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Effect of planting method and nutritional modules on nutrient uptake and yield of onion

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Abstract
A field experiment was conducted during *kharif* season (2018-19) to find out the effect of nutritional modules (Vermicompost and inorganic fertilizers) on growth, yield and nutrient uptake by onion (*Allium cepa* L.). There were fifteen treatments comprised of varied levels of vermicompost and chemical fertilizers. The experiment was laid out under Split plot design (SPD) and the treatments were triplicated during the experiment. Significantly higher yield of onion (31.84t ha^{-1}) was observed in the plots received 50% K through vermicompost +50% K through fertilizers (T_4) as compared to other treatments. Similar significant effect was observed on nutrient content (N, P and K) and nutrient uptake (N, P and K). On the basis of results obtained it can be concluded that the nutritional modules (vermicompost and inorganic fertilizers) can substitute the potassium requirement of plant to the extent of 20-23% and increased the yield, content and uptake of N, P and K by onion significantly over the sole use of chemical fertilizers.

Keywords: Kharif onion, nutritional modules, vermicompost, potassium

Introduction
Onion crop is very responsive to potassium nutrition. Both yield and storability of onion is influenced by potassium nutrition (Fatma *et al*., 2014) [3]. *Kharif* onion productions need the lien period requirement by stabilizing its market price that high sharply in the month of December and January. Cultivation of kharif onion is critical due to erratic monsoon, cloudy weather, constant drizzling and effect of foliar and soil borne diseases. But, poor storability of the *kharif* onionis one of the most important limitations in the way of popularity of the crop among farming community. As potassium nutrition influences storability of *kharif* onion, so the effect of compost and chemical K containing fertilizer on dynamics of potassium and productivity of the crop is required to be studied to achieve the higher yield of the crop.
Planting method is one of the most important factors which affect the production of crop. Among three planting methods (flat bed, raised bed and ridge bed) raised bed method of planting is most suitable for production of *kharif* onion while ridge bed suitable for enhancing growth characters. Flat bed method of planting for *kharif* onion some disadvantages due to drainage problem.
Vermicompost is organic manure, which is act a reservoir of nutrients as well as maintaining soil health and removes the harmful effect of chemical fertilizer. It is an important source of K. Potassium present in the vermicompost releases slowly in soil which meet the demand of onion crop during complete growth period of the crop. But scanty of information is available on effect of vermicompost application on transformation of potassium the *kharif* onion. So, to achieve higher production and storability of *kharif* onion, study the effect of vermicompost and K containing fertilizer alone or in combination is require urgently.
The *kharif* onion gets sensitive under heavy rainfall and water stagnation conditions. The germination percentage hampered and ultimately yield gets affected. For assessing the better yield under rainy season from *kharif* onion, it will be essential to know about planting method. The establishment method is a very important factor among the entire factors. There is lack of information regarding responses of planting methodin combinations with organic and synthetic fertilizers as well as the relationship among the various potassium fractions for improvement of productivity, production and storability of the crop.

Materials and Method
To study the interaction effect of different plantings methods and nutritional modules on nutrient uptake, growth and yield of *kharif* onion, a field experiment was conducted at Bihar Agricultural College Farm, Sabour during the year 2018-19 followed by laboratory analysis of the post-harvest soil and plant samples.

The experiment was conducted at vegetable farm of Bihar Agricultural University, Sabour, Bhagalpur which is located in south Bihar of Agro-climatic Zone III A. Geographically, it is located at 25°50' N latitude, 87°19' E longitude and at an altitude of52.73 meters above mean sea-level. The initial physico-chemical properties *viz*. soil texture (Sandy loam), pH (1:2.5; 7.41), EC (1:2.5; 0.23 dSm^{-1}), organic C (4.13 g kg^{-1}), available N (202.63 kg ha^{-1}) available P (15.68kg ha^{-1}) and available K (230.49 kg ha^{-1}) of experimental plot.

Experiment design and treatment details

The experiment was laid out in Split plot design (SPD) during *Kharif* seasons with fifteen treatments and three replications. The details of various treatments applied to onion crop along with the symbols used are as:

T_1:Flat bed, T_2:Raised bed, T_3: Ridge bed, C_1: control (No use of potassium) C_2:100% potassium through fertilizer, C_3: 100% potassium through vermicompost, C_4: 50% potassium through vermicompost +50% potassium through fertilizer and C_5: 25% potassium through vermicompost +75% potassium through fertilizer.

