Journal of Experimental Agriculture International

Volume 47, Issue 1, Page 133-141, 2025; Article no.JEAI.128302
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Enhancing Growth and Yield of Tulsi (*Ocimum sanctum* L.): Influence of Organic Manure and Inorganic Fertilizer Applications

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jeai/2025/v47i13211

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/128302

Original Research Article

Received: 22/10/2024
Accepted: 24/12/2024
Published: 13/01/2025

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Cite as: *Shinde, Sharmila, Kranti Patil, R. T. Gaikwad, and Pravin Khaire. 2025. "Enhancing Growth and Yield of Tulsi (Ocimum Sanctum L.): Influence of Organic Manure and Inorganic Fertilizer Applications". Journal of Experimental Agriculture International 47 (1):133-41. https://doi.org/10.9734/jeai/2025/v47i13211.*

ABSTRACT

The indiscriminate use of inorganic fertilizers depletes soil fertility and reduces crop yields. Limited information exists on nutrient management for Tulsi (*Ocimum sanctum* L.). A field experiment conducted from 2016-17 to 2019-20 at Rahuri (MS) evaluated the effects of organic manure and inorganic fertilizer levels on Tulsi yield. The randomized block design (RBD) experiment included 12 treatments combining chemical fertilizers (N:P2O5:K2O) at three levels (30:20:10, 40:30:20, and 50:40:30 kg ha^{-1}) with or without farmyard manure (FYM) at 5 or 10 t ha^{-1}, alongside FYM-only and control treatments. The results showed that, the treatment T9 (50:40:30 kg ha^{-1} + FYM 10 t ha^{-1}) significantly improved plant height, branches per plant, fresh and dry herbage yield, and soil nutrient status (N, P, and K) over the control. T9 also achieved the highest economic returns with a superior B:C ratio, closely followed by T8 (40:30:20 kg ha^{-1} + FYM 10 t ha^{-1}). This study concludes that combining higher inorganic fertilizer levels with FYM (10 t ha^{-1}) optimizes growth, yield, and soil fertility in Tulsi cultivation.

Keywords: Yield optimization; integrated nutrient management; Farmyard Manure (FYM); soil fertility enhancement; herbal crop economics; ocimum sanctum growth.

1. INTRODUCTION

"The export of herbs and value-added extracts of medicinal herbs has been gradually increasing over years. In 2017-2018, India exported US$ 330.18 million worth of herbs at a growth rate of 14.22 per cent over the previous year. Also, exports of value-added extracts of medicinal herbs and herbal products in 2017-2018 stood at US$ 456.12 million, recording a growth rate of 12.23 per cent over the previous year. The demand for herbal/value-added extracts of medicinal herbs is gradually increasing in foreign countries, especially in European and other developed countries" (Annonymous., 2021). Tulsi (*Ocimum sanctum*) is known as the queen of herb. The main chemical constituents of tulsi are oleanolic acid, ursolic acid, rosmarinic acid, eugeol, carvacrol, linalool and B-caryophyllene have been used extensively for many years in food products, perfumery, dental and oral products etc. (Panchal and Parvez, 2019) and plant extract continues the numerous searches for more effective drugs of plant origin (Annonymous., 2021). The demand and market value of this herb have rapidly risen during pre and post corona pandemic and everyone know it's nutritional, medicinal and economical values. It has widest distribution which covers the entire Indian sub-continent as cending up to 1800 MSL in the Himalayas and in Andaman and Nicobar Islands. "This plant occupies a wide range of habitats. It is, an annual herb, cultivated extensively in Indonesia, Thailand, Vietnam, USA, Combodia, Laos, Taiwan, France, Egypt, Greece, Morocco, Israel and many other regions of the world" (Ram et al., 2019). The increasing emphasis on environmental conservation has led to substantial efforts to minimize the use of chemical fertilizers and pesticides (Samanta et al., 2023). The yield of tulsi can be increased by supplying essential nutrients through chemical fertilizers alone but considering the point of sustaining soil health in mind we choose to apply integrated sources of nutrients and as well as it is a medicinal plant we must have to give priority for market value and quality of the crop. The organic fertilizers have the great role as a plant growth promoter, plant health by disease resistance and also help in the disease management which ultimately leads to get the more yield of the crops (Khaire et al., 2021). "On tulsi very limited studies were carried out on the combined effect of organic and inorganic fertilizers on growth and yield" (Kalavala and Abhilasha 2024, Mirudhula et al. 2023). Keeping this view investigation of the effect of integrated nutrient management on growth and yield of tulsi was carried out.

