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Efficacy of bio-fertilizers and the combinations with chemical fertilizers on growth, yield and quality of okra (Arka Anamika) [*Abelmoschus esculentus* (L.) Moench]

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Abstract
Field experiments were conducted at horticultural field of Rama University, Kanpur India to evaluate "Efficacy of biofertilizers and the combinations with chemical fertilizers on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]" during Feb to June 2022 to evaluate the effect of organic and inorganic fertilizers on the yield of okra cv. Arka anamika. There were three replication and eight treatments which is design in RBD. The treatments were T_1 (Recommended dose of fertilizers (RDF), T_2 (*Azotobacter* + 50% NPK), T_3 (PSB + 50% NPK), T_4 (*Azospirillum* + 75% NPK), T_5 (PSB + *Azotobacter* + 50% NPK), T_6 (PSB + *Azospirillum* + 50% NPK), T_7 (PSB + *Azospirillum* + *Azotobacter* 50%), T_8 (Azotobacter + *Azospirillum* 50%) Growing conditions were found highly significant in respect to all the recorded parameters. Arka anamika variety of Okra was found highly significant in respect to plant height, number of leaves, fruit diameter, number of flowers, number of fruits, length of fruit, fruit weight, yield in the treatment (T_6) (PSB + *Azospirillum* + 50% NPK) and minimum in T_1 (Recommended dose of fertilizers (RDF).

Keywords: Okra, bio-fertilizers, yield

Introduction
Okra botanically known as *Abelmoschus esculentus (*L. Moench) having chromosome number 2n=130 belongs to the family of Malvaceae. Okra is a flowering plant originating from tropical and subtropical Africa and is natural to West Africa (Tindal, 1983) [15]. It was formerly considered a species of hibiscus, but is now classified in the genus *Abelmoschus*. The word okra is of Africa origin and means "Lady's fingers" in Igbo, a language spoken in Nigeria. Okra is mainly cultivated for its "pods" which are cooked and eaten in countries like Sudan, Egypt and Nigeria. Okra is one of the commercially significant vegetable crops cultivated both on big commercial farms and as a garden crop in tropical and subtropical regions of the world. However, occasionally, it is sold in canned or dried versions. Its soft green fruits are often offered in the fresh stage. Tyagi and others (2016). It is grown commercially in India. India ranks first in the world with 3.5 million tonnes (70% of the total world production) of okra produced from over 0.35 million ha land (FAOSTAT 2008). It is quite popular in India because of easy cultivation, dependable yield and adaptability to varying moisture conditions. The major (okra) producing states are Uttar Pradesh, Bihar, West Bengal, Odisha, Assam, Andhra Pradesh and Karnataka.It is also important in other tropical areas including Asia central and South America. Vegetables play a vital role in the improvement of the diet of mankind. Okra is a good source of vitamins, minerals, calories and amino acid found in seeds. One of India's most significant vegetable crops, okra is cultivated in a variety of soil types and climates. It grows best in temperatures between 22 °C and 35 °C and is a warm-season crop**.** When the temperature falls below 12 °C, okra might freeze**.** The subtropical humid climate of India has a hot climate that is ideal for the growth of okra**.** Intense farming practises and the use of High Yielding Varieties (HYV) reduced the soil's nutritional content. Inadequate nitrogen levels and nutrient imbalance were caused by the over use of chemical fertilizers to achieve high yields, which also posed various risks to the soil (Singh *et al*., 1989), ultimately resulting in the reduction of crop yield. Hence, it has planned to study the effect of endophytic nitrogen fixing bacterial species on growth and yield of okra. In recent years we are creating awareness for eco-friendly organic products.

Sustainable and eco-friendly agriculture which minimizes the use of harmful energy intensive inputs is achievable through the use of organic and bio-fertilizers. Organic nutrition for vegetables is especially important as they provide quality foods, which are very important for providing health security to people. Since the vegetables are mostly consumed as fresh or partially cooked, they should be devoid of residual effect of chemical fertilizers. Increase in the yield of chilli, okra, tomato and brinjal by application of organic manure was reported by Gaur *et al*., (1984) [5]. Nowadays the practice of using microbial inoculants as bio-fertilizers as a partial substitute for chemical fertilizers is gaining much momentum. In general.

