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Effect of different concepts of fertilizer application and vermicompost on yield attributes, yield, NPK uptake and cost benefit ratio of cotton in rainfed alfisols

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Abstract
The research experiment was conducted during *kharif* 2016-17 and 2017-18 at RARS Warangal, located at 18^0 01.077 N latitude 79^0 36.197 E longitude and an altitude of 259 m above mean sea level to study the effect of different concepts of fertilizer application and vermicompost on yield attributes, yield, nutrient uptake and cost benefit ratio of cotton in rainfed alfisols. The results indicated that higher sympodial branches, bolls per plant, boll weight, seed cotton yield, total nitrogen, phosphorus and potassium uptake *i.e.,* 20.02 kg ha^{-1}, 35.00 kg ha^{-1}, 4.31g, 1824 kg ha^{-1}, 31.32 kg ha^{-1}, 8.52 kg ha^{-1} and 36.79 kg ha^{-1}and lower i.e.16.63 kg ha^{-1}, 17.00 kg ha^{-1}, 3.88 g, 1604 kg ha^{-1}, 28.82 kg ha^{-1}, 5.53 kg ha^{-1} and 28.89 kg ha^{-1} were found with application of 180-60-60 (T_6) and 127-34-30kg NPK ha^{-1} (T_3), respectively. Similarly, higher sympodial branches, bolls plant^{-1}, boll weight, seed cotton yield, total nitrogen, phosphorus and potassium uptake *i.e.,*18.91 kg ha^{-1}, 34 kg ha^{-1}, 4.31g, 1769 kg ha^{-1}, 27.77 kg ha^{-1},7.94 kg ha^{-1} and 36.63 kg ha^{-1}and lower i.e.17.22 kg ha^{-1}, 30 kg ha^{-1}, 3.92 g, 1632 kg ha^{-1}, 25.02 kg ha^{-1}, 6.30 kg ha^{-1}and 30.31 kg ha^{-1} were found with application of vermicompost over without vermicompost, respectively and interaction effect between NPK levels and vermicompost on sympodial branches, bolls plant^{-1}, boll weight, seed cotton yield, total nitrogen, phosphorus and potassium uptake were non-significant. The highest benefit cost ratio (1.12) and net income (9380/-) was recorded by the application of 180-60-60 kg NPK ha^{-1} and lowest benefit cost ratio (0.95) and net loss 3,970/- was recorded by the application of 120-60-60 kg NPK ha^{-1}along with vermicompost.

Keywords: NPK levels, vermicompost, sympodial branches, bolls plant^{-1}, boll weight and seed cotton yield

Introduction
Fertilizer application is one of the efficient means of increasing agricultural profitability. The fertilizer prices have gone up and hence their use in required amounts depends much upon the purchasing ability of the farmers. Cotton (*Gossypium hirsutum* L.) is considered the main fiber crop throughout industry in India as well as in Telangana state. In India cotton was cultivated in 122.35 lakh ha^{-1} with a production of 377 lakh bales and lint yield of 524 kg ha^{-1}. In Telangana state it was cultivated in 18.24 lakh ha^{-1} with a production of 57 lakh bales and lint yield of 531 kg ha^{-1}.

However, in India the productivity of cotton is as low as 505 kg lint ha^{-1} as compared to global average of 735 kg lint ha^{-1} (Nasarabad *et al.,* 2013) [6]. The obvious reasons for low productivity of cotton can be attributed to large area (>90 per cent) under rain fed conditions, use of suboptimum doses of fertilizer application and irrigation water at improper stages of crop growth as well as the imbalanced plant nutrition. To overcome these problems, it is imperative to apply optimum doses of nutrients with judicious use of irrigation water at proper crop growth stages. Water and fertilizers are the most important critical inputs for producing vigorous healthy plants and improving the yield of cotton crop. At the same time a balanced fertilization has to be considered for maintaining soil health for sustainable use because indiscriminate and imbalanced use of fertilizers has already distorted soil fertility and deteriorated soil health in India (Santhi *et al.*, 2011) [7]. Accordingly much attention is given to the integrated use of organic and mineral nutrition for meeting the economic needs of farmers as well as for sustainability in terms of productivity and soil fertility.

