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Influence of Nutrients, Organics and Bioagents on Growth, Yield, Leaf Nutrient Status and Economics of Okra (*Abelmoschus esculentus* (L.) Moench) "CoBhH 1"

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The present experiment was carried out on okra 'COBhH 1' during 2010-11 with the objective of studying the influence of nutrients, organics and bio-agents on growth, yield, leaf nutrient status and economics of okra. The results pooled over two seasons indicated that application of *Pseudomonas fluorescens* (seed treatment @ 10g kg^{-1} + soil application @ 2.5 kg ha^{-1} with FYM and foliar spray of humic acid @ 0.2 per cent improved the growth, yield and leaf nutrient contents. The parameters such as plant height, fruit length, fruit girth, fruit weight, fruits per plant, fruit yield per plant and per ha marketable fruit yield per plant and per ha were found highest with application of *P. fluorescens.* The shortest inter nodal length, the lowest first flowering node, earliness in flowering and higher leaf nutrient content of N, P, K, Ca, Mg, S and micronutrients were observed with application of 0.2 % humic acid as foliar spray. The highest net return per hectare and benefit cost ratio were observed with application of *P. fluorescens.*

Key words: Okra nutrients, organics, yield, *Pseudomonas,* net return, humic acid.

Okra is one of the most important vegetables grown throughout the world covering an area of 0.45 million ha with production of 4.80 MT and productivity of 10.6 t ha^{-1} in India (Anon., 2010). The immature fruits are used as vegetables. Apart from its use as a vegetable, its stem and roots are used for cleaning the cane juice from which sugar is prepared. The fruits are good source of dietary fibre, vitamins A, B and C and also rich in protein, carbohydrate, fat and minerals like iron, calcium and iodine (Bose *et al.*, 1993). Ever increasing cost of energy would be an important constraint for increased use of chemical fertilizers in crop production. To ensure high yield, adequate application of nutrients and organics are of paramount importance than any other improved cultural practices. Use of nutrients, organics and bio-agents to meet the requirement of crop would be an inevitable practice in the years to come for sustainable agriculture (Tripathy and Maity, 2007). Keeping these facts in mind, the study was undertaken to study the influence of nutrients, organics and bio-agents on growth, yield, leaf nutrient content and economics of okra.

Materials and Methods

The present investigation was carried out at Horticultural College and Research Institute, TNAU, Coimbatore, during the year 2010-11 in two seasons (March to June, 2010 and October, 2010 to February, 2011) with okra hybrid 'CoBhH 1'. The experiment was laid out in Randomized Block Design with nine treatments replicated thrice. The experimental soil was clay loam in texture having organic carbon 0.35 %, pH 8.1, EC 0.16 dSm^{-1}, available nitrogen 185 kg ha^{-1}, available phosphorus 12.17 kg ha^{-1} and available potassium 198.23 kg ha^{-1}. The treatments comprised of nutrients, organics and bio-agents *viz.,*

T_1 : Sulphate of potash 1%
T_2 : Micronutrient mixture {Zn (1.68%) + Fe (7.60%) + Mn (1.22%) + Mo (0.14%) + Cu (1.00%) + B (2.48%)} 0.25%)
T_3 : Cow urine 10%
T_4 : Fermented buttermilk 10%
T_5 : Humic acid 0.2%
T_6 : Neem oil 0.3%
T_7 : *Pseudomonas fluorescens* as seed treatment @ 10g kg^{-1} + soil application @ 2.5kg ha^{-1} with FYM on 15 DAS+ foliar spray @ 0.2% on 30,45 and 60 DAS
T_8 : Recommended practice - Soil application of carbofuran 3g 1kg a.i ha^{-1} + foliar spray of dimethoate 30 EC 0.03%
T_9 : Control