Bio-fertilizer from associative N_2 fixing bacteria could be used especially for cash crops such as vegetables, fruits, flowers and medicinal or herbal crops. It is a breakthrough technology that promises very significant impact on the country's farmers in terms of increasing farm productivity and income as well saving the country's dollars reserve due to decreased importation of inorganic nitrogenous fertilizers.

It is mainly composed of microorganisms that can convert the nitrogen gas into available form to sustain the nitrogen requirement of host plants. These bacteria once associated with roots of some vegetable plants can enhance their root development growth and yield. In the present agricultural practices there are number of microbial inoculants used as bio-fertilizers. They induce *Azospirllum* and *Azotobacter* and phosphor- bacterium, which have been given much attention as they are responsible to plant growth and yield of crops under field inoculation (Shaheen *et al*., 2007) [13]. *Azospirillum* is an associative symbiotic nitrogen fixing bacterium having high potential for nitrogen fixation and produces growth hormones. *Azospirillum* inoculation is known to increase the yield of crops by 5 to 20 per cent (Dart, 1986) [3]. *P. fluorescens* belong to Plant Growth Promoting bacteria, the group of bacteria that play a major role in plant growth promotion, induced systemic resistance, biological control of pathogens etc. With regard to the plant growth promoting potential of *P. fluorescens*, Fernando Dini Andreote, 2009 reported Pseudomonas is a novel competent endophyte from potato and causes cultivar-dependent suppression of *Phytophthora infestans* in his study of Endophytic Colonization of Potato (*Solanum tuberosum* L.). In the present investigation the endophytic growth promoting nitrogen fixing bacteria and inorganic fertilizers were studied in combinations to establish the growth and yield and bhendi (*Abelmoschus esculentus*, L.). The results showed that application of microbial inoculants and inorganic fertilizers and their combinations significantly influenced the growth, yield, quality and nutritional contents of okra.

Material and Methods

A field experiment entitled **"**Efficacy of bio fertilizers and the combinations with chemical fertilizers on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]" was conducted at Horticultural Field of Rama University, Kanpur, India during Feb to June 2022 to evaluate the effect of biofertilizer and inorganic fertilizers in balanced proportion may be helpful to increase the productivity of vegetable crops. The finding of the investigation are summarized below.

There were three replication and eight treatments which is design in RBD. The treatments were T_1 (Recommended dose of fertilizers (RDF), T_2 (*Azotobacter* + 50% NPK), T_3 (PSB + 50% NPK), T_4 (*Azospirillum* + 75% NPK), T_5 (PSB + *Azotobacter* + 50% NPK), T_6 (PSB + *Azospirillum* + 50% NPK), T_7 (PSB + *Azospirillum* + *Azotobacter* 50%), T_8 (*Azotobacter* + *Azospirillum* 50%) Growing conditions were found highly significant in respect to all the recorded parameters. Arka anamika variety of Okra was found highly significant in respect to plant height, number of leaves, fruit diameter, number of flowers, number of fruits, length of fruit, fruit weight, yield.

The research will be conducted on 20 February 2022 in the field of Rama University, Mandhana, Kanpur, Uttar pradesh, India. The trial was carried out in cultivable land, during the season of February to July 2022, in a Randomised block design with eight treatments and three replications. Immediately after uprooting of 30 days old seedlings from proplates, the roots of the seedlings with coco peat were dipped in solution prepared with *A. brasilense* and *P. fluorescens* cultures as per treatments for 60 seconds. Then the seedlings of bhendi from proplates was transplanted at the rate of two seedlings per hill with spacing of 45 cm for bhendi between rows and plants respectively in field as per treatments and irrigation was done. sixten seedlings were planted per pot as per the treatments and irrigated immediately

Results and Discussion

The data obtained at the time of maturity of plants, The maximum plant height (131.31 cm) was observed in the treatment (T_3) (PSB + 50% NPK followed the treatment (T_8) (*Azotobacter* + *Azospirillum* 50% (126.31 cm). The plant height was found to be minimum (83.23cm) in the treatment (T_1)

Table 1: Effect of bio fertilizer and chemical fertilizers on plant height.

