

Original Research Article

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## Efficacy of Vermicompost and Inorganic Source of Potassium on Yield Attributing Characters, Bulb Yield of *Kharif* Onion and Residual Fertility Status of Soil

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### ABSTRACT

Among all essential plant nutrients, potassium is the 3<sup>rd</sup> most likely, after nitrogen and phosphorus to limit plant productivity. The production and productivity of onion is very sensitive to potassium status in soil. Thus, it has become essential to replenish the reserve of potassium which are removed or lost from the soil. Effect of organic and inorganic sources of potassium or alone influence on productivity and storability of *kharif* onion. A field experiment was conducted in split plot design with 15 treatments and 3 replications at Bihar Agricultural College Farm of BAU, Sabour, (Bhagalpur) during the year 2018-19. Three planting methods of *kharif* onion (T<sub>1</sub>: Flat bed, T<sub>2</sub>: Raised bed and T<sub>3</sub>: Ridge bed) and five nutritional modules (C<sub>1</sub>: Control, C<sub>2</sub>: 100% K<sub>Fert.</sub>, C<sub>3</sub>: 100% K<sub>VC</sub>, C<sub>4</sub>: 50% K<sub>Fert.</sub> + 50% K<sub>VC</sub> and C<sub>5</sub>: 75% K<sub>Fert.</sub> + 25% K<sub>VC</sub>) where allocated in main and sub-plots respectively. Results from field experiment indicated that planting methods did not influenced growth parameter, yield attributing characters and quality parameter of onion bulb, significantly. The maximum number of leaves at 70 DAT (5.99), 90 DAT (8.14) and 120 DAT (9.95) were recorded in plot receiving 50% recommended K through vermicompost and 50% recommended K through chemical fertilizer. The neck thickness was not influenced by nutritional modules. The maximum polar diameter of bulb (4.22 cm) was found with C<sub>4</sub> (50% K<sub>Fert.</sub> + 50% K<sub>VC</sub>) treatment. The highest TSS content of bulb (12.42 °Brix) was recorded with treatment C<sub>3</sub> (100% potassium through vermicompost). However, yield of *kharif* onion was augmented significantly by planting methods and the highest bulb yield (31.84 t ha<sup>-1</sup>) was recorded in Raised bed method. The physiological weight losses were found the highest (34.81%) in C<sub>2</sub> and lowest (26.82%) in C<sub>3</sub> after 90 days of storage, as compared to the initial weight of bulbs. Rotting percentage of bulb was also recorded to be the lowest in C<sub>3</sub> treated onion bulb. After harvest, soil reaction (pH), Electrical conductivity (EC) and Cation exchange capacity (CEC) were not affected by planting methods and nutritional modules. The maximum value of SOC, available nitrogen and available phosphorus was obtained in that soil in which 100% of recommended K was supplied through vermicompost (VC).

#### Keywords

Kharif onion,  
Storability,  
Vermicompost, Soil  
fertility,  
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## Introduction

Among the different cropping cycle *kharif* onion imparts special attention of small stakeholder farmer due to high market demand after November month. But due rainy days in *kharif* season infestation of insect-pest and water stagnation were severe which prime constraints in adoption of farming of onion. The poor storability and continuous use of heavy dose of inorganic fertilizer and inadequate management practice of soil fertility play a crucial role in limiting the onion cultivation among the society of farmer. There was significant response of application of organic and inorganic fertilizer was showed by onion crops Nasreen and Hossain, 2000. Among the different nutrients, response to potassium by onion crop was appeared to be highest. Both yield and storability of onion is influenced by potassium nutrition Fatma *et al.*, (2014). The regulation of stomata opening and closing of plants was operating by potassium ions as well as helping plants to adapt environmental stresses. Good potassium nutrition is linked to improved drought tolerance, winter hardening and better tolerance to pest and diseases. Vermicompost is organic manure, which act as reservoir of nutrients as well as maintaining soil health and removes the harmful effect of chemical fertilizer. Beside this, it have positive effect on the growth of root by enhancing the root rhizosphere conditions (structure, humidity, etc.) Shaheen *et al.*, (2007). 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 accounting the higher yield under rainy season from *kharif* onion, it will be necessary to know about different methods of planting and nutrition module. The information about the responses of planting method with combinations of organic and synthetic fertilizers was lacking nowadays. With objective of higher yield under rainy days with keeping the view of soil fertility status, the present study was carried out.

