International Journal of Tropical Agriculture
Volume 43, Numbers (3-4) • 2025 : pp. 251-258
ISSN: 0254-8755

A Study to Find Out the Optimum Nutrient Treatment with Combination of Vermiwash for Better Growth and Yield of Okra

Meenakshee Dwivedi, Saraswati Patel and Sakshi Dwivedi[2]

Department of Horticulture, College of Agriculture, JNKVV Jabalpur -482004, (MP)
[2]Department of Horticulture, College of Agriculture Sehore, RVSKVV Gwalior 474002, (MP)
E-mail id- meenakshee1988@gmail.com

Abstract: A field experiment was conducted to study the effect of vermiwash, vermicompost and NPK on growth and yield of okra (*Abelmoschus esculentus* L.) cv. VRO 6 to find out the optimum nutrient treatment with combination of Vermiwash for better growth and yield of okra. The experiment was conducted with 13 treatment combinations of NPK, Vermicompost and Foliar spraying of Vermiwash in Randomized Complete Block Design with three replications. Seeds of Okra, cv. VRO.-6 were sown on plot size of 3.6m X 3.0 m. The row to row and plant to plant spacing was maintained at 60 cm and 30 cm, respectively hence each plot accommodated 60 plants. The observations were recorded treatment wise by selecting 5 random plants. The treatment T5 (Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS) recorded maximum plant height (16.10cm., 115.40cm. and 163.19 cm.) at 30, 60 and 90 DAS, nodes per plant (19.66), internodal length (6.04cm.), leaves per plant (23.66) at 90 DAS and branches of 2.46 and 4.13 per plant at 60 and 90 DAS respectively. The earliest flowering in 35.58 days was recorded under treatment T10 (Vermicompost @ 5t/ha + Vermiwash 5 sprays at 1week interval after 30 DAS) and late flowering was recorded with treatment T13 (Rec. NPK 150:80:100). The treatment T10 (Vermicompost @ 5t/ha + Vermiwash 5 sprays at 1week interval after 30 DAS) recorded the maximum 4.93 nodes to first flowering. Days taken to 50 % flowering (43.50days) and first picking (45.23 days) was observed in T10 (Vermicompost @ 5t/ha + Vermiwash 5 sprays at 1week interval after 30 DAS) showed earliness. Number of flowers (19.66) and fruits per plant (18.66) was recorded in treatment T5 (Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS). The maximum fruit length (17.96cm), fruit girth (17.03mm) and fruit weight (18.16g) was recorded with the application of Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS. The significantly maximum fruiting span 48.86 days as well as maximum fruit yield (144.66g/plant), and 80.47q/ha) was obtained under T5 (Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS). The maximum net return of Rs 38484/ha was found in treatment T11 (Rec. NPK + Vermiwash (soil treatment)+3 foliar spray at 1 week interval after 30 DAS) and cost benefit ratio is 2.01. On the basis of present investigation it is concluded that the okra cv. VRO-6 responded well in terms of growth, yield and net profit to application of Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS. It produced tallest plant, having more number of nodes, internodal length, number of leaves as well as maximum number of branches per plant. The same treatment having the potential to produce higher fruit yield q/ha. Therefore, it is recommended that such technology can be adopted for commercial cultivation in the farmer's field.

Keywords: okra, Vermiwash, Vermicompost, NPK.

Article History: Received: 11 August 2025; Revised: 20 August 2025; Accepted: 10 September 2025; Published: 30 November 2025

