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# Effect of potassium management on yield, nutrient uptake and storability of *kharif* onion (*Allium cepa* L.) and residual fertility of soil under the Alluvial Zone of Bihar

**Mukta Rani and AK Jha**

**Abstract**

Due to increasing population, industrialization and urbanization, a fundamental shift has been taken place in food production and agricultural research. Today, the drive for productivity is increasingly combined with a desire for sustainability and to be sustainable in the long term, it will be necessary to replenish the reserves of nutrients which are removed or lost from the soil. A field experiment was carried out at vegetable farm of Bihar Agricultural University, sabour, Bhagalpur in sandy loam soil during *kharif* 2016-17 with *kharif* onion cv. Agrifound Dark Red using *Azolla* and vermicompost for sustainable crop production and soil health management. The experiment comprised of 8 treatments viz. $T_1$ (no K application), $T_2$ (50 per cent RDK), $T_3$ (100 per cent RDK), $T_4$ (50 per cent RDK + 50 per cent K by *Azolla*), $T_5$ (50 per cent RDK + 50 per cent K by Vermicompost), $T_6$ (50 per cent RDK + 25 per cent K by *Azolla* + 25 per cent K by Vermicompost), $T_7$ (100 per cent K by *Azolla*) and $T_8$ (100 per cent K by Vermicompost). Full dose of N and P were applied in all the treatments through urea and SSP respectively. However, potassium was supplied through muriate of potash (MOP) having 60 per cent $K_2O$, vermicompost (0.8 per cent potassium) and *Azolla* (2.62 per cent potassium on dry wt. basis). Results from field experiment showed that the treatment $T_5$ resulted in the highest bulb yield (13.17 t $ha^{-1}$) which was 16.24 and 41.46 per cent higher as compared to that recorded with $T_3$ and $T_1$ respectively. The highest uptake of N (58.40 kg $ha^{-1}$) was recorded with treatment $T_7$. However, phosphorus uptake was found to be the highest (12.14 kg $ha^{-1}$) with treatment $T_8$. Treatment $T_6$ had uptake the highest amount of potassium (65.29 kg $ha^{-1}$). The plots which were not treated with potassium showed lowest N, P and K uptake (30.29 kg $ha^{-1}$, 5.82 kg $ha^{-1}$, 27.46 kg $ha^{-1}$ respectively) by onion crops. Treatment $T_7$ increased the storability by 20.33 per cent over $T_3$ and 29.76 per cent over control after 60 days of storage. Treatment $T_4$ showed the highest available N content (287.80 kg $ha^{-1}$) in residual soil. Available phosphorus content in residual soil was highest in treatment $T_5$ (33.46 kg $ha^{-1}$). The highest available potassium content (259.27 kg $ha^{-1}$) in residual soil was observed in treatment $T_4$. However, the lowest value (208.08 kg $ha^{-1}$) of available K was recorded in control plot. The study indicated that the application of *Azolla* and vermicompost alone or in combination resulted in higher bulb yield, nutrient uptake and found to be beneficial for improving fertility of the soil.

**Keywords:** *Kharif* onion, *Azolla*, vermicompost, nutrient uptake, residual fertility, storability

## 1. Introduction

The fertility status of Indian soils has been declining continuously due to intensive cropping and non-restoration of nutrients in the soil. For farming systems to remain productive, and to be sustainable in the long term, it will be necessary to replenish the reserves of nutrients which are removed or lost from the soil (Peoples *et al*., 1995) [21]. Potassium is one of the most important essential major plant nutrients, which is required by the plants in large amount and is available to the plants in cationic form ($K^+$). K is required for photosynthesis, fruit formation, osmotic regulations, disease resistance, promotion of enzymes activity, translocation of assimilates and maintaining agronomic productivity and sustainability (Mengel, 1985) [15]. Due to suboptimal application rates of K fertilizers and manures in India, depletion of K stocks in soil resources has been reported (Srinivasarao *et al*., 2014) [34]. Hence, it is required to apply potassium at recommended dose for successful crop cultivation. But, the destitute condition of the Indian farmers may not allow them to put the K optimally in the soil owing to high cost of imported fertilizers. Also, the continuous and liberal use of potassic fertilizer alone through inorganic sources affects soil productivity and thus results in lower yield with poor quality of produce (Mamatha, 2006) [14]. Thus, there is a need to search some alternative sources of potassic fertilizers on sustainability consideration. Use of organics such as *Azolla*, vermicompost, farmyard manure (FYM) can serve as healthy and economical potassium nutrition sources. Out of the potential organics, *Azolla* has its own significance due to higher biomass production rate, fair K content and suitability for *kharif* crops.

