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Influence of Graded Doses of Organic and Inorganic Nutrients on Growth, Yield and Economics of Tikhur (*Curcuma aungustifolia* Roxb.) in Inceptisol of Bastar Plateau

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A B S T R A C T

The investigation was undertaken during kharif season 2016 at Shaheed Gundadhoor College of Agriculture and Research Station, Jagdalpur, Bastar (Chhattisgarh). The experiment was laid out in a factorial randomized complete block design with the treatments comprised of four levels of fertilizers ($N_0P_0K_0$, $N_{30}P_{20}K_{30}$, $N_{60}P_{40}K_{60}$ and $N_{90}P_{60}K_{90}$ kg ha^{-1}) and four levels of vermicompost (0, 10, 20 and 30 t ha^{-1}) with three replications. Individual application of fertilizer @ $N_{60}P_{40}K_{60}$ and vermicompost @ 20 t ha^{-1} had significantly increased the number of leaves per plant, plant height and leaf area index of *tikhur* as compared to control and primary rhizome yield, secondary rhizome yield, total rhizome yield, gross and net return as compared to fertilizer $N_{30}P_{20}K_{30}$ and vermicompost @ 10 t ha^{-1}. The increase in fertilizer dose up to $N_{60}P_{40}K_{60}$ had significantly increased and increase in vermicompost dose up to 20 kg ha^{-1} significantly decreased the gross and net benefit: cost ratio of tikhur. The interaction of $N_{60}P_{40}K_{60}$ with 20 t ha^{-1} vermicompost was found superior in case of total rhizome yield, gross and net return whereas, gross and net benefit: cost ratio was found superior under interaction of $N_{60}P_{40}K_{60}$ with 0 t ha^{-1} vermicompost.

Introduction

Tikhur (*Curcuma angustifolia*; family Zingiberaceae) is a rhizomatous herb also known as white turmeric or East Indian arrowroot. It is generally propagated by rhizomes and a good source of starch and fibre (Misra and Dixit, 1983). The plant grows wild in many places, it is found in moist and cool situations at altitudes of about 450m.Tikhur cultivated as medicinal crop in many parts of the state under moist deciduous mixed and Sal forest of Madhya Pradesh, Chhattisgarh and Jharkhand. Its cultivation has now been undertaken by the farmers of Bastar on a large area. Total area of tuber crops in Chhattisgarh is 2391.13 ha, total production is 64880.25 t and average productivity of all tuber crops is 22.70 t ha^{-1} as per the data recorded though conventional survey from all 27 districts of Chhattisgarh during the year 2013-14.

Farmer's yields are less due to lack of improved and high starch yielding genotypes and proper nutrient management practices. It is understood that there is a wide gap between potential yield and the yield obtained under actual field situations for tuber crops. Among the different factors contributing to this yield gap, soil-plant nutrition is worthy of mention as soil fertility management and proper nutrition of these crops can result in large yield gains. It is well known that addition of organic manures has shown considerable increase in crop yield, quality and exert significant influence on physical, chemical and biological properties of soil. Work related to nutrient management in Indian arrowroot was carried out by some workers. Ramesan *et al.,* (1996) studied the nutritional requirement of arrowroot on biomass production, rhizome yield, nutrient uptake and available N, P and K status of the soil and found that N and K @ 50 and 75 kg ha^{-1} significantly increased rhizome yield. Maheswarappa *et al.,* (2000) and Veena (2000) reported highest uptake of N and K at the highest level of fertilization in arrowroot intercropped in coconut gardens. Suja *et al.,* (2006) studied the influence of nutrient management on arrowroot yield, nutrient uptake and soil nutrient status and found that application of N P and K @ 50:25:75 kg ha^{-1} was ideal to obtain better yield (23.29 t ha^{-1}), higher uptake of nutrients and substantial improvement in the nutrient status. Looking to very limited information on the proper nutrient doses to maximize yield of Indian arrowroot, present investigation was undertaken with the objective to investigate the influence of graded levels of organic and inorganic sources of nutrients on growth, yield and economics of *Tikhur* (*Curcuma aungustifolia* Roxb.) in *Inceptisol* of *Bastar* Plateau region of Chhattisgarh