INTRODUCTION

Indian agriculture has been traditionally dependent on organic manurial sources, but the share of these sources in total nutrients supply has been drastically curtailed with the introduction of intensive agriculture, which demands heavy nutrient availability. However, energy crisis resulted into high price index of chemical fertilizers coupled with their limited availability. Fertilizer cost, soil health, sustainability and pollution have led to a renewed interest in the use of organic manures. Organics play a vital role in maintenance of physical and biological condition of soil and supply macro and micro nutrients to crops besides maintenance of humic substances in soil [1]. Neither organic manures nor chemical fertilizer alone can achieve the yield sustainability separately under intensive farming. Their integrated use may help in improving soil health, productivity and quality of vegetable crop like okra. No doubt modern agriculture is based on the use of organic manures, which play a major role for producing good quality with higher production of okra from per unit area. There is a need to seek alternate sources of nutrient which could be a cheaper and eco-friendly so that farmers may be able to reduce the investment made on fertilizer along with maintaining good soil environmental conditions leading to ecological sustainable farming. Organic manure like vermicompost, compost, FYM and poultry manure etc. are very popular among the farmers and can easily be produced. Okra or Ladies finger, which is also known as 'Bhindi', is one of the important vegetable crops in India [2] [3]. It is grown throughout the tropical and sub-tropical regions and also in the warmer parts of the temperate regions. The nutritional value of 100g of edible okra is characterized 1.9g protein, 0.2g fat, 6.4g carbohydrate, 0.7g minerals and 1.2g fibers. Okra has a good potential as a foreign exchanger crop and accounts for 60% of the export of fresh vegetables. The major okra producing states are U.P., Bihar, Orissa, West Bengal and Andhra Pradesh. Nutrition plays a very important role in growth and productivity of okra. Nowadays, use of inorganic and organic nutrient sources is playing significant role in horticulture. It plays a major role for producing good quality and high yield per unit area. Vermiwash is an indispensable part of vermicompost, which is a watery extract of earthworms. It is basically a combination of secretion and wash of earthworms, present in the medium, honey brown in colour. It is a nutrient rich liquid produced by earthworms, feeding on organic waste material and plants residues. It is also non toxic and eco-friendly, which arrests bacterial growth and forms as a protective layer for their survival and growth[4][5]. Vermiwash contains NPK, Ca and hormones such as Auxins, Cytokinins, some other secretions and many useful microbes like heterotrophic bacteria, fungi etc. The quality of Vermiwash produced by earthworms depends on the vermicompost that is used. Vermiwash is a mixed culture containing soil bacteria mixed and an effective strain of earthworms. Earthworm has efficiency to consume all type of organic rich waste material including vegetable waste, industrial waste and other organic waste[6] [7]. Vermicomposting refers to the production of plant nutrient excreta of worms.

MATERIAL AND METHODS

The present investigation entitled "A Study to find out the optimum nutrient treatment with combination of Vermiwash for better growth and yield of okra" . The experimental detail of treatments comprised of 13 treatments with Vermiwash, vermicompost and recommended dose of NPK at different time interval are presented in Table 1.

Table 1: Detail of treatments and check used in the study

S. No.	*Treatment symbol*	*Detail of treatments*
1.	T1	Rec. NPK+ Vermiwash 1 spray at 1 week interval after 30 DAS
2.	T2	Rec. NPK+ Vermiwash 2 spray at 1 week interval after 30 DAS
3.	T3	Rec. NPK+ Vermiwash 3 sprays at 1 week interval after 30 DAS.
4.	T4	Rec. NPK+ Vermiwash 4 sprays at 1 week interval after 30 DAS.
5.	T5	Rec. NPK+ Vermiwash 5 sprays at 1 week interval after 30 DAS.
6.	T6 .	Vermicompost@5t/ha + Vermiwash 1 spray at1 week interval after 30 DAS
7.	T7 .	Vermicompost@5t/ha + Vermiwash 2 spray at1 week interval after 30 DAS
8.	T8	Vermicompost@5t/ha + Vermiwash 3 sprays at 1 week interval after 30 DAS.
9.	T9	Vermicompost@5t/ha + Vermiwash 4 spray at 1 week interval after 30 DAS.
10.	T10	Vermicompost@5t/ha + Vermiwash 5 sprays at 1 week interval after 30 DAS.
11..	T11.	Rec. NPK+ Vermiwash (Soil treatment) + 3 foliar sprays at 1 week interval after 30 DAS
12.	T12.	Vermicompost @5t/ha + Vermiwash (Soil treatment) + Vermiwash 3 foliar sprays
13	T13.	Recommended NPK (150:80:100)

STATISTICAL METHODOLOGY

The data obtained in respect of all the characters has been subjected to the following statistical analyses:

Mean

It was calculated by using following formula.

$$Mean = \frac{\Sigma X}{N}$$

ΣX

Mean= ----------

where;

ΣX = Sum of all the observations.

N = Number of observations.