Plant height(cm)				
Treatment	**Treatment combination**	**30 DAYS**	**60 DAYS**	**90 DAYS**
T_1	Recommended dose of fertilizers (RDF)	31.17	83.23	115.75
T_2	*Azotobacter* + 50% NPK	32.36	105.51	124.93
T_3	PSB + 50% NPK	32.31	107.33	131.33
T_4	*Azospirillum* + 75% NPK	32.42	126.64	125.48
T_5	PSB + *Azotobacter* + 50% NPK	32.47	116.15	125.86
T_6	PSB + *Azospirillum* + 50% NPK	34.56	117.03	125.31
T_7	PSB + *Azospirillum* + *Azotobacter* 50%	25.59	117.64	125.33
T_8	*Azotobacter* + *Azospirillum* 50%	20.4	107.11	126.31
	C.D.	1.707	4.131	4.382
	S.E.(m)	0.456	1.104	1.172

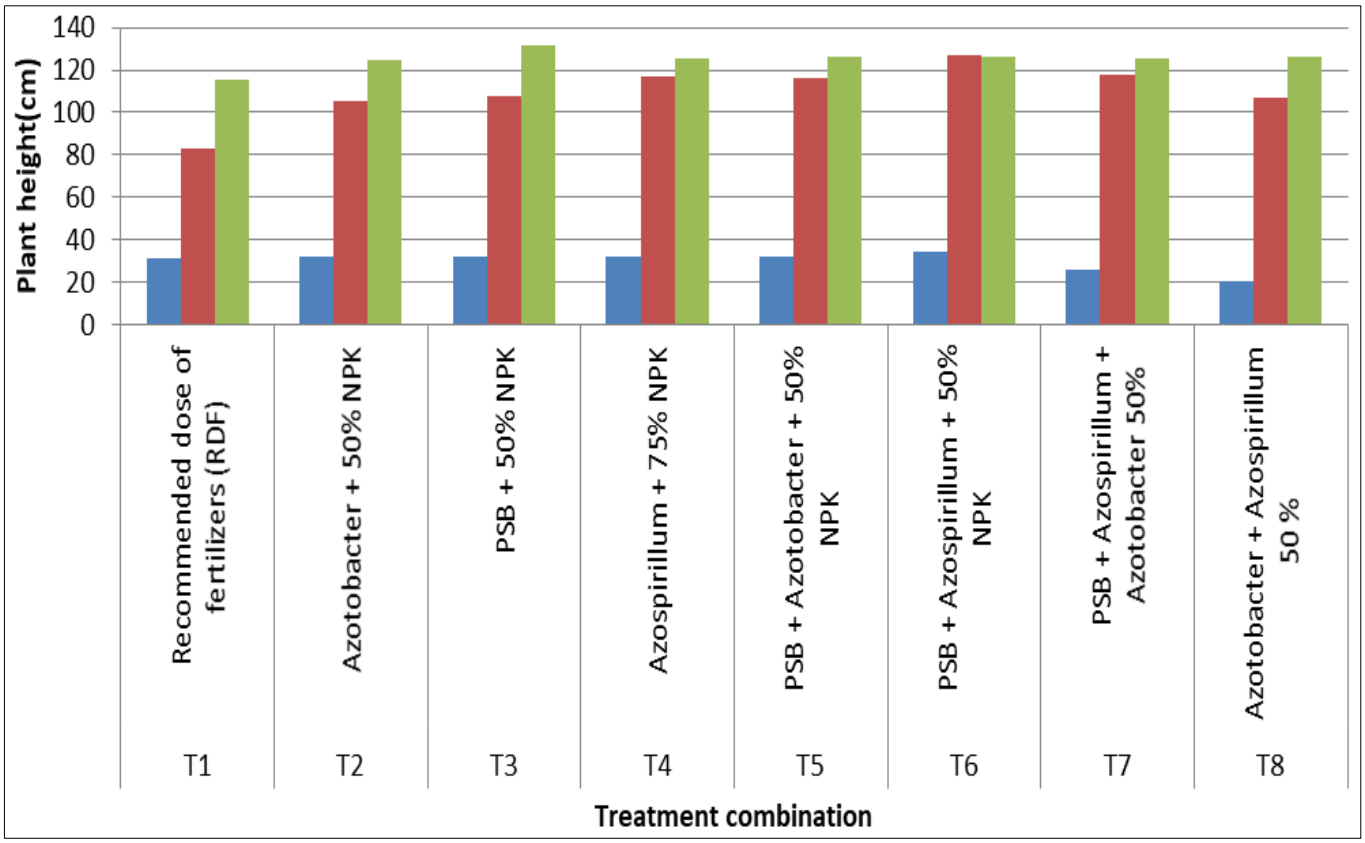


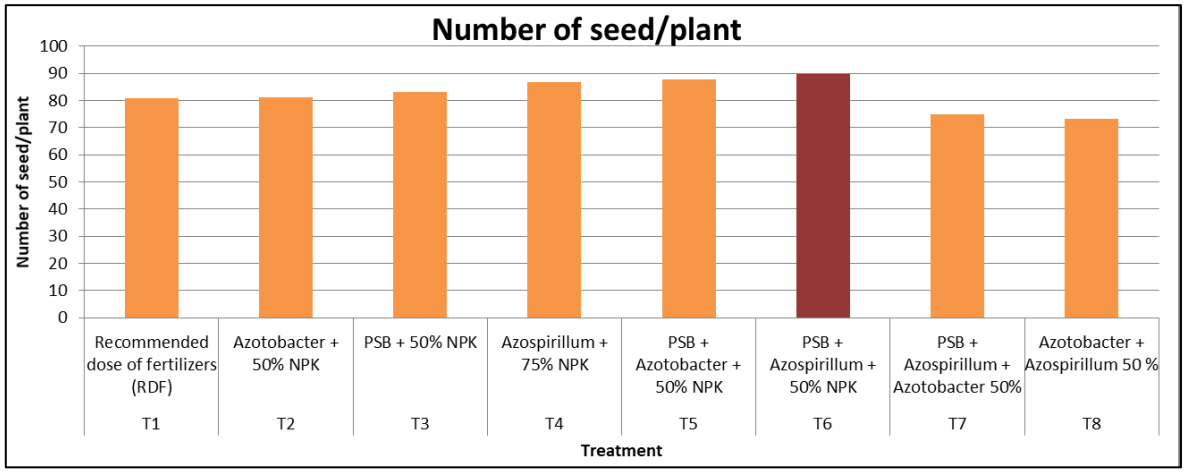
Fig 1: Effect of bio fertilizer and chemical fertilizers on plant height

The number of leaves per plant was found to be significant among the treatments. The maximum number of leaves per plant (12.16) was observed in the treatment (T_6) followed the treatment (T_5) (10.13). The number of leaves per plant was found to be minimum (5.06) in the treatment (T_8) Table (1). The increase in number of leaves per plant may be due to the maximum growth of plant stimulated through supply of adequate amount of chemical fertilizers. The number of branches per plant was found to be differing significant among the treatments.