Materials and Methods

The investigation was undertaken during the *kharif* season of 2016 at Indira Gandhi Krishi Vishwavidyalaya, Shaheed Gundadhoor College of Agriculture and Research Station, Jagdalpur, Bastar (Chhattisgarh). The experiment was laid out in a factorial randomized complete block design with the treatments comprised of four levels of fertilizers ($N_0P_0K_0$, $N_{30}P_{20}K_{30}$, $N_{60}P_{40}K_{60}$ and $N_{90}P_{60}K_{90}$ kg ha^{-1}) and four levels of vermicompost (0, 10, 20 and 30 t ha^{-1}) and three replications.

The experimental soil was loamy in texture, comes under *Inceptisols* order and had initial soil physicochemical properties like 46% sand, 30% silt, 24% clay, 5.5 pH, 0.03 dSm^{-1} electrical conductivity, 0.71% organic carbon, 1.43g cm^{-3} bulk density, 14.5C mol (p+) kg^{-1} cation exchange capacity, 202.2kg ha^{-1} available N, 13.9 kg ha^{-1} available P, 206kg ha^{-1} available K, 16.6kg ha^{-1} available S, 2.51meq/100 g available Ca, 1.82meq/100 g soil available Mg. The nutritional composition of vermicompost used in the study was 1.4% N, 0.6% P and 1.1 % K. The planting of Tikhur was done on May 17, 2016. Full dose of vermicompost, phosphorus and potassium and 1/3 dose of nitrogen, as per treatment, were applied in the form of diammonium phosphate, *muriate* of potash and urea, at the time of planting and there maining dose of nitrogen was applied at 60 and 75 days after planting. The Intercultural operation like, hand weeding done three times at 60, 90 and 120 days after planting respectively, earthing up done at 110 days after planting, spraying of macoban (carbendazim + mancozeb) fungicide for the control of blight disease at 100 days after sowing and crops are grown in rainfed field conditions. The crop was harvested at 30 December 2016 after complete maturity, as indicated by the leaf drying and falling down of plants.

For recording observations, randomly ten plants were selected in each of the plot. The Plant height was recorded with the help of a meter scale from ground level to upper most point of plant, total number of leaves recorded which included all the leaves from the base of the plants, leaf area index was estimated from randomly plants having 3 functional leaves and estimated by dividing the total leaf area of the plant by ground area, dry matter of rhizomes (%) was calculated by dividing the dry weight of rhizomes by fresh weight of rhizome multiplied by hundred, After harvesting of whole rhizomes, primary rhizomes (fingers) were separated from mother rhizomes of selected plants and weighted and averaged for primary rhizome weight per plant, After harvesting of whole rhizomes, secondary rhizomes (fingers) were separated from primary rhizomes of selected plants and weighted and averaged for secondary rhizome and total weight of rhizomes harvested from selected plants was recorded during maturity. The gross return was obtained by the using local market price of tikhur powder @ 500 Rs. kg^{-1} calculated by multiplied starch yield to local market price, net return estimated by gross return minus cost of cultivation, gross benefit: cost ratio calculated by dividing gross return by cost of cultivation and net benefit: cost ratio calculated by dividing net return by cost of cultivation.

Results and Discussion

Number of leaves per plant

The data presented in (Table 1) revealed that organic and inorganic nutrients had significant effect on number of leaves per plant. However, the interaction effect of fertilizers with vermicompost on number of leaves per plant was not found significant. The number of leaves per plant of *tikhur* ranges from 8.70 to 9.16 due to vermicompost levels with the highest value under application of vermicompost @ 30 t ha^{-1} which was significantly higher than 0 and 10t ha^{-1} but at par with 20 t ha^{-1}. The number of leaves per plant of tikhur ranges from 8.73 to 9.10 due to fertilizers levels with the highest value under application of fertilizer @ $N_{90}P_{60}K_{90}$ kg ha^{-1} which was significantly higher than $N_0P_0K_0$ and $N_{30}P_{20}K_{30}$ but at par with $N_{60}P_{40}K_{60}$**.** Similar findings were also reported by Odedina *et al.,* (2012) and Thomas *et al.,* (2002).