A significant value of F test indicates that the test differ significantly among themselves which requires computing C.D.

$$C.V. = \frac{\sqrt{EMS}}{GM} \times 100$$

$$SEm\pm = \sqrt{\frac{EMS}{r}}$$

$$S\,E_{diff} = \sqrt{\frac{2EMS}{r}}$$

CD at 5% prob. level = SE diff x $t_{5\%}$ (table value)

where,

c.v. = Coefficient of variation

SEm± = Standard error of means

S E diff = Standard error of difference

GM = Grand mean

C.D. = Critical difference

t 5% = Table value at 5% probability level.

Economics of each treatment was computed on the basis of existing market price of all inputs used and the value of produce realized. Benefit : cost ratio of each treatment was determined by using the following formula.

Benefit : cost ratio = Gross value of the produce (Rs/ha.)

RESULTS AND DISCUSSION

The present study has been carried out with the objectives to find out the optimum nutrient treatment with combination of Vermiwash for better growth and yield of okra. Different growth and yield attributes as influenced by different treatments of Vermiwash, Vermicompost and NPK on okra are depicted in Table 2.The data clearly indicated that the plant height of okra responded significantly to different treatments of Vermiwash, vermicompost and NPK at all the growth stages under present studies. The treatment combination of T5 (Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS) was recorded maximum plant height 16.10 cm, 115.40 cm and 163.19 cm at 30, 60 and 90 DAS, respectively, followed by T4 Rec. NPK + Vermiwash 4 spraying

at 1week interval after 30 DAS] 15.86 cm, 106.58cm and 145.21cm at 30, 60 and 90 DAS, respectively and which were at par. As regards the application of vermicompost applied @5 t/ ha along with 5 spray of Vermiwash showed significant among the level of vermicompost and plant height of 143.90 cm. was recorded at 90DAS[8][9][10]. Soil application of vermicompost had not showed significant effect on plant height as compaired to same level of fertilizer and vermicompost along with 3 spray of Vermiwash. While, the lowest plant height of 12.20cm, 69.14cm and 110.23cm was recorded in treatment T6 (vermicompost @ 5 t/ha + Vermiwash 1 sprays at 1week interval after 30 DAS) at 30, 60 and 90 days after sowing, respectively[3]. The number of fruits per plant was recorded treatment wise and the mean values are depicted in Table 2. The application of Vermiwash in combination with recommended dose of NPK and Vermicompost @ 5t/ha showed significant differences in number of fruit per plant. The maximum fruits per plant (18.66) was recorded in the treatment T5 (Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS) followed by T4, T11, T3 and T2 which were at par with each other. Whereas, the minimum number of fruits per plant (10.60) was noted in treatment T6 (Vermicompost @5t/ha +Vermiwash 1 spray) [11][12]. The mean fruit length was significantly affected by the different spraying treatments of Vermiwash in combination of Vermicompost is given in Table 2. The maximum fruit length of 17.96cm, 17.58cm and 17.36cm were noted under the treatment combinations of T5 (Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS), T 4 (Rec. NPK + Vermiwash 4 sprays at 1 week interval after 30 DAS) and T11 (Rec. NPK + Vermiwash Soil treatment) + 3 foliar spray at 1week interval after 30 DAS), respectively and were found at par with each other. While, lowest fruit length of 15.27 cm was recorded under in treatment T6 (Vermicompost @5t/ha + Vermiwash 1 spray). The fruit weight was increased significantly by the various treatments of Vermicompost and recommended doses of NPK applied recommendation with spraying of Vermiwash on okra is given in Table 2. Application of treatment T5 (Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS) recorded maximum fruit weight (18.16 g), T4 (Rec. NPK + Vermiwash 4 sprays at 1 week interval after 30 DAS) which recorded 17.43 g fruit weight. Therefore, minimum fruit weight (13.86 g) was recorded in T6 (Rec. NPK 150:80:100). The yield of any crop is the final index of the experiment which indicated the success or failure of any treatment. With this view, the fruit yield of okra was recorded. The data for the fruit yield per plot under different treatments were recorded and converted into fruit yield per hectare (q)[13][14][15]. analysis of variance showed that okra fruit yield per hectare (q/ ha) was significantly affected due to different treatment combination of vermicompost, recommended doses of NPK and spraying of Vermiwash. Significantly maximum fruit yield (53.67, 52.54, 50.91 q/ha) were obtained under the treatments treatment T5 (Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS), T4 (Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS) T11 (Rec. NPK +Vermiwash (soil treatment)+ 3 foliar sprays at 1 week interval after 30 DAS), respectively and which were at par. However, the lowest fruit yield (35.69 q/ha) was observed in treatment T6 (Rec. NPK 150:80:100). [16][17].