The maximum number of branches per plant (5.21) was observed in the treatment (T_6) (PSB + *Azospirillum* + 50% NPK) followed the treatment (T_5) (4.36). The number of branches per plant was found to be minimum (1.49) in the treatment (T_8) Table (3). The possible reason for maximum number of branches may be due to the combination of boifertilizer and chemicals enhances fertilizer use efficiency of the crop. The treatment (T_6) (PSB + *Azospirillum* + 50% NPK) have maximum number of fruits per plant (17.55) followed by the treatment (T_5) (15.58). The number of fruits per plant was found to be minimum (9.42) in treatment (T_8). The treatment (T_6) (PSB + *Azospirillum* + 50% NPK) have maximum fruit length 9,80cm followed the treatment (T_5) (9.54 cm). The fruit length was found to be minimum 7.41 cm in treatment (T_8). The treatment (T_6) (PSB + *Azospirillum* + 50% NPK) have maximum fruit diameter 1.75 cm followed the treatment (T_5) (1.68 cm). The fruit diameter was found to be minimum 1.02 cm in treatment (T_8). Maximum fruit yield per plant (9.88 g) was observed in the treatment (T_6) (PSB + *Azospirillum* + 50% NPK) followed the treatment (T5) (9.43 g). The fruit yield was found to be minimum (6.46g) in the treatment (T_8). The significantly maximum fruit yield (111.79 Q/ha) was observed in the treatment (T_6) (PSB + *Azospirillum* + 50% NPK) followed the treatment (T5) (105.85 Q/ha). Total yield was found to be minimum (76.77Q/ha) in the treatment (T_8).

Table 2: Effect of bio fertilizer and chemical fertilizers on plant leaves, branches, flowers fruits and yield.

