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Effect of bio-fertilizers and inorganic manures on growth, yield and quality of okra (*Abelmoschus esculentus* L. Moench) under Prayagraj Agro-climatic condition

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Abstract
A field experiment was carried out to assess the "Effect of bio-fertilizers and inorganic manures on growth, yield and quality of Okra (*Abelmoschus esculentus* L. Moench) under Prayagraj Agro-climatic condition". during kharif season, 2015 at Vegetable Research Field, Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj (U.P.). Different levels and combination of bio-fertilizers and inorganic manures was applied to assess the vegetative growth, yield and quality characteristics of Okra cv. Kashi Pragati (VRO-6). The experiment was laid out in factorial randomized block design (FRBD) with sixteen treatments and three replications. Regarding the different parameters of growth, yield and quality; the treatment T_{12} (Azotobactor+PSB+NPK@100:50:50) differ significantly. viz. Higher number of nodes (27.60), diameter of stem (2.08cm), days taken to first flower appearance (38.07), Days taken to 50 % flowering (53.67), diameter of fresh fruit (1.44cm), average fruit length (14.13cm), average fruit weight (12.80g), number of fruit per plant (22.33), fruit yield per plant (285.87g), total yield of fruits (179.99 q/h), total seed yield per plant (24.2g), ascorbic acid (19.30mg/100g), TSS (14.97^0Brix), incidence of Y.V.M.V. (0.90%) and BC ratio except plant height (169.23cm) and number of leafs (33.90) which were observed the maximum in the treatment T_{16} (Azotobactor+PSB+NPK@120:60:60).

Keywords: Azotobactor, PSB, okra, nitrogen, phosphorus and potash

Introduction
Okra botanically known as *Abelmoschus esculentus* (L. Moench) having chromosome number 2n=130 belongs to the family of Malvaceae. Okra is one of the economically important vegetable crops grown as a garden crop as well as on large commercial farms in tropical and sub-tropical parts of the world. Its tender green fruits are generally marketed in the fresh stage, however sometimes, it is canned or dehydrated forms Tyagi *et al.* (2016) [35].
In present time the harmful effects of chemical fertilizers is a major problem. So the Integrated nutrient management is best way to obtain quantity and quality yield in okra and other crops. Therefore, a judicious combination strategy of using inorganic fertilizers as well as bio-fertilizers may be helpful in increasing okra production. Organic fertilizer, now a day's plays a vital role in improving the fruit quality, beneficial effects of Azotobactor and PSB in crop production are well established more interestingly (Presekhar and Rajashree 2009) [25]. It was found that joint inoculation of above bio-fertilizers can cause synergistic effect Sajid *et al.* (2012) [30]; Prabhakaran and Pitachai (2002) [23]. Zero adverse impact on agro-ecosystem quality by balanced fertilization of organic manure, Inorganic fertilizers and bio-inoculants. The INM enhances the availability applied as well as native soil nutrients, improves and sustains the physical and biological function of soil.

Materials and Methods
The experiment was carried out at the Vegetable Research Farm, Department of Horticulture, Prayagraj School of Agriculture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (Uttar Pradesh) during Kharif season of 2015. The soil of the experimental field was sandy loam in texture, poor in nitrogen, comparatively rich in phosphorus and medium in potash with slightly alkaline reaction. A basal dose of N, P and K along with Azotobactor and PSB culture were applied behalf of treatment. One third nitrogen and entire quantity of P and K was applied prior to sowing. Remaining dose of nitrogen was applied in two splits i.e. 20 and 60 days after sowing. The experiment was laid out in factorial randomized block design (FRBD) with sixteen treatments and three replications.