Most of the cotton growing soils are losing their fertility level due to continuous mining of the nutrients from the soil (Blaise and Prasad, 2005) [1]. Thus an efficient nutrient management plan is the key in the light of the negative nutrient balances. Nutrient management in Bt-cotton is a better challenge to boost production and productivity.

For a healthy growth and better yield of cotton crop needs continuous supply of essential nutrient elements. Deficiency or toxicity of any one nutrient results in reduction of plant growth and ultimately yield. It is established fact that optimum nutritional requirement of cotton are of primary importance to boost up its production. Under present conditions fertilizer recommendations developed decades back assuming that they were not meet the requirement of cotton crop to get the optimum yields. Hence there is need to work out the optimum fertilizer dose for cotton for Central Telangana. Therefore, the present study was carried out to determine an economically optimal dose of fertilizer nutrients at which cotton gave maximum yield.

Soomro *et al.* (2000) [5] reported that the application of 100-50-50 kg NPK ha^{-1} remained on top with 2434 kg ha^{-1} followed by 150-50-50 kg NPK ha^{-1} with 2403 kg ha^{-1} of seed cotton yield and also revealed that yield contributing components i.e. bolls per plant and boll weight were significantly increased with the balance use of NPK fertilizers. Non-significant higher seed cotton yield (3102 kg ha^{-1}) and stalk yield (2505 kg ha^{-1}) was found with application of 180-60-60 over 150-60-60 and 120-60-60 kg NPK ha^{-1} and similar trend was also observed in case of number of bolls $plant^{-1}$, boll weight, ginning percent and harvest index of cotton grown in sandy loam, neutral soil, with low in available nitrogen, phosphorus and high in available potassium (Nagender *et al.*, 2017; Mahadevappa *et al.*, 2018) [9, 10] reported that significantly higher plant height (109 cm), number of bolls $plant^{-1}$ (19), boll weight (4.7 g), seed index (9.1 g),seed cotton yield (1714 kg ha^{-1}), lint yield (636 kg ha^{-1}) and stalk yields (2484 kg ha^{-1}) were obtained with application of 225-60-60 kg NPK ha^{-1} and was comparable with 150-60-60 kg NPK ha^{-1} when cotton grown in neutral sandy loam soil with low in available nitrogen, phosphorus and higher in available potassium. Vinoda Kumar *et al.* (2012) [4] reported that application of 150-75-75 kg NPK ha^{-1}+ FYM @ 5 t ha^{-1} (50%) + Vermicompost @ 0.5 t ha^{-1} (50%) + NAA @ 10 ppm + 2% DAP spray recorded significantly higher seed cotton yield (2982 kg ha^{-1}) over 225-112.5-112.5 kg NPK ha^{-1} (2695 kg ha^{-1}) and 150-75-75 kg NPK ha^{-1} (2178 kg ha^{-1}), similarly uptake of N, P and K by cotton crop was significantly higher with application of 150-75-75 kg NPK ha^{-1} + FYM @ 5 t ha^{-1} (50%) + VC. 0.5 t ha^{-1} (50%) + NAA (10 ppm) + 2% DAP spray and it was followed by 150-75-75 kg NPK ha^{-1} + FYM @ 10 t ha^{-1} + NAA (10 ppm) + 2% DAP spray and 150-75-75 kg NPK ha^{-1} + FYM @ 5 t ha^{-1} (50%) + VC 0.5 t ha^{-1} (50%). This shows that there was 12.47 and 9.19 per cent increase in uptake of N, 33.87 and 4.97 per cent in uptake of P as well as 7.61 and 2.39 per cent uptake of K increase in treatment which received 150-75-75 kg NPK ha^{-1} + FYM @5 t ha^{-1} (50%) + VC 0.5 t ha^{-1} (50%) + NAA (10 ppm) + 2% DAP spray over 150-75-75 and 225-112.5-112.5 kg NPK ha^{-1} application, respectively. The increase in seed cotton yield is ascribed to increased uptake of nutrients. Deepa and Aladakatti (2016) [2] reported that the application of 150% RDF (150-75-75 NPK kg ha^{-1}) recorded significantly higher number of bolls $plant^{-1}$ (80.7), boll weight (4.0 g), seed cotton yield $plant^{-1}$ (312 g) and $hectare^{-1}$(4167 kg) as compared to application of 125% RDF (76.2, 3.6 g, 298 g & 3818 kg, respectively) and 100% RDF (76.3, 3.4 g, 271 g & 3688 kg, respectively). More number of fruiting bodies with application of 150% RDF might have resulted in more number of bolls $palnt^{-1}$ ultimately resulting into higher seed cotton yield**.** Jyothi and Hebsur (2017) [8] expressed that the application of 150-50-75 kg N-P_2O_5-K_2O ha^{-1} recorded significantly higher nitrogen (133 kg ha^{-1}), phosphorus (31.26 kg ha^{-1}) and potassium (128.94 kg ha^{-1}) uptake by cotton. The interaction affects with respect to total micronutrients (Zn, Fe, Mn and Cu) uptake remained non-significant at all the growth stages. Desai *et al.* (2013) [3] reported that the yield attributes of *Bt* cotton showed marked improvement with successive increase in nitrogen levels up to 300 kg N ha^{-1}, consequently highest seed cotton and stalk yields were recorded under 300 kg N ha^{-1} which was significantly higher over 180 kg N ha^{-1}, but it was remained at par with 240 kg N ha^{-1}. Increased nitrogen level enhanced leaf photosynthetic rate, which might have resulted in higher accumulation of metabolites thus impacted number of bolls and boll weight and ultimately effect on yields.