## Materials and Methods

An experiment on the soil order “Inceptisols” and sub group “Typichesteps” was conducted at Bihar Agricultural College Farm, Sabour 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 of 52.73 meters above mean sea-level during the year 2018-19 on *kharif* onion to study the effects of interaction among the different plantings methods and application of different nutritional modules on yield attributing character such as neck thickness, polar diameter, leaf number, TSS and yield.

The hottest month is May with an average maximum temperature of 35 - 39°C while, coldest month is January of the year with mean minimum temperature varies from 5 - 10°C. The average annual rainfall is about 1380 mm and mostly occurs between mid-June to mid-October. The experiment was proceed in split plot design having three replication under three planting methods such as Flatbed (T<sub>1</sub>), Raised bed (T<sub>2</sub>) and Ridged bed (T<sub>3</sub>) in main plot and Control (C<sub>1</sub>), 100% Potassium through fertilizer (C<sub>2</sub>), 100% Potassium through vermicompost (C<sub>3</sub>), 50% Potassium through vermicompost +50%

Potassium through fertilizer (C<sub>4</sub>) and 25% Potassium through vermicompost + 75% Potassium through fertilizer (C<sub>5</sub>) in sub-plot. Soil were collected before sowing and after harvesting of crop at depth of 0-15 cm. Soil sample were air dried and passes with 2 mm sieve and go for analyzed of the parameter. Recommended dose of nitrogen, phosphorus and potassium was applied at the times of transplanting. First of all potassium was supplied either through vermicompost or murate of potash or their combinations. Amount of nitrogen or phosphorus supplied through vermicompost was computed and then were detected from total amount of nitrogen or phosphorus to be supplied. Rest of the nitrogen or phosphorus was supplied through urea and single super phosphate respectively.

## Results and Discussion

### Leaf Number

It is vivid from table: 1 that leaf number was not affected by planting method and nutritional modules at 35 day stage of plant growth. However, nutritional module affected the leaf number at 70, 90 and 120 days significantly. The maximum number of leaves at 70 DAT (5.99), 90 DAT (8.14) and 120 DAT (9.95) were recorded in plot receiving 50 % recommended K through vermicompost and 50 % recommended K through chemical fertilizer.

### Neck thickness

It is obvious from the data presented in table: 1 that neck thickness of onion bulbs was not affected by both, nutritional modules and planting methods. But the highest neck thickness of bulb (1.68 cm) was observed with C<sub>4</sub> (50 % potassium through vermicompost + 50 % potassium through inorganic fertilizer).

### Polar diameter

It is evident from the data presented in table: 1 that planting methods did not influence the polar diameter of onion bulb significantly, however, nutritional modules affected the polar diameter significantly. The highest polar diameter of bulb (4.22 cm) was observed with C<sub>4</sub> (50 % potassium through vermicompost + 50 % potassium through inorganic fertilizer) which were at par with the treatments, C<sub>5</sub> (25 % potassium through vermicompost + 75 % potassium through inorganic fertilizer) and C<sub>3</sub> (100 % potassium through vermicompost) whereas, the lowest polar diameter of bulb (3.19 cm) was recorded in C<sub>1</sub> (control).

### Total soluble solid (TSS)

It is obvious from table: 1 that nutritional module influenced TSS of onion bulbs significantly. The TSS content of bulb was improved due to application of vermicompost. The highest TSS content of bulb (12.42° Brix) was recorded with treatment C<sub>3</sub> (100% potassium through vermicompost). This TSS content was at par with that obtained with the treatments, C<sub>4</sub> (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) and C<sub>5</sub> (25% potassium through vermicompost + 75% potassium through inorganic fertilizer). The lowest TSS content of bulb (10.11 °Brix) was recorded in bulb obtained from control plots.