Field was prepared by cross harrowing followed by transplanting of seeding. Full care was taken to level the plots uniformly and grasses were removed from the plots. 30 days old onion seeding of cultivar Agrifound Dark Red was transplanted at spacing of 15 × 10 cm in the plots having net plot area of 3.375 m^2. Recommended doses of nitrogen, phosphorus and potassium i.e. @ 100, 60 and 60 kg ha^{-1}, potassium was supplied @ 60 kg ha^{-1} either through vermicompost or murate of potash (as for treatment plan). However, nitrogen and phosphorus were applied @ 100 kg ha^{-1} and 60 kg ha^{-1} respectively. In case of vermicompost application, only the remaining amount of recommended N and P were supplied through urea and single super phosphate. Vermicompost use for the experimentation was containing. Nitrogen was applied through urea, uniform based application of phosphorus and potassium was made through single super phosphorus and murate of potash, respectively to all plots. The elemental composition of vermicompost (1.33% N; 0.80% P; 0.80% K) so obtained had been used to supplement the nitrogen requirement of onion crop. The crop was harvested on 5th Jan 2019. Yield and yield contributing data were recorded at the harvest. The diameter of onion bulb obtained circumference of onion bulb by the factor 3.14. After harvesting, the weight of onion bulb was recorded. After harvesting, the weight of onion bulb was recorded. Plant samples drawn at harvesting were dried in shade and chaffedinto pieces and then kept in oven at 60 °C for 12-16 hours to make free from moisture. After that, the dried samples were ground in a grinder. After mixing well the ground samples were digested in diacid mixture prepared by Nitric acid and perchloric acid in the ratio of 10:4. The digested samples used to determine the nitrogen, phosphorus, and potash content by following the standard procedures.

Statistical analysis

Data on morphological and yield attributes parameters were subjected to statistical analyses. All data were given as mean and standard error by split-plot designs (Box *et al*, 2005) [19]. The differences between the treatment groups and controls were statistically analyzed. The level of signifi-cance was set at $P< 0.05$.

Results and Discussion

Plant height

Effect of planting methods and nutritional modules on height of plant at 35, 70, 90 and 120 DAT in *kharif* onion under irrigated condition Table 1. Plant height was not affected significantly by planting method and nutritional modules at 35 day stage of plant growth. However, nutritional module affected the plant height at 70, 90 and 120 days significantly. The highest plant height at 70 DAT (39.88 cm), 90 DAT (55.20 cm) and 120 DAT (59.27 cm) were recorded with 50% potassium through vermicompost + 50% potassium through inorganic fertilizer. However, the lowest values of plant height were recorded in control plots. Plant height probably due to higher availability of potassium to the plants in this treatment. The increase in overall growth of plants with application of potassium through vermicompost and chemical fertilizer might be due to better translocation of photosynthates and assimilates, formation of chlorophyll and proteins and its role mainly in the activation of enzymes during growth periods of onion (Verma and Singh 2012) [20].

Bulb weight and bulb equatorial diameter

It is vivid from the data presented in table 1, that both planting methods and nutritional modules influenced fresh weight of bulb (g) significantly. Out of main plot treatments, T_3 (Ridge bed) was found to be significantly superior over all other treatments to increase weight of the bulb. The highest fresh weight of bulb (46.18 g) was recorded in plot treated with treatment T_3 (Ridge bed) and the lowest (43.10 g) in T_1 (flat bed). Among nutritional modules, the highest fresh weight of bulb (51.40 g) was observed in plot receiving treatment C_4 (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) and the lowest (34.04 g) in control plot.This might be due to fact that release nutrient such as nitrogen, phosphorus and potassium from vermicompost during their decomposition at later stages of plant growth, which was helpful in increasing the nutrient status throughout the growth stages and at bulb formation, however, chemical fertilizer was applied at the time of transplanting, help in supply of nutrient during early stage. Similarly, significantly higher weight of bulb due to application of organics and integration of different nutrient has been reported by Jayathilake *et al*. 2002 [4]; Hari *et al*. 2009 [5]; Bagali *et al*. 2012 [6, 11]; Kumar *et al*. 2016 [7].

Among different combinations of treatments, the highest equatorial diameter of bulb (7.38 cm) was observed with C_4 (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) whereas, the lowest equatorial diameter of bulb (4.61cm) was recorded in C_1 (control). The data has been presented in table 1.It might be due to the application of vermicompost which contain major and micro nutrients resulted in enhanced nitrogen metabolism, chlorophyll formation, photosynthetic activity and auxin contents in plants which help in increasing the polar and equatorial diameter of bulb. Organic manures help in reduction of bulk density thus results in increased the porosity and improved the physical condition of soil for better growth of bulb of onion plant. In the other hand, chemical fertilizer improved water soluble and exchangeable K^+ in early stage of plant growth and its combination with vermicompost assures potassium availability in letter stage and it might be the probable reason of higher polar and equatorial diameters of bulbs in integrated nutrient management system. Higher polar and equatorial diameter of bulb with the combine application of organic manures with in organics has been reported by

Chowdappan 1972 [8]; Thimmaiah 1989; Singh *et al*. 1993; Mallanagouda *et al*. 1995; Varu *et al*. 1997 [10]; Baghali *et al*. 2012 [6].

