DOI : 10.5958/0974-0112.2020.00073.0

Indian J. Hort. 77(3), September 2020: 508-512

Effect of proportional substitution of potassic fertilizer with biofertilizers in onion

Mukta Rani[*,] and Arun Kumar Jha**

Department of Soil Sci. & Agril. Chemistry, Bihar Agricultural University, Sabour, Bhagalpur 813 210, Bihar

ABSTRACT

A fundamental shift has taken place in agricultural research and world food production. Today, the drive for productivity is increasingly combined with a desire for sustainability. A field experiment was carried out in sandy loam soil during *kharif* 2016-17 with *kharif* onion cv. Agrifound Dark Red using *Azolla* and vermicompost for sustainable crop production. The experiment comprised of 8 treatments, 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 treatment T_7 was found significantly superior over all other treatments to increase plant height of onion at 90 (45.59 cm) and 120 DAT (50.80 cm) and the lowest plant height was recorded in control (T_1). Dry matter content (14.34 g plant^{-1}) was found to be the highest with treatment T_5 at 120 DAT. However, treatment T_4 resulted highest dry matter 0.513, 1.52, 5.54 g plant^{-1} at 30, 60 and 90 DAT respectively. Equatorial (55.86 mm) and polar (47.59 mm) diameters of onion bulbs were found to be significantly higher with treatment T_5. The highest bulb weight (45.17 g) and yield of onion (13.17 t ha^{-1}) were recorded with treatment T_5 which was 16.24 and 41.46 per cent higher bulb yield as compared to that recorded with T_3 and T_1 respectively. However, the lowest bulb weight (35.10 g) and bulb yield (9.31t ha^{-1}) were recorded in the plots receiving no potassium. Calculation of cost of production and benefit obtained showed that the treatment T_3 gave maximum benefit: cost ratio of 2.1. However, B: C ratio of T_4 and T_5 was 1.9 and 1.6, respectively.

Keywords: *Allium cepa*, biofertilizers, benefit-cost ratio.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the important vegetable crops belonging to family *alliaceae*. It is an indispensable item in every kitchen as vegetable and condiment liked for its flavour and pungency. *Kharif* onion plays an important role in fulfilling 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 tonnes). But, productivity (16.13 MT ha^{-1}) of this crop is very low as compared to world average (NHRDF, 8). Among the constraints for low productivity of onion, imbalanced nutrition is one of the important limiting factors.

Potassium (K) 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 underpinning agronomic productivity and sustainability (Mengel, 7). Depletion of K stocks in soil resources has been reported due to suboptimal application rates of K fertilizers and manures in India (Srinivasarao *et al.*, 14). 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. Thus, there is a need to search some alternative sources of potassic fertilizers for sustainability. Use of organics such as *Azolla*, vermicompost, farmyard manure (FYM) can serve as healthy and economical sources of potassium. Out of the potential sources of potassium, *Azolla* has its own significance due to higher biomass production rate, fair K content and suitability for *kharif* crops. The judicious combinations of organic and inorganic sources of plant nutrients are essential not only to maintain the soil health but also to sustain productivity of the crops. Thus, there is an urgent need to quantify the amount of organic and

*Corresponding author's Email: ranimukta28@gmail.com

**Department of Soil Sc. & Agril. Chemistry, Institute of Agricultural Sciences, BHU, Varanasi 221 005, U.P.

inorganic sources of potassium for higher production and productivity of the onion crop in agro-climatic conditions of Bihar.