2. MATERIALS AND METHODS

The field experiment was laid out during *Kharif* season from 2016 to 2020 at AICRP on Medicinal aromatic and Betelvine project. The geographical location of the study area is lie between 74.65' E longitudes and 19.35' N latitude with an average elevation of 511 m above mean sea level (msl). The average annual rainfall is about 621 mm. The Average minimum and maximum temperature during experimental period from June to September were ranged from 33.4 ^{0}C to 23.0^{0}C respectively. The soil of

experimental field belongs to an inceptisol soil having soil pH was slightly alkaline in reaction pH (8.11), electric conductivity (0.19 dSm^{-1}), low in organic carbon (0.21%), low in available nitrogen (157.67 kg ha^{-1}), medium in available phosphorus (23.0 kg ha^{-1}) and high in available in potassium (238.00 kg ha^{-1}). The experiment was laid out in a Randomised Block Design with twelve treatments which were replicated thrice. The experiment comprising of twelve treatments consisting of chemical fertilizers levels of $N:P_2O_5:K_2O$ and organic manures *viz.,* T_1- 30:20:10 kg ha^{-1}, T_2- 40:30:20 kg ha^{-1},T_3- 50:40:30 kg ha^{-1}, T_4 - 30:20:10 kg ha^{-1} + FYM 5 t ha^{-1}, T_5- 40:30:20 kg ha^{-1} + FYM 5 t ha^{-1},T_6- 50:40:30 kg ha^{-1} + FYM 5 t ha^{-1}, T_7- 30:20:10 kg ha^{-1} + FYM 10 t ha^{-1}, T_8- 40:30:20 kg ha^{-1} + FYM 10 t ha^{-1}, T_9-50:40:30 kg ha^{-1}+ FYM 10 t ha^{-1} , T_{10} -FYM 5 t ha^{-1}, T_{11}-FYM 10 t ha^{-1} and T_{12}-absolute control. The farmyard manure was applied as per treatment, 15 days before transplanting of seedlings with light irrigation. The thirty days old healthy and uniformly rooted seedlings of tulsi was transplanted in the field at 60 x 45 cm^2 spacing. The N, P_2O_5 and K_2O were applied through straight fertilizers like urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. The half dose of N and full dose of P_2O_5 and K_2O was applied at the time of transplanting as basal dose and remaining half dose of N, 30 days after transplanting as top dressing. The weeding was done manually and flood irrigation was given an interval of 4-5 days in initial stages and subsequently, depending on the soil moisture condition. Initially, the representative soil sample from experimental site was taken to know the nutrient status of soil. At physiological maturity stage of crop, treatment wise representative soil samples from each plot were collected from 0-20 cm depth with the help of screw augur from five randomly selected spots within the net plot area and these samples were subjected to analysis for pH, electrical conductivity (EC), organic carbon (OC) and available N (av. N), available P (av. P), available K (av. K) in soil by using standard methods. Soil pH of the samples was determined in 1:2.5 soil: water ratio (w/v) with the help of glass electrode pH meter (Jackson, 1973). Electrical Conductivity was estimated in 1:2.5 soil: water suspension with EC meter (Jackson, 1973). Organic carbon was estimated by rapid titration method (Walkley and Black, 1934), soil available nitrogen by Alkaline permanganate method (Subbiah and Asija 1956), P by Olsen's method (Olsen et al*.,* 1954) and K by Flame photometer (Jackson, 1973). The statistical analysis of data recorded for various characters studied in the investigation was followed by using statistical procedures appropriate to RBD as described by (Panse and Sukhatme (1978) and the significance was tested by "Variance ratio" i.e. "F" test. Five percent level of significance was used to test the significance of results. The pooled results are summarized as under.