Yield of onion

It is obvious from the data presented in table 2,that planting methods and nutritional modules significantly increased the bulb yield of kharif onion. The highest bulb yield (30.08 t ha^{-1}) was recorded in T_2 (Raised bed) and lowest (25.19 t ha^{-1}) in T_1 (flat bed). Among nutritional modules, the highest yield of bulb (31.84 t ha^{-1}) was recorded with C_4 (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) whereas, the lowest (22.30 t ha^{-1}) in control plot. Interaction of planting methods and nutritional modules increased the bulb yield significantly. Interaction of T_2 (Raised bed) and C_4 (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) resulted the highest bulb yield (31.84 t ha^{-1}) and found significantly superior to rest of the treatment combinations. The yield of bulb was found significantly higher in raised bed method of planting. Higher bulb yield in raised bed method of planting was might be due to higher availability of moisture, survival percentage and better environment condition to the plants in comparison to flat method of planting. Similar results have been reported by Malviya *et al*. 2012 [13].

Nutrients content in onion bulbs

The highest nitrogen content of nitrogen was recorded in treatment C_4 (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) treated plants and the value was at par with that recorded with treatment C_5 (25% potassium through vermicompost + 75% potassium through inorganic fertilizer), C_2 (100% potassium through inorganic fertilizer) and C_3 (100% potassium through vermicompost). The lowest nitrogen content in plant (0.940%) was found in plants collected from control plots. It is evident from the data presented in table 3,that the highest phosphorus content in plant (0.217%) was obtained in vermicompost treated plots i.e. C_3 (100% potassium through vermicompost).The value was at par with treatment C_4 (50% potassium through vermicompost + 50% potassium through inorganic fertilizer), C_5 (25% potassium through vermicompost + 75% potassium through inorganic fertilizer), C_2 (100% potassium through inorganic fertilizer).The lowest phosphorus content (0.162%) was found in C_1.The potassium content in plant was increased with increasing the use of chemical fertilizer. Result showed that highest potassium content in plant (1.271%) was in plants treated with C_2 (100% potassium through inorganic fertilizer). Whereas, the lowest phosphorus content (0.957%) was found in control. The significantly higher nitrogen content in plant obtained when 50% of recommended K was supplied through vermicompost and remaining 50% was supplied through chemical fertilizer. Nitrogen, phosphorus and potassium content in plant were found highest under integrated nutrient management system. It was probably due to higher nitrate concentration in vermi-cast and minimal loss of chemical N, P and K under integrated nutrient management system. The other probable reason might be higher multiplication of microbes in vermicompost treated soil which convert organically bound and inherent N, P and K to inorganic form of nitrogen, phosphorus and potassium similar result reported by Singh *et al*. 2014.

Nutrients uptake by onion

The highest nitrogen uptake by plant (58.44 kg ha^{-1}) was recorded in treatment C_4 (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) which was statistically at par with C_5 (25% potassium through vermicompost + 75% potassium through inorganic fertilizer) and C_3(100% potassium through vermicompost (Table 3). Synergistic effect between manure and chemical fertilizer helped in better uptake of nitrogen. Increased nitrogen uptake due to integrated use of organics manure and chemical fertilize has also been reported by Chavan *et al*. 1997 [15]; Subbiah *et al*. 1982 [16].

It is evident from table 3 that Phosphorus uptake (kg ha^{-1}) was not influenced by planting methods. However, nutritional modules affected Phosphorus uptake by onion plants. Result showed that the significantly higher phosphorus uptake by plant (15.67 kg ha^{-1}) was observed in treatment C_3 (100% potassium through vermicompost) which was statistically at par with C_5 (25% potassium through vermicompost + 75% potassium through inorganic fertilizer), C_4 (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) whereas, lower the uptake of phosphorus (6.26 kg ha^{-1}) was found in control plot.The higher phosphorus availability in this treatment especially during growth period was probably due to conversion of native organic P into available pool by phosphate solubilising microorganism**.** It has been reported by Singh and Pandey 2006 [17]; Sharma *et al*., 2009 [18].

