria treatments. The lowest fresh weight of plant at various (15, 30, 45 and 60 DAS), was recorded in the crops grown without plant growth promoting rhizobacteria. While compared with plant growth promoting rhizobacteria treatments, among the PGPR, the *Azospirillum* has played dominant role in fresh weight.

Dry weight of plant (g/plant)

Table 6 displays the findings of the impact of plant growth-promoting rhizobacteria on the dry weight (g/plant) of the bhendi crop at different growth stages (15, 30, 45, and 60 DAS). The bhendi crop cultivated with PGPF treatment obtained the highest dry weight of plants. The crops planted without plant growth-promoting rhizobacteria had the lowest dry weights of plants at (15, 30, 45, and 60 DAS).

Table 1. Effect of PGPR and PGPF on seed germination, seedling growth, vigour index, fresh and dry weight of Bhendi (*Abelmoschus esculentus* (L.) Moench.) Seedlings.

Treatments	Germination percentage	Seedling length (cm/seedling)	Vigour index (seedling length × germination percentage)	Seedling dry weight (g/seedling)	Seedling fresh weight (g/seedling)
Control (T0)	87 ± 2.61	9.5 ± 0.58	826.5 ± 13.44	1.02 ± 0.031	3.06 ± 0.092
Rhizobium (T1)	90 ± 2.67	11.8 + 0.64	1062.0 ± 15.88	1.16 ± 0.035	3.14 ± 0.104
Phosphobacteria (T2)	92 ± 2.76	12.2 + 0.71	1122.4 ±18.27	1.29 ± 0.039	3.37 ± 0.116
Azospirillum (T3)	93 ± 2.82	12.4 + 0.74	1153.6 ± 20.29	1.42 ± 0.043	3.94 ± 0.128
Trichoderma viride (T4)	96 ± 2.88	12.6 + 0.77	1209.6 ± 22.35	1.54 ± 0.046	4.12 ± 0.139

Table 2. Effect of PGPR and PGPF on shoot length (cm/plant) of Bhendi (*Abelmoschus esculentus* (L.) Moench.) at different growth stages.

Treatments	Age of the plant in days			
	15	30	45	60
Control (T0)	15.4 ± 0.34	30.7 ± 0.92	54.3 ± 1.36	88.4 ± 0.85
Rhizobium (T1)	23.2 ± 1.56	33.1 ± 0.99	67.8 ± 1.43	97.1 ± 0.97
Phosphobacteria (T2)	24.0 ± 1.22	36.2 ± 1.09	70.4 ± 0.49	108.2 ± 1.03
Azospirillum (T3)	27.2 ± 1.47	38.4 ± 1.18	75.8 ± 0.55	110.2 ± 1.15
Trichoderma viride (T4)	29.5 ± 1.33	41.5 ± 1.24	80.4 ± 0.61	120.3 ± 1.32

Values are mean ± SD of three replicates

Table 3. Effect of PGPR and PGPF on root length (cm/plant) of Bhendi (*Abelmoschus esculentus* (L.) Moench.) at different growth stages.

Treatments	Age of the plant in days			
	15	30	45	60
Control (T0)	5.7 ± 0.73	9.6 ± 0.29	13.4 ± 0.40	15.5 ± 0.46
Rhizobium (T1)	6.4 ± 0.35	10.9 ± 0.33	14.1 ± 0.42	16.0 ± 0.48
Phosphobacteria (T2)	7.1 ± 0.92	12.1 ± 0.36	14.8 ± 0.44	16.6 ± 0.50
Azospirillum (T3)	7.5 ± 0.58	12.9 ± 0.39	15.4 ± 0.46	17.4 ± 0.52
Trichoderma viride (T4)	8.5 ± 0.11	13.5 ± 0.40	16.0 ± 0.48	18.0 ± 0.54

Values are mean ± SD of three replicates

Table 4. Effect of PGPR and PGPF on total leaf area (cm2/plant) of Bhendi (*Abelmoschus esculentus* (L.) Moench.)

Treatments	Age of the plant in days			
	15	30	45	60
Control (T0)	11.00 ± 0.33	13.78 ± 0.41	15.86 ± 0.84	18.26 ± 1.12
Rhizobium (T1)	11.57 ± 0.35	14.46 ± 0.53	16.36 ± 0.96	19.46 ± 1.26
Phosphobacteria (T2)	12.13 ± 0.36	15.26 ± 0.60	17.56 ± 1.06	21. 61 ± 1.32
Azospirillum (T3)	12.67 ± 0.38	15.26 ± 0.69	18.46 ± 1.16	23.16 ± 1.47
Trichoderma viride (T4)	13.21 ± 0.40	16.46 ± 0.76	19.46 ± 1.27	24.31 ± 1.61

Values are mean ± SD of three replicates

Table 5. Effect of PGPR and PGPF on fresh weight (g/plant) of bhendi (*Abelmoschus esculentus* (L.) Moench.) at various stages of its growth.