Onion (*Allium cepa* L.) is one of the important vegetable crops belonging to family amaryllidaceae and liked for its flavor and its pungency. *Kharif* onion plays an important role in meeting consumers demand and stabilizing the price of onion in the country. Globally, India ranks first in total area (11.73 lakh hectare) and second in production (189.27 lakh millions tons). But, productivity (16.13MT $ha^{-1}$) of this crop is very low as compared to world average (National Horticulture Research and Development Foundation, 2015) [17]. Among the constraints for low productivity of onion, imbalanced nutrition and storability of the produce are important limiting factors of the crop. There is a wide scope for improving the yield and shelf life of onions using only organic substances or in combination with inorganic fertilizers (Gupta *et al.*, 1999) [7]. Faten *et al*. (2010) [6] showed that the application of potassium reduces the onion germination during storage due to its role in controlling plant turgor and maintaining the integrity of cell membranes to reduce water loss. Bulb crops like onion are responsive to potassium for higher productivity and storability. Thus an attempt was made in the present investigation to explore the suitability of *Azolla* and vermicompost in sustainable production of *kharif* onion under agro-climatic conditions of Bihar.

## 2. Materials and Method

A field experiment was carried out at Vegetable farm of Bihar Agricultural University, Sabour, Bhagalpur (25º 50'N, 87º 19'E, 52.73 m asl), India in sandy loam soil during *kharif* 2016-17 with *kharif* onion Cv. Agrifound Dark Red. The experiment comprised of 8 treatments (Table 1), each replicated thrice in Randomised Block Design. The gross plot size was 2.5 m × 2.4 m (6 $m^2$) with row to row and plant to plant spacing of 15 cm and 10 cm respectively. The recommended dose of fertilizer was 100: 60: 60 kg $ha^{-1}$. Full dose of Nitrogen (N) and Phosphorus (P) were applied in all the treatments through urea and SSP respectively. However, potassium (K) was supplied through muriate of potash, vermicompost and *Azolla*. Initial analysis of soil for physio-chemical properties of soil revealed that pH, electrical conductivity (EC) and oxidisable organic carbon was 7.52, 0.27 $dSm^{-1}$ and 0.76 per cent respectively. While, available N, $P_2O_5$ and $K_2O$ status of soil was 273, 27 and 214 kg $ha^{-1}$ respectively. Chemical analysis of *Azolla* and vermicompost was done for determining total K content in it by standard procedure as outlined by Jackson (1973) [9] and reported 2.62 per cent (dry wt. basis) and 0.8 per cent potassium in *Azolla* and vermicompost respectively. Thus, the amount of *Azolla* and vermicompost applied was calculated for inorganic potassium substitution. The standard agronomic practices for raising *kharif* onion crop were followed. After 120 days of transplanting (physiological maturity), the onion top was bended over to check the growth of *kharif* onion. Then, it was harvested at 139 days of transplanting.

Leaves and bulb samples from the respective treatments were taken and dried in shade and then oven-dried at 70 deg. celsius for 48 hours for nutrient analysis (total N, P and K) by method outlined by Jackson, 1973 [9] and nutrient uptake. Soil samples of 0-15 cm depth were collected from each experimental unit after harvesting of the crop. Samples were processed after proper drying under shade and analysed for determination of pH, EC, soil organic carbon, available N, P and K as per the methods suggested by Jackson (1973) [9], Jackson (1973) [9], Walkley and Black (1934) [37], Subbiah and Asija (1956) [36], Olsen *et.al.* (1954) [18] and Hanway and Heidel (1952) [8] respectively. The observation on storability of onion after harvest of the crop was done at vermicompost unit under the department of soil science and agricultural university of Bihar Agricultural University, Sabour in Bhagalpur district in ambient environmental condition with proper aeration and ventilation. Twenty-five onion bulbs were selected randomly for each treatment and kept in perforated plastic basket to study the shelf-life at 15, 30, 45 and 60 days of storage. The total numbers of healthy bulbs were counted discarding the sprouted and rotted bulbs at each 15 days interval up to 60 days of storage. The data were statistically analyzed using methods suggested by Panse and Sukhatme (1967) [20].

