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Effect of mycorrhizal inoculation, organic manure and inorganic fertilizers on growth and yield of okra [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT

In the present experiment the influence of Bio-fertilizer, organic manure and inorganic fertilizers individually and in combination on okra cv. VRO-6 were tested in a randomized block design with 8 treatments and 3 replications during summer-rainy season of 2009-2010. Mycorrhizal application promoted the growth and yield of okra in as all mycorrhizal combinations produced better results than sole organic manure and inorganic fertilizers. Results revealed that the combined application of mycorrhiza + 50% organic manure + 50% inorganic fertilizer or mycorrhiza + 75% organic manure +25% inorganic fertilizer produced the highest fruit yield (13.67 t/ha) and its attributes and other morphological characters under study all the treatments. Sole mycorrhizal application did not produce any better results unless it was combined with organic manure and inorganic fertilizers.

Keywords: Integrated nutrient management, mycorrhiza, okra

Okra [*Abelmoschus esculentus* (L.) Moench], is a malvaceous summer vegetable and also known as "Power house of valuable nutrients", but its yield still remain low under Varanasi condition. The yield of okra is influenced by numerous horticultural, ecological and edaphic factors. For increasing the yield of okra with less amount of chemical fertilizer, use of bio-fertilizers can play an important role. Mycorrhiza mines the soil at a greater distance from roots for nutrients especially phosphorous that are poorly mobile in soil. It also helps in absorption of water and blocking of pest and diseases. Inoculation of bio-fertilizers exerted significant effect on crop aerial biomass at all the growth stages (Pramanik and Bera, 2013). Highest system productivity (9.26 t $ha^{-1}year^{-1}$) was obtained when the crop received 50% recommended doses of NPK through fertilizer in combination with 50% recommended doses of nutrients through green leaf manure during *Kharif* season and l00% recommended doses through chemical fertilizer during boro season (Banerjee *et al*, 2006). AM hyphae secrets gluey sugar based compound called Glomalin, which helps in binding soil particles and make soil aggregates. This gives soil structure, improves air, water infiltration and enhances the carbon and nutrient storage (Peters, 2012). Therefore, it was felt that investigations with this economically important vegetable crop would provide detailed information about the effectiveness of mycorrhiza in combination with organic manure and inorganic fertilizer on alluvial soil of Varanasi.

MATERIALS AND METHODS

An investigation on the "effect of mycorrhiza, organic manure and inorganic fertilizers on growth and yield of okra" cv. VRO-6 was undertaken at Vegetable Research Farm Department of Horticulture, Institute of Agricultural Sciences, BHU, Varanasi during 2009-2010. The experiment consisting of eight treatment combinations were laid out in randomized block design with three replications at a spacing of 60x30cm accommodating 50 plants per plot (3x3m). The treatments constituted of different levels of inorganic fertilizers (nitrogen, phosphorus and potassium) and FYM (farm yard manure) along with or without mycorrhiza. The recommended dose NPK @ 100:60:50 kg ha^{-1} along with FYM 20 t ha^{-1} was considered for the experiment and source of N, P and K were urea SSP and MOP respectively. Seeds were inoculated with mycorrhiza in a ratio of 10:1, *i.e.* 10 kg of seeds mixed with 1 kg of mycorrhizal fungus. The eight treatment combinations are as follows: **T_1:** Control, **T_2:** Mycorrhiza, **T_3:** Organic manure -FYM 0.18q $plot^{-1}$, **T_4:** Inorganic fertilizer- Urea @ 0.19 kg $plot^{-1}$, SSP @ 0.33kg $plot^{-1}$, MOP @ 0.07 kg $plot^{-1}$, **T_5:** Mycorrhiza + 100% Organic manure-FYM @ 0.18q $plot^{-1}$), **T_6:** Mycorrhiza +75% Organic manure +25% Inorganic fertilizer-fertilizer- Urea @ 0.04 kg/plot, SSP @ 0.08 kg $plot^{-1}$, MOP @ 0.01 kg $plot^{-1}$, FYM 0.13 q $plot^{-1}$, **T_7:** Mycorrhiza +100% Inorganic fertilizer- Urea @ 0.19 kg $plot^{-1}$, SSP @ 0.33 kg $plot^{-1}$, MOP @ 0.07 kg $plot^{-1}$ and **T_8:** Mycorrhiza +50% Organic manure +50% Inorganic fertilizer - Urea @ 0. 09 kg $plot^{-1}$, SSP @ 0.16 kg $plot^{-1}$, MOP @ 0.03 kg $plot^{-1}$, FYM @ 0.09 q $plot^{-1}$. For seed inoculation, 60 g of seeds were taken in a beaker and 6 g of powder form of mycorrhizal fungus, then 10 ml water was added and mixed the seeds. The mycorrhiza species

