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NPK uptake and biological yield performance of rainfed *Bt.* cotton under different sources of composts

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Abstract
Evaluation of different composts for uptake of NPK and biological yield performance of rainfed *Bt.* cotton" as conducted during *kharif* 2023-24 at Research Field of Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola, Maharashtra. There were eight treatments viz. T_1- Absolute control, T_2-10 t ha^{-1} FYM, T_3-75% RDN through VNIT compost, T_4-75% RDN through Vermicompost, T_5-75% RDN through PDKV phospho-compost, T_6-100% RDN through VNIT compost, T_7-100% RDN through Vermicompost and T_8-100% RDN through phospho-compost replicated three times in RBD. The results indicated that the significantly highest seed cotton yield (19.49 ha^{-1}), stalk yield (45.11 ha^{-1}), total uptake of N (69.48 ha^{-1}), P (39.32 ha^{-1}) and K (86.42 ha-^{1}) by *Bt*, cotton (Ajeet 155) was observed with application of 100% RDN through phospho-compost @ 7.5 t ha^{-1} which was at par to the application of vermicompost @ 10 t ha^{-1}.

Keywords: Phosphocompost, Vermicompost, NPK uptake and yield of *Bt.* cotton

Introduction
Cotton (Gossypium spp.) is one of the important predominant crops under cultivation in the semi-arid regions of India and some other parts of the world. It is commonly referred to as "white gold, "a very valuable commodity that is crucial to the economics of many nations and is regarded as the king of all fibre crops. It is an important source of fibre, oil and animal feed (Dai and Dong 2014). The main goal of cotton cultivation to the farmers is to obtain the fibre, elongated and thickened single cell of the seed epidermis. The Indian Textile Industry consumes a diverse range of fibres and yarns and the ratio of cotton usage to non-cotton fibres in India is around 60:40, while it is 30:70 for the rest of the world (Anonymous, 2024) [2].

India has obtained the first rank in the world in cotton acreage with 124.69 lakh hectares area under cultivation, the 2nd place in the world with an estimated production of 323.11 lakh bales (5.50 million metric tonnes) during the cotton season 2023-24. In terms of productivity, it is on the 33rdrank with the average yield of 441 kg ha-1. India is also the 2nd largest consumer of cotton in the world with an estimated consumption of 317 lakh bales (5.39 million metric tones) (Anonymous, 2024) [2]. Maharashtra is the leading state in terms of the area under cotton cultivation i.e., 42.22 lakh hectares.

Organic farming or natural farming is necessary to support the developing organic, sustainable and non-pollution agriculture (Sakal K. *et al.*, 2019) [14]. Organic cotton is the production system, which can bring back the cotton cultivation on sustainable basis without affecting environment (Khuspure J. *et al.*, 2019) [8]. Organic sources like FYM, vermicompost and phospho-compost are well-known for improving soil quality and productivity. These sources contain most of the nutrients required by the crops, which could help to improve physical properties and create a more favourable soil environment for root growth development. Organic manures also contain traces of micro-nutrients and also provide food for soil microorganisms. This increases activity of microbes which in turn helps to convert unavailable plant nutrients into available and also fixing atmospheric nitrogen (Manchala S. *et al.*, 2017) [10].

Organic manure is important for nutrient uptake because it provides nutrients to plants slowly and steadily. Organic manures have potential for improving soil and water conservation and sustaining soil productivity and enhancing crop yield (Khuspure J. *et al.*, 2015) [9].

In this context, the present investigation was conducted to study the Evaluation of different composts for uptake of NPK and biological yield performance of rainfed *Bt.* cotton on the Research Farm, Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra.

Materials and Methods

The field experiment was initiated from 2023-24 to study the "Evaluation of different composts for uptake of NPK and biological yield performance of rainfed *Bt.* cotton" at Research Field of Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola, Maharashtra. There were eight treatments viz. T_1- Absolute control, T_2-10 t ha^{-1} FYM, T_3-75% RDN through VNIT compost, T_4-75% RDN through Vermicompost, T_5-75% RDN through PDKV phospho-compost, T_6-100% RDN through VNIT compost, T_7-100% RDN through Vermicompost and T_8-100% RDN through phospho-compost replicated three times in Randomized Block Design. The recommended dose of fertilizers to *Bt.* Cotton is 90:45:45 N:P:K kg ha^{-1} and the doses of organic compost was given on the basis of nitrogen equivalent.