## 3. Results and Discussion

**Yield of onion bulb:** Result showed that the highest bulb yield (13.17 t $ha^{-1}$) was recorded in treatment $T_5$ (50 per cent RDK + 50 per cent K by vermicompost), which was significantly superior to treatment $T_1$ (no potassium application) as well as $T_2$ (50 per cent RDK) and $T_3$ (100 per cent RDK). While, the lowest bulb yield (9.31t $ha^{-1}$) was observed in control. Use of *Azolla* and vermicompost have positive impact on bulb production which might be due to the fact that inclusion of vermicompost has improved soil physical conditions owing to its pulverizing effect on soil that have resulted in better root and bulb growth, nutrient absorption and better bulb development (Bagali *et al*., 2012; Rabari *et al*., 2014 and Singh *et al*., 2014) [3, 22, 33]. similar result have been found by Jayathilake *et al*., 2006 [12] that showed that integrated use of biofertilizers, organic manure and chemical fertilizers resulted in increased yield in comparison with the exclusive application of chemical fertilizer due to the increase in nutrient availability that resulted in faster synthesis and translocation of photosynthates from source (leaves) to sink (bulb).

**Mineral nutrient content in onion plant:** Treatments had significant effect on nitrogen, phosphorus and potassium content in onion plant. The highest N content (1.13 per cent) was recorded in treatment $T_7$ (50 per cent K basal by *Azolla* + 50 per cent K by mulching of *Azolla)* and was significantly superior to $T_1$ (Control) and $T_2$ (50 per cent RDK) and $T_3$ (100 per cent RDK). However, it was at par with treatment $T_4$ (50 per cent RDK + 50 per cent K by *Azolla*), $T_5$ (50 per cent RDK + 50 per cent K by vermicompost), $T_6$ (50 per cent RDK + 25 per cent K by *Azolla* + 25 per cent K by vermicompost) and $T_8$ (100 per cent K by vermicompost). The lowest N content (0.92 per cent) was found in treatment with no potassium application. The highest P content (0.25 per cent) was observed in $T_8$. Whereas, the lowest P content (0.18 per cent) was found in $T_1$ receiving no K. $T_8$ was at par treatment $T_5$, $T_6$ and $T_7$. The highest K content (1.36 per cent) in onion plant was recorded in $T_3$, which was significantly superior to treatment $T_2$, $T_1$ as well as treatments with 100 per cent organic K application by *Azolla* and vermicompost ($T_7$ and $T_8$ respectively). However, $T_3$ was at par with treatment receiving integrated K application i.e. $T_4$, $T_5$ and $T_6$. The lowest K content (0.84 per cent) was found in treatment $T_1$ with no K application.

The increase in N content of onion plant with application of potassium by *Azolla* and vermicompost may be attributed to additional supply of nitrogen from these organic sources leading to greater multiplication of soil microbes, which could convert organically bound N to inorganic form. *Azoll*a contains more nitrogen than vermicompost and this was reflected in the result findings. Inclusion of organic sources also shows positive effect on P content in onion plant that might be attributed to the fact that organic sources of nutrients increases availability of P by dissolution of insoluble phosphorus fractions by release of organic acids that ultimately reflected in P content of the plant. These results corroborate the findings of Sharma *et al*. (2009)[28] and Singh *et al.* (2014) [33]. The availibilty of K due to addition of K to the available pool of the soil, besides reduction of K fixation and release of K due to interaction of organic matter with clay resulted in higher uptake of potassium by crop that reflects in increased K content in onion plant.