### Bulb yield

Data pertaining in figure: 1 that nutritional modules and planting methods significantly increased the bulb yield of *kharif* onion. The highest bulb yield (30.08 t ha<sup>-1</sup>) was recorded in T<sub>2</sub> (Raised bed) and lowest (25.19 t ha<sup>-1</sup>) in T<sub>1</sub> (flat bed). Among nutritional modules, the highest yield of bulb (31.84 t ha<sup>-1</sup>) was recorded with C<sub>4</sub> (50% potassium through vermicompost + 50% potassium through

inorganic fertilizer) whereas, the lowest ( $22.31 \text{ t ha}^{-1}$ ) in control plot. Interaction of planting methods and nutritional modules increased the bulb yield significantly. Interaction of T<sub>2</sub> (Raised bed) and C<sub>4</sub> (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) resulted the highest bulb yield ( $31.84 \text{ t ha}^{-1}$ ) and found significantly superior to rest of the treatment combinations

### **Chemical properties of soil after harvest the crop**

#### **Soil Reaction (pH)**

It has been presented in table: 3 that soil reaction was slightly alkaline and ranged from 7.19 to 7.34. Both, nutritional modules and planting methods of onion crop did not influence pH of experimental soil significantly.

#### **Electrical conductivity (EC)**

It is vivid from table 3 that both, nutritional modules and planting methods of onion crop did not influenced electrical conductivity of experimental soil significantly.

#### **Cation Exchange capacity (CEC)**

It is evident from table: 3 that both, nutritional modules and planting methods of onion crop did not influenced CEC of experimental soil significantly.

#### **Soil organic carbon (SOC)**

It is obvious from the table: 3 that SOC increased due to application of vermicompost. The highest SOC ( $4.88 \text{ g kg}^{-1}$ ) was determined in the soil treated with C<sub>3</sub> (100% potassium through vermicompost) and the lowest ( $4.20 \text{ g kg}^{-1}$ ) in case of treatment C<sub>1</sub> (control) followed by C<sub>2</sub> (100% potassium through inorganic fertilizer).

#### **Available nitrogen**

It is evident from table: 3 that available nitrogen increased more pronouncedly due to application of vermicompost.

The highest residual nitrogen ( $196.67 \text{ kg ha}^{-1}$ ) was observed in treatment receiving 100% potassium through vermicompost. It was at par with the data recorded with C<sub>4</sub> (50% potassium through vermicompost + 50% potassium through inorganic fertilizer). The lowest residual nitrogen ( $179.23 \text{ kg ha}^{-1}$ ) was recorded in control soil.

#### **Available phosphorus**

In case of nutritional modules, highest residual phosphorus ( $19.80 \text{ kg ha}^{-1}$ ) was recorded in soil treated with C<sub>3</sub> (100% potassium through vermicompost). This value was at par with that recorded in C<sub>4</sub> (50% potassium through vermicompost + 50% potassium through inorganic fertilizer), C<sub>5</sub> (25% potassium through vermicompost + 75% potassium through inorganic fertilizer), C<sub>2</sub> (100% potassium through inorganic fertilizer) treated soil. The lowest residual phosphorus ( $16.79 \text{ kg ha}^{-1}$ ) in case of treatment with C<sub>1</sub> (control). The data have been presented in table: 3.

#### **Available potassium**

The maximum residual available potassium was found in C<sub>4</sub> treated plot (Table: 3). The soil residual potassium was increased with addition of organic fertilizer and chemical fertilizer. The highest residual potassium was observed in treatment receiving with C<sub>4</sub> (50% potassium through vermicompost + 50% potassium through inorganic fertilizer) However, the lowest residual potassium ( $154.63 \text{ kg ha}^{-1}$ ) in case of treatment with C<sub>1</sub> (control).