The plant samples were collected randomly from every plot at the harvest of the *Bt.* cotton. The samples were washed in sequence with detergent solution (0-25%), dilute 0.02 n HCL solution and deionized water. The extra moisture is wiped out, the sample is placed in an oven at 60 ℃ for 14 hrs. After drying, the samples are homogenized in laboratory using a sample mill. The floor samples have been saved in polythene bags with the right labeling for further chemical analysis.

Total nitrogen was determined by digesting the plant sample in a microprocessor-based digestion system (KES12L) using conc. H_2SO_4 and catalyst mixture (Kjeldahl`s method) and distillation with automatic distillation system (Piper, 1966) [12]. Total phosphorus was estimated using di-acid extract with the aid of using vanadomolybdate phosphoric acid yellow coloration method (Jackson 1973) [6]. Total potassium was estimated from the di-acid extract by using a flame photometer (Piper, 1966) [12].

The uptake of nutrient from different plant parts was calculated based on the data of their concentration in component plant parts and their average dry weights and converted on hectare basis. The total uptake was worked out by summing the uptake of respective nutrients in different plant component. (Piper, 1966). Yield of cotton was picked from net plots in all the replications and yield per plot and yield per hectare was calculated.

Results and Discussion

Influence of organic sources on nutrient content and uptake by rainfed *Bt.* cotton in Vertisols

Content of nutrients in cotton

Cotton plant samples were analyzed for their per cent N, P and K content in leaves, roots, stalk and seed at harvest and presented in table 1, 2 and 3, respectively. The data revealed that, the N, P, K content in seed cotton and their stalk was improved non significantly. However, their respective uptake was significant over the control treatment.

Nitrogen content

Nitrogen content and uptake in seed and plant as influenced by different organic treatments has been presented in table 1. Nitrogen uptake in seed and stalk were significantly influenced under all the organic treatments over control and maximum uptake was found in application of 100% RDN through Phosphocompost (47.80 kg ha^{-1} and 21.67 kg ha^{-1} respectively) which was at par with 100% RDN through Vermicompost (42.27 kg ha^{-1} & 19.54 kg ha^{-1} respectively). While the lowest content and uptake of nitrogen were obtained with absolute control.

Phosphorus Content: Table 2 presents the data on phosphorus content and uptake in seed cotton at harvest. Phosphorus uptake in seed and stalk were significantly influenced all the organic treatments. The maximum phosphorus uptake in seed cotton was observed with the application of 100% RDN through Phospho-compost (16.49 kg ha^{-1}) which was at par with 100% RDN through Vermicompost (14.87 kg ha^{-1}) and 100% RDN through VNIT compost (14.32 kg ha^{-1}). However the maximum phosphorus uptake in stalk of cotton was observed with the application of 100% RDN through Phospho-compost (22.84 kg ha^{-1}) which was at par with 100% RDN through Vermicompost (19.67 kg ha^{-1}), 100% RDN through VNIT compost (17.85 kg ha^{-1}) and 75% RDN through PDKV Phospho-compost (17.23 kg ha^{-1}). While absolute control recorded the lowest value for phosphorus content and uptake in cotton.