**Nutrient uptake by Onion crop:** Data shows that the highest N uptake (58.40 kg $ha^{-1}$) by onion crop was recorded in $T_7$ (50 per cent K basal by *Azolla* + 50 per cent K by mulching of *Azolla*) which was at par with treatment receiving integrated K application or organic K application i.e. $T_4$ (50 per cent RDK + 50 per cent K by *Azolla*), $T_5$ (50 per cent RDK + 50 per cent K by vermicompost), $T_6$ (50 per cent RDK + 25 per cent K by *Azolla* + 25 per cent K by vermicompost) and $T_8$ (100 per cent K by vermicompost). Treatment with no potassium application showed the lowest N uptake (30.29 kg $ha^{-1}$) by onion plant. The highest uptake of phosphorus (12.14 kg $ha^{-1}$) by onion plant was found in $T_8$ (100 per cent K by vermicompost) which was significantly superior to $T_1$ (control), $T_2$ (50 per cent RDK) and $T_3$ (100 per cent RDK). All those treatments that received integrated K application or organic K application were at par with $T_8$. The lowest uptake of P by onion plant (5.82 kg $ha^{-1}$) was found in $T_1$ (control). Result showed that the highest K uptake (65.29 kg $ha^{-1}$) was found in $T_6$ (50 per cent RDK + 25 per cent K by *Azolla* + 25 per cent K by vermicompost) which was at par with $T_3$ (100 per cent RDK), $T_4$ (50 per cent RDK + 50 per cent K by *Azolla*), $T_5$ (50 per cent RDK + 50 per cent K by vermicompost), $T_7$ (50 per cent K basal by *Azolla* + 50 per cent K by mulching of *Azolla*) and $T_8$ (100 per cent K by vermicompost). The lowest uptake of potassium (27.46 kg $ha^{-1}$) was recorded in treatment $T_1$ with no potassium application. It is vivid from the result that N uptake increased with the addition of organic sources of nutrients such as *Azolla* and vermicompost. These sources have positive effect on yield and dry matter production of onion and better availability of nutrients by decomposition of complex nitrogenous compounds and make steady N supply throughout the period of crop growth and additional nutrient supply, leading to increased nutrient uptake by the crop (Subbiah *et al*., 1982) [35]. *Azolla* contains more N than vermicompost, thus increase in N uptake in treatment receiving *Azolla*. The higher values of N uptake with K addition could be attributed to enhanced vigour of crop growth with increased N utilization and translocation into the plants resulting increase of yield (Singh *et al*., 2010) [30, 31]. The results were in consonance with the findings of Sharma *et al*. (2009) [28] and Singh *et al.* (2014) [33]. Use of integrated sources as well as organic sources showed positive effect on P uptake of onion plant that might be attributed to fact that organic sources of nutrients increases availability of P by dissolution of fixed P by release of organic acids that ultimately reflected in P uptake by plant. Similar result have been reported by Singh and Pandey (2006) [32]; Sharma *et al*. (2009) [28] and Singh *et al.* (2014) [33] by inclusion of organic manures. Pachauri *et al.* (2003) [19] also reported significant increase in P and K uptake with increase in K application. Vermicompost has more phosphorus content than *Azolla* that leads to more P uptake in treatment with vermicompost application. The significant uptake of K might be due to addition of K to the available pool of the soil, besides reduction of K fixation and release of K due to interaction of organic matter with clay. Integrated application of inorganic and organic sources of nutrients supply all essential nutrients, reduce the losses of nutrients from soil solution, improve physical properties of soil causing proliferous root system development under balanced nutrient application resulting in better absorption of nutrients by crop (Sharma *et al*., 2009; Dubey *et al*., 2012 and Singh *et al.*, 2014) [28, 4, 33].