3. RESULTS AND DISCUSSION

3.1 Yield Attributing Characters of Tulsi

The four years (2016-17 to 2019-20) of experimentation pooled results are summarized in Tables 1 and 2 indicated that the application of inorganic fertilizer along with the FYM influenced the yield attributing characters. The result showed wide range between values of growth characters due to single application of organic, inorganic and its combined application. The significantly maximum height of plant (76.44 cm) was recorded by the treatment T_9 ($N:P_2O_5:K_2O$ 50:40:30 kg ha^{-1} + FYM 10 t ha^{-1}), while minimum height was observed (60.47cm) in the treatment T_{12} (Absolute control). In case of number of branches, the significantly maximum branches (22.37) was observed in treatment T_9 ($N:P_2O_5:K_2O$ 50:40:30 kg ha^{-1}+FYM 10 t ha^{-1}), but it was statistically a par with treatment T_8 ($N:P_2O_5:K_2O$ 40 : 30:20 + FYM 10 tha^{-1}), T_7 ($N:P_2O_5:K_2O$ 30:20:10 kg ha^{-1}+ FYM 10 t ha^{-1}) and T_6($N:P_2O_5:K_2O$ 50:40:30 kg ha^{-1} + FYM 5 t ha^{-1}) which recorded 21.15, 21.04 and 21.03 branches per plant, respectively. The minimum number of branches per plant (15.85) was observed in the treatment T_{12} (Absolute control). It was found that only application of FYM manure recorded plant height in the range of 62.54 to 65.11 cm., only application of $N:P_2O_5:K_2O$ chemical fertilizers recorded plant height in range of 60.00 to 61.29 cm. and combined application of FYM + $N:P_2O_5:K_2O$ fertilizers recorded plant height in the range of 66.00 to 76.44 cm. As regards the number of branches per plant, only application of FYM manure recorded 16.93 to 18.03 branches per plant, only application of $N:P_2O_5:K_2O$ fertilizers recorded 18.32 to 18.80 branches per plant and combined application of FYM + NPK fertilizers recorded 18.59 to 22.37 branches per plant. It clearly indicated that increased rate of nutrients resulted in to increased growth characters. This might be due to better nutritional environment in the root-zone for growth and development of the crop (Meena and Dhaka, 2022). Enhancing in tulsi growth

Table 1. Effect of integrated nutrient management growth attributes of Tulsi

Treatments	Plant height (cm)					No. of branches plant^{-1}				
	2016-17	2017-18	2018-19	2019-20	Pooled mean	2016-17	2017-18	2018-19	2019-20	Pooled mean
T_1 - N:P_2O_5:K_2O 30: 20:10 kg ha^{-1}	58.40	60.46	62.77	60.14	60.44	18.20	18.48	19.42	17.42	18.38
T_2 -N:P_2O_5:K_2O 40:30:20 kg ha^{-1}	57.97	58.96	60.32	62.77	60.00	17.50	19.76	20.42	17.53	18.80
T_3 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1}	60.13	59.97	61.68	63.39	61.29	18.30	18.56	17.96	18.45	18.32
T_4 - N:P_2O_5:K_2O 30:20:10 kg ha^{-1} + FYM 5 t ha^{-1}	64.20	67.91	66.46	65.43	66.00	17.20	23.32	20.73	19.95	18.59
T_5 - N:P_2O_5:K_2O 40:30:20 kg ha^{-1} + FYM 5 t ha^{-1}	67.23	66.60	65.85	68.46	67.04	18.90	16.36	18.25	20.83	20.49
T_6 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1} + FYM 5 t ha^{-1}	67.00	72.68	74.79	72.44	71.73	17.80	20.48	21.35	20.83	21.03
T_7 - N:P_2O_5:K_2O 30:20:10 kg ha^{-1} + FYM 10 t ha^{-1}	69.20	73.76	74.33	72.31	72.40	19.90	20.23	21.19	21.92	21.04
T_8 - N:P_2O_5:K_2O 40:30:20 kg ha^{-1} + FYM 10 t ha^{-1}	71.83	72.51	73.37	75.45	73.29	20.80	20.69	24.12	22.41	21.15
T_9 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1} + FYM 10 t ha^{-1}	75.70	76.93	75.44	77.70	76.44	23.60	23.32	23.43	23.55	22.37
T_{10} - FYM 5 t ha^{-1}	58.73	63.43	65.39	62.60	62.54	14.90	18.51	16.41	17.88	16.93
T_{11} - FYM 10 t ha^{-1}	63.94	65.18	67.37	63.96	65.11	17.10	20.31	18.27	16.42	18.03
T_{12} – Absolute control	58.53	63.32	59.47	59.52	60.21	15.23	15.96	16.75	15.45	15.85
S.E. ±	3.02	2.40	2.31	2.37	0.96	0.58	0.65	0.75	0.65	0.57
C.D. at 5%	8.85	7.04	6.76	6.97	2.40	1.71	1.91	2.21	1.90	1.61

Table 2. Effect of integrated nutrient management on fresh and dry herbage yield of Tulsi