		Number of leaves/plant(cm)			Number of branches/plant			Number of flower/plant			Fruits/plant	Fruit length(c	Fruit Gir	Fruit wei	yield/plan	Yield Q/l
Treatment	Treatment combination	30DAYS	60DAYS	90DAYS	30DAYS	60DAYS	90DAYS	30DAYS	60DAYS	90DAYS	Fruits/plant	Fruit length(c	Fruit Gir	Fruit wei	yield/plan	Yield Q/l
T1	Recommended dose of fertilizers (RDF)	7.09	14.12	25.16	-	0	2.54	0	7.06	7.29	10.21	7.76	1.16	7.46	309.33	89.06
T2	*Azotobacter* + 50% NPK	6.77	16.07	30.17	-	0	2.37	0	7.27	7.16	10.49	8.6	1.34	7.89	318.14	95.78
T3	PSB + 50% NPK	7.15	17.08	27.38	-	1.06	3.3	0	9.27	8.04	13.46	8.78	1.45	8.54	355	101.78
T4	*Azospirillum* + 75% NPK	10.04	19.01	32.02	-	1	4.34	0	9.86	18.16	13.65	8.76	1.55	8.95	366.41	103.88
T5	PSB + *Azotobacter* + 50% NPK	10.13	19.14	32.23	-	1.01	4.36	0	10.09	10.06	15.58	9.54	1.68	9.43	378.28	105.85
T6	PSB + *Azospirillum* + 50% NPK	12.16	19.72	34.08	-	1.1	5.21	0	9.02	9.37	17.55	9.8	1.75	9.88	405.89	111.79
T7	PSB + *Azospirillum* + *Azotobacter* 50%	6.18	16.27	24.29	-	1	3.11	0	6.63	6.77	10.33	7.73	1.11	6.81	320.41	84.67
T8	*Azotobacter* + *Azospirillum* 50 %	5.06	10.15	20.06	-	0	1.49	0	5.39	11.36	9.42	7.41	1.02	6.46	306.56	76.77
	C.D.	1.257	1.462	1.349	-	0.014896	0.857		2.938	1.251	1.21	1.291	0.357	1.172	5.819	5.802
	S.E.(m)	0.336	0.391	0.361	-	0.003984	0.229		0.785	0.334	0.323	0.345	0.095	0.313	1.556	1.552



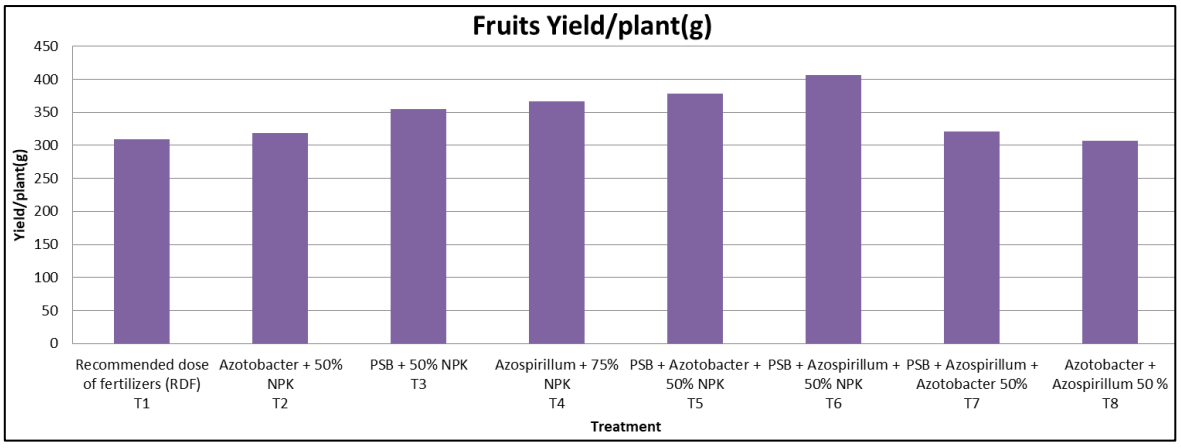


Fig 2: Effect of bio fertilizer and chemical fertilizers on number of seeds/plant fruits yield