**Effect on pH, EC, Oxidisable OC and nutrient status of residual soil:** Soil pH decreases with organic manure application but there was no significant effect of treatments. EC of soil after harvest of crop too does not show any significant differences among treatments, though the highest EC (0.30 $dSm^{-1}$) was obtained in treatment $T_3$ (100 per cent RDK) due to the use of inorganic fertilizers which accumulated and raised the soil EC while the lowest EC (0.26 $dSm^{-1}$) was obtained by the treatment $T_8$ (100 per cent K by vermicompost). The highest (0.81 per cent) value of OC was obtained in the treatment $T_4$ (50 per cent RDK + 50 per cent K by mulching of *Azolla*) and the lowest (0.76 per cent) was observed in the treatment $T_1$ (Control) and $T_2$ (100 per cent RDK). Application of organic manures increased the OC content over 100 per cent RDK treated plots but was statistically non-significant. Treatments had significant effect on availability of nitrogen, phosphorus and potassium in soil. The highest available N (287.80 kg $ha^{-1}$) in soil after harvest of the crop was reported in $T_4$ **(**50 per cent RDK + 50 per cent K by mulching of *Azolla*). However, this was at par with $T_5$ (50 per cent RDK + 50 per cent K by vermicompost), $T_6$ (50 per cent RDK + 25 per cent K by *Azolla* + 25 per cent K by vermicompost), $T_7$ (50 per cent K basal by *Azolla* + 50 per cent K by mulching of *Azolla*) and $T_8$ (100 per cent K by vermicompost). The lowest available N (275.03 kg $ha^{-1}$) was found in $T_1$ (no k application). The highest available phosphorus (33.46 kg $ha^{-1}$) in soil was found in $T_5$ which was at par to all the treatments except $T_1$, $T_2$ (50 per cent RDK) and $T_3$ (100 per cent RDK). The lowest available P (25.80 kg $ha^{-1}$) was observed in control. The highest available potassium (259.27 kg $ha^{-1}$) in soil was found in $T_4$ which was at par with $T_5$ and $T_6$. The lowest value (208.08 kg $ha^{-1}$) of available potassium in soil was observed in $T_1$ (no K application).

Organic material addition to soil brings about changes in physio-chemical properties of soil due to release of $H^+$ ions from the organic manures during mineralization (Rai *et al*., 2014) [23]. But, there are reports of non-significant effect of organic manures on soil pH (Agbede *et al*., 2008) [2]. In addition the highest EC that was obtained from the inorganic fertilizer treatment could be due to the high use of chemical fertilizers. While, the lower EC values in the organic plots may be due to improved soil aggregation that increases in the water holding capacity and thus reducing the salt concentration (Duhan and Singh, 2002 and Abu- Zahra and Tahboub, 2008) [5, 1]. The increase in OC may be attributed to the addition of organic materials and better root growth in organically treated plots. These observations are in agreement with the findings of Sharma *et al*. (2005) [27]; Agbede *et al*. (2008) [2] and Rai *et al*. (2014) [23]. Increase in available nitrogen with *Azolla* or vermicompost application might be attributed to the direct addition of nitrogen through *Azolla* and vermicompost to the available pool of the soil. The response of higher available nitrogen in integrated application of K might be due to fact that organic matter improves the nitrogen pool due to mineralization of the organic sources of nutrients as well as better nutrient holding capacity of the organic matter. The increase in availability of phosphorus in soil due to incorporation of organics may be attributed to the direct addition of P as well solubilization of native P through release of various organic acids during their decomposition. The increase in availability of P in vermicompost could be due to increased mobilization of organic P attributed to higher level of phosphatase activity in earthworm (Satchel, 1983) [25]. Organics during decomposition produce large amounts of organic acids which have a tendency to dissolve the K present either in the mineral form or in the non-exchangeable form thereby bringing it into water soluble form and also due to the formation of organo-K complexes of higher solubility. Addition of organic manures could increase the CEC of the soil, which can hold more exchangeable K and convert K from non- exchangeable form to exchangeable form. The finding was in agreement with that of Jayathilake *et al.* (2006) [12]; Sharma *et al*. (2009) [28]; Rai *et al*. (2014) [23]; Singh *et al*. (2014) [33]; Yaduvanshi *et al*. (2001) [38]; Sawarkar *et al*. (2013) [26] and Mazumdar et al. (2014) [16] Singh and Ram (2015) [29].