Treatments	Age of the plant in days			
	15	30	45	60
Control (T0)	25.79 ± 0.77	61.89 ± 1.86	132.82 ± 3.98	151.18 ± 4.58
Rhizobium (T1)	28.90 ± 0.87	73.39 ± 2.20	153.78 ± 4.61	170.29 ± 5.11
Phosphobacteria (T2)	32.00 ± 0.96	84.31 ± 2.53	172.42 ± 5.17	203.38 ± 5.46
Azospirillum (T3)	35.49 ± 1.06	96.53 ± 2.90	190.12 ± 5.70	231.46 ± 5.66
Trichoderma viride (T4)	38.64 ± 1.16	110.39 ±3.31	218.19 ± 6.54	253.58 ± 5.72

Values are mean ± SD of three replicates

Table 6. Effect of PGPR and PGPF on dry weight (g/plant) of Bhendi (*Abelmoschus esculentus* (L.) Moench.)

Treatments	Age of the plant in days			
	15	30	45	60
Control (T0)	8.60± 0.26	20.63±0.62	44.27±1.33	50.39±1.38
Rhizobium (T1)	9.63±0.29	24.46±0.73	51.26±1.54	56.76±1.55
Phosphobacteria (T2)	10.67±0.32	28.10±0.84	57.47± 1.72	67.79±1.63
Azospirillum (T3)	11.83±0.35	32.18±0.96	63.37±1.90	77.15±1.75
Trichoderma viride (T4)	12.88±0.39	36.80± 1.10	72.73±2.18	84.52±1.84

Values are mean ± SD of three replicates

Fig. 4. Seedling growth stages (15 DAS) of *Abelmoschus esculentus* (L.) Moench., using various biofertilisers.

Fig. 5. Seedling growth stages (30 DAS) of *Abelmoschus esculentus* (L.) Moench., using various biofertilisers.
(T0 – Control T1- Rhizobium, T2- Azospirillum, T3- Phosphobacteria and T4- Trichoderma viride).

Yield parameters

In Table 7, it is demonstrated how different treatments of plant growth-promoting rhizobacteria (PGPR) and plant growth-promoting (PGPF) affected the yield characteristics of bhendi. The crop fed with fungus that promotes plant growth produced the most pods, seeds, and weight per hundred seeds. The crops growing in the control plants had the fewest pods, seeds, and hundred seed weights, according to the records.

Table 7. Effect of PGPR and PGPF on yield parameters on Bhendi (*Abelmoschus esculentus* (L.) Moench.)

Treatments	Number of pods/plant	Number of seeds/plant	100 seed weight
Control (T0)	18.0 ± 0.90	45.0 ± 1.35	5.8 ± 1.37
Rhizobium (T1)	27.0 ± 1.09	52.0 ± 1.8	6.1 ± 1.47
Phosphobacteria (T2)	28.0 ± 1.11	57.0 ± 1.95	6.5 ± 1.53
Azospirillum (T3)	29.0 ± 1.20	60.0 ± 1.95	6.9 ± 1.62
Trichoderma viride (T4)	30.0 ± 1.25	65.0 ± 2.16	7.2 ±1.67

Values are mean ± SD of three replicates

DISCUSSION

The main objective of the present study is to assess the effect of PGPR and PGPF on growth parameters and pigments alteration in Bhendi plant. The results obtained on growth and yield is discussed hereunder.

One of the best instruments available today for current agricultural operations is bio-fertilizer. It is a gift from the science of modern agriculture. In the agricultural field, biofertilizers are used in place of our traditional fertilizers. Green manure, compost, and household garbage are all included in conventional fertilizers. These are not as efficient as fertilizers made of chemicals. In order to promote crop development, farmers frequently try to utilize chemical fertilizers in the field. However, it is clear that chemical fertilizers are not eco-friendly. The microorganisms in bio-fertilizer help to guarantee that the host plants receive an adequate supply of nutrients and that their growth and physiology are properly regulated [24].

Biofertilizers are created using living microorganisms. Only microorganisms with particular roles in promoting plant growth and reproduction are used [25]. The microorganisms employed in bio-fertilizers come in a variety of forms. In order to preserve long-term soil fertility and sustainability, bio-fertilizers, which are crucial elements of organic farming, are extremely important [24].

Only through imports and subsidies have chemical fertilizers been made accessible and affordable at the farm level in India. Because they are environmentally safe, simple to use, non-toxic, and economical, biofertilizers have evolved into a highly effective alternative to chemical fertilizers today. Additionally, they enable plants to use nutrients that are naturally rich in soil or the environment and serve as a complement to agrochemicals [26].