Plant height

Plant height of *tikhur* was influenced significantly (Table 1) with individual levels of organic and inorganic nutrients, however, their interaction was not found significant. The plant height of *tikhur* ranges from 42.5 to 48.6 cm due to fertilizers levels with the highest value under application of fertilizer @ $N_{90}P_{60}K_{90}$kg ha^{-1} which was significantly higher than $N_0P_0K_0$ and $N_{30}P_{20}K_{30}$ but at par with $N_{60}P_{40}K_{60}$. The plant height of *tikhur* ranges from 42.1 to 48.7 cm due to vermicompost levels with the highest value under application of vermicompost @ 30 t ha^{-1} which was significantly higher than 0 and 10 t ha^{-1} but at par with 20 t ha^{-1}. Similar findings were reported by many workers (Iwuagwu *et al.,* 2016 and Mama *et al.,* 2016).

Leaf area index

The organic and inorganic nutrients, individually had significant effect on leaf area index of *tikhur* (Table 1), however, their interaction was not found significant. The leaf area index ranges from 0.93 to 1.23 and 0.90 to 1.24 with the highest under application of fertilizer @ $N_{90}P_{60}K_{90}$kg ha^{-1} and vermicompost @ 30t ha^{-1}, respectively. The effect of fertilizer @ $N_{90}P_{60}K_{90}$kgha^{-1} was significantly higher than $N_0P_0K_0$ and $N_{30}P_{20}K_{30}$ but at par with $N_{60}P_{40}K_{60}$, similarly vermicompost @30t ha^{-1} had significantly increased leaf area index as compared to 0 and 10t ha^{-1} but its effect was at par as compared to vermicompost dose @ 20t ha^{-1}. Similar findings were also recorded by Swadija *et al.,* (2013) and Sandhu *et al.,* (2014).

Dry matter percent of rhizome

The dry matter percent of rhizome (Table 1) was significantly influenced by individual levels of organic and inorganic nutrients, however, their interaction was not found significant. The dry matter percent of rhizome ranges from 30.3 to 33.9% and 29.9 to 34.1% with the highest value under application of fertilizer @ $N_{90}P_{60}K_{90}$kg ha^{-1} and vermicompost @ 30t ha^{-1}, respectively. Increasing fertilizer level up to $N_{60}P_{40}K_{60}$ kg ha^{-1} and vermicompost up to 20 t ha^{-1} significantly increased dry matter percent of rhizome. Similar findings were also recorded by several workers (Amanullah *et al.*, 2007, Ogbomo and Remison, 2008, Verma *et al.*, 2012, Ezeocha *et al.*, 2014 and Hota *et al.*, 2014).

Primary rhizome yield

The primary rhizome yield was significantly influenced by individual levels of organic and inorganic nutrients (Table 1), however, their interaction was not found significant.

The primary rhizome yield ranges from 29.5 to 40.4 q ha^{-1} and 30.2 to 39.9 q ha^{-1} with the highest value under application of fertilizer @ $N_{90}P_{60}K_{90}$ kg ha^{-1} and vermicompost @ 30t ha^{-1}, respectively. The effect of fertilizer @ $N_{90}P_{60}K_{90}$ kg ha^{-1} was significantly higher than $N_0P_0K_0$ and $N_{30}P_{20}K_{30}$ but at par with $N_{60}P_{40}K_{60}$ kg ha^{-1}, similarly vermicompost @ 30t ha^{-1} had significantly increased primary rhizome yield as compared to 0 and 10t ha^{-1} but its effect was at par as compared to vermicompost dose @ 20t ha^{-1}.