Keeping in view of above facts, the current study was designed to investigate the influence of varying NPK levels and vermicompost on yield attributes, yield, nutrient uptake and cost benefit ratio of cotton in rainfed alfisols.

Materials and Methods

The research experiment was conducted during kharif-2016-17 and 2017-18 at RARS Warangal, located at 18^0 01.077 N latitude 79^0 36.197 E longitude and an altitude of 259 m above mean sea level to study the influence of varying NPK levels and vermicompost on yield attributes, yield, nutrient uptake and cost benefit ratio of cotton in rainfed alfisols. A composite soil sample was collected from 0-20 cm depth during the study years, processed and tested for pH, electrical conductivity, organic carbon, soil available nitrogen, phosphorus, potassium and micronutrients (Zn, Cu, Fe, Mn and Boron) following standard procedures. The experiment was laid out in completely randomized block design with 12 treatments replicated in three times.

The cotton seeds were sown on 3rd July in both seasons in rows 90 cm apart and plants 60 cm apart within a row where one plant left after thinning at 10 days after sowing. Soil application of varying levels of NPK arrived by different concepts of fertilizer application was adopted. Quantity of nitrogen in three equal splits in the form of urea, phosphorus as basal in the form of single super phosphate, potassium in two equal splits as muriate of potash, as per the treatments and the other cultural practices were carried out according to the usual practices in cotton crop.

Results and Discussion

Soil fertility status

The results showed that the soil was clay loam in texture, slightly alkaline in reaction (pH 7.80), non-saline in nature (EC 0.21 dSm-1), lower in organic carbon (0.48%), lower in available nitrogen (239 kg ha^{-1}), medium in available phosphorus (38 kg ha^{-1}), medium in available potassium (215 $kgha^{-1}$), sufficiently available Zn, Cu, Fe and Mn 0.62, 0.96, 7.48 & 2.52 mg kg^{-1}, respectively**.**

Sympodial branches

Higher number of sympodial branches i.e. 26.03, 14.01 and 20.02 were found with application of 180-60-60 kg NPK ha^{-1}(T_6) and lower i.e. 21.15,12.11 and 16.63 were found with application of 127-34-30 kg NPK ha^{-1} (T_3) in 2017, 2018 and in pooled mean, respectively (Table-1).The increase in number of sympodial branches per plant of cotton under higher level of fertilizer application might be due to enhanced availability and uptake of nutrients leads to enhanced

photosynthesis, expansion of leaves and translocation of nutrients to reproductive parts results in higher sympodial branches as compared to lower rate of fertilizer application. Reported that increased nitrogen levels led to increased number of sympodial branches per plant and also maximum number of sympodial branches plant^{-1} (7.51) was recorded in 225 kg N ha^{-1} and lowest number of sympodial branches plant^{-1} (5.53) were found in control and similar type of results were also reported by Desai *et al*. (2012) [4]. Non significantly higher number of sympodial branches i.e.23.91,13.58 and 18.91 were found with application of vermicompost over without vermicompost *i.e.*, 22.14, 12.50 and 17.22 in 2017, 2018 and in pooled mean, respectively. However, the quantity of vermicompost application is not sufficient to influence the sympodial branches significantly. Interaction effect between NPK levels and vermicompost on sympodial branches were non-significant in both the years and in pooled mean (Table-1).