All the different combination of biofertilizers and inorganic manures treatments viz; T_1: M_0F_1– (Microbial inoculants 0 + N_{60}:P_{30}:K_{30}), T_2: M_1F_1 – (Azotobactor + N_{60}:P_{30}:K_{30}), T_3: M_2F_1 – (PSB + N_{60}:P_{30}:K_{30}), T_4: M_3F_1 – (Azotobactor + PSB + N_{60}:P_{30}:K_{30}), T_5: M_0F_2 – (Microbial inoculants 0 + N_{80}:P_{40}:K_{40}), T_6: M_1F_2 – (Azotobactor + N_{80}:P_{40}:K_{40}), T_7: M_2F_2 – (PSB + N_{80}:P_{40}:K_{40}), T_8: M_3F_2 – (Azotobactor + PSB + N_{80}:P_{40}:K_{40}), T_9: M_0F_3 – (Microbial inoculants 0 + N_{100}:P_{50}:K_{50}), T_{10}: M_1F_3 – (Azotobactor + N_{100}:P_{50}:K_{50}), T_{11}: M_2F_3 – (PSB + N_{100}:P_{50}:K_{50}), T_{12}: M_3F_3 – (Azotobactor + PSB + N_{100}:P_{50}:K_{50}), T_{13}: M_0F_4 – (Microbial inoculants 0 + N_{120}:P_{60}:K_{60}), T_{14}: M_1F_4 – (Azotobactor + N_{120}:P_{60}:K_{60}), T_{15} : M_2F_4 – (PSB + N_{120}:P_{60}:K_{60}) and T_{16}: M_3F_4 – (Azotobactor + PSB + N_{120}:P_{60}:K_{60}) are randomly arranged and observations recorded at regular intervals from the experimental field. The all parameters characters were analyzed by the analysis of variance (ANOVA) technique. The critical difference values were calculated at 5 % level of significance.

Results and Discussion

The experimental results of the present investigation have been presented and the results obtained for growth, yield, and quality parameters of different treatments have been discussed in the subsequent pages under appropriate headings.

Growth and Yield Parameters

The data are presented in table 1 showed that, significant difference among the treatments for all the growth and some yield parameters like plant height, numbers of leaves per plant, number of nodes per plant, diameter of main stem, number of days taken to first flower appearance, days taken to 50% flowering, diameter of fruit, average fruit length and average fruit weight. The maximum plant height (169.23cm) and numbers of leaves per plant (33.90) was observed in T_{16} (Azotobactor+PSB+N_{120}:P_{60}:K_{60}) which was at par with T_{14} (Azotobactor + N120:P60:K60) and T_{15} (M_2F_4 –PSB + N_{120}:P_{60}:K_{60}) while the minimum plant height (164.40cm) and numbers of leaves per plant (28.67) were observed in T_1 (Microbial inoculants 0+N_{60}:P_{30}:K_{30}). Higher level of N, P and K with combination of Azotobactor and PSB gave better results these results are more or less in conformity with the finding reported by Rana (2015) [27]. However, the maximum number of nodes per plant (27.60) and diameter of main stem (2.08cm) were observed in T_{12} (Azotobactor + PSB + N_{100}:P_{50}:K_{50}) followed by T_{11} (PSB + N_{100}:P_{50}:K_{50}) and the minimum number of nodes per plant (21.97) and diameter of main stem (1.46cm) was observed in T_1 (Microbial inoculants 0 + N_{60}:P_{30}:K_{30}). Significant increase in okra plant diameter of main stem was observed due to biofertilizers inoculation. These results are more or less in conformity with the finding reported by Khan *et al*. (2013) [16] and Thirunavukkarasu and Balaji (2015) [34], number of days taken to first flower appearance, and days taken to 50% flowering, number of nodes per plant There was significant difference among the treatments for days taken to first flower appearance in the minimum days (38.07) and the minimum days taken to 50% flowering (53.67) was observed in T_{12} (Azotobactor + PSB + N_{100}:P_{50}:K_{50}) followed by T_{11} (PSB + N_{100}:P_{50}:K_{50}), while the maximum days (45.00) taken to first flower appearance was observed in T_1 (Microbial inoculants 0 + N_{60}:P_{30}:K_{30}). Baliah *et al*. (2017) [5] Jat and Ahlawat (2004) [14] also find similar result in case of number of days taken to first flower appearance (Hisham *et al.* 2014) [13] and Hammad *et al.* (2016) [12] for days taken to 50% flowering in okra. There was significant difference among the maximum diameter of fruit (1.44cm), average fruit length (14.13cm) and average fruit weight (12.80g) was observed in T_{12} (Azotobactor + PSB + N_{100}:P_{50}:K_{50}) followed by T_{11} (PSB + N_{100}:P_{50}:K_{50}), while the minimum diameter of fresh fruit (1.17cm), average fruit length (11.83cm) and fruit length (11.16g) was observed in T_1 (Microbial inoculants 0 + N_{60}:P_{30}:K_{30}). This finding agreed with the finding of Yadav *et al.* (2006) [36] reported that the application of 90 kg N ha^{-1} through urea, poultry manure, FYM and vermicompost significantly increased number of fruits, diameter of fruit, fruit length, Average fruit weight and total yield of okra as compared to control.