Secondary rhizome yield

The organic and inorganic nutrients had significant effect on secondary rhizome yield (Table 1), however, their interaction was not found significant. The secondary rhizome yield ranges from 13.4 to 18.9 q ha^{-1} and 13.3 to 18.6 q ha^{-1} with the highest value under application of fertilizer @ $N_{90}P_{60}K_{90}$ kg ha^{-1} and vermicompost @ 30t ha^{-1}, respectively. The effect of fertilizer @ $N_{90}P_{60}K_{90}$ kg ha^{-1} was significantly higher than $N_0P_0K_0$ and $N_{30}P_{20}K_{30}$ but at par with $N_{60}P_{40}K_{60}$ kg ha^{-1}, similarly vermicompost @ 30t ha^{-1} had significantly increased secondary rhizome yield as compared to 0 and 10t ha^{-1} but its effect was at par as compared to vermicompost dose @ 20t ha^{-1}.

Total rhizome yield

The data presented in (Tables 1 and 2) revealed that organic and inorganic nutrients had significant simple and interaction effect on total rhizome yield. The total rhizome yield ranges from 62.4 to 104.9 q ha^{-1} to 75.7 to 97.8 q ha^{-1} with the highest value under application of fertilizer @ $N_{90}P_{60}K_{90}$ kg ha^{-1} and vermicompost @ 30t ha^{-1}, respectively.

In case of interaction effect (Table 2), the total rhizome yield of *tikhur* increased under all the fertilizer levels as we increased vermicompost levels up to 20 t ha^{-1}, increasing vermicompost levels, their after, did not increase total rhizome yield significantly. Similarly, the total rhizome yield of *tikhur* increased under all the vermicompost levels as we increased fertilizer levels up to $N_{60}P_{40}K_{60,}$ increasing fertilizer level further did not statistically increases the total rhizome yield.

The higher total rhizome yield 110.4 q ha^{-1} was achieved due to 30 t ha^{-1} vermicompost X $N_{90}P_{60}K_{90}$ kg ha^{-1} which was statistically at par with $N_{60}P_{40}K_{60}$ X 30 t ha^{-1} vermicompost, $N_{90}P_{60}K_{90}$ X 20 t ha^{-1} vermicompost and $N_{60}P_{40}K_{60}$ X 20 t ha^{-1} vermicompost. The combination of $N_{60}P_{40}K_{60}$ X 20 t ha^{-1} vermicompost was found superior as it saves cost on fertilizer and vermicompost and provides yield comparable to other higher doses of fertilizer and vermicompost.

Table.1 Effect of graded doses of inorganic and organic sources of nutrients on growth, yield and economics of *Tikhur*

Treatments	No of leaves per plant	Plant height (cm)	LAI	DMCR (%)	PRY (q ha^{-1})	SRY (q ha^{-1})	TRY (q ha^{-1})	Gross Return (Rs. ha^{-1})	Net Return (Rs.ha^{-1})	Gross B:C ratio (Rs. $Re.^{-1}$)	Net B:C ratio (Rs.$Re.^{-1}$)
Fertilizer Levels (kg ha^{-1})											
$N_0P_0K_0$	8.73[a]	42.5[a]	0.93[a]	30.3[a]	29.5[a]	13.4[a]	62.4[a]	307444[a]	158485[a]	2.13[a]	1.14[a]
$N_{30}P_{20}K_{30}$	8.88[ab]	44.4[ab]	1.02[ab]	31.2[a]	33.3[b]	15.0[b]	85.8[b]	440034[b]	262137[b]	2.55[b]	1.55[b]
$N_{60}P_{40}K_{60}$	8.97[b]	45.2[b]	1.09[b]	32.4[ab]	38.3[c]	18.2[c]	104.0[c]	580498[c]	372090[c]	2.86[c]	1.86[c]
$N_{90}P_{60}K_{90}$	9.10[b]	48.6[c]	1.23[b]	33.9[b]	40.4[c]	18.9[c]	104.9[c]	587532[c]	375110[c]	2.84[c]	1.84[c]
CD(P=0.05)	**0.23**	**2.6**	**0.15**	**2.2**	**2.1**	**0.8**	**1.1**	**7929**	**6344**	**0.03**	**0.03**
Vermicompost Levels (t ha^{-1})											
0	8.70[a]	42.1[a]	0.90[a]	29.9[a]	30.2[a]	13.3[a]	75.7[a]	382903[a]	260176[a]	3.04[a]	2.04[a]
10	8.84[ab]	43.7[ab]	1.00[ab]	31.1[ab]	33.5[b]	15.7[b]	86.8[b]	458264[b]	290466[b]	2.68[b]	1.68[b]
20	8.99[b]	46.1[b]	1.13[b]	32.7[b]	37.9[c]	17.9[c]	96.7[c]	533462[c]	320623[c]	2.48[c]	1.48[c]
30	9.16[b]	48.7[b]	1.24[b]	34.1[b]	39.9[c]	18.6[c]	97.8[c]	540879[c]	296557[b]	2.19[c]	1.19[c]
CD(P=0.05)	**0.23**	**2.6**	**0.15**	**2.2**	**2.1**	**0.8**	**1.1**	**7929**	**6344**	**0.03**	**0.03**
Interaction CD(P=0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**2.14**	**15859**	**12687**	**0.05**	**0.51**