MATERIALS AND METHODS

A field experiment was carried during *kharif* 2016 at vegetable farm of Bihar Agriculture College, Sabour, Bhagalpur (25º 50'N, 87º 19'E, 52.73 m asl), India. The soil of the experimental site was sandy loam (*Typic Haplustepts*). The pH, EC and oxidisable organic carbon of initial soil samples were 7.52, 0.27 dSm^{-1} and 0.76 per cent, respectively; While, available N, P and K of intial soil were 273, 27 and 214 kg ha^{-1}. *Kharif* onion variety "Agrifound Dark Red" was sown with row to row spacing of 15 cm and plant to plant spacing of 10 cm. The experiment was laid out in randomized block design with eight treatments, T_1 (no K application), T_2 (50 per cent Recommended Dose of potassium, i.e. 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) with three replications. Recommended dose of NPK for the experiment was 100: 60: 60 kg ha^{-1}. Full doses of N and P were applied in all the treatments through urea and SSP, respectively. However, potassium was supplied through muriate of potash, vermicompost and *Azolla* as per the treatments. Nitrogen, phosphorus and potassium content in *Azolla* were 4.1, 1.8 and 2.62 per cent, respectively on dry weight basis; While vermicompost has N, P and K content of 1.3, 0.8 and 0.8 per cent, respectively. Suitable agronomic practices were followed for raising the given crop. Onion crop was harvested at 139 days after transplanting. However, crop attained physiological maturity at 120 days after transplanting after which onion tops were rolled down to boost the ripening process of onion and checking the vegetative growth of *kharif* onion by restricting water flow. The plants were pulled along with leaves and spread on the respective plot in the field for curing. Then the foliages were cut with sharp clean knives leaving 2.5 cm top above the bulb.

Plant height (cm) and dry matter content (g $plant^{-1}$) was measured at 30, 60, 90 and 120 day after transplanting. In yield attributing characters, polar diameter, equatorial diameter, neck thickness and fresh bulb weight were taken. Total bulb yield was obtained after harvest of the crop and yield per ha was computed. The economics (benefit-cost ratio) was worked out for each plot. Observations recorded were subjected to statistical analysis as per procedure of Panse and Sukhatme (9). Differences among means and treatments were compared by the least significant differences (LSD) at $P<0.05$.

RESULTS AND DISCUSSION

Results showed that different treatments had non-significant effect on plant height at 30 and 60 days after transplanting (DAT) of crop. At 90 DAT and 120 DAT (maturity stage), significant difference in plant height was recorded (Table 1). It was found that treatment T_7 receiving 100 per cent K by *Azolla* (split as 50 per cent at basal and rest 50 per cent as mulching at 35 and 70 DAT) recorded the highest plant of 45.59 cm at 90 DAT and was significant to control (38.93 cm) , 50 per cent RDK (39.38 cm) and 100 per cent RDK (41.43 cm), while, it was at par with treatment T_8 (100 per cent K from VC), T_4 (50 per cent K from *Azolla* and 50 per cent K from MOP), T_5 (50 per cent K from VC and 50 per cent K from MOP), and T_6 (25 per cent K from *Azolla*, 25 per cent K from VC and 50 per cent K from MOP) in addition to 100 per cent N and 100 per cent P through inorganic sources to all the treatments. At 120 DAT, treatment T_7 recorded the highest plant height and was significant to treatment T_1, T_2 and T_3, while, it was at par with treatment T_4, T_5, T_6 and T_8. Significant increase in plant height was recorded in T_7 (50.80 cm) at maturity. While the lowest plant height (38.93 and 42.86 cm) at 90 DAT and 120 DAT respectively was found in control treatment (T_1). It is clear from the data that treatment with organic sources along with inorganic N and P perform better in terms of plant growth and that may be due to reason that they provide N from decomposition at 90 DAT and at maturity in additional to inorganic N that was common to all the treatments. K too has effect on plant height and it can be observed from the control treatment receiving no potassium. Since potassium plays an important role in the translocation of photosynthates, the added K might have translocated photosynthates from leaves to bulb, which were further utilized in building up of new cells leading to better height and vigour. Jayathilake *et al*. (3), Farooq *et al*. (2) and Kumar *et al.* (6) also reported increase in plant height with application of organic sources of nutrients.

The treatments had significant effect on dry matter content at 30, 60, 90 and 120 days after transplanting. Significantly higher dry matter of 0.513, 1.520, 5.54 g $plant^{-1}$ was found in treatment T_4 at 30, 60 and 90 DAT, respectively. However, at 120 DAT (maturity stage) significantly the highest dry matter content (14.34 g $plant^{-1}$) was found in T_5. At 30 DAT, T_4 was at par with T_3, T_5, T_6, T_7 and T_8. Whereas, at 60, 90 and 120 DAT, treatment receiving no K or only inorganic K were found to give lower dry matter content in comparison to integrated K application or

Table 1. Average plant height (cm) and dry matter content (g $plant^{-1}$) as influenced by treatments at different stages of crop growth in *kharif* onion.