Boll number

Significantly higher number of bolls per plant i.e.52 and 35 were recorded with application of 180-60-60 kg NPK ha^{-1}(T_6) over other treatments but at par with application of 150-60-60 kg NPK ha^{-1} (T_5) i.e.50 and 34 in 2017 and in pooled mean, respectively but did not significantly found higher number of bolls per plant (19) with application of 180-60-60 kg NPK ha^{-1}(T_6) and lower number of bolls per plant (17) were recorded with application of 127-34-30 kg NPK ha^{-1} (T_3) in 2018. The increase in number of bolls plant^{-1} of cotton under higher level of fertilizer application might be due to enhanced availability and uptake of nutrients leads to enhanced photosynthesis, expansion of leaves and translocation of nutrients to reproductive parts results in higher sympodial branches and bolls plant^{-1}as compared to lower rate of fertilizer application. Similar trend of results were reported by Deepa and Aladakatti (2016) [2]. Significantly higher number of bolls per plant i.e. 49, 19 and 34 were found with application of vermicompost over without vermicompost i.e. 44, 17 and 30 in 2017, 2018 and in pooled mean, respectively. Interaction effect between NPK levels and vermicompost on number of bolls were non- significant in both the years and in pooled mean (Table 2).

Table 1: Effect of different concepts of fertilizer application and vermicompost on sympodial branches of cotton

Treatments	Different concepts of fertilizer application (N-P_2O_5-K_2O kg ha^{-1})	Sympodial branches plant^{-1}		
		2017	2018	Pooled
T_1	Current RDF (N, P, K) (120-60-60)	22.74	13.17	17.96
T_2	ST based fertilizer usage N, P, K (30% excess/less) (156-42-42)	22.02	12.92	17.47
T_3	STCR based Eq: Production-I (current highest in dist/Zone) (127-34-30)	21.15	12.11	16.64
T_4	STCR based Eq: Production-II (15% Higher of current highest in dist/Zone) (157-39-30)	21.50	12.86	17.18
T_5	New treatment for Production-I, N=150% RDN if available N is <140 Kg/ha else 125% RDN. P=100% RDP if available P is high, else 125%. K=125% RDK if low else 100% RDK (150-60-60)	24.72	13.18	19.95
T_6	New treatment for Production-II N=200%RDN if available N is <140 Kg/ha else 150% RDN. P=100% RDP if available P is high, else 150%. K=125% RDK if low else 100% RDK (180-60-60)	26.03	14.01	20.03
SEm±		1.71	1.05	0.88
LSD(0.05)		NS	NS	NS
Without vermicompost		22.14	12.50	17.32
With vermicompost		23.91	13.58	18.75
SEm±		0.99	0.61	0.51
LSD(0.05)		NS	NS	NS
Interaction				
SE m±		2.42	1.49	1.24
LSD (0.05)		NS	NS	NS

Table 2: Effect of different concepts of fertilizer application and vermicompost on boll number of cotton.

Treatments	Different concepts of fertilizer application (N-P_2O_5-K_2O kg ha^{-1})	Boll number		
		2017	2018	Pooled
T_1	Current RDF (N, P, K) (120-60-60)	45.84	16.83	31.34
T_2	ST based fertilizer usage N, P, K (30% excess/less) (156-42-42)	44.50	18.00	31.26
T_3	STCR based Eq: Production-I (current highest in dist/Zone) (127-34-30)	42.17	16.50	29.34
T_4	STCR based Eq: Production-II (15% Higher of current highest in dist/Zone) (157-39-30)	43.17	18.17	30.67
T_5	New treatment for Production-I N=150% RDN if available N is <140 Kg/ha else 125% RDN. P=100% RDP if available P is high, else 125%. K=125% RDK if low else 100% RDK (150-60-60)	49.83	18.33	34.08
T_6	New treatment for Production-II N=200% RDN if available N is <140 Kg/ha else 150% RDN. P=100% RDP if available P is high, else 150%. K=125% RDK if low else 100% RDK (180-60-60)	52.00	18.50	35.25
SEm±		2.01	0.78	1.03
LSD(0.05)		5.93	NS	3.03
Without vermicompost		43.61	16.94	30.28
With vermicompost		48.89	18.50	33.70
SEm±		1.16	0.45	0.59
LSD(0.05)		3.42	1.32	1.75
Interaction				
SEm±		1.10	1.45	1.28
LSD(0.05)		NS	NS	NS