Treatments	Fresh herbage yield (q ha^{-1})					Dry herbage yield (q ha^{-1})				
	2016-17	2017-18	2018-19	2019-20	Pooled mean	2016-17	2017-18	2018-19	2019-20	Pooled mean
T_1 - N:P_2O_5:K_2O 30: 20:10 kg ha^{-1}	94.32	107.65	111.28	100.88	96.99	17.89	20.91	21.51	18.58	18.72
T_2 -N:P_2O_5:K_2O 40:30:20 kg ha^{-1}	118.50	116.47	112.90	105.32	108.29	22.81	22.81	21.72	20.26	20.91
T_3 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1}	121.66	119.46	117.20	109.89	111.97	23.05	23.06	22.76	21.58	21.61
T_4 - N:P_2O_5:K_2O 30:20:10 kg ha^{-1} + FYM 5 t ha^{-1}	118.07	123.21	123.20	113.65	114.30	23.15	23.65	23.58	21.87	22.06
T_5 - N:P_2O_5:K_2O 40:30:20 kg ha^{-1} + FYM 5 t ha^{-1}	133.48	128.00	131.27	115.91	121.04	25.58	24.36	25.10	22.37	23.36
T_6 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1} + FYM 5 t ha^{-1}	143.77	141.97	136.10	119.84	130.73	27.65	27.73	26.40	23.13	24.69
T_7 - N:P_2O_5:K_2O 30:20:10 kg ha^{-1} + FYM 10 t ha^{-1}	144.81	146.70	142.33	123.48	127.93	27.83	28.31	27.37	23.26	25.23
T_8 - N:P_2O_5:K_2O 40:30:20 kg ha^{-1} + FYM 10 t ha^{-1}	164.15	150.38	147.32	127.34	147.77	31.86	29.02	28.61	24.58	28.52
T_9 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1} + FYM 10 t ha^{-1}	168.85	162.87	156.73	134.57	156.84	33.03	31.51	30.65	25.91	30.27
T_{10} - FYM 5 t ha^{-1}	111.63	115.33	114.05	99.26	103.99	21.21	23.17	22.14	17.75	20.07
T_{11} - FYM 10 t ha^{-1}	139.70	121.97	119.72	101.74	114.72	26.54	23.87	21.85	20.28	22.14
T_{12} – Absolute control	96.07	98.76	102.79	92.45	86.58	18.39	19.06	17.46	16.06	16.71
S.E. ±	3.03	2.97	2.46	2.73	2.43	0.95	1.10	1.19	1.19	0.97
C.D. at 5%	8.89	8.73	7.21	8.02	6.56	2.79	3.23	3.51	3.51	2.42

might be due to the gradual increase in doses of N P_2O_5-K_2O which increased the uptake of nutrients. These results are line with the reports of (Basavaraju et al., (2012). (Rehman et al. (2014) reported that the growth and yield characters significantly influenced by organic manures and fertilizers in Tulsi and Pudina. Present results are also in close conformity with the (Phalak et al. (2016) in Glory lily and (Renata et al. (2012) in common Basil.

3.2 Tulsi Yield

The data in respect of fresh and dry herbage yield is presented in Table 2. The results in respect of fresh herbage yield, ranged between 86.58 to 156.84 q ha^{-1} and of dry herbage yield between 16.71 to 30.27 q ha^{-1}. Integrated nutrient management practices had significant effect on fresh and dry herbage yield at different growth stages of the plant. Nitrogen is the major constituent of chlorophyll that serves for photosynthesis. Phosphorus is also major binding block of nucleic acid and potassium plays a very important role in the regulation of metabolic activities in plants. A gradual increase in fertilizer doses with certain amount of farm yard manure increases the fresh and dry herbage yield gradually. The application N:P_2O_5:K_2O 50:40:30 kg ha^{-1}+FYM 10 t ha^{-1} (T_9) resulted significantly highest fresh herbage yield of 156.84 q ha^{-1} as well as dry herbage yield of 30.27 q ha^{-1}. However, it was statistically at par with application of N:P_2O_5:K_2O 40:30:20 kg ha^{-1} + FYM 10 t ha^{-1} (T_8) which recorded 28.52 q ha^{-1} of dry herbage yield. The minimum fresh herbage yield (86.58 q ha^{-1}) and dry herbage yield (16.71 q ha^{-1}) were recorded in the treatment T_{12} (Absolute control). As regards the fresh and dry herbage yield, only application of FYM manure recorded 103.99 to 114.72 q ha^{-1} fresh herbage yield and 20.07 to 22.14 q ha^{-1} dry herbage yield while, only application of N:P_2O_5:K_2O fertilizers recorded 96.99 to 111.97 q ha^{-1} fresh herbage yield and 18.72 to 21.61 q ha^{-1} dry herbage yield whereas combined application of FYM + N:P_2O_5:K_2O fertilizers recorded 114.30 to 156.84 q ha^{-1} fresh herbage yield and 22.06 to 30.27 q ha^{-1} dry herbage yield. It clearly indicated that integrated application of straight chemical fertilizers with farmyard manure found to be best over soil application of chemical fertilizers or manure. The reason may be due to integrated effect of chemical fertilizers and FYM which help in overall growth and development of crop. Higher fresh and dry herbage could be attributed to better growth and dry matter accumulation, which is due to enhanced availability and uptake of nutrients. Almost similar results have been reported by (Rehman et al (2014) also reported that the fresh leaf yield was significantly influenced by organic manures and fertilizers. As the tulsi responds well for the different nutrients levels, it directly effects on the growth characters, ultimately results into increased yield. (Allam et al. (2001) has reported the increased nitrogen level increases dry leaf biomass and yield of stevia plant. Similar results were also obtained by (Elamin (1999) and (Salem et al. (2005) in Senna crop.