Treatment	30 DAT		60 DAT		90 DAT		120 DAT	
	Plant height (cm)	Dry matter content (g $plant^{-1}$)	Plant height (cm)	Dry matter content (g $plant^{-1}$)	Plant height (cm)	Dry matter content (g $plant^{-1}$)	Plant height (cm)	Dry matter content (g $plant^{-1}$)
Control (T_1)	25.62	0.407	28.13	1.187	38.93	4.43	42.86	10.55
50% RDK (T_2)	26.90	0.445	29.48	1.317	39.38	4.59	43.81	11.39
100% RDK (T_3)	28.41	0.487	30.21	1.377	41.43	5.01	45.16	12.22
50% RDK + 50% K by mulching of *Azolla* (T_4)	29.29	0.513	32.33	1.520	44.12	5.54	48.46	13.78
50% RDK + 50% K by vermicompost (T_5)	28.28	0.510	31.57	1.493	43.11	5.33	46.49	14.34
50% RDK + 25% K by *Azolla* + 25% K by vermicompost (T_6)	29.06	0.483	32.23	1.503	44.11	5.39	46.80	14.01
50% K basal by *Azolla* + 50% K by mulching of *Azolla* (T_7)	29.33	0.510	32.76	1.517	45.59	5.46	50.80	13.34
100% K by vermicompost (T_8)	28.56	0.509	31.91	1.467	42.24	5.22	48.55	14.27
SEm (±)	1.01	0.017	1.22	0.047	1.30	0.16	1.56	0.50
CD (p=0.05)	NS	0.050	NS	0.137	3.81	0.46	4.57	1.47

DAT= Days after transplanting

organic K application. This might be due to greater uptake of potassium by onion from soil which might have increased the biomass due to increased water uptake and translocation of photosynthates. These results are similar to those obtained by Singh and Dhankar (11) and Kumar *et al.* (5) who observed a decrease in dry matter yield of crops in the absence of potassium. Highest dry matter production in integrated K as well as organic K application in addition to recommended inorganic N and P could be attributed to the better vegetative growth and yield attributes which in turn resulted in production of more fresh weight and dry weight compared to other treatments. Improved dry matter production was also related to altered root permeability of the plant for maximum uptake of minerals into the plant system. The present findings are in coherence with those of Jayathilake *et al.* (4).

Highest equatorial diameter (55.86 mm) was recorded in treatment T_5 which was at par with T_4, T_6 and T_8 (Table 2). Lowest equatorial diameter (45.18 mm) was found in treatment with no potassium application (T_1). Highest polar diameter (47.59 mm) was also found in treatment T_5 which was at par with T_4, T_6, T_7 and T_8. Lowest polar diameter (39.67 mm) was noted in control. Significantly, lower bulb diameter was recorded in treatment with no potassium or graded doses of inorganic potassium application.

Increased bulb diameter might be due to result of better growth of plant with respect to growth parameters like plant height and dry matter accumulation at higher levels of potassium as well as supply of nutrients throughout the crop stages as vermicompost and *Azolla* release nutrients slowly but continuously throughout the growth of plant. Kumar *et al.* (5) reported that the dry matter production and translocation of photosynthates contributed to the swelling of bulbs which resulted in increased diameter of bulbs at higher K levels. These results are in accordance with observations of Kumar *et al.* (6). Also, addition of organic sources of nutrients adds nitrogen which accelerates the synthesis of chlorophyll and amino acids, resulting in more translocation of photosynthates from leaves to bulb causing increased bulb diameter (Jayathilake *et al.*, 3). More bulb diameter in vermicompost in comparison to *Azolla* may be due to pulverizing action of vermicompost in soils that brings about structural improvement of soil structure, increasing aeration within and causes roots to extend into a large volume of soil.

Highest neck thickness (11.71 mm) was found in T_5, while the lowest (10.18 mm) was in T_1 but treatment effect was non-significant. Organics lead to increase in neck thickness of onion (Kumar *et al.,* 6).

Treatments had significant effect on average bulb weight. Highest bulb weight (45.17 g) was recorded in treatment T_5 which was significantly superior to T_1,

Table 2. Bulb equatorial diameter (mm), polar diameter (mm), neck thickness (mm), fresh weight of bulb (g), bulb yield (t ha^{-1}) and benefit-cost ratio as affected by treatments in *kharif* onion.