The treatments were applied through foliar spray on 15, 30, 45 and 60 DAS. The spacing adopted was 45x30 cm in a gross plot size of 10m^2 and. Okra crop was fertilized with recommended dose of FYM 20t and NPK 40:50:30 kg ha^{-1}. Nitrogen, phosphorus and potassium were applied in the form of urea, superphosphate and muriate of potash respectively. Half the dose of nitrogen and full dose of phosphorus and potassium were applied uniformly as basal dose as per treatments. The remaining half N was applied as top dressing on thirty days after sowing (Anon, 2004). The observations regarding the yield attributing characters and yield were recorded from

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10 representative plants. The fruits were harvested at 2-3 days interval starting from 45 DAS, fresh weight of fruits was calculated from all the pickings and the fruit yield expressed in t ha^{-1}. The third youngest leaf was used as the standard leaf for nutrient estimation (Patel *et al.,* 2008). The leaf nutrient contents on dry weight basis were estimated by different methods (Table 1) and data were analyzed statistically (Gomez and Gomez, 1976).

Table 1. Methods of leaf nutrient analysis

Component	Methods	Authors
Total N (%)	Micro Kjeldahl digestion	Piper (1966)
Total P (%)	Vanadomolybdate phosphoric yellow colour	Jackson (1973)
Total K (%)	Flame photometry	Jackson (1973)
Total Ca (%)	Using tri-acid extract	Piper (1966)
Total Mg (%)	Versanate titration	Piper (1966)
Total S (%)	Using di-acid extract (Nitric and Perchloric acid)	Chaudhry and Cornfield (1966)
Boron (ppm)	Colorimetric micro determination	Naftel (1986)
Total micronutrients (Zn,Cu,Fe and Mn) (ppm)	Atomic absorbtion spectro photometer –AA-120, Varian techtron	Jackson (1973)

Results and Discussion

Growth parameters

The mean data on plant height as influenced by nutrients, organics and bio -agents recorded at harvest are presented in Table 2. The pooled mean performance revealed that the treatment effect was significant and treatment T_7 (*Pseudomonas fluorescens* as seed treatment @ 10g kg^{-1} + soil application @ 2.5kg ha^{-1} with FYM on 15 DAS+ foliar spray @ 0.2% on 30,45 and 60 DAS) was found superior with the highest plant height (95.0 cm). The lowest plant height was registered in treatment T_9 (control). This might be due to synthesis of phytohormones like gibberellins, cytokinins and indole acetic acid by plant growth promoting rhizobacteria (Ramamoorthy *et al.*, 2001). No significant differences were observed for days taken for 50 % flowering, internodal length and first flowering node (Table 2). Among the treatments, T_5 (humic acid @ 0.2 %) was found to have earliness in flowering (39.66), shortest internode (4.26) and first flowering node (4.58). The early flowering can also be attributed to the gibberellin activity of humic acid (Vaughan *et al*., 1985) and also this may be attributed to the presence of phenolic group in humic acid, which would have inhibited the IAA oxidase activity (Mato *et al*., 1972).

Table 2. Effect of nutrients, organics and bio-agents on growth and yield of okra 'COBhH 1' (pooled data of two seasons of 2010-2011)

Treatment	Plant height (cm)	Days to 50 % flowering	Internodal length (cm)	First flowering node	Fruit length (cm)	Fruit girth (cm)
Sulphate of potash 1%	84.31	42.50	5.00	5.06	14.21	4.51
Micronutrient mixture 0.25%)	83.95	45.16	4.95	5.35	14.21	4.35
Cow urine 10%	83.08	43.16	4.96	5.28	14.16	4.35
Fermented buttermilk 10%	83.81	41.83	4.78	4.98	14.33	4.61
Humic acid 0.2%	92.43	39.66	4.26	4.58	15.05	5.18
Neem oil 0.3%	87.06	42.83	5.06	5.03	14.70	4.95
P. fluorescens as seed treatment 10g kg^{-1} + soil application 2.5kg ha^{-1} with FYM on 15 DAS+ foliar spray 0.2% on 30,45 and 60 DAS	95.00	41.66	4.90	4.78	15.26	5.43
Recommended practice - Soil application of carbofuran 1kg a.i ha^{-1} + foliar spray of dimethoate 0.03%	81.45	46.50	5.11	5.25	13.93	4.35
Control	73.91	48.16	5.31	5.63	13.36	4.00
SEd	1.87	1.54	NS	NS	0.25	0.18
CD (0.05)	3.77	3.11	---	---	0.50	0.38