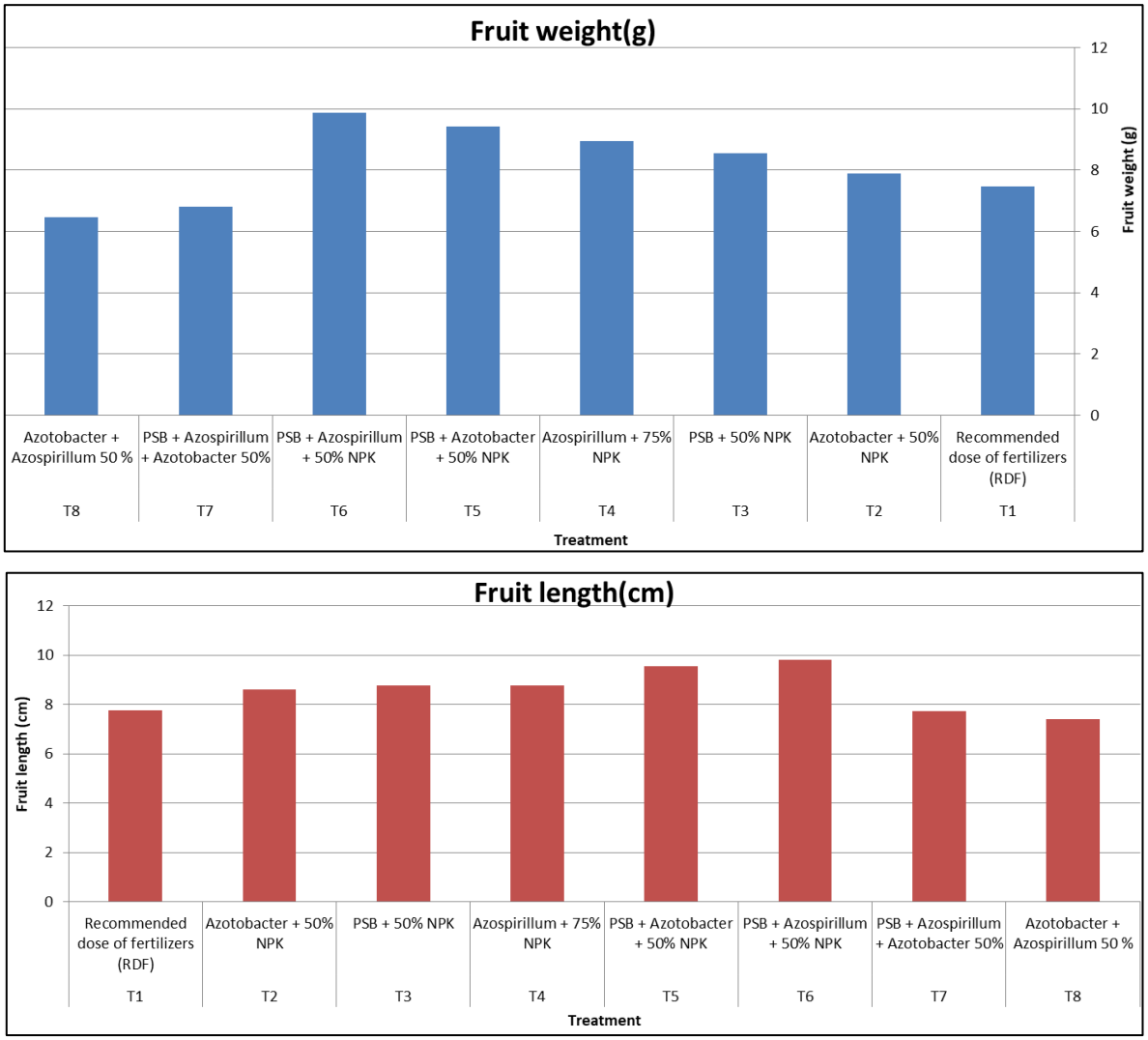


Fig 4: Effect of bio fertilizer and chemical fertilizers on fruits weight and fruit length

Conclusion

From the above findings and results, it was clear that the microbial inoculants and the process of nitrogen fixation have greater contribution in soil fertility in agricultural field. The combination of both the inoculants effectively influence the growth and yield attributes of okra in all observed parameters in the study. So it was an attempt in vegetable crops to isolate and identify effective strains of plant growth promoting bacterial endophytes in okra. It is our aim and objective to isolate and trace more nitrogen fixers exist as endophytes for further biotechnological potential for sustainable, eco-friendly agricultural production. Generally, a more comprehensive understanding of plant colonization by bacteria has to be developed in order to better predict how bacteria interact with plants interiors and whether they are likely to establish themselves in the plant environment after field application as biofertilizers.

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