Treatment	Equatorial dia. (mm)	Polar dia. (mm)	Neck dia. (mm)	Bulb w.(g)	Bulb yield (t ha^{-1})	Benefit-cost ratio
Control (T_1)	45.18	39.67	10.18	35.10	9.31	1.6
50% RDK (T_2)	46.92	41.63	10.66	36.60	10.70	1.9
100% RDK (T_3)	48.32	42.46	11.59	39.97	11.33	2.1
50% RDK + 50% K by mulching of *Azolla* (T_4)	50.45	44.82	11.21	41.07	12.13	1.9
50% RDK + 50% K by vermicompost (T_5)	55.86	47.59	11.71	45.17	13.17	1.6
50% RDK + 25% K by *Azolla* + 25% K by vermicompost (T_6)	53.58	45.39	11.35	43.67	12.40	1.7
50% K basal by *Azolla* + 50% K by mulching of *Azolla* (T_7)	49.69	44.93	10.73	40.83	11.26	1.6
100% K by vermicompost (T_8)	51.63	45.44	10.77	43.83	11.73	0.9
SEm (±)	1.93	1.54	0.38	1.52	0.61	0.16
CD (p=0.05)	5.66	4.51	NS	4.45	1.78	0.67

T_2 and T_3. However, T_5 was at par with integrated K application or organic K applied treatments. Lowest bulb weight (35.10 g) was recorded in treatment receiving no potassium. This might be due to fact that organic sources release nutrients slowly but throughout the growth stages and thus nutrients are available at bulb formation and filling stage, while inorganic fertilizers when applied basal, supply more nutrients initially than during later phase of development. Also, the average bulb weight is known to be influenced by equatorial and polar diameter of bulb which in turn determines the bulb yield. Similarly, significantly higher bulb weight due to integrated nutrient management and use of organics was reported by Jayathilake *et al*. (3) and Kumar *et al*. (6).

Result showed that the highest bulb yield (13.17 t ha^{-1}) was recorded in treatment T_5 which was significantly superior to treatment with no potassium application as well as treatment with inorganic K application only. T_5 were at par with treatments T_4, T_6 and T_8. Lowest bulb yield (9.31 t ha^{-1}) was noted in control. Use of *Azolla* and vermicompost was found to have positive impact on bulb production due to their positive effect on growth parameters as well as yield attributing parameters. It is clear from the data that inclusion of vermicompost improved soil physical conditions that might have resulted in better root growth, nutrient absorption and better bulb development (Rabari *et al*., 10). Datta *et al.* (1) also reported that beneficial effect of organic manures on yield might be due additional supply of plant nutrients as well as improvement in physical and biological properties of soil. It could also be attributed to the fact that after decomposition and mineralization, the organic sources supply available nutrients directly to plants and also have solubilizing effect on fixed form of nutrients (Singh *et al*., 13). The higher yield of crops with the use of vermicompost for potassium source in comparison to *Azolla* may be ascribed to the higher K content of vermicompost. Jayathilake *et al*. (4) too showed that integrated use of biofertilizers, organic manure and chemical fertilizers resulted in yield increase in comparison with the exclusive application of chemical fertilizer. This could be due to the increase in nutrient availability and uptake of nutrients resulting in faster synthesis and translocation of photosynthates from source (leaves) to sink (bulb). Also, use of organics increase yield attributes and their component effects might have resulted into higher bulb yield.

Calculation of cost of production and benefit obtained showed that T_3 gave maximum benefit-cost ratio of 2.1, while 100 per cent vemicompost application was not profitable due to high cost of vermicompost. Integrated application of *Azolla* and vermicompost gave good benefit ratio of 1.9 and 1.6, respectively. Although highest yield was recorded with vermicompost and inorganic K combination, but the high cost of vermicompost resulted in the lower benefit cost ratio and net return as compared to recommended dose of fertilizers. *Azolla* can be better organic material to get benefits of higher yield, improving soil fertility and getting good return in onion crop. Yadav *et al*. (15) reported high benefit cost ratio by inclusion of organic material. Singh *et al.* (12) reported high benefit: cost ratio of 1.55 in onion with application of 120 kg K_2O ha^{-1} and minimum due to no K fertilization (control).