NS – Non Significant

Yield attributes

The effect of nutrients and organics on yield parameters showed significant differences among the treatments (Table 2,3). The highest values of fruit length (15.26 cm), fruit girth (5.43 cm), fruit

Table 3. Effect of nutrients, organics and bio-agents on yield parameters of okra 'COBhH 1' (pooled data of two seasons of 2010-2011)

Treatment	Fruit weight (g)	Fruits / plant	Yield / plant (g)	Yield / ha (t)	Marketable yield / plant (g)	Marketable yield / ha (t)
Sulphate of potash 1%	14.41	14.93	215.33	15.05	202.00	14.76
Micronutrient mixture 0.25%)	14.38	14.71	212.50	14.86	201.33	14.51
Cow urine 10%	14.30	14.86	213.50	15.03	202.50	14.61
Fermented buttermilk 10%	14.63	15.15	223.00	15.26	214.50	14.76
Humic acid 0.2%	15.31	15.66	241.66	15.95	228.66	15.35
Neem oil 0.3%	14.95	15.45	232.33	15.76	217.33	15.10
P. fluorescens as seed treatment 10g kg^{-1} + soil application 2.5kg ha^{-1} with FYM on 15 DAS+ foliar spray 0.2% on 30,45 and 60 DAS	15.71	15.83	249.50	16.13	237.66	15.55
Recommended practice - Soil application of carbofuran 1kg a.i ha^{-1} + foliar spray of dimethoate 0.03%	14.40	14.70	211.50	14.90	195.50	14.60
Control	13.98	13.33	186.33	10.96	159.16	10.46
SEd	0.21	0.29	7.77	0.24	7.81	0.23
CD (0.05)	0.44	0.58	15.62	0.49	15.71	0.46

weight (15.71 g), fruits/plant (15.83), yield/plant (249.5 g), yield/ha (16.13 t) marketable fruit yield / plant (237.66 g) and marketable fruit yield/ha (15.55 t) were obtained with treatment T_7 (*Pseudomonas fluorescens* as seed treatment @ 10g kg^{-1} + soil application @ 2.5kg ha^{-1} with FYM on 15 DAS+ foliar spray @ 0.2% on 30,45 and 60 DAS) which was on par with T_5 and T_6. The increase in yield and yield parameters may be due to the secondary metabolites of *Pseudomonas fluorescens*, which are mostly involved in the induction of resistance and promoting plant growth and yield (Van Loon *et al*., 1998; Haas *et al*., 2000; Kloepper, 2003).

Table 4. Influence of nutrients, organics and bio agents on leaf nutrient contents of okra 'COBhH 1' (pooled data of two seasons of 2010-2011)

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Zn (ppm)	Cu (ppm)
Sulphate of potash 1%	1.43	0.59	1.61	0.48	0.23	0.29	85.70	1.59
Micronutrient mixture 0.25%)	1.42	0.58	1.58	0.55	0.24	0.25	91.16	1.63
Cow urine 10%	1.52	0.63	1.54	0.58	0.26	0.26	86.06	1.55
Fermented buttermilk 10%	1.49	0.62	1.59	0.61	0.21	0.22	88.83	1.52
Humic acid 0.2%	1.54	0.66	1.65	0.64	0.29	0.30	92.03	1.65
Neem oil 0.3%	1.49	0.57	1.54	0.49	0.20	0.23	86.43	1.57
P. fluorescens as seed treatment 10g kg^{-1} + soil application 2.5kg ha^{-1} with FYM on 15 DAS+ foliar spray 0.2% on 30,45 and 60 DAS	1.50	0.62	1.57	0.57	0.25	0.24	89.43	1.62
Recommended practice - Soil application of carbofuran 1kg a.i ha^{-1} + foliar spray of dimethoate 0.03%	1.41	0.54	1.51	0.46	0.18	0.22	80.23	1.49
Control	1.13	0.30	0.99	0.28	0.11	0.15	62.73	1.23
SEd	0.05	0.04	0.07	0.05	0.03	NS	2.18	0.03
CD (0.05)	0.11	0.09	0.16	0.11	0.07	----	4.62	0.06