Among different nutritional modules, treatment C_4 (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) resulted into the highest K uptake by plant (62.30 kg ha^{-1}). It was at par with C_3 (100% potassium through vermicompost), C_5 (25% potassium through vermicompost + 75% potassium through inorganic fertilizer) and C_2 (100% potassium through fertilizer).The data pertaining to K uptake by *kharif* onion plant has been presented in table 3. It might be due to application of both organic such as vermicompost and inorganic sources of K. During decomposition of vermicompost, it releases some acids, which helps in reduction of potassium fixation and improves the K availability Dubey *et al*. 2012 [1].

Table 1: Effect of planting methods and nutritional modules on plant height, bulb weight and bulb equatorial diameter at different growth stages of kharif onion.

Treatment	Plant Height (cm)				Equatorial diameter	Bulb weight
	35 DAT	70 DAT	90 DAT	120 DAT	(cm)	(g)
Planting Methods						
Flat bed	22.81	36.48	48.29	52.98	5.93	43.10
Raised bed	23.53	37.07	49.94	53.98	6.15	47.24
Ridge bed	23.99	38.41	50.07	55.39	6.40	46.18
SEm(±)	0.71	0.61	0.56	1.87	0.13	0.57
LSD (p=0.05)	NS	NS	NS	NS	NS	2.94
Control	20.92	34.20	42.57	43.33	4.61	34.04
100% $K_{Fert.}$	22.42	36.46	47.62	54.54	5.64	46.96

100% K_{VC}	23.12	37.33	49.57	55.29	6.32	47.07
50% $K_{Fert.}$ + 50% K_{VC}	25.40	39.88	55.20	59.27	7.38	51.40
75% $K_{Fert.}$ + 25% K_{VC}	25.36	38.73	53.61	58.14	6.70	48.07
SEm(±)	1.17	0.65	1.03	1.79	0.16	1.36
LSD (p=0.05)	NS	1.90	3.00	5.23	0.47	3.96
Interaction (P×N)	NS	NS	NS	NS	NS	NS

Significantly different at 0.05 probability levels. NS: not significant.

Table 2: Effect of planting methods and nutritional modules on bulbyield of kharif onion.

Treatments	Flat bed	Raised bed	Ridge bed	Mean
Control	21.22	23.31	22.36	22.30
100% $K_{Fert.}$	25.10	29.16	26.88	27.04
100% K_{VC}	24.31	29.56	28.01	27.30
50% $K_{Fert.}$ + 50% K_{VC}	28.62	35.42	31.46	31.84
75% $K_{Fert.}$ + 25% K_{VC}	26.74	32.98	28.18	29.30
Mean	25.19	30.08	27.36	
LSD (p=0.05) T	2.31			
LSD (p=0.05) C	2.26			
LSD (p=0.05) T x C	3.90			

Significantly different at 0.05 probability levels. NS: not significant

Table 3: Effect of planting methods and nutritional modules on nutrient content and nutrient uptakeof kharif onion.

Treatment	Nutrients Content (%) in onion			Nutrients uptake (kg ha^{-1}) by onion		
	N	P	K	N	P	K
Planting Methods						
Flat bed	0.991	0.186	1.057	45.00	11.50	45.00
Raised bed	1.019	0.201	1.211	51.73	13.50	51.68
Ridge bed	1.008	0.198	1.150	50.42	12.44	50.23
SEm(±)	0.01	0.01	0.04	1.75	1.62	2.17
LSD (0.05)	NS	NS	NS	NS	NS	NS
Nutritional modules						
Control	0.940	0.162	0.957	30.15	6.26	30.84
100% $K_{Fert.}$	1.017	0.179	1.271	50.54	11.05	52.88
100% K_{VC}	0.980	0.217	1.123	51.50	15.67	53.34
50% $K_{Fert.}$ + 50% K_{VC}	1.063	0.209	1.169	58.44	15.39	54.13
75% $K_{Fert.}$ + 25% K_{VC}	1.030	0.203	1.176	54.62	13.76	53.74
SEm(±)	0.02	0.01	0.07	2.52	1.14	2.24
LSD (0.05)	0.06	0.03	0.19	7.34	3.33	6.52
Interaction (P×N)	NS	NS	NS	NS	NS	NS

Significantly different at 0.05 probability levels. NS: not significant.

Conclusion

On the basis of these results it can be concluded that the nutritional modules (vermicompost and chemical fertilizers) can substitute the Potassium requirement of plant and increased the yield, content and uptake of N, PandK by onion significantly over the sole use of chemical fertilizer. The plots which had received vermicompost and chemical fertilizers have showed significant improvement in residual soil fertility. It could also be concluded that the application of vermicompost with inorganic fertilizers has good performance over the sole input. In general, the use of vermicompost and fertilizers increases the yield and reduces the dose of inorganic potassium source by 5-10 percent.

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