Table 1: Influence of different organic sources on nitrogen content and Uptake in cotton at harvest

Treatments	Seed Cotton		Cotton Stalk	
	N Content (%)	N Uptake (kg ha^{-1})	N Content (%)	N Uptake (kg ha^{-1})
T_1- Absolute Content	2.17	30.87	0.35	10.19
T_2- 10 t ha^{-1} FYM (University Recommended Dose of FYM)	2.36	37.09	0.43	15.54
T_3- 75% RDN through VNIT compost	2.23	33.07	0.45	15.43
T_4- 75% RDN through Vermicompost compost	2.37	36.24	0.42	14.73
T_5- 75% RDN through PDKV Phospho-compost	2.36	36.44	0.46	16.36
T_6- 100% RDN through VNIT compost	2.31	40.54	0.41	16.77
T_7- 100% RDN through Vermicompost	2.37	42.27	0.47	19.54
T_8- 100% RDN through Phospho-compost	2.45	47.80	0.48	21.67
SE(m)±	0.007	2.13	0.007	1.03
CD at 5%	NS	6.47	NS	2.13

Table 2: Influence of different organic sources on phosphorus content and Uptake in cotton at harvest

Treatments	Seed Cotton		Cotton Stalk	
	P Content (%)	P Uptake (kg ha^{-1})	P Content (%)	P Uptake (kg ha^{-1})
T_1- Absolute Content	0.78	11.06	0.49	13.88
T_2- 10 t ha^{-1} FYM (University Recommended Dose of FYM)	0.79	12.47	0.46	16.48
T_3- 75% RDN through VNIT compost	0.81	12.07	0.48	16.39
T_4- 75% RDN through Vermicompost compost	0.81	12.38	0.47	16.14
T_5- 75% RDN through PDKV Phospho-compost	0.83	12.72	0.48	17.23
T_6- 100% RDN through VNIT compost	0.82	14.32	0.44	17.85
T_7- 100% RDN through Vermicompost	0.83	14.87	0.49	19.67
T_8- 100% RDN through Phospho-compost	0.85	16.49	0.51	22.84
SE(m)+	0.006	0.737	0.007	1.063
CD at 5%	NS	2.24	NS	3.22

Potassium Content

The data pertaining to the potassium content in seed cotton and stalk of cotton as influenced by various organic treatments (Table 3). The highest potassium uptake in seed cotton was observed with the application of 100% RDN through Phospho-compost (39.65 kg ha^{-1}) which was at par with 100% RDN through Vermicompost (36.13 kg ha^{-1}) and 100% RDN through VNIT compost (35.86 kg ha^{-1}). However the maximum potassium uptake in stalk of cotton was observed with the application of 100% RDN through Phospho-compost (86.42 kg ha^{-1}) which was at par with 100% RDN through Vermicompost (77.81 kg ha^{-1}), 100% RDN through VNIT compost (74.95 kg ha^{-1}). While the lowest potassium content and uptake in cotton were recorded with absolute control.

Table 3: Influence of different organic sources on potassium content and Uptake in cotton at harvest

Treatments	Seed Cotton		Cotton Stalk	
	K Content (%)	K Uptake (kg ha^{-1})	K Content (%)	K Uptake (kg ha^{-1})
T_1- Absolute Content	1.56	22.22	0.96	28.08
T_2- 10 t ha^{-1} FYM (University Recommended Dose of FYM)	1.76	27.72	1.11	40.63
T_3- 75% RDN through VNIT compost	1.55	22.99	1.04	35.60
T_4- 75% RDN through Vermicompost compost	1.62	24.76	1.08	37.96
T_5- 75% RDN through PDKV Phospho-compost	2.02	31.09	0.96	34.77
T_6- 100% RDN through VNIT compost	2.05	35.86	0.97	39.09
T_7- 100% RDN through Vermicompost	2.03	36.13	1.01	41.68
T_8- 100% RDN through Phospho-compost	2.04	39.65	1.03	46.78
SE(m)+	0.011	1.734	0.013	2.324
CD at 5%	NS	5.258	NS	7.049

Total uptake of N, P, K by *Bt.* cotton under organic treatments

Organic manure is important for nutrient uptake because it provides nutrients to plants slowly and steadily. The application of organic nutrient sources slowly release of N from applied organic manures induces a residual effect on soil nutrient status which results in to improved nutrient status of soil and higher crop yield.

The results related to nutrient uptake of cotton crop as influence by the application of different organic sources were presented in table 4 and illustrate in fig. 1.