**Storability of kharif onion:** Treatments had significant effect on storability of onion throughout the storage period. Among the different treatments, the highest marketable bulbs (%) were obtained in T7 (50 per cent K basal by *Azolla* + 50 per cent K by mulching of *Azolla*) at all days of storage (15, 30, 45 and 60 DAS) followed by T4 (50 per cent RDK + 50% K by mulching of *Azolla*). While the lowest marketable bulb (%) were recorded in T1 (no potassium application). 50 per cent K by basal application of *Azolla* + 50 per cent K by mulching of *Azolla* showed 20.33 per cent increase in storability over 100 per cent inorganic K, while 29.76 per cent increase over treatment receiving no K (control) after 60 days of storage. The highest marketable bulb (per cent) obtained in treatment T7 was mainly due to least rotting (per cent) and sprouting (per cent) of the bulbs during the storage.

The rotting and sprouting loss was less with potassium sources. This was attributed to potential activity of potassium against the rotting of the bulbs. Potassium results in less sprouting loss during storage due it role in controlling plant turgidity, maintains the integrity of the cell membranes and reduces water loss (Faten *et al*., 2010) [6]. Organics contains trace elements and produces more dry matter by reducing moisture content and ensures higher and continuous uptake of potassium nutrients throughout the crop growth and better accumulation of sulphur and phosphorus which would have helped in maintaining the cell wall turgidity. These results are in accordance with the results obtained by Sankar *et al*. (2005) [24] in onion. Kale and Allolli (2015) [13] also shows the importance of potassium on increasing storability of onion. While Jawadagi *et al*. (2014) [10] recorded more marketable onion bulb (per cent) with the application of organic material (FYM, vermicompost and biofertilizers).

**Table 1:** Treatment details for field experiment

| Treatment Notation | Treatment details |
|---|---|
| $T_1$ | Control |
| $T_2$ | 50% RDK |
| $T_3$ | 100% RDK |
| $T_4$ | 50% RDK + 50% K by mulching of *Azolla* |
| $T_5$ | 50% RDK + 50% K by Vermicompost |
| $T_6$ | 50% RDK + 25% K by *Azolla* + 25% K by Vermicompost |
| $T_7$ | 50% K basal by *Azolla* + 50% K by mulching of *Azolla* |
| $T_8$ | 100% K by Vermicompost |

**Table 2:** Effect of treatments on onion bulb yield and nutrient content (%) in *kharif* onion plant

| Treatments | Bulb yield (t ha$^{-1}$) | N (%) | P (%) | K (%) |
|---|---|---|---|---|
| Control ($T_1$) | 9.31 | 0.92 | 0.18 | 0.84 |
| 50% RDK ($T_2$) | 10.70 | 0.95 | 0.19 | 1.03 |
| 100% RDK ($T_3$) | 11.33 | 1.03 | 0.20 | 1.36 |
| 50% RDK + 50% K by mulching of *Azolla* ($T_4$) | 12.13 | 1.06 | 0.22 | 1.33 |
| 50% RDK + 50% K by vermicompost ($T_5$) | 13.17 | 1.05 | 0.23 | 1.26 |
| 50% RDK + 25% K by *Azolla* + 25% K by vermicompost ($T_6$) | 12.40 | 1.07 | 0.23 | 1.31 |
| 50% K basal by *Azolla* + 50% K by mulching of *Azolla* ($T_7$) | 11.26 | 1.13 | 0.23 | 1.18 |
| 100% K by vermicompost ($T_8$) | 11.73 | 1.08 | 0.25 | 1.15 |
| SEm (±) | 0.61 | 0.03 | 0.01 | 0.04 |
| CD (P=0.05) | 1.78 | 0.09 | 0.03 | 0.12 |

**Table 3:** Treatments effect on N, P and K uptake (kg ha$^{-1}$) by *kharif* onion crop

| Treatments | N (kg ha$^{-1}$) | P (kg ha$^{-1}$) | K (kg ha$^{-1}$) |
|---|---|---|---|
| Control ($T_1$) | 30.29 | 5.82 | 27.46 |
| 50% RDK ($T_2$) | 36.91 | 7.36 | 39.62 |
| 100% RDK ($T_3$) | 44.81 | 8.81 | 58.98 |
| 50% RDK + 50% K by mulching of *Azolla* ($T_4$) | 47.53 | 9.84 | 59.75 |
| 50% RDK + 50% K by vermicompost ($T_5$) | 47.62 | 10.59 | 56.95 |
| 50% RDK + 25% K by *Azolla* + 25% K by vermicompost ($T_6$) | 53.55 | 11.30 | 65.29 |
| 50% K basal by *Azolla* + 50% K by mulching of *Azolla* ($T_7$) | 58.40 | 11.72 | 61.50 |
| 100% K by vermicompost ($T_8$) | 53.14 | 12.14 | 56.43 |
| SEm (±) | 4.06 | 0.99 | 5.08 |
| CD (P=0.05) | 11.89 | 2.89 | 14.87 |