Boll weight

Non significantly higher boll weight i.e.3.63, 4.99 and 4.31 g were found with application of 180-60-60 kg NPK ha^{-1} (T_6) in 2017, 2018 and in pooled mean, respectively and lower boll weight of 3.28, 4.49 and 3.88 g were found with application of 127-34-30 kg NPK ha^{-1} (T_3) in 2017, 2018 and in pooled mean, respectively. The increase in boll weight of cotton under higher level of fertilizer application might be due to enhanced availability and uptake of nutrients leads to enhanced photosynthesis, expansion of leaves and translocation of nutrients to reproductive parts results higher boll weight as compared to lower rate of fertilizer application. Significantly higher boll weight of 3.63, 4.99 and 4.31 g were found with application of vermicompost over without vermicompost *i.e.*, 3.27, 4.57 and 3.92 g in 2017, 2018 and in pooled mean, respectively. Similar trend of results were reported by Nagender *et al.* (2017) [9] and Mahadevappa *et al.* (2018) [10]. Interaction effect between NPK levels and vermicompost on boll weight was non-significant in 2017, 2018 and in pooled mean (Table-3).

Table 3: Effect of different concepts of fertilizer application and vermicompost on boll weight of cotton.

Treatments	Different concepts of fertilizer application (N-P_2O_5-K_2O kg ha^{-1})	Boll weight (g)		
		2017	2018	Pooled
T_1	Current RDF (N, P, K) (120-60-60)	3.43	4.90	4.17
T_2	ST based fertilizer usage N, P, K (30% excess/less) (156-42-42)	3.41	4.84	4.13
T_3	STCR based Eq: Production-I (current highest in dist/Zone) (127-34-30)	3.28	4.49	3.88
T_4	STCR based Eq: Production-II (15% Higher of current highest in dist/Zone) (157-39-30)	3.37	4.56	3.97
T_5	New treatment for Production-I N =150% RDN if available N is <140 Kg/ha else 125% RDN. P =100% RDP if available P is high, else 125%. K=125% RDK if low else 100% RDK (150-60-60)	3.59	4.90	4.24
T_6	New treatment for Production-II N=200% RDN if available N is <140 Kg/ha else 150% RDN. P=100% RDP if available P is high, else 150%. K=125% RDK if low else 100% RDK (180-60-60)	3.63	4.99	4.31
SEm±		0.16	0.20	0.15
CD		NS	NS	NS
Without vermicompost		3.27	4.57	3.92
With vermicompost		3.63	4.99	4.31
SEm±		0.09	0.11	0.09
CD		0.27	0.34	0.25
Interaction				
SEm±		0.23	0.28	0.21
CD		NS	NS	NS

Seed cotton yield

Higher seed cotton yield of 1667, 1980 and 1824 kg ha^{-1} were recorded with application of 180-60-60 kg NPK ha^{-1} (T_6) in 2017, 2018 and pooled mean, respectively and lower yield of 1532, 1676 and 1604 kg ha^{-1}were found with application of 127-34-30 kg NPK ha^{-1} (T_3) in 2017, 2018 and in pooled mean, respectively. The increase in seed cotton yield of cotton under higher level of fertilizer application might be due to enhanced availability and uptake of nutrients leads to enhanced photosynthesis, expansion of leaves and translocation of nutrients to reproductive parts results in higher sympodial branches, boll number, boll weight and seed cotton yield as compared to lower rate of fertilizer application. Significantly higher seed cotton yield 1694 kg ha^{-1} was found with application of vermicompost over without vermicompost (1528 kg ha^{-1}) in 2017 and non-significantly higher seed cotton yield 1843 and 1769 kg ha^{-1} was found with application of vermicompost over without vermicompost (1736 and 1632 kg ha^{-1}) in 2018 and in pooled analysis, respectively (Table-4). Interaction effect between NPK levels and vermicompost on seed cotton yield was non-significant in 2017, 2018 and in pooled mean. Similar trend of results were reported by Nagender *et al.* (2017) [9] and Mahadevappa *et al.* (2018) [10].