Table 3. Effect of integrated nutrient management on soil fertility at harvest

Treatments	Soil available nutrients (kg ha^{-1})			
	O.C. (%)	N	P	K
T_1 - N:P_2O_5:K_2O 30: 20:10 kg ha^{-1}	0.19	147.00	19.00	347.00
T_2 - N:P_2O_5:K_2O 40:30:20 kg ha^{-1}	0.19	149.00	20.00	254.33
T_3 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1}	0.20	152.00	21.00	254.00
T_4 - N:P_2O_5:K_2O 30:20:10 kg ha^{-1} + FYM 5 t ha^{-1}	0.29	153.00	20.00	260.00
T_5 - N:P_2O_5:K_2O 40:30:20 kg ha^{-1} + FYM 5 t ha^{-1}	0.33	160.00	24.00	264.00
T_6 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1} + FYM 5 t ha^{-1}	0.34	163.00	26.00	269.00
T_7 - N:P_2O_5:K_2O 30:20:10 kg ha^{-1} + FYM 10 t ha^{-1}	0.36	163.33	20.00	362.00
T_8 - N:P_2O_5:K_2O 40:30:20 kg ha^{-1} + FYM 10 t ha^{-1}	0.36	164.00	28.00	372.00
T_9 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1} + FYM 10 t ha^{-1}	0.39	166.00	28.00	380.00
T_{10} - FYM 5 t ha^{-1}	0.31	141.00	20.67	234.00
T_{11} - FYM 10 t ha^{-1}	0.29	147.33	23.00	240.00
T_{12} – Absolute control	0.16	138.00	16.00	238.00
SE ±	0.01	1.39	1.03	10.21
CD 5%	0.03	4.08	3.03	30.55

Table 4. Effect of different levels of nutrients on economics of Tulsi

Treatments	Dry herbage yield (q ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross monitory return (Rs. ha^{-1})	Net monitory return (Rs. ha^{-1})	B: C ratio
T_1 - N:P_2O_5:K_2O 30: 20:10 kg ha^{-1}	18.72	82395	149760	67365	1.82
T_2 - N:P_2O_5:K_2O 40:30:20 kg ha^{-1}	20.91	84591	167200	82609	1.98
T_3 -N:P_2O_5:K_2O 50:40:30 kg ha^{-1}	21.61	86788	172880	86092	1.99
T_4 - N:P_2O_5:K_2O 30:20:10 kg ha^{-1} + FYM 5 t ha^{-1}	22.06	90395	176480	86085	1.95
T_5 - N:P_2O_5:K_2O 40:30:20 kg ha^{-1} + FYM 5 t ha^{-1}	23.36	92591	186880	94289	2.02
T_6 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1} + FYM 5 t ha^{-1}	24.69	94788	201840	107052	2.01
T_7 - N:P_2O_5:K_2O 30:20:10 kg ha^{-1} + FYM 10 t ha^{-1}	25.23	98395	197520	99125	2.13
T_8 - N:P_2O_5:K_2O 40:30:20 kg ha^{-1} + FYM 10 t ha^{-1}	28.52	100591	228160	127569	2.27
T_9 - N:P_2O_5:K_2O 50:40:30 kg ha^{-1} + FYM 10 t ha^{-1}	30.27	102788	242160	139372	2.36
T_{10} - FYM 5 t ha^{-1}	20.07	94000	160560	66560	1.71
T_{11} - FYM 10 t ha^{-1}	22.14	100000	177120	77120	1.77
T_{12} - Absolute control	16.71	80000	133680	53680	1.67