**Table 4:** Effect of treatments on soil physio-chemical properties and NPK status of soil after harvest of crop.

| Treatments | pH | EC (dSm$^{-1}$) | Oxidisable OC (%) | Available N (kg ha$^{-1}$) | Available P (kg ha$^{-1}$) | Available K (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|
| Control ($T_1$) | 7.52 | 0.27 | 0.76 | 275.03 | 25.80 | 208.08 |
| 50% RDK ($T_2$) | 7.52 | 0.28 | 0.76 | 277.60 | 26.45 | 231.87 |
| 100% RDK ($T_3$) | 7.53 | 0.30 | 0.77 | 279.57 | 27.75 | 242.53 |
| 50% RDK + 50% K by mulching of *Azolla* ($T_4$) | 7.47 | 0.28 | 0.81 | 287.80 | 31.32 | 259.27 |
| 50% RDK + 50% K by vermicompost ($T_5$) | 7.48 | 0.27 | 0.79 | 285.83 | 33.46 | 254.37 |
| 50% RDK + 25% K by *Azolla* + 25% K by vermicompost ($T_6$) | 7.45 | 0.29 | 0.80 | 286.77 | 30.91 | 255.43 |
| 50% K basal by *Azolla* + 50% K by mulching of *Azolla* ($T_7$) | 7.46 | 0.28 | 0.78 | 284.27 | 29.77 | 242.40 |
| 100% K by vermicompost ($T_8$) | 7.47 | 0.26 | 0.78 | 282.77 | 29.92 | 242.33 |
| SEm (±) | 0.06 | 0.01 | 0.03 | 2.50 | 1.53 | 5.11 |
| CD (P=0.05) | NS | NS | NS | 7.31 | 4.48 | 14.95 |

**Table 5:** Influence of treatments on marketable bulbs (%) of onion stored under ambient conditions

| Treatments | Marketable bulbs (%) Days After Storage (DAS) | | | |
|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 60 DAS |
| Control ($T_1$) | 64.67 | 59.67 | 46.33 | 38.33 |
| 50% RDK ($T_2$) | 65.67 | 61.33 | 51.67 | 40.67 |
| 100% RDK ($T_3$) | 66.00 | 61.67 | 54.67 | 41.33 |
| 50% RDK + 50% K by mulching of *Azolla* ($T_4$) | 73.09 | 66.67 | 61.00 | 49.00 |
| 50% RDK + 50% K by vermicompost ($T_5$) | 66.33 | 62.00 | 56.00 | 41.67 |
| 50% RDK + 25% K by *Azolla* + 25% K by vermicompost ($T_6$) | 66.67 | 62.67 | 56.67 | 42.33 |
| 50% K basal by *Azolla* + 50% K by mulching of *Azolla* ($T_7$) | 74.12 | 67.00 | 62.00 | 49.67 |
| 100% K by vermicompost ($T_8$) | 65.67 | 61.67 | 56.00 | 41.00 |
| SEm (±) | 2.08 | 1.43 | 1.59 | 1.70 |
| CD (P=0.05) | 6.09 | 4.18 | 4.66 | 4.97 |

## 4. Conclusion

The study indicated that the application of *Azolla* and vermicompost alone or in combination with inorganic fertilizer resulted in higher nutrient uptake, bulb yield and storability in *kharif* onion. NPK status of experimental soil also increased due to application of these organic sources of plant nutrients. *Azolla* and vermicompost maintains potassium availability in soil and ensures constant availability of potassium as well as other nutrients throughout the growth period of onion crop.

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