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Effect of organic, inorganic and biofertilizers on yield, storage quality and soil nutrient status of onion (*Allium cepa* L.) under vertisols of western Maharashtra

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Abstract

A treatment receiving 100:40:60:40 kg NPKS + 7.5 t FYM + 2.5 t poultry manure + 2.5 t vermicopost + biofertilizer (5 kg each of Azospirillum + phosphobacteria) hectare^{-1} recorded the highest bulb yield of 54.21 t ha^{-1} as compared to absolute control (25.76 t ha^{-1}) and recommended dose of fertilizers (35.28 t ha^{-1}). It is indicated that the use of biofertilizers in combination with inorganic fertilizers and organic manures offers a great opportunity to increase the production of onion. The maximum increase in total bulb yield was recorded in integrated nutrient management treatment over control. The soil nutrient status was also influenced by various treatments comprising of organic, inorganic and biofertilizers in onion under investigation. The total storage losses were also increased as nutrients levels increases and it was lowest in absolute control. The total nutrient uptake of N, P, K, S, Zn and B was influenced by various treatments of integrated nutrient management system. The nutrient from all sources influence the yield and yield contributing characters and soil fertility in onion under vertisols of western Maharashtra.

Keywords: Onion, organic, inorganic, biofertilizer, soil fertility, INM.

Introduction

Onion (*Allium cepa* L.) has occupied an important place in Indian diet being consumed throughout the year by almost all classes of people. It adds flavor to various vegetable preparations, hence it is called as queen of kitchen. It is found in a large number of recipes and preparations spanning almost the totality of the word's culture. Onion is important bulbous vegetable crop widely grown in Maharashtra. There is a need to standardize the optimum organic and inorganic nutrients along with biofertilizers to such an important crop in western Maharashtra for sustaining the soil health. As the availability of land is decreasing day by day, application of chemical fertilizers has become necessary to meet the demand for food grains. So to sustain soil health and benign environment, balanced application of organic and inorganic fertilizers is essential. Much research has been conducted on the use of inorganic fertilizers in onion to increase the production and productivity of the crop. The integrated use of organic and inorganic fertilizers along with biofertilizers, offers a good opportunity to increase the yield and quality parameters along with soil nutrients status. In onion, nutrition is one of the most important factors. Application of organic, inorganic and biofertilizers would be the optimum integrated nutrient management practices for higher yield, nutrient uptake and fertility status of soil. Soil fertilization is the basic condition for adequate mineral supply to the plants (Sharma *et.al.* 2002). Organic and biological routes of improving soil health and fertility for optimum crop production form the vital component of integrated plant nutrient supply system. The yields obtained with the use of fertilizers in combination with organic manure are higher than the use of inorganic fertilizers alone (Warade *et.al.* 1995). The soil status for crop and the uptake of nutrients by the crop is important for deciding the fertilizer requirement in integrated nutrient management system (Shanti *et.al.* 2005). Growing of high value vegetables like onion, to obtain higher yields is important. Hence there is need to study the nutrient uptake by onion under integrated nutrient management practices for western Maharashtra conditions. An attempt has therefore been made to investigate the suitable organic, inorganic and biofertilizes for onion to obtain higher yield and uptake of nutrients and to investigate which integrated nutrient management system is best suited for maximization of production in onion.

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Materials and methods

The present investigation was conducted at All India Coordinated Research Project on Vegetable Crops, Mahatma Phule Krishi Vidyapeeth, Rahuri during rabi season of 2010-11, 2012-13 and 2013-14. The trial was laid out in a Randomized Block Design with three replications having ten treatments including one absolute control and one treatment of recommended dose of fertilizers. The onion variety N-2-4-1 was used for present investigation. The soil of the experimental plot was medium black with pH of 8.14, EC (d Sm^{-1}) 0.26, organic carbon 0.49, $CaCO_3$ 7.23 percent and available N, P_2O_5 and K_2O were 175.61, 17.96 and 375.01 kg ha^{-1} respectively. The available Sulphur was 7.81 mg kg^{-1}. The available zinc was 0.63 mg kg^{-1} and available boron was 0.48 mg kg^{-1}. The details of treatment schedule were T_1– absolute control, T– 100:50:50 kg NPK ha^{-1}, T_3– 100:50:50 kg NPK + 20 t FYM ha^{-1}, T_4– 110:40:60:40 kg NPKS + 15 t FYM ha^{-1}, T_5– 110:40:60:40 kg NPKS + 7.5 t PM ha^{-1}, T_6– 110:40:60:40 kg NPKS + 7.5 t VC ha^{-1}, T_7– 110:40:60:40 kg NPKS + 7.5 t FYM + 2.5 t PM ha^{-1}, T_8– 110:40:60:40 kg NPKS + 7.5 t FYM + 2.5 t VC ha^{-1}, T_9– 110:40:60:40 kg NPKS + 3.5 t PM + 3.5 t VC ha^{-1}, and T_{10}– 100:40:60:40 kg NPKS + 7.5 t FYM + 2.5 t PM + 2.5 t VC ha^{-1}.