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Glomus aggregatum is collected from TERI (The Energy and Resources Institute, New Delhi). The seedsI were retained overnight for better inoculation. Next day seeds were sown in marked plots. The observations were taken on 8 quantitative characters as an average of 10 randomly selected competitive plants in each replication in each treatment. The characters *viz*., height of plant, number of leaves and number of branches per plant were recorded thrice at 15, 30 and 45 days after sowing (DAS).

RESULTS AND DISCUSSION

Analysis of variance study indicated that all the treatments were differed significantly for most of the characters. The mean values of various growth and yield attributes of okra cv. VRO-6 as a response to mycorrhizal, organic manure and inorganic fertilizers was presented in table 1. Maximum plant height at 15, 30 and 45 DAS was recorded when plant was treated with mycorrhiza +50% organic fertilizer +50% inorganic fertilizers (T_8). However, at 30 DAS T_6 (mycorrhiza +75% organic fertilizer +25% inorganic fertilizer), and at 45 DAS T_6 and T_7 (mycorrhiza +100% inorganic fertilizer) were found to be *at par* with T_8. At 45 and 60 DAS, mycorrhizal application (T_2) resulted in lower plant height than other treatments as the plants might be deprived of nitrogen due to lack of nitrogen source. The increase in plant height in combination treatments might be attributed to increased nutrient uptake. Similar results were also reported by JenHshun (2006). Meena and Dixit (2008) reported that VAM + *Azatobactor* inoculation increased the plant height in okra cultivar Arka Anamika. Mycorrhizal application alone (T_2) did not show any significant increase in number of leaves per plant when compared with control. However, all the treatments where mycorrhiza was applied in combination with organic and inorganic fertilizers ($T_{5, 6, 7 \text{ and } 8}$) produced higher number of leaves than sole applications ($T_{2, 3 \text{ and } 4}$) and were found to be at par at 15 and 30 DAS. Almost similar number of branches per plant was recorded at 15 DAS with all the treatments and mycorrhizal application alone (T_2) did not show any increase the number of branches as compared to the control at all three stages. Nevertheless, combination with organic manure and inorganic fertilizers significantly increased the number of branches per plant at 30 and 45 DAS. In both the intervals T_8 yielded maximum number of branches per plant and it was found to be *at par* with T_6. The reason could be that the plants were deprived of all essential nutrients in sole plots ($T_{2, 3 \text{ and } 4}$) and the other treatments were able to supply sufficient amount of nutrients for successive leaf and branch emergence.

Longer pods were obtained from T_6 plot and it was found to be with $T_{3, 4, 5 \text{ and } 6}$. Pod recorded with$T_2$ (mycorrhiza alone) was found to be longer as compared to control but the values were statistically insignificant. Mycorrhiza in combination with organic and inorganic sources of nutrients increased the pod length in same manner except in combination with 100% inorganic fertilizers (T_7). Number of pods per plant was also followed the similar trend with pod length. Maximum number of pods per plant was produced in T_8 and was at par with $T_{3, 4, 5 \text{ and } 6}$. Like pod length, T_2 (mycorrhiza alone) produced similar number of pods per plant when compared with control even though it was found to be smaller. Mycorrhiza in combination with organic manure and inorganic fertilizers increased the number of pods per plant in same manner except in combination with 100% inorganic fertilizers (T_7). Pod weight differed significantly among the treatments and maximum pod weight was found in T_8 followed by T_7 and T_6. Similar to other characters pod weight was not influenced by sole mycorrhizal application (T_2) when compared with control, but increased pod weight was observed in combination treatments. Highest fruit and seed yield was found in T_6 akin to T_8 for fruit yield and to $T_{3, 4, 5, 6 \text{ and } 7}$ for seed yield. In both the cases sole mycorrhizal application (T_2) did not increase the yield significantly as compared to control. Similar type of results showing increase in yield of okra by mycorrhizal application in combination with organic and inorganic fertilizers were reported by Chinnamuthu and Venkatakrishnan (2001) in sunflower, and Ravikumar, *et al.* (2010) in coleus. Deshpande, *et al*. (2006) also reported higher yield in okra due to combination of mycorrhiza, organic manure and inorganic fertilizers. These findings showed that growth and yield attributes in okra were highly influenced by mycorrhizal application in combination with organic manure and inorganic fertilizers.