Table 4: Effect of different concepts of fertilizer application and vermicompost on seed cotton yield

Treatments	Different concepts of fertilizer application (N-P_2O_5-K_2O kg ha^{-1})	Seed cotton yield (kg ha^{-1})		
		2017	2018	Pooled
T_1	Current RDF (N, P, K) (120-60-60)	1652	1755	1704
T_2	ST based fertilizer usage N, P, K (30% excess/less) (156-42-42)	1596	1737	1667
T_3	STCR based Eq: Production-I (current highest in dist/Zone) (127-34-30)	1532	1676	1604
T_4	STCR based Eq: Production-II (15% Higher of current highest in dist/Zone) (157-39-30)	1557	1703	1630
T_5	New treatment for Production-I N=150% RDN if available N is <140 Kg/ha else 125% RDN. P=100% RDP if available P is high, else 125%. K=125% RDK if low else 100% RDK (150-60-60)	1662	1886	1774
T_6	New treatment for Production-II N=200% RDN if available N is <140 Kg/ha else 150% RDN. P=100% RDP if available P is high, else 150%. K=125% RDK if low else 100% RDK (180-60-60)	1667	1980	1824
SEm±		96.04	98.91	83.54
CD		NS	NS	NS
Without vermicompost		1528	1736	1632
With vermicompost		1694	1843	1769
SEm±		55.45	57.11	48.23
CD		NS	NS	NS
Interaction				
SEm±		135.82	139.88	118.14
CD		NS	NS	NS

Total nitrogen uptake

Significantly higher nitrogen uptake *i.e.,* 33.82, 28.82 and 31.32 kg ha^{-1} were recorded by the application of 180-60-60 kg NPK ha^{-1} (T_6) over 120-60-60 (T_1), 156-42-42 (T_2) and 127-34-30 (T_3) kg NPK ha^{-1} but at par with other treatments in 2017, 2018 and in pooled analysis, respectively. Increasing the fertilizer dose resulted in increased availability of nutrients which might be the reason for higher uptake of nutrients by crop and also uptake is a product of nutrient concentration and dry matter accumulation as indicated in the present study. Significantly higher nitrogen uptake i.e 30.44, 25.11 and 27.77 kg ha^{-1} were recorded with application of vermicompost over without vermicompost i.e. 27.41, 22.74 and 25.07 kg ha^{-1} in 2017, 2018 and in pooled mean, respectively (Table-5). This improvement in nutrient uptake due to integrated use of organic manures and fertilizers could be due to their own contribution and solubilization of nutrients present in the soil (Badole and More, 2000). Availability of sufficient nutrients coupled with improvement in soil properties during the entire crop growth period might have helped in higher nutrient uptake. Interaction effect between NPK levels and vermicompost on nitrogen uptake was non-significant in 2017, 2018 and in pooled mean (Table-5).

Total phosphorus uptake

Higher total phosphorus uptake i.e. 9.33, 7.70 and 8.52 kg ha^{-1} were found with application of 180-60-60 kg NPK ha^{-1} (T_6) and lower i.e. 5.74, 5.32 and 5.53 kg ha^{-1} were recorded by the application of 127-34-30 kg NPK ha^{-1} (T_3) in 2017, 2018 and in pooled mean, respectively. The increase in total phosphorus uptake in cotton under higher level of fertilizer application might be due to enhanced availability and uptake of nutrients leads to enhanced photosynthesis, expansion of leafs and translocation of nutrients to reproductive parts results in higher sympodial branches, boll number, boll weight and seed cotton yield leads to higher phosphorus uptake as compared to lower rate of fertilizer application. Non-significantly higher phosphorus uptake (8.34 kg ha^{-1}) was recorded with application of vermicompost over without vermicompost (6.82 kg ha^{-1}) in 2017. Significantly higher phosphorus uptake of 7.55 and 7.94 kg ha^{-1} were recorded with application of vermicompost over without vermicompost i.e. 5.79 and 6.30 kg ha^{-1}in 2018 and in pooled analysis, respectively. Interaction effect between NPK levels and vermicompost on total phosphorus uptake was non-significant (Table-6).