Effect of organic sources on total uptake of nutrients i.e. N, P, K of the plant was studied and discussed under the following heads. In general it was noted that, the treatment of 100% RDN through Phospho-compost reported significantly highest total uptake of N, P and K during growth of cotton crop.

The table 4 and Fig. 1 illustrate the total uptake of nitrogen by cotton crop under various treatments was range from 41.05 to 69.81 kg ha^{-1}. The study stated that, the application of (100% RDN through Phospho-compost) recorded the highest uptake of nitrogen (69.81 kg ha^{-1}), which was at par to treatment 100% RDN through Vermicompost (61.81 kg ha^{-1}). The lowest (41.05 kg ha^{-1}) nitrogen uptake was obrseved in Absolute control treatment. The results are in confirmation with the findings of Age *et al.*, (2019) [1] who reported that a significantly higher uptake of nitrogen by cotton was recorded with application of 100% P through phosphocompost over other treatments. Similar results were obtained by Karangami *et al.*, (2017) [7], Pal *et al.*, (2020) [11].

Table 4: Total uptake of nutrient by *Bt.* cotton as influenced by various compost treatments

Treatments	Total Uptake (kg ha^{-1})		
	N	P	K
T_1- Absolute Control	41.05	24.94	50.30
T_2-10t ha^{-1} FYM (Recommended Dose of FYM)	52.63	28.95	68.35
T_3- 75% RDN through VNIT compost	48.51	28.45	58.60
T_4- 75% RDN through Vermicompost compost	50.97	28.52	62.73
T_5- 75% RDN through PDKV Phospho-compost	52.81	29.95	65.87
T_6- 100% RDN through VNIT compost	57.31	32.17	74.95
T_7-100% RDN through Vermicompost	61.81	34.54	77.81
T_8-100% RDN through Phospho-compost	69.48	39.32	86.42
SE(m)+	2.67	1.57	4.37
CD at 5 %	8.19	4.81	13.41

Total phosphorus uptake by *Bt.* cotton under different treatments, ranges from 24.94 to 39.32 kg ha^{-1}. The study found that the application of 100% RDN through phospho-compost recorded the highest phosphous uptake (39.32 kg ha^{-1}). However, it was statistically at par with 100% RDN through Vermicompost (34.54 kg ha^{-1}). The control plot had the lowest uptake of phosphorus (24.94 kg ha^{-1}). The results are in confirmation witht the findings of Age *et al.,* (2019) [1] who reported that a significantly higher uptake of phosphorus by cotton was recorded with application of 100% P through phosphocompost over other treatments. These results are consistent with previous findings by Garrido *et al.,* (2009) [5] and Pal *et al.,* (2020) [11].

Total potassium uptake by *Bt.* cotton under different treatments, ranges from 50.30 to 86.42 kg ha^{-1}. The study showed that, the application of 100% RDN through phospho-compost resulted in the highest uptake (86.42 kg ha^{-1}). 100% RDN through Vermicompost (77.81 kg ha^{-1}), and 100% RDN through VNIT compost (74.95 kg ha $^{-1}$) which were at par with treatment. Absolute control had the lowest potassium uptake at 50.30 kg ha^{-1}. The results confirm the findings of Age *et al.,* (2019) [1] who reported that applying 100 % P through phosphocompost in cotton recorded higher potassium uptake than other treatments and revealed that the increase in total potassium uptake was due to the incorporation of decomposed material like FYM, phosphocompost, vermicompost and glyricidia green leaf manuring along with inorganic fertilizers. These findings closely align with the findings from Pal *et al*., (2020) [11].

Influence of organic sources on yield performance of rainfed *Bt.* cotton in Vertisols

Seed cotton yield

The data in the table 5 and Fig. 2 illustrate the seed cotton yield was significant under various organic treatments, ranging from 14.18 to 19.49 q ha^{-1}. The treatment received 100% RDN through phospho-compost recorded the significantly highest seed cotton yield (19.49 q ha^{-1}) and was at par with 100% RDN through Vermicompost and 100% RDN through VNIT compost treatment. The use of 100% RDN through Phospho-compost and VNIT compost led to an increase in seed cotton yield per hectare might be due to the higher availability of nutrients from well decomposed manures. The lowest seed cotton yield (14.18 q ha^{-1}) was observed in the absolute control treatment.