Where, LAI= Leaf area index, DMCR= Dry matter content of rhizome (%), PRY= Primary rhizome yield, SRY= Secondary rhizome yield and TRY=Total rhizome yield. Same small letter in a column have no significant difference as per *Duncan's* Multiple Range Test.

Table.2 Interaction effects of graded doses of inorganic and organic sources of nutrients on yield and economic parameters of *Tikhur*

Fertilizer levels (kg ha^{-1})	Vermicompost levels (t ha^{-1}) 0	10	20	30	CD (P=0.05) for Interaction
Total Rhizome Yield (q ha^{-1})					
$N_0P_0K_0$	44.6^{aA}	57.9^{aB}	72.8^{aC}	74.1^{aC}	2.1
$N_{30}P_{20}K_{30}$	68.0^{bA}	82.9^{bB}	95.5^{bC}	96.6^{bC}	
$N_{60}P_{40}K_{60}$	94.2^{cA}	102.5^{cB}	109.2^{cC}	110.0^{cC}	
$N_{90}P_{60}K_{90}$	95.9^{cA}	104.0^{cB}	109.3^{cC}	110.4^{cC}	
Gross Return (Rs. ha^{-1})					
$N_0P_0K_0$	209230^{aA}	279586^{aB}	365777^{aC}	375180^{aC}	15859
$N_{30}P_{20}K_{30}$	326228^{bA}	417906^{bB}	503759^{bC}	512244^{bC}	
$N_{60}P_{40}K_{60}$	489976^{cA}	563941^{cB}	631425^{cC}	636649^{cC}	
$N_{90}P_{60}K_{90}$	506176^{dA}	571625^{cB}	632885^{cC}	639443^{cC}	
Net Return (Rs. ha^{-1})					
$N_0P_0K_0$	124914^{aA}	151199^{aB}	190152^{aC}	167674^{aC}	12687
$N_{30}P_{20}K_{30}$	216092^{bA}	259435^{bB}	298117^{bC}	274905^{bC}	
$N_{60}P_{40}K_{60}$	344673^{cA}	373845^{cB}	397831^{cC}	372012^{cC}	
$N_{90}P_{60}K_{90}$	355025^{cA}	377383^{cB}	396392^{cC}	371639^{cC}	
Gross Benefit: Cost ratio (Rs. Re^{-1})					
$N_0P_0K_0$	2.48^{aA}	2.18^{aB}	2.08^{aC}	1.81^{aD}	0.05
$N_{30}P_{20}K_{30}$	2.96^{bA}	2.64^{bB}	2.45^{bC}	2.16^{bD}	
$N_{60}P_{40}K_{60}$	3.37^{cA}	2.97^{cB}	2.70^{cC}	2.41^{cD}	
$N_{90}P_{60}K_{90}$	3.35^{cA}	2.94^{cB}	2.67^{cC}	2.39^{cD}	
Net Benefit: Cost ratio (Rs. Re.$^{-1}$)					
$N_0P_0K_0$	1.48^{aA}	1.18^{aB}	1.08^{aC}	0.81^{aD}	0.05
$N_{30}P_{20}K_{30}$	1.96^{bA}	1.64^{bB}	1.45^{bC}	1.16^{bD}	
$N_{60}P_{40}K_{60}$	2.37^{cA}	1.97^{cB}	1.70^{cC}	1.41^{cD}	
$N_{90}P_{60}K_{90}$	2.35^{cA}	1.94^{cB}	1.67^{cC}	1.39^{cD}	

Same capital letter in a row and small letter in a column have no significant difference as per *Duncan's* Multiple Range Test.