The study indicated that application of *Azolla* and vermicompost alone or in combination with inorganic fertilizer resulted in improved growth pattern and increased bulb yield by ensuring constant availability of nutrient throughout the growth stages of onion crop. Integrated application of K (50 per cent RDK + 50 per cent K by vermicompost) gave 16.24 per cent and 41.46 per cent higher yield in comparison to 100 per cent RDK and control respectively. Also, economics of crop production can taken care of by providing better marketing channel facilities for the farmers so that more benefit can be withdrawn by them. Thus, it is the need of the hour to focus on organic sources of nutrients for sustainable agriculture and environment.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Department of Soil Science and Agricultural Chemistry and Department of Horticulture (Vegetable and Floriculture), Bihar Agricultural University, Sabour, Bhagalpur, Bihar in carrying out this research work.

REFERENCES

1. Datt, N., Sharma, R.P. and Sharma, G.D. 2003. Effect of supplementary use of farmyard manure along with chemical fertilizers on productivity and nutrient uptake by vegetable pea (*Pisum sativum* var *arvense*) and build up of soil fertility in Lahaul valley of Himachal Pradesh. *Indian J. Agri. Sci.* **73**: 266-68.

2. Farooq, M., Malik, A.H., Niaz, A., Uzma, K., Abdul, M. and Habib, A. 2015. Nutrient management for improving onion productivity. *American-Eurasian J. Agric. Env. Sci.* **15**: 220-25.

3. Jayathilake, P.K.S., Reddy I.P., Srihari D., Neeraja G. and Reddy R. 2002. Effect of nutrient management on growth, yield and yield attributes of rabi onion (*Allium cepa* L.). *Veg. Sci.* **29**: 184-85.

4. Jayathilake, P.K.S., Reddy, I. P., Srihari, D. and Reddy, K. R. 2006. Productivity and soil fertility status as influenced by integrated use of N-fixing biofertilizers, organic manures and inorganic fertilizers in onion. *J. Agri. Sci.* **2**: 46-58.

5. Kumar, A., Singh, R. and Chhillar, R.K. 2001. Influence of nitrogen and potassium application on growth, yield and nutrient uptake by onion (*Allium cepa). Indian J. Agron.* **46**: 742-46.

6. Kumar, S., Meena, M.L., Lal, D. and Rai, T. 2016. Effect of integrated nutrient management on growth and yield of onion (*Allium cepa* L.). *Res. Env. Life Sci*. **9**: 56-8.

7. Mengel, K. 1985. Potassium movement within plants and its importance in assimilate transport. *Potassium in Agriculture*, pp. 397-411.

8. NHRDF. 2015 (National Horticultural Research Development Foundation).

9. Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers*, Indian Council of Agricultural Research, New Delh, pp: 1-359. *Circular*, **939**: 1-19.

10. Rabari, K.V., Patel, M.V., Kadu, S.P. and Umale, A.A. 2014. Combined effect of organic and inorganic fertilizers on growth, yield attributes, bulb yield and soil nutrient status after harvest of onion (*Allium cepa* L.). *Trends Biosci.* **7**: 3861-64.

11. Singh, J. and Dhankar, B.S. 1989. Effect of nitrogen, potash and zinc on storage loss of onion bulbs (*Allium cepa)*. *Veg. Sci.* **16**: 136-44.

12. Singh, J.P., Singh, S. and Singh, V. 2010. Soil potassium fractions and response of cauliflower and onion to potassium. *J. Indian Soc. Soil Sci.* **58**: 384-87.

13. Singh, S.N., Rai, P., Singh, S.R., Goyal, S.K. and Singh, S.P. 2014. Effect of integrated use of organic manures and fertilizers on yield, nutrient uptake and soil fertility in onion on red soils of vindhyan region. *Veg. Sci.* **41**: 150-54.

14. Srinivasarao, C., Kundu, S., Ramachandrappa, B.K., Reddy, S., Lal, R., Venkateswarlu, B., Sahrawat, K.L. and Naik, R.P. 2014. Potassium release characteristics, potassium balance, and fingermillet (*Eleusine coracana* G.) yield sustainability in a 27-year long experiment on an Alfisol in the semi-arid tropical India. *Plant and Soil*. **374**: 315-30.

15. Yadav, B.D., Khandelwal, R.B. and Sharma, Y.K. 2005. Use of biofertilizer in onion. *Indian J. Hort.* **62**: 168-70.

(Received : March, 2019; Revised : July, 2020;
Accepted : August, 2020)