NS – Non Significant

Leaf nutrient status

The present study revealed that the nutrients and organics had significant role in increasing the nutrient contents (Table 4,5). Among the treatments, T_5 (foliar spray of humic acid @ 0.2 %) recorded the highest nitrogen, phosphorus, potassium, calcium, manganese, sulphur, zinc, copper, boron, magnesium and iron content at the final stage and was on par with T_2, T_3, T_4 and T_7. This may be attributed to principal physiological function of humic acid that they reduce the oxygen deficiency in plants which result in uptake of larger amount of N, P and K. (Bhuma, 2001).

The same trend was observed by Peng Zheng Ping *et al.* (2001) in brassica. The improved content of calcium and magnesium may be attributed to altered membrane permeability by humic acid, which would have allowed higher nutrient absorption process and enhanced the cuticle and cell membrane penetration (Virgine Tenshia, 2003). The leaf micronutrient contents were recorded the highest in plants which received foliar spray of humic acid @ 0.2%. The increased micronutrient contents in the leaf might be due to the effect of humic acid on the permeability of biomembrane for electrolytes resulting in increased intake of micronutrients from soil (Samson and Visser, 1989).

Table 5. Influence of nutrients, organics and bio agents on leaf nutrient contents and cost economics of okra 'COBhH 1' (pooled data of two seasons)

Treatment	Fe (ppm)	Mn (ppm)	B (ppm)	Cost of cultivation / ha (Rs)	Net return / ha (Rs)	B:C ratio
Sulphate of potash 1%	206.43	23.83	11.76	45,150	77,250	1:2.71
Micronutrient mixture 0.25%)	219.10	29.06	12.80	43,150	76,850	1:2.78
Cow urine 10%	210.16	25.53	11.74	41,550	79,250	1:2.90
Fermented buttermilk 10%	206.47	26.13	11.06	44,350	78,850	1:2.77
Humic acid 0.2%	221.86	32.20	13.41	43,230	83,970	1:2.94
Neem oil 0.3%	204.06	24.66	11.08	43,450	81,350	1:2.87
P. fluorescens as seed treatment 10g kg^{-1} + soil application 2.5kg ha^{-1} with FYM on 15 DAS+ foliar spray 0.2% on 30,45 and 60 DAS	214.86	26.53	12.54	42,850	87,550	1:3.04
Recommended practice - Soil application of carbofuran 1kg a.i ha^{-1} + foliar spray of dimethoate 0.03%	198.37	21.53	11.40	43,040	72,960	1:2.69
Control	162.06	16.10	9.69	40,350	45,250	1:2.12
SEd	3.40	1.93	0.46	---	---	---
CD (0.05)	7.21	4.10	0.98	---	---	---

Cost economics

It is evident from the Table 5 that the treatment T_7 (*Pseudomonas fluorescens* as seed treatment @ 10g kg^{-1} + soil application @ 2.5kg ha^{-1} with FYM on 15 DAS+ foliar spray @ 0.2% on 30,45 and 60 DAS)

proved to be the most profitable treatment in terms of highest net income (Rs 87,550) and benefit cost ratio with 1:3.04.

Conclusion

From the findings of present investigation, it was evident that increased growth, yield and leaf nutrient contents were obtained by using *Pseudomonas fluorescens* (seed treatment @ 10g kg^{-1} + soil application @ 2.5 kg ha^{-1} with FYM + foliar spray @ 0.2 %) and humic acid (0.2 %) which was highly effective, economical and eco-friendly.

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