Yield and Quality parameters

The data presented in table 2 showed that, there was significant difference among treatments for all the yield related and quality parameters like No. of fruit/ plant, Fruit yield/plant, Fruits yield per hectare, Ascorbic acid, TSS , Incidence of Y.V.M.V. percentage, Net income and B: C ratio. The treatments maximum numbers of fruit per plant (22.33), fruit yield (285.87g) per plant and fruit yield (179.99 q) per hectare was observed in T_{12} (Azotobactor + PSB + N_{100}:P_{50}:K_{50}) followed by T_{11} (PSB + N_{100}:P_{50}:K_{50}), while the minimum numbers of fruit per plant (17.33), fruit yield (193.38g) per plant and fruit yield (121.76 q) per hectare was observed in T_1 (Microbial inoculants 0 + N_{60}:P_{30}:K_{30}). The number of fruits per plant and average fruit weight are directly linked with the fruit yield. The best result was comes due to combine effect of NPK, PSB and Azotobactor. This finding agreed with the finding of Khan *et al.* (2013) [16] and Tyagi1 *et al.* (2016) [35]. There was significant difference among the treatments maximum Ascorbic acid content (19.30g), was observed in T_{12} (Azotobactor + PSB + N_{100}:P_{50}:K_{50}) followed by T_{11} (PSB + N_{100}:P_{50}:K_{50}) i.e., (18.97), while the minimum Ascorbic acid (16.03g), was observed in T_1 (Microbial inoculants 0 + N_{60}:P_{30}:K_{30}). Reddy *et al.* (2001) [28] and Hisham *et al.* (2014) [13] also reported more or less similar result. The application of FYM plus seedling inoculation in Azotobactor showed pod yield, significantly higher Ascorbic acid content in okra fruits. TSS (Brix). There was significant difference among the treatments (table) maximum TSS (14.97 ^{0}Brix) was observed in T_{12} (Azotobactor + PSB + N_{100}:P_{50}:K_{50}) followed by T_{11} (PSB + N_{100}:P_{50}:K_{50}), while the minimum TSS (11.97^{0}Brix) was observed in T_1 (Microbial inoculants 0 + N_{60}:P_{30}:K_{30}). Application of organic manure would have helped in the plant metabolic activity through the supply of such important micronutrients in the early crop growth phase, which in turn encouraged early vigorous growth, due to this effect total soluble solid also increase; Olowoake *et al.* (2015) [20] also reported more or less similar result. There was significant difference among the treatments minimum incidence of Y.V.M.V. (0.90%) was observed in T_{12} (Azotobactor + PSB + N_{100}:P_{50}:K_{50}) followed by T_{11} (PSB + N_{100}:P_{50}:K_{50}), while the maximum incidence of Y.V.M.V. (3.34%) was observed in T_1 (Microbial inoculants 0 + N_{60}:P_{30}:K_{30}). Ali *et al.* (2012) [2] observed that the similar finding of epidemiological factors of okra yellow vein mosaic virus. The variety VRO-6 was highly resistant to the YVMV. The maximum net return per hectare (Rs. 176721) was observed in T_{12} (Azotobactor + PSB + NPK N_{100}:P_{50}:K_{50}) followed by T_{11} (PSB + N_{100}:P_{50}:K_{50}), i.e., (Rs. 153216) while the minimum net return per hectare (Rs. 92264) was observed in T_1 (Microbial inoculants 0 + N_{60}:P_{30}:K_{30}). As for economics of treatment is concerned, the highest benefit cost (2.89) ratio was observed with T_{12} (Azotobactor + PSB + NPK @ 100:50:50) which was at par

with T_{11} (PSB + NPK @ 100:50:50) due to its higher yield per hectare. Treatment T_{12} (Azotobactor + PSB + N_{100}:P_{50}:K_{50}) was superior over all other treatments in relation to Benefit: Cost ratio. Ogundare *et al.* (2015) [19], Swain *et al.* (2003) [33] also find similar results.