CONCLUSIONS

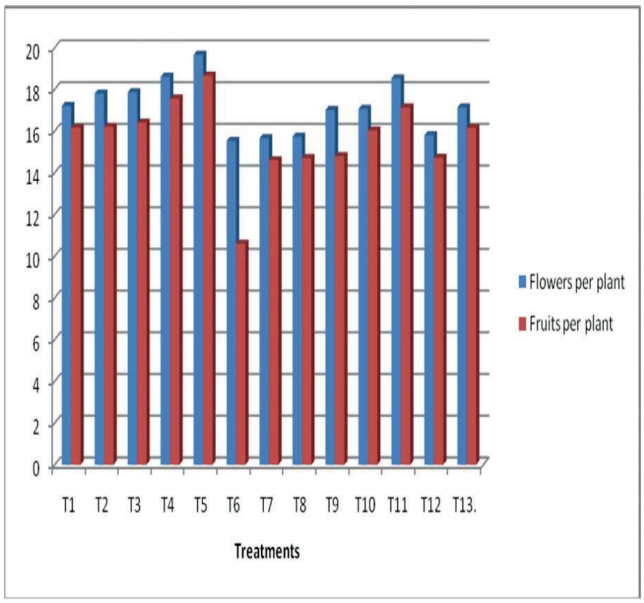
On the basis of present investigation it is concluded that the okra cv. VRO-6 responded well in terms of growth, yield and net profit to application of Rec. NPK + Vermiwash 5 sprays at 1 week interval after 30 DAS. It produced tallest plant, having more number of nodes, internodal length, number of leaves as well as maximum number of branches per plant. The same treatment having the potential to

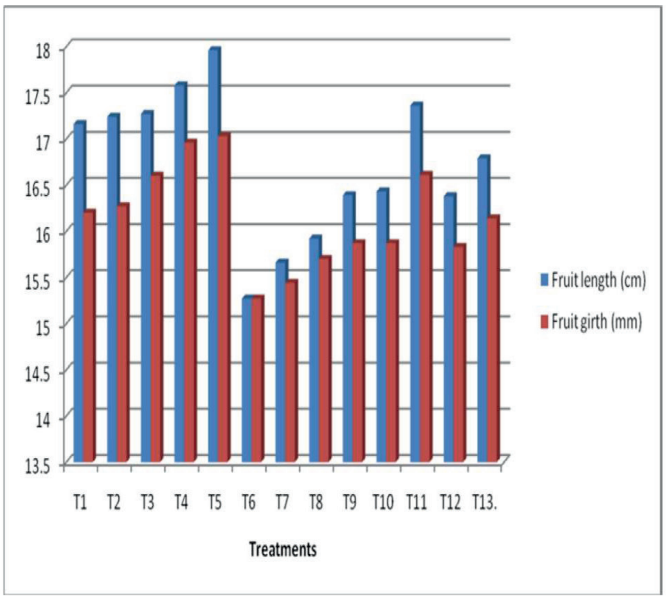
Table 2 : Economics of different treatments for okra