Table 5: Effect of different concepts of fertilizer application and vermicompost on total nitrogen uptake by cotton

Treatments	Different concepts of fertilizer application (N-P_2O_5-K_2O kg ha^{-1})	Total nitrogen uptake		
		2017	2018	Pooled
T_1	Current RDF (N, P, K) (120-60-60)	25.46	20.46	22.96
T_2	ST based fertilizer usage N, P, K (30% excess/less) (156-42-42)	27.97	22.97	25.47
T_3	STCR based Eq: Production-I (current highest in dist/Zone) (127-34-30)	22.21	17.21	19.71
T_4	STCR based Eq: Production-II (15% Higher of current highest in dist/Zone) (157-39-30)	31.71	26.71	29.21
T_5	New treatment for Production-I N=150%RDN if available N is <140 Kg/ha else 125% RDN. P=100% RDP if available P is high, else 125%. K=125% RDK if low else 100% RDK (150-60-60)	32.38	27.38	29.88
T_6	New treatment for Production-II N=200% RDN if available N is <140 Kg/ha else 150% RDN. P=100% RDP if available P is high, else 150%. K=125% RDK if low else 100% RDK (180-60-60)	33.82	28.82	31.32
SEm±		1.16	1.16	1.15
CD (P=0.05)		3.41	3.42	3.40
Without vermicompost		27.41	22.74	25.07
With vermicompost		30.44	25.11	27.77
SEm±		0.67	0.70	0.66
CD (P=0.05)		1.97	1.98	1.96
Interaction				
SEm±		1.64	1.64	1.63
CD (P=0.05)		NS	NS	NS

Total potassium uptake

Non significantly higher total potassium uptake i.e. 34.74 kg ha^{-1} was recorded with application of 180-60-60 kg NPK ha^{-1}and lower i.e. 26.17 kg ha^{-1} was recorded by the application of 127-34-30 kg NPK ha^{-1}in 2017, in 2018 significantly higher potassium uptake (38.84 kg ha^{-1}) was recorded with application of 180-60-60 kg NPK ha^{-1}over 127-34-30 kg NPK ha^{-1}but at par with other treatments and significantly higher potassium uptake (36.79 kg ha^{-1}) was recorded with application of 180-60-60 kg NPK ha^{-1} over application of 156-42-42, 127-34-30 and 157-39-30 kg NPK ha^{-1} but at par with other treatments in pooled mean. Increasing the fertilizer dose resulted in increased availability of nutrients which might be the reason for higher uptake of nutrients by crop at higher doses of fertilizers as indicated in the present study. Significantly higher potassium uptake i.e. 34.27, 39.00 and 36.63 kg ha^{-1}was recorded with application of vermicompost over without vermicompost i.e. 26.93, 33.69 and 30.31 kg ha^{-1}in 2017, 2018 and in pooled analysis, respectively. Interaction effect between NPK levels and vermicompost application on total potassium uptake was non-significant (Table-3).

Table 6: Effect of different concepts of fertilizer application and vermicompost on total phosphorus uptake by cotton.

Treatments	Different concepts of fertilizer application (N-P_2O_5-K_2O kg ha^{-1})	Total phosphorus uptake		
		2017	2018	Pooled
T_1	Current RDF (N, P, K) (120-60-60)	7.40	5.87	6.86
T_2	ST based fertilizer usage N, P, K (30% excess/less) (156-42-42)	7.45	6.32	6.66
T_3	STCR based Eq: Production-I (current highest in dist/Zone) (127-34-30)	5.74	5.32	5.53
T_4	STCR based Eq: Production-II (15% Higher of current highest in dist/Zone) (157-39-30)	7.58	7.55	7.56
T_5	New treatment for Production-I N=150% RDN if available N is <140 Kg/ha else 125% RDN. P=100% RDP if available P is high, else 125%. K=125% RDK if low else 100% RDK (150-60-60)	7.99	7.27	7.63
T_6	New treatment for Production-II N=200% RDN if available N is <140 Kg/ha else 150% RDN. P=100% RDP if available P is high, else 150%. K=125% RDK if low else 100% RDK (180-60-60)	9.33	7.70	8.52
SEm±		0.90	0.67	0.76
CD		NS	NS	NS
Without vermicompost		6.82	5.79	6.30
With vermicompost		8.34	7.55	7.94
SEm±		0.52	0.39	0.44
CD		NS	1.15	1.30
Interaction				
SEm±		1.28	0.95	1.07
CD		NS	NS	NS