Table 1: Effect of bio-fertilizers and inorganic manures on Growth and yield parameters of Okra cv. Kashi Pragati

Treatment symbol	Plant height (cm)	No of leaves	Number of nods	Diameter stem (cm)	Days taken to first flower appearance	Days taken to 50% flowering	Diameter fruit (cm)	Fruit length (cm)	Fruit weight (g)
T_1	164.40	28.67	21.97	1.46	45.00	58.03	1.17	11.83	11.16
T_2	165.37	29.50	22.27	1.50	44.53	57.47	1.19	12.49	11.27
T_3	164.90	29.00	23.37	1.63	42.77	56.10	1.25	13.34	11.53
T_4	165.63	30.27	23.80	1.70	41.93	55.47	1.28	13.54	11.71
T_5	165.87	30.67	23.13	1.59	43.30	56.40	1.24	11.92	11.45
T_6	166.43	31.43	23.57	1.66	42.30	55.63	1.26	12.14	11.58
T_7	166.17	30.90	24.33	1.87	39.57	54.77	1.35	13.42	12.23
T_8	166.70	31.67	24.97	1.98	38.87	54.33	1.38	13.78	12.53
T_9	167.00	31.93	24.20	1.83	40.23	54.97	1.33	12.39	12.07
T_{10}	167.63	32.47	24.70	1.93	39.33	54.50	1.37	13.67	12.37
T_{11}	167.33	32.20	26.27	2.03	38.43	54.03	1.40	13.90	12.63
T_{12}	167.90	32.77	27.60	2.08	38.07	53.67	1.44	14.13	12.80
T_{13}	168.23	33.07	22.63	1.53	43.97	57.07	1.20	12.05	11.32
T_{14}	168.80	33.53	22.90	1.56	43.70	56.80	1.22	12.28	11.39
T_{15}	168.53	33.30	23.95	1.75	41.27	55.17	1.29	13.08	11.83
T_{16}	169.23	33.90	24.07	1.78	40.77	55.00	1.31	13.21	11.95
SEd. (±)	0.36	0.49	0.21	0.05	0.38	0.46	0.02	0.35	0.15
CD (5%)	0.73	0.99	0.43	0.10	0.78	0.94	0.03	0.71	0.32
CV (1%)	0.26	1.89	1.07	3.43	1.13	1.01	1.47	3.27	1.60

Table 2: Effect of bio-fertilizers and inorganic manures on yield and quality parameters of Okra cv. Kashi Pragati

Treatment symbol	No. of fruit/ plant	Fruit yield/ plant (g)	Fruits yield (q/ha)	Ascorbic acid (mg/100g)	TSS (^{0}Brix)	Incidence of Y.V.M.V. (%)	Net income (Rs.)	B:C
T_1	17.33	193.38	121.76	16.03	11.97	3.34	92264	2.02
T_2	17.60	198.41	124.92	16.17	12.30	3.06	96704	2.07
T_3	17.97	207.15	130.42	17.00	13.20	2.37	104954	2.16
T_4	18.17	212.79	133.98	17.43	13.43	2.08	109994	2.21
T_5	17.95	205.53	129.41	16.77	13.00	2.56	102595	2.12
T_6	18.10	209.66	132.01	17.20	13.33	2.18	106195	2.16
T_7	19.27	235.69	148.4	18.33	14.27	1.47	130780	2.42
T_8	20.40	255.66	160.97	18.80	14.60	1.23	149335	2.62
T_9	18.73	226.05	142.33	18.13	14.07	1.67	120831	2.3
T_{10}	20.17	249.4	157.03	18.60	14.43	1.32	142581	2.53
T_{11}	20.63	260.67	164.12	18.97	14.77	1.01	153216	2.65
T_{12}	22.33	285.87	179.99	19.30	14.97	0.90	176721	2.89
T_{13}	17.70	200.43	126.2	16.33	12.60	2.78	95492	2.02
T_{14}	17.90	203.87	128.36	16.53	12.80	2.67	98432	2.05
T_{15}	18.20	215.26	135.53	17.63	13.63	1.90	109187	2.16
T_{16}	18.40	219.89	138.45	17.93	13.83	1.77	112967	2.19
SEd. (±)	0.12	3.47	3.67	0.24	0.26	0.09		
CD (5%)	0.24	7.08	7.5	0.48	0.53	0.18		
CV (%)	0.76	1.90	3.32	1.65	2.34	5.32		

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