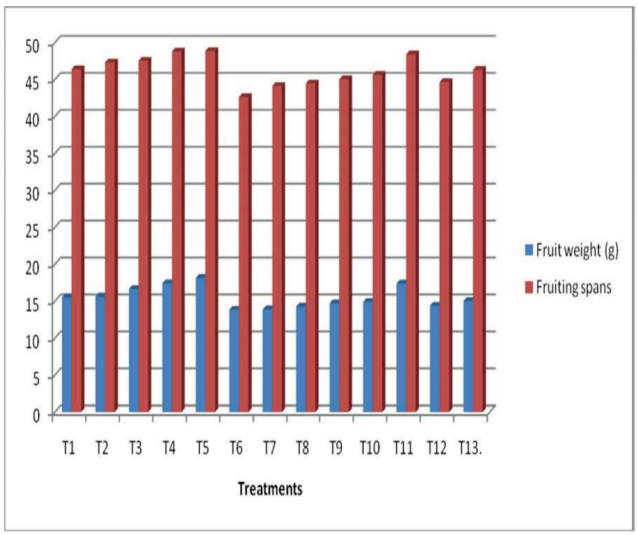
Treatment symbol	*Treatments*	*Fruit yield (q/ha)*	*Gross income (Rs/ha)*	*Expenditure (Rs/ha)*	*Net income (Rs/ha)*	*C:B ratio*
T1	Rec. NPK+ V W 1 spray	69.65	69650	51100	18550	1.36
T2	Rec. NPK+ V W 2 sprays	72.79	72790	54400	18390	1.33
T3	Rec. NPK+ V W 3 sprays	74.18	74180	41126	33054	1.8
T4	Rec. NPK+ V W 4 sprays	78.81	78810	54176	24634	1.45
T5	Rec. NPK+ V W 5 sprays	80.47	80470	44426	36044	1.81
T6	VC@5t/ha + V W 1 spray	53.55	53550	27926	25624	1.91
T7	VC@5t/ha + V W 2 spray	55.68	55680	64152	-8472	0.86
T8	VC@5t/ha + V W 3 spray	56.33	56330	31226	25104	1.8
T9	VC@5t/ha + V W 4 spray	62.71	62710	44500	18210	1.4
T10	VC@5t/ha + V W 5 sprays	66.41	66410	41200	25210	1.61
T11	Rec. NPK+ V W (Soil treatment) + 3 foliar sprays	76.31	76310	37826	38484	2.01
T12	VC@5t/ha + V W (Soil treatment) + V W 3 foliar spra	62.25	62250	47800	14450	1.3
T13.	Rec NPK (150:80:100)	69.09	69090	34526	34564	2

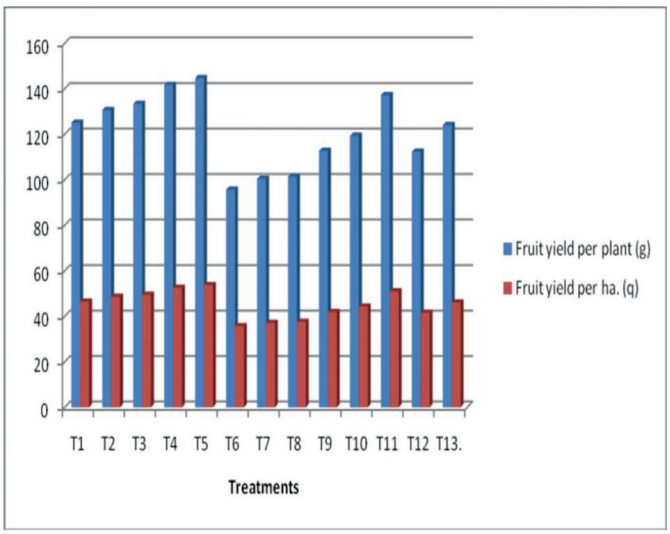
Table 3: Different growth and yield attributes as influenced by different treatments of Vermiwash, Vermicompost and NPK on okra