The results mentioned are similar to the findings of Solunke *et al.,* (2018) [15], who reported that a significantly higher seed cotton yield was achieved under the treatment of FYM followed by Vermicompost compared to the control treatment. This increase is attributed to enhanced microbial activity, which in turn helps in the transformation of nutrients, making them more available to plants. These results align with the findings of Bonge et al., (2017) [4], Sonune et al. (2012) [16] and Bhalerao and Gaikwad (2011) [3].

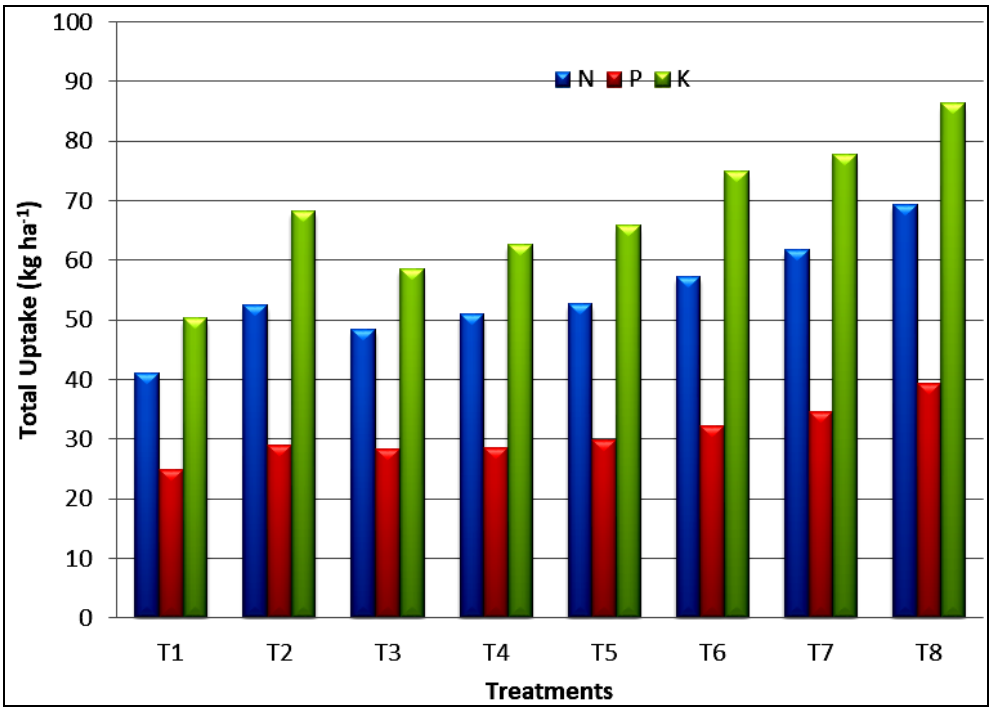

Fig 1: Effect of different compost treatments on nutrient uptake by cotton in vertisols