Similar findings were also recorded by Thomas *et al.,* (2002), Kamal and Yousuf (2012), Zewide *et al.,* (2012), Asieku *et al.,* (2015) Iwuagwu *et al.,* (2016) and Misgina N. A. (2016).

Gross return

The organic and inorganic nutrients had significant simple and interaction effect on gross return of *tikhur* (Tables 1 and 2). The gross return ranges from 307444 to 587532 Rs.ha^{-1} and 382903 to 540879Rs.ha^{-1}with highest value due to application of fertilizer @ $N_{90}P_{60}K_{90}$kg ha^{-1} and vermicompost @ 30t ha^{-1}, respectively. The effect of fertilizer @ $N_{90}P_{60}K_{90}$kg ha^{-1} was significantly higher than $N_0P_0K_0$ and $N_{30}P_{20}K_{30}$ but at par with $N_{60}P_{40}K_{60}$, similarly vermicompost @ 30t ha^{-1}had significantly increased gross return as compared to 0 and 10t ha^{-1}but its effect was at par as compared to vermicompost dose @ 20 t ha^{-1}.

In case of interaction effect (Table 2), the gross return of *tikhur* increased under all the fertilizer levels as we increased vermicompost levels up to 20 t ha^{-1}, increasing vermicompost levels their after, did not increase gross return significantly. Similarly, the gross return of *tikhur* increased under all the vermicompost levels, as we increased fertilizer levels up to $N_{60}P_{40}K_{60}$, increasing fertilizer level further did not statistically increase the gross return. The higher gross return 639443Rs.ha^{-1} was achieved due to interaction of vermicompost @30 t ha^{-1} with fertilizer @$N_{90}P_{60}K_{90}$kg ha^{-1} which was statistically at par with the interactions of $N_{60}P_{40}K_{60}$ X vermicompost @ 30t ha^{-1}, $N_{90}P_{60}K_{90}$ X vermicompost @ 20t $ha^{-1}$and $N_{60}P_{40}K_{60}$ X vermicompost @ 20t ha^{-1}. The combination of $N_{60}P_{40}K_{60}$X 20 t ha^{-1} vermicompost was found superior as it saves cost on fertilizer and vermicompost and provides gross return comparable to higher doses of fertilizer and vermicompost.

Net return

The data presented in (Tables 1 and 2) revealed that organic and inorganic nutrients had significant simple and interaction effect on net return of *tikhur*. The net return ranges from 158485 to 375110 Rs.ha^{-1} and 260176 to 320623 Rs.ha^{-1} with highest value due to application of fertilizer @ $N_{90}P_{60}K_{90}$ kg ha^{-1} and vermicompost @ 20t ha^{-1}, respectively. The effect of fertilizer @ $N_{90}P_{60}K_{90}$ kg ha^{-1} was significantly higher than $N_0P_0K_0$ and $N_{30}P_{20}K_{30}$ but at par with $N_{60}P_{40}K_{60}$ and the application of vermicompost @ 20 t ha^{-1} had significantly higher net return as compared to 0, 10 and 30t ha^{-1}.