Beneficial bacteria called plant growth promoting rhizobacteria (PGPR) invade the roots of plants and promote plant growth through a number of different methods [27]. Bhendi seeds were treated with plant growth-promoting rhizobacteria PGPR and plant growth-promoting fungus PGPF before being placed in soil for germination trials.

They were allowed to grow up to seven days. The morphological growth parameters such as germination percentage, seedling length, vigour index, fresh weight and dry weight of bhendi seedlings were taken into consideration. The best growth at germination level was evaluated under various treatment of plant growth promoting fungus and of plant growth promoting rhizobacteria when compared to control plants. Similar results were observed in *Raphanus sativus* and *Cynara scolymus*. On the germination of radish (*Raphanus sativus* L.) seeds, plant growth-promoting rhizobacteria (PGPR) are present. Utilizing bacteria strains greatly increased the percentage of seed germination in three radish cultivars. To increase the percentage of radish seeds that germinate, PGPR may be helpful [28].

Similar outcomes were seen in a number of other plants. *Cicer arietinum* seedlings' shoot, root, and dry matter production all increased dramatically, and the use of PGPR isolates greatly increased the percentage of germination [29]. The percentage of seed germination is dramatically increased by using PGPR isolates. The inoculants and biofertilizers may be useful for growing chickpeas in saline conditions [30]. Wheat germination rate was substantially higher after seed inoculation with PGPR strains compared to the control. In maize, PGPR has also been reported to improve seed germination parameters [31].

Choure and Dubey [32] reported that PGPR and PGPF enhanced the root and shoot, fresh weight and dry weight in *Cajanus cajan* seedlings. Mishra et al. [29] reported that most of isolated bacteria resulted in a significant increase of fresh weight and dry matter production in shoot and root of *Cicer arietinum* seedlings [33].

In this investigation, the PGPF treatment of plant growth promoting fungus was followed by various plant growth boosting rhizobacteria, and when compared to control, the greatest root length and shoot length of bhendi were observed. The following studies also showed the same outcomes. Naturally occurring soil bacteria called plant growth-promoting rhizobacteria (PGPR) aggressively invade plant roots and provide plants with a better environment for growth [34].

The maximum total leaf area was observed in pistachio seedling [35]. PGPR could successfully promote the leaf area per plant of banana seedlings [36]. Similar increases in leaf area were observed in different crops inoculated with PGPR strains [37]. Inoculation of PGPR and PGPF species could increase the growth attributes like leaf area in Musa plantlets when compared to the uninoculated control [38].

PGPF and PGPR have significantly increased the whole plant fresh and dry weight of bhendi. When compare with different strains of PGPR, the PGPF *T. viride* played very significant role in the alterations of leaf area. Minimum leaf area was observed in non-treated biofertilizers group of bhendi plants. The same results were observed in *Sesbania grandiflora* treated with Bacillus subtilis and PGPR mixture showed highest total plant fresh weight and highest total plant dry weight [39]. The fresh and dry weight of chickpea significantly increased by biofertilizers [40].

The plant growth promoting rhizobacteria (PGPR) and plant growth promoting (PGPF) increased yield parameters of bhendi. The maximum number of pods, number of seeds, hundred seed weight were recorded in the crop grown with plant growth promoting fungus. The lowest number was noted in the control plants. The similar results were observed in various investigations. Co-inoculation of legumes with PGPR and rhizobia significantly increased the growth and yield of legumes crops [41].

Lokanath et al. [42] reported that the seed inoculation with PGPR (single or combined) improved yield components such as number of pods plant^{-1}, dry pod weight plant^{-1}, shelling percent, 100-kernel weight of groundnut. PGPF and PGPR have increased supportable agriculture practices. Rhizobia along with other co-inoculants increased high yield increases [43].

CONCLUSION

Based on the present investigation, the following conclusions were made.

1. Among Plant Growth Promoting Rhizobacteria (*Azospirillum*, Phosphobacteria and *Rhizobium*) and Plant Growth Promoting

fungus (*Trichoderma viride*) on the productivity of Bhendi *Abelmoschus esculentus* (L.) Moench., the PGPF showed better growth and yield.

2. Among various PGPR (*Azospirillum*, Phosphobacteria and *Rhizobium*) the *Azospirillum* delivered notable variations in growth and yield.

3. Non-treated plants of bhendi showed minimum growth and yield when compared to various biofertilizers treated plants.

4. Among the various biofertilizers treatments, the present findings revealed that the PGPF (*Trichoderma viride*) and PGPR (*Azospirillum*, Phosphobacteria and *Rhizobium*) improved the growth and yield content. *Trichoderma viride* and *Azospirillum* can be used as potential biofertilizers to increase the growth and yield productivity of *Abelmoschus esculentus* (L.) Moench. plant.

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