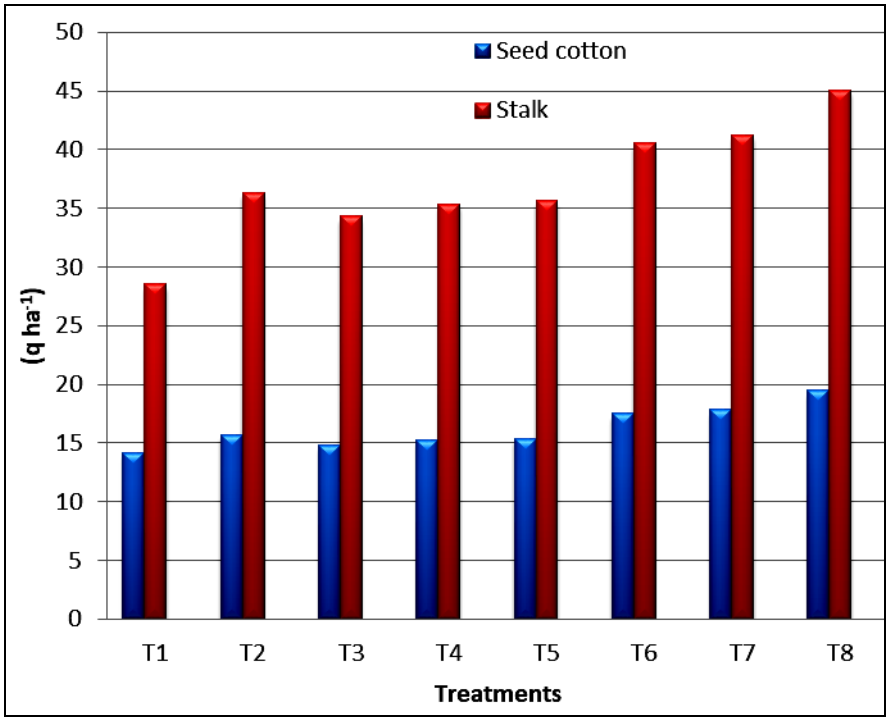

Fig 2: Effect of different compost sources on cotton yield

Table 5: Influence of different organic treatments on yield of *Bt*. cotton

Treatments	Seed cotton yield (q ha^{-1})	Cotton stalk yield (q ha^{-1})
T_1- Absolute Control	14.18	28.55
T_2-10t ha^{-1} FYM (Recommended Dose of FYM)	15.72	36.38
T_3- 75% RDN through VNIT compost	14.83	34.32
T_4- 75% RDN through Vermicompost compost	15.29	35.38
T_5- 75% RDN through PDKV Phospho-compost	15.39	35.62
T_6- 100% RDN through VNIT compost	17.53	40.57
T_7-100% RDN through Vermicompost compost	17.83	41.27
T_8-100% RDN through Phospho-compost	19.49	45.11
SE(m)±	0.92	2.16
CD at 5%	2.82	6.64

Cotton stalk yield

The data on cotton stalk yield mentioned in the table 5 and depicted in the figure 2 show a significant influence of various organic sources FYM, VNIT compost, vermicompost, and Phospho-compost, on stalk yield.

Fig. 2 shows that, cotton stalk yield ranged from 28.55 to 45.11 q ha^{-1}. It was observed that stalk yield increased with the higher doses of well-decomposed organic manures. The highest cotton stalk yield of 45.11 q ha^{-1} was recorded in the 100% RDN throught Phospho-compost and was at par with 100% RDN through Vermicompost compost (41.27 q ha^{-1}) followed by 100% RDN through VNIT compost (40.57 q ha^{-1}), and 10 t ha^{-1} FYM (36.38 q ha^{-1}). The lowest cotton stalk production (28.55 q ha^{-1}) was observed in the absolute control treatment.

These results are consistent with the findings of Bonge V.E. *et al.*, (2017) [4] who reported that farmyard manure (FYM) significantly increased cotton stalk yield compared to other sources. The increase in stalk yield with organic sources and treatments may be attributed to higher photosynthetic activity, leading to a better supply of carbohydrates, resulting in increased branches and dry matter accumulation. Rao *et al.*, (2017) [13] also reported that the highest stalk yield of cotton was observed in the FYM 10 t ha^{-1} treated plot, possibly due to the improved influence of FYM application, which may have increased the photosynthesis rate and acted as a source of additional nutrients and moisture retention

Conclusion

After the first cycle of rainfed organic *Bt.* cotton experimentation, it can be concluded that, significant improvement in the yield performance of *Bt.* cotton was observed under the 100% RDN through well decomposed PDKV-phosphocompost followed by vermicompost, which can be evident by significant uptake of nitrogen, phosphorus and potassium by cotton crop. The rainfed organic *Bt.* cotton response well to the enriched compost like phosphocompost (@ 7.5 t ha^{-1}) and vermicompost (@ 10 t ha^{-1}).

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