Table 7: Effect of different concepts of fertilizer application and vermicompost on total potassium uptake by cotton

Treatments	Different concepts of fertilizer application (N-P_2O_5-K_2O kg ha^{-1})	Total potassium uptake		
		2017	2018	Pooled
T_1	Current RDF (N, P, K) (120-60-60)	30.52	36.87	33.69
T_2	ST based fertilizer usage N, P, K (30% excess/less) (156-42-42)	30.73	37.20	33.97
T_3	STCR based Eq: Production-I (current highest in dist/Zone) (127-34-30)	26.17	31.60	28.89
T_4	STCR based Eq: Production-II (15% Higher of current highest in dist/Zone) (157-39-30)	29.17	35.84	32.51
T_5	New treatment for Production-I N=150% RDN if available N is <140 Kg/ha else 125% RDN. P=100% RDP if available P is high, else 125%. K=125% RDK if low else 100% RDK (150-60-60)	32.27	37.73	35.00
T_6	New treatment for Production-II N=200% RDN if available N is <140 Kg/ha else 150% RDN. P=100% RDP if available P is high, else 150%. K=125% RDK if low else 100% RDK (180-60-60)	34.74	38.84	36.79
SEm±		2.31	1.46	1.22
CD		NS	4.31	3.59
Without vermicompost		26.93	33.69	30.31
With vermicompost		34.27	39.00	36.63
SEm±		1.34	0.84	0.70
CD		3.94	2.49	2.07
Interaction				
SEm±		3.27	2.06	1.72
CD		NS	NS	NS

Economics of applied inputs to cotton

The benefit cost ratio ranged from 0.95 to 1.12 and net income ranged from -1673 to 9380/- rupees per hectare. The highest benefit cost ratio (1.12) and net income (9380/-) was recorded by application of 180-60-60 kg NPK ha^{-1} and lowest benefit cost ratio (0.95) and net loss 3970/- was recorded by the application of 120-60-60 kg NPK ha^{-1}along with vermicompost. Though the seed cotton yield and gross income recorded higher by application of varying NPK levels along with vermicompost but net income and benefit cost ratios were low due to additional cost of vermicompost (Table-4).

Table 8: Effect of different concepts of fertilizer application and vermicompost on economics of applied inputs to cotton

Treatments	Cost of cultivation (Rs)		Gross returns (Rs)		Net returns (Rs)		B:C ratio	
	Without VC.	With VC.	Without VC.	With VC.	Without VC.	With VC.	Without VC.	With VC.
T_1	76420	86420	79200	82450	2780	-3970	1.04	0.95
T_2	75574	85574	77100	87050	1526	1476	1.02	1.02
T_3	74423	84423	80700	82750	6277	-1673	1.08	0.98
T_4	75133	85133	80850	89550	5717	4417	1.08	1.05
T_5	76870	86870	85050	92350	8180	5480	1.11	1.06
T_6	77320	87320	86700	94850	9380	7530	1.12	1.09

VC: Vermicompost. Unit cost of nutrients (N-15/-, P-52/-, K-25/-), Vermicompost-

Conclusion

It can be concluded from the results that the cotton responds to the application of 180-60-60 kg NPK $ha^{-1}$by producing the higher sympodial branches, bolls $plant^{-1}$, boll weight, seed cotton yield, total nitrogen, phosphorus and potassium uptake over the application of 127-34-30 kg NPK $ha^{-1}$and also responds to the application of vermicompost over without vermicompost when cotton grown in clayey, moderately alkaline, non-saline soil with higher in organic carbon, medium in available nitrogen, higher available phosphorus, medium in available potassium and available Zn, Cu, Fe and Mn were marginal.

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