3.3 Soil Residual Fertility Status

The results in respect of residual soil fertility status were presented in Table 3. As regards the fertility status of the soil, among all the treatments increased trend of organic carbon, soil available nitrogen, phosphorus and potassium were observed over control due to application of chemical fertilizers along with organic manure FYM. The results showed that soil organic carbon ranged between 0.16 to 0.39 %, available nitrogen between 138.0 to 166.0 kg ha^{-1}, available phosphorus between 16.0 to 28.0 kg ha-1 and available potassium between 238.0 to 380.0 kg ha-1. The treatment T_9 ($N:P_2O_5:K_2O$ 50:40:30 kg ha^{-1} + FYM 10 t ha^{-1}) recorded highest values of organic carbon (0.39 %), av. nitrogen (166.0 kg ha^{-1}), av. phosphorus (28.0 kg ha^{-1}) and av. potassium (380.00 kg ha^{-1}) than the rest of the treatments. The least values of organic carbon (0.16 %), av. N (138.0 kg ha^{-1}), av. P (16.0 kg ha^{-1}) and av.K (238.0 kg ha^{-1}) was observed in absolute control. As regards the influence of FYM manure, NPK fertilizers and its combined application was concerned, only application of FYM manure recorded OC between 0.29 to 0.31% organic carbon, only application of NPK fertilizers recorded 0.19 to 0.20 % organic carbon whereas, combined application of FYM + NPK fertilizers recorded 0.29 to 0.39% organic carbon. This suggests a highest residual effect of FYM with regards to sequestration of C in soil. “In addition, high biomass production and consequently, high rhizodeposition of carbonaceous materials through root and sloughed off tissue may be one of the reasons for higher organic C in treated soils” (Franzluebbers et al. 1995).

In case of av. N, only application of FYM manure recorded av.N between 141.0 to 147.331 kg ha^{-1}, only application of chemical fertilizers recorded 147.0 to 152.0 kg ha^{-1} whereas, combined application of FYM + NPK fertilizers recorded 153.0 to 166.0 kg ha^{-1}. In case of av. P, only application of FYM manure recorded av. P between 20.67 to 23.0 kg ha^{-1}, only application of $N:P_2O_5:K_2O$ fertilizers recorded 19.0 to 21.0 kg ha^{-1} whereas, combined application of FYM + NPK fertilizers recorded 20.0 to 28.0 kg ha^{-1}. In case of av. K, only application of FYM manure recorded av. K between 234.0 to 240.0 kg ha^{-1}, only application of NPK fertilizers recorded 254.0 to 347.0 kg ha^{-1} whereas, combined application of FYM + NPK fertilizers recorded 260.0 to 380.0 kg ha^{-1}. There was a higher buildup of nitrogen in soil in organic manure (alone or in combination with NPK) treated soils than in soils receiving NPK alone. This may be due to slow mineralization of the nitrogen from FYM compared with inorganic fertilizer, a higher application of N through organic sources and a sustained availability to the crop as evidenced by a higher herbage yield in. It clearly indicated that increased rate of nutrients resulted in to increased fertility status of soil. (Sharma et al. 2020, Hassain et al. 2015) and (Sharafzadeh and Amid 2011) reported the same results.

3.4 Economics

As the economics of the study concerned, the highest gross monetary return (242160/- Rs.ha^{-1}) and net monetary returns (139372/- Rs.ha^{-1}) were obtained in treatment T_9 ($N:P_2O_5:K_2O$ 50:40:30 kg ha^{-1} + FYM 10 t ha^{-1}) with highest B:C ratio of 1: 2.36 among all the treatments.

4. CONCLUSION

On the basis of four year results emerged out from present study, it was concluded that the integrated application of organic manure FYM @ 10 t ha^{-1} and N, P_2O_5 and K_2O 50:40:30 kg ha^{-1} found best in terms of tulsi yield (30.27 q ha^{-1}) and net monetary returns (1,39,372 Rs.ha^{-1}) which was significantly superior to other treatment in Tulsi.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/128302