Treatment symbol	Treatments	Plant height (cm)			Nodes per plant90 DAS	Internodal length (cm) 90 DAS	Leaves per plant 90 DAS	Branches per plant		Days to first flowering	Nodes to first flowering	Daysto 50% flowering	Days to first picking	Flowers per plant	Fruits per plant	Fruit length (cm)	Fruit girth (mm)	Fruit weight (g)	Fruiting spans	Fruit yield per plant (g)	Fruit yield per ha. (q)
		30 DAS	60 DAS	90 DAS				60 DAS	90 DAS												
T1	Rec. NPK+ V W 1 spray	14.56	93.50	141.86	17.20	5.65	21.73	1.63	2.96	38.32	4.8	43.33	48.33	17.2	16.16	17.16	16.2	15.53	46.40	125.03	46.47
T2	Rec. NPK+ V W 2 sprays	14.73	100.73	143.10	17.80	5.68	21.9	1.7	3.2	38.06	4.8	43.33	48.33	17.8	16.2	17.24	16.27	15.63	47.3	130.66	48.53
T3	Rec. NPK+ V W 3 sprays	15.26	101.96	143.16	17.86	5.77	22.1	1.73	3.6	37.66	4.56	43.02	47.66	17.86	16.4	17.27	16.6	16.66	47.53	133.33	49.46
T4	Rec. NPK+ V W 4 sprays	15.86	106.58	145.21	18.60	5.86	23.33	2.23	4	37.63	4.53	43.1	47.66	18.6	17.56	17.58	16.96	17.43	48.8	141.66	52.54
T5	Rec. NPK+ V W 5 sprays	16.10	115.40	163.19	19.66	6.04	23.66	2.46	4.13	37.14	4.53	43.1	47.66	19.66	18.66	17.96	17.03	18.16	48.86	144.66	53.67
T6	VC@5t/ha + V W 1 spray	12.20	69.14	110.23	15.33	4.71	18.93	0.94	2.06	37.1	4.4	42.43	47.63	15.53	10.6	15.27	15.27	13.86	42.63	95.66	35.69
T7	VC@5t/ha + V W 2 spray	13.10	78.30	112.15	15.66	4.9	19.96	1.11	2.2	36.7	4.33	42.23	47.33	15.66	14.6	15.66	15.44	13.9	44.13	100.42	37.14
T8	VC@5t/ha + V W 3 spray	13.60	79.46	135.23	15.73	4.98	21.03	1.2	2.22	36.4	4.26	41.66	47.33	15.73	14.7	15.92	15.7	14.28	44.46	101.33	37.55
T9	VC@5t/ha + V W 4 spray	14.06	83.50	136.73	17.00	5.12	21.23	1.4	2.26	36.3	4.2	41.33	46.66	17.01	14.8	16.39	15.87	14.73	45.03	112.66	41.85
T10	VC@5t/ha + V W 5 sprays	14.36	92.06	138.96	17.06	5.34	21.6	1.43	2.64	35.58	4.2	41.01	45.23	17.06	16.03	16.43	15.87	14.9	45.63	119.33	44.31
T11	Rec. NPK+ V W (Soil treatment) + 3 foliar sprays	15.33	103.23	143.90	18.53	5.78	22.8	1.86	3.86	37.8	4.6	43.02	48.33	18.53	17.13	17.36	16.61	17.4	48.4	137.22	50.91
T12	VC@5t/ha + V W (Soil treatment) + V W 3 foliar sprays	13.65	83.50	137.06	15.80	5.06	21.07	1.26	2.25	36.57	4.33	42	46.66	15.8	14.71	16.38	15.83	14.4	44.66	112.33	41.54
T13.	Rec NPK (150:80:100)	14.40	92.66	139.37	17.13	5.53	21.63	1.46	2.93	38.84	4.93	43.5	49.54	17.13	16.15	16.79	16.14	15.03	46.33	124.02	46.06
SEm±		0.843	2.163	1.431	0.76	0.259	0.48	0.253	0.386	0.56	0.09	0.36	0.3	0.76	0.7	0.42	0.25	0.49	0.65	6.167	2.261
C.D. at 5%		NS.	6.571	4.348	2.21	0.787	1.3	0.769	1.174	1.703	0.27	1.06	0.89	2.21	2.04	1.24	0.72	1.44	1.99	18.73	6.86









produce higher fruit yield q/ha. Application of recommended dose of NPK + Vermiwash as soil treatment with 3 foliar sprays of Vermiwash at 1 week interval after 30 DAS fetched maximum net return and C:B ratio as comparison to other treatments.

REFERENCES

Basavaraja, N.; Ravi Hunje and B. Chandravathi (2009). Influence of organic and inorganic source of nutrients on growth and seed yield of okra [*Abelmoschus esculentus* (L.) Moench]. *Proceedings of International conference on Horticulture held at Bangalore,* November, **9-12**, *2009.* pp 1386-1390.

Choudhary, A. K. (2006). Genetic behaviour of yield and its components in hybrid okra [*Abelmoschus esculentus* (L.) Moench]. *M.Sc. (Ag.) Thesis*, J.N.K.V.V., Jabalpur.

Ganga, M.; M. Jawaharlal; K. Padmadevi and V. Jagadeeswari (2009). Response of dendrobium cv. Sonia 17 to integrated nutrient management. *Proceeding of International conference on Horticulture held at Bangalore,* November **9-12**, 2009. pp 936-939.