In case of interaction effect(Table 2),the net return of *tikhur* increased under all the fertilizer levels as we increased vermicompost levels up to 20 t ha^{-1} increasing vermicompost levels their after, decreased net return significantly. Similarly, the net return of *tikhur* increased under all the vermicompost levels as we increased fertilizer levels up to $N_{60}P_{40}K_{60}$, increasing fertilizer level further did not increase the net return. The higher net return 397831.3Rs.ha^{-1} was achieved due to interaction of $N_{60}P_{40}K_{60}$X 20 t ha^{-1} vermicompost which was statistically at par with $N_{90}P_{60}K_{90}$X 20 t ha^{-1} vermicompost. The combination of $N_{60}P_{40}K_{60}$X 20 t ha^{-1} vermicompost was superior as it gave the highest net return.

Gross benefit: cost ratio

The data presented in (Table 1 and 2) revealed that organic and inorganic nutrients had significant simple and interaction effect on gross B: C ratio. The gross B:C ratio ranges from 2.13 to 2.86 Rs. Re^{-1} and 2.19 to 3.04 Rs. Re^{-1} (Table 1) with highest value due to application of fertilizer @ $N_{60}P_{40}K_{60}$ kg ha^{-1} and vermicompost @ 0 t ha^{-1} respectively. The effect of fertilizer @ $N_{60}P_{40}K_{60}$kg ha^{-1} on gross B: C ratio was significantly higher than $N_0P_0K_0$ and $N_{30}P_{20}K_{30}$ but at par with $N_{90}P_{60}K_{90}$. Similarly vermicompost @ 0 t ha^{-1} had recorded significantly higher gross B: C ratio as compare to 20 and 30 t ha^{-1} but it was at par as compared to vermicompost dose @ 10 t ha^{-1}.

In case of interaction effect (Table 2), the gross B: C ratio of *tikhur* decreased under all the fertilizer levels as we increased vermicompost levels up to 30 t ha^{-1}. The gross B:C ratio of *tikhur* increased significantly under all the vermicompost levels as we increased fertilizer levels up to $N_{60}P_{40}K_{60}$, increasing fertilizer levels further did not statistically increases the gross B:C ratio. The higher gross B: C ratio 3.37 was achieved due to $N_{60}P_{40}K_{60}$kg ha^{-1} X 0 t ha^{-1} vermicompost which was statistically at par with $N_{90}P_{60}K_{90}$X 0 t ha^{-1} vermicompost. The combination of $N_{60}P_{40}K_{60}$X 0 t ha^{-1} vermicompost was found superior due to no use of costlier input of vermicompost.

Net benefit: cost ratio

The data presented in (Tables 1 and 2) revealed that the organic and inorganic nutrients had significant simple and interaction effect on net B: C ratio. The net B:C ratio ranged from1.14 to 1.86 Rs.Re^{-1} and 1.19 to 2.04 Rs.Re^{-1} (Table 1) with highest value due to application of fertilizer @ $N_{60}P_{40}K_{60}$ kg ha^{-1} and vermicompost @ 0 t ha^{-1} respectively. The effect of fertilizer @ $N_{60}P_{40}K_{60}$kg ha^{-1} was significantly higher than $N_0P_0K_0$ and $N_{30}P_{20}K_{30}$ but at par with $N_{90}P_{60}K_{90}$. Contrarily, vermicompost @ 0 t ha^{-1} had significantly higher net B: C ratio as compared to 20 and 30 t ha^{-1} but its effects was at par as compared to vermicompost @ 10 t ha^{-1}.

In case of interaction effect (Table 2), the net B: C ratio of *tikhur* decreased under all the fertilizer levels as we increased vermicompost levels up to 30 t ha^{-1}. The net B:C ratio of *tikhur* increased under all vermicompost levels as we increased fertilizer levels up to $N_{60}P_{40}K_{60}$, increasing fertilizer levels further did not statistically increase the net B:C ratio. The higher net B: C ratio 2.37 was achieved due to $N_{60}P_{40}K_{60}$kg ha^{-1} X 0 t ha^{-1} vermicompost which was statistically at par with $N_{90}P_{60}K_{90}$ X 0 t ha^{-1} vermicompost. The combination of $N_{60}P_{40}K_{60}$ X 0 t ha^{-1} vermicompost was found superior due to no use of costlier input of vermicompost. Similar findings were also recorded by Choudhary and Kumar (2013), Singh *et al.*, (2016).

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