**Table.1** Leaf number, neck thickness (cm), polar diameter (cm), TSS (° Brix), as influenced by planting methods and nutritional modules after harvest of *kharifonion* crop

| Treatment                                      | Leaf Number |        |        |         | Neck thickness | Polar diameter | TSS    |
|--|-------------|--------|--------|---------|----------------|----------------|--------|
|  | 35 DAT      | 70 DAT | 90 DAT | 120 DAT | cm             | cm             | ° Brix |
| <b>Planting Methods</b>                        |             |        |        |         |                |                |        |
| Flat bed                                       | 3.33        | 4.85   | 7.07   | 8.78    | 1.41           | 3.83           | 11.33  |
| Raised bed                                     | 3.36        | 5.07   | 7.37   | 8.93    | 1.45           | 3.84           | 11.66  |
| Ridge bed                                      | 3.65        | 5.27   | 7.41   | 9.09    | 1.60           | 3.95           | 11.81  |
| SEm(±)   | 0.16        | 0.14   | 0.22   | 0.25    | 0.05           | 0.08           | 0.26   |
| LSD (p =0.05)                                  | NS          | NS     | NS     | NS      | NS             | NS             | NS     |
| <b>Nutritional modules</b>                     |             |        |        |         |                |                |        |
| Control  | 2.52        | 3.78   | 5.99   | 7.79    | 1.19           | 3.19           | 10.11  |
| 100 % K <sub>Fert.</sub>                       | 3.55        | 5.06   | 7.12   | 8.48    | 1.52           | 3.84           | 11.18  |
| 100 % K <sub>VC</sub>                          | 3.54        | 5.14   | 7.27   | 8.54    | 1.56           | 4.06           | 12.42  |
| 50 % K <sub>Fert.</sub> + 50 % K <sub>VC</sub> | 3.87        | 5.99   | 8.14   | 9.95    | 1.68           | 4.22           | 12.23  |
| 75 % K <sub>Fert.</sub> + 25 % K <sub>VC</sub> | 3.76        | 5.35   | 7.90   | 9.89    | 1.49           | 4.07           | 12.04  |
| SEm(±)   | 0.21        | 0.24   | 0.26   | 0.31    | 0.19           | 0.19           | 0.33   |
| LSD ( p=0.05)                                  | NS          | 0.71   | 0.77   | 1.06    | NS             | 0.55           | 0.96   |
| Interaction (P×N)                              | NS          | NS     | NS     | NS      | NS             | NS             | NS     |

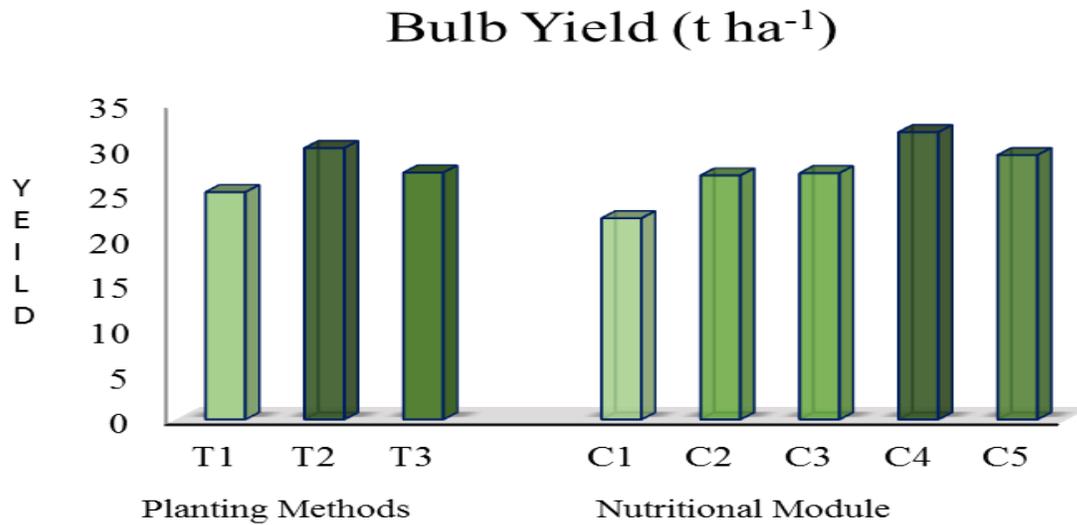
**Table.2** Effect of planting methods and nutritional modules on moisture percentage and physiological weight loss at different period of onion bulb storage under ambient room temperature