Ansari, A. A. Sukhraj Kumar (2010). Effect of vermiwash and vermicompost on soil parameters and productivity of okra. Current Advances in Agricultural Sciences 2010 2:1, 1-4

Maithy, T.K. and P. Tripathy (2009). Impact of integrated nutrient management on growth yield, quality, nutrient content and soil fertility in okra [*Abelmoschus esculentus* (L.) Moench]. Hybrids. *Proceedings of International conference on Horticulture held at Bangalore,* November **9-12,** 2009. PP. 677-679.

Pandey, S.K.; Anant Bahadur; Raghavendra Singh and M. C. Singh (2009). Effect of organic manures and biofertilizers on biomass distribution, growth and yield of okra. *Veg. Sci.* **36 (3):** 415-417.

Ravi, S.; K. Kempe Gowda and R. Krishnamanohar (2006). Influence of integrated nutrient management on vegetative growth parameters and yield in bhindi [*Abelmoschus esculentus* (L.) Moench] cv. Arka Anamika. *South Indian Hort.,* **54 (1-6):** 165- 170.

Sharma, T.R.; A.K. Pandey; S.D. Updhyaya and S.B. Agrawal (2010). Effect of vermicompost on yield and quality of Kharif season okra [*Abelmoschus esculentus* (L.) Moench]. *Veg. Sci*. **37 (1-2):** 181-183.

Gorakhnath and Keshav Singh (2009). Effect of different concentration of vermiwash of different vermicompost of different combination of animal agro and kitchen waste on the growth (cm) of okra. *J Cent. Eur. Agric.* **10 (4):** 417-426.

Singh, R. V. (2001). Effect of intercrop and N, P fertilization on performance of okra [*Abelmoschus esculentus* (L.) Moench]. *J. Res. Bira .Agril. Univ.,* **13 (1):** 41-44.

Paramasivan, M.; D. Jawahar and V. V. Krishnamoorthi (2006). Effect of organic manures and inorganic fertilizers on yield and economics of okra [*Abelmoschus esculentus* (L.) Moench] In an Alfisol of Tambiraparani Tract. *South Indian Hort.,* **53 (1-6):** 312- 315.

Singh, J.K.; Anant Bahadur; N.K.Singh and T.B. Singh (2010). Effect of using varying level of NPK and biofertilizers on vegetative growth and yield of okra [*Abelmoschus esculentus* (L.) Moench]. *Veg. Sci*. **37 (1):** 100-101.

Sundaram, V. and V. Kanthaswamy (2006). Effect of specialty fertilizers on yield of bhindi. *South Indian Hort.,* **54 (1-6):** 352-356.

Sankar, Mini and T. Radha (2009).Effect of organic sources of nutrients on vegetative and f loral characters of tuberose (*Polianthes tuberose* L.). *Proceeding of International conference on Horticulture held at Bangalore,* November **9-12**, 2009. pp 1736-1738

Singh, R. K., Pandey, P. C., & Verma, D. P. (2020). Role of organic amendments in sustainable vegetable production: A review. Indian Journal of Horticulture, 77(2), 139- 149.Chapman, H.D. and Pratt, P.F. (1961) Methods of analysis for soil, plant and water. Division of Agricultural Science, California University, USA. 309.

Yassen AA, Essa EM, Marzouk NM, Zaghloul SM. Impact of vermicompost and foliar spray of vermiwash on growth, yield and nutritional status of lettuce plants. Plant Arch. 2020;20(1):449-55.

Joshi A. D, L. R. Yadav, Bhavna Singh Ratore, Hritik Srivastava, Ram Singh Verma, Biram Singh Gurjar, Mamta Yadav, Chetana Sharma and Anchal Karol (2023). Enhancing Nutrient Uptake and Economics of Black Gram through Vermicompost andVermiwashApplication. *International Journal of Environment and Climate Change.Joshi A. D , L. R. Yadav, Bhavna Singh Ratore, Hritik Srivastava, Ram Singh Verma, Biram Singh Gurjar, Mamta Yadav, Chetana Sharma and Anchal Karol (2023). Enhancing Nutrient Uptake and Economicsof Black Gram through Vermicompost and Vermiwash Application. International Journal of Environment and Climate Change.*