From the results of present investigation it can be concluded that mycorrhizal application would increase performance of okra genotypes in terms of growth and yield as all combination treatments proved to be more effective by producing better results as compared with sole organic and inorganic treatments. But, sole mycorrhizal application could fail to produce better yield and other desirable morphological characters. It is clear that the combination of mycorrhiza organic manure and inorganic fertilizer would be more effective than any other combinations suggesting the integrated nutrient management for getting better results in okra

Table 1: Mean values of various growth and yield attributes of okra cv. VRO-6 as a response to mycorrhiza, organic manure and inorganic fertilizers

Treatments	Mean													
	Height of plants (cm)			No. of leaves plant^{-1}			No. of branches plant^{-1}			Length of pods (cm)	No. of pods plant^{-1}	Weight of pods (g)	Fruit yield (kg m^{2})	Seed yield (kg m^{2})
	15 DAS	30 DAS	45 DAS	15 DAS	30 DAS	45 DAS	15 DAS	30 DAS	45 DAS					
T_1	9.97	20.16	39.54	3.17	6.53	11.36	3.21	6.87	7.50	13.16	8.51	8.2	5.09	1.58
T_2	10.09	20.41	49.99	3.53	7.20	11.40	3.53	7.00	7.93	12.81	8.49	8.8	5.47	1.67
T_3	10.81	23.13	64.35	3.77	7.67	13.63	3.49	7.63	8.23	16.07	19.92	8.6	9.11	2.37
T_4	11.32	24.44	76.64	3.83	7.70	15.73	4.02	7.90	8.17	17.04	20.08	9.23	10.35	2.44
T_5	9.11	21.96	61.56	4.13	7.53	13.66	3.73	6.90	7.43	17.53	19.84	9.20	10.08	2.49
T_6	12.14	25.88	82.49	4.17	9.00	15.36	3.93	8.60	8.87	18.10	20.38	10.2	13.67	2.86
T_7	10.90	24.58	68.15	4.30	8.77	13.73	4.23	7.93	8.10	15.67	16.2	10.8	9.73	2.30
T_8	12.97	28.83	84.01	4.43	9.73	15.86	4.26	9.00	9.67	18.09	20.72	10.9	11.51	2.70
SEm (±)	**0.44**	**1.34**	**5.91**	**0.17**	**0.33**	**0.83**	**0.25**	**0.29**	**0.78**	**0.74**	**0.41**	**0.76**	**1.06**	**0.23**
LSD (0.05)	**1.29**	**3.91**	**17.30**	**0.50**	**0.96**	**2.43**	**0.74**	**0.84**	**1.29**	**2.17**	**1.21**	**1.63**	**3.12**	**0.66**

Note: *T_1: Control, T_2: mycorrhiza, T_3: organic manure-FYM 0.18q plot^{-1}, T_4: inorganic fertilizer- Urea @ 0.19 kg plot^{-1}, SSP @ 0.33 kg plot^{-1}, MOP @ 0.07 kg plot^{-1}), T_5: (mycorrhiza + 100% organic manure -FYM @ 0.18 q plot^{-1}), T_6: (mycorrhiza +75% organic manure +25% inorganic fertilizer-Urea @ 0.04 kg plot^{-1}, SSP @ 0.08 kg plot^{-1}, MOP @ 0.01 kg plot^{-1}, FYM 0.13 q plot^{-1}), T_7: (mycorrhiza +100% inorganic fertilizer- Urea @ 0.19kg plot^{-1}, SSP @ 0.33 kg plot^{-1}, MOP @ 0.07 kg plot^{-1}) and T_8: (mycorrhiza +50% organic manure+50% inorganic fertilizer - Urea @ 0. 09 kg plot^{-1}, SSP @ 0.16 kg plot^{-1}, MOP @ 0.03 kg plot^{-1}, FYM @ 0.09 q plot^{-1}).*

cultivation. Application of mycorrhiza +50% organic manure +50% inorganic fertilizers or mycorrhiza +75% organic manure +25% inorganic fertilizer may be recommended for better growth, development and yield of okra.

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