| Treatment                                      | Physiological weight loss (%) |        |        |        |
|--|-------------------------------|--------|--------|--------|
|  | Moisture %                    | 30 DAH | 60 DAH | 90 DAH |
| <b>Planting Methods</b>                        |                               |        |        |        |
| Flat bed                                       | 87.65                         | 11.60  | 21.39  | 31.85  |
| Raised bed                                     | 87.91                         | 11.29  | 20.71  | 30.97  |
| Ridge bed                                      | 87.25                         | 11.47  | 20.13  | 31.00  |
| SEm(±)   | 0.71                          | 0.28   | 0.68   | 1.18   |
| LSD (0.05)                                     | NS                            | NS     | NS     | NS     |
| <b>Nutritional modules</b>                     |                               |        |        |        |
| Control  | 88.14                         | 12.46  | 24.10  | 36.17  |
| 100 % K <sub>Fert.</sub>                       | 88.50                         | 13.01  | 22.65  | 34.81  |
| 100 % K <sub>VC</sub>                          | 87.05                         | 9.45   | 17.78  | 26.82  |
| 50 % K <sub>Fert.</sub> + 50 % K <sub>VC</sub> | 87.27                         | 10.49  | 18.81  | 28.03  |
| 75 % K <sub>Fert.</sub> + 25 % K <sub>VC</sub> | 87.06                         | 11.87  | 20.37  | 30.54  |
| SEm(±)   | 1.06                          | 0.44   | 0.98   | 1.99   |
| LSD (0.05)                                     | NS                            | 1.30   | 2.28   | 5.82   |
| Interaction (P×N)                              | NS                            | NS     | NS     | NS     |

**Table.3** Effect of planting methods and nutritional modules on soil chemical parameters after harvest of *kharif* onion crop

| Treatments   | After harvest the crop |      |  |                               |                                     |                                       |                                      |
|--|------------------------|------|--|-------------------------------|-------------------------------------|---------------------------------------|--------------------------------------|
|  | pH                     | EC   | CEC<br>( $\text{cmol(p+)}\text{kg}^{-1}$ ) | SOC<br>( $\text{g kg}^{-1}$ ) | Nitrogen<br>( $\text{kg ha}^{-1}$ ) | Phosphorus<br>( $\text{kg ha}^{-1}$ ) | Potassium<br>( $\text{kg ha}^{-1}$ ) |
| <b>Planting Methods</b>                                      |                        |      |  |                               |                                     |                                       |                                      |
| Flat bed   | 7.31                   | 0.33 | 18.44                                      | 4.41                          | 187.66                              | 17.92                                 | 193.67                               |
| Raised bed   | 7.20                   | 0.28 | 18.48                                      | 4.57                          | 187.83                              | 18.99                                 | 196.53                               |
| Ridge bed  | 7.34                   | 0.35 | 18.31                                      | 4.57                          | 189.14                              | 18.60                                 | 192.03                               |
| SEm( $\pm$ )   | 0.04                   | 0.03 | 0.26                                       | 0.01                          | 0.81                                | 0.22                                  | 3.82                                 |
| LSD (0.05)   | NS                     | NS   | NS   | NS                            | NS                                  | NS                                    | NS                                   |
| <b>Nutritional modules</b>                                   |                        |      |  |                               |                                     |                                       |                                      |
| Control  | 7.34                   | 0.30 | 16.949                                     | 4.20                          | 179.23                              | 16.79                                 | 154.63                               |
| 100 % $\text{K}_{\text{Fert.}}$                              | 7.33                   | 0.36 | 19.07                                      | 4.37                          | 183.06                              | 17.50                                 | 197.64                               |
| 100 % $\text{K}_{\text{VC}}$                                 | 7.19                   | 0.25 | 18.91                                      | 4.88                          | 196.67                              | 19.80                                 | 203.27                               |
| 50 % $\text{K}_{\text{Fert.}}$ + 50 % $\text{K}_{\text{VC}}$ | 7.27                   | 0.34 | 18.59                                      | 4.70                          | 194.54                              | 19.77                                 | 208.82                               |
| 75 % $\text{K}_{\text{Fert.}}$ + 25 % $\text{K}_{\text{VC}}$ | 7.30                   | 0.35 | 18.55                                      | 4.45                          | 187.56                              | 18.65                                 | 206.02                               |
| SEm( $\pm$ )   | 0.11                   | 0.05 | 0.59                                       | 0.01                          | 2.75                                | 0.55                                  | 4.18                                 |
| LSD (0.05)   | NS                     | NS   | NS   | 0.03                          | 8.04                                | 1.61                                  | 12.19                                |
| Interaction (P×N)  | NS                     | NS   | NS   | NS                            | NS                                  | NS                                    | NS                                   |

**Figure.1** Effect of planting methods and nutritional module on yield of onion crops



### Moisture percentage

It is evident from the data presented in table: 4.3 that both, planting method and nutritional module did not influence moisture percentage in onion bulb. Moisture percentage in onion bulb ranged between 87.06 and 88.50.

### Physiological weight Loss (PWL)

Table: 2 is representing the effect of planting methods and nutritional modules on physiological weight loss in onion bulb at 30, 60 and 90 days after storage under ambient room temperature. The physiological weight loss was observed less in vermicompost treated plot. Among the different treatments, the highest weight loss (13.01 %, 22.71 % and 34.81 %) was occurred in those bulbs in which 100 % of recommended K was supplied through chemical fertilizer.

### Leaf number

Data pertaining the influence of planting methods and nutritional modules on the plant growth parameters such as number of leaves has been presented in table: 1. It is obvious

from the data presented in these tables that C<sub>4</sub> (50 % potassium through vermicompost + 50 % potassium through inorganic fertilizer) resulted higher plant growth than other treatments especially in number of leaves 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 and secondly, vermicompost supplies several enzymes and plant growth promoters (Gupta 2005). Earlier, Jayathilake *et al.*, (2002) also reported improved plant height and number of leaves in plant with application of 50 % VC and 50 % NPK treated plot. Reddy and Reddy 2005 has also reported significantly higher plant height in onion with application of vermicompost.

### Neck thickness and polar diameter

Data related to the effect of planting methods (flat, Raised and ridge bed) and nutritional

modules on yield attributing characters, like neck thickness, polar diameter of bulb have been presented in table: 1. In the present study, neck thickness was found non-significant, but vermicompost helped in increasing the neck thickness of onion, This result is in close conformity of the findings of Bagali et al.2012; Kumar *et al.*, (2016). The polar diameter of bulb was found significantly high in C<sub>4</sub> (50 % potassium through vermicompost + 50 % potassium through inorganic fertilizer) treated plot. 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<sup>+</sup> in early stage of plant growth and its combination with vermicompost assures potassium availability in later stage and it might be the probable reason of higher polar diameters of bulbs in integrated nutrient management system. Higher polar and equatorial diameter of bulb with the combine application of organic manures with inorganics has been reported by Chowdappan (1972), Thimmaiah (1989), Singh *et al.*, (1993), Mallanagouda *et al.*, (1995), Varu *et al.*, (1997) Baghali *et al.*, (2012).

### **Total soluble salt (TSS)**

The TSS content of bulb was improved due to application of vermicompost. It is obvious from table: 1 that nutritional module influenced TSS of onion bulbs significantly. The TSS content of bulb was recorded significantly higher when 100% of recommended K was supplied through vermicompost. Total soluble salt is a quality

parameter of bulb and its content of onion high under vermicompost treated plot might due to mucin deposited in epidermal cell and coelomic cell containing several types of growth factor and vitamin B which directly help in improving the TSS quality of onion (Singh et al.2015).

### **Bulb yield**

Figure: 1 presented that higher yield of bulb was observed in raised bed method of planting compare to other planting methods. Higher bulb yield in raised bed method of planting was might be due to higher availability percentage and moisture content. Similar finding was also reported by Malviya *et al.*, 2012. The augmented effect of vermicompost and on the availability of potassium applied through inorganic fertilizer which enhanced the growth period throughout the *kharif* onion that regulated supply of water to the plants as well as helped in creation of carbohydrates and foods translocation to bulbs from leaves. Similar finding was also reported by Sharma *et al.*, 2003. According to Datt *et al.*, 2003 application of organic manures help in enhancing the yield of onion which might be due surplus availability of plant nutrients which might be due to development of physical and biological environment of soil. The results found that integrated application of organic manure, bio fertilizers as well as chemical fertilizer help in enhancing the bulb yield compare to the alone use of chemical fertilizer (Jayathilake *et al.*, 2006)

### **Storability**

The physiological weight loss (PWL) was observed less in vermicompost treated plot (Table: 2). Among the different treatments, the significantly lowest PWL was occurred in those bulbs in which 100 % of recommended K was supplied through vermicompost and it might be due to high content of N, P, K, Ca,

and Mg in earthworm's cast and its easy availability to the plants. Beside this it is also rich in vitamins, enzymes and growth promoting substances which improves the self-life of bulb. Potassium was found to be helpful to reduce sprouting and rotting percentage of bulbs. It played vital role in enhancing crop quality and improved the shelf-life of onion bulbs (Wayse 1967). The sprouting percentage was found less in K treated plot might be due to role of potassium in controlling plant turgidity, maintaining the integrity of the cell membranes and reducing water loss (Faten *et al.*, 2010). Kale and Allolli 2015 studied on physiological loss in *kharif* onion and found that that integrated application of potassium and nitrogen helped in improving the shelf life of onion by reducing sprouting and rotting percentage during storage.

### **Chemical properties of soil after harvest the crop**

The soil reaction (pH), Electrical conductivity (EC) and Cation exchange capacity (CEC) were not affected by planting methods and nutritional modules, however, Soil organic carbon (SOC), available nitrogen, phosphorus and potassium were affected by these factors (Table: 3). The highest value of SOC, available nitrogen and available phosphorus was obtained in that soil in which 100 % of recommended K was supplied through vermicompost. It was probably due to supply of organic carbon through vermicompost and release of various types of carbonic acid (Mufti *et al.*, 2018) and increase in exchange site (Manivannan *et al.*, 2007). Sharma *et al.*, 2005; Rai *et al.*, 2014; Hossain *et al.*, 2017 were reported that the improved organic carbon to the soil with addition of organic manure. Agbede *et al.*, 2008 also described that organic manures improved the microbial population and their activities in the soil and that increased the organic matter content in

soils. An application of vermicompost increased carbon content in Vertisol soil order (Hangarge *et al.*, 2002). Availability of nitrogen and phosphorus increased more pronouncedly in vermicompost treated soil. Significantly higher nitrogen was estimated in that soil in which 100 % of recommended K was supplied through vermicompost. It was probably due to high content of  $\text{NO}_3^-$  nitrogen in vermicast. Sharma *et al.*, 2009 reported that with the application of manure leads to increases in the available nitrogen in the soil and similar result has been found by Kumari *et al.*, 2019. Vermicompost contains good percentage of phosphorus and it solubilizes the native phosphorus and as a result phosphorus content increased in vermicompost treated soil. Available potassium increased due to addition of organic fertilizer combined with chemical fertilizer. The highest residual potassium was observed in the soil receiving 50 % potassium through vermicompost and 50 % potassium through inorganic fertilizer. An increase in soil available K might be due to beneficial effect of vermicompost, during decomposition, releases organic acid leads to reduce the fixation of K and improves the available  $\text{K}^+$  pool into the soil. Vermicompost minimizes the leaching loss. Kher and Minhas 1991 reported significantly increased available potassium in FYM treated soil.

On the basis of one year of field experimentation, it may be concluded that among the planting methods and nutritional modules, raised bed method of *kharif* onion planting and integrated nutrient management system (half dose of potassium through vermicompost and half through fertilizer) is most useful to achieve higher production, productivity and storability of *kharif* onion. Integrated nutrient management system (half dose of potassium through vermicompost and half through fertilizer) increases availability of potassium for existing crop and improves

fertility of soil to achieve higher productivity of succeeding crops. This technology may enhance the benefits of *kharif* onion growers.

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