The half dose of nitrogen and full dose of phosphrous, potassium, FYM (farmyard manure), PM (poultry manure), VC (vermicompost) and sulphur were given at the time of transplanting and half of nitrogen was applied one month after transplanting (i.e. top dressing with urea). The biofertilizars *viz.* Azospirillum and phosphobacteria each of 5 kg ha^{-1} was applied to all treatments except treatment T_1 and T_2. The root portion of the seedlings was dipped into the solution of Azospirillum + Phosphobacteria for 15 minutes period as per treatment and then transplanted in main field. Seed of cv. N-2-4-1 was sown on raised beds on 28th October, 2010, 3rd October, 2012 and 19th October, 2013, respectively for the year 2010-11, 2012-13 and 2013-14. The main field was prepared to fine tilth and flat beds of 3 x 2 m were made. Eight week old healthy and uniform seedlings having about 15-20 cm height were used for transplanting. The transplanting was done on 5th January, 2011, 10th December, 2012 and 23rd December, 2013 respectively for the year 2010-11, 2012-13 and 2013-14. The transplanting was done at spacing 15 x 10 cm. Recommended agronomic practices and plant protection measures were taken to grow healthy crop. Five randomly selected plants were taken for recording the biometrical parameters like plant height (cm), number of leaves, neck thickness (cm), polar and equatorial diameter of bulbs (cm), average weight of bulb (g), TSS (^{0}B), A-grade bulbs (%), B-grade bulbs (%), C-grade bulbs (%), doubles (%), bolters (%), total bulb yield (t ha^{-1}), marketable bulb yield (t ha^{-1}) and total storage losses (%). The ten kg of uniform bulbs of each treatment were used for studying the storage losses for six months from May to October in each respective year. The treatment wise total bulb yield (t ha^{-1}) was recorded. The soil nutrient status was analyzed before the application of treatments and after the harvesting of the crop by adopting the methods suggested by AOAC (1990).

For nutrient uptake plant samples were collected from each treatment separately at harvest and dried in diffused sunlight and then in an oven at 60^{o}C till constant weight. The oven dry samples were grind and finely powdered in Willey Mill into composite sample. The samples were further digested with 1:1 mixture of the concentrated sulphuric acid in kjeldahl digestion unit at required temperature as suggested by Parkinson and Alien (1975). The acid extract was used for the analysis of N, P, K, S, Zn and B concentration by using standard method of analysis. The total uptake of N, P, K, S, Zn and B was calculated from concentrations of N, P, K, S, Zn and B and bulb yield was recorded and the data was analysed as method suggested by Panse and Sukhatme (1989).

Results and Discussion

The balanced nutrition to onion is essential as in the form of organic, inorganic and biofertilizer for enhancing productivity. Significant variations among the treatments under investigations were observed for all the characters like plant height, number of leaves, neck thickness, polar diameter, equatorial diameter, average weight of bulb, % ABC grade bulbs, % doubles, % bolters, TSS (^{0}B), total bulb yield (t ha^{-1}) and marketable yield (t ha^{-1}) (Table 1). The integrated approach of nutrient application improved these characters when compared to sole application of recommended dose of fertilizers and absolute control. There is a considerable range of variation was observed from T_1 to T_{10} treatments.

The treatment T_{10} i.e. application of 100:40:60:40 kg NPKS + 7.5 t FYM + 2.5 t PM + 2.5 t VC ha^{-1} recorded maximum plant height (75.80 cm), number of leaves (13.69) and neck thickness (1.38) as compare to treatment T_3 i.e. application of 100:50:50 kg NPK + 20 t FYM ha^{-1} (69.72 cm, 11.78 and 0.91 cm respectively). As regards to yield and yield contributing characters, the treatment T_{10} recorded the maximum polar diameter (5.95 cm), equatorial diameter (7.09 cm) and average weight of bulb (80.57 g) than other treatments. The absolute control recorded the values *viz;* 3.97 cm, 4.67

Table 1: Influence of different INM treatment on growth and yield of onion (pooled data of three years).

Treatments	Plant height (cm)	Number of leaves	Neck thickness (cm)	Polar diameter (cm)	Equatorial diameter (cm)	Average weight of bulb (g)	TSS (^{0}B)	% AGB	% BGB	% CGB	% Bolters	% Doubles (Twin bulbs)	Total yield (t/ha)	Marketable yield (t/ha)
T_1	61.57	9.60	0.75	3.97	4.67	55.14	10.76	15.02	60.67	21.94	0.23	1.13	25.76	22.80
T_2	64.65	10.26	0.77	4.03	4.92	58.91	11.01	16.06	62.03	19.11	0.64	1.43	29.42	27.47
T_3	69.72	11.78	0.91	4.87	5.88	63.44	11.30	19.15	61.75	17.70	0.45	1.29	35.28	33.94
T_4	68.07	10.68	0.99	4.59	5.58	64.45	11.43	18.91	63.35	15.53	0.52	1.19	33.47	31.98
T_5	70.74	11.81	1.08	5.36	6.47	69.41	11.74	20.12	62.40	15.33	0.41	1.22	41.22	40.16
T_6	71.82	12.01	1.17	5.34	6.46	71.93	11.60	20.63	60.17	16.41	0.57	1.77	42.36	40.86
T_7	73.40	12.40	1.26	5.49	6.71	74.41	11.97	23.12	59.99	16.02	0.78	1.45	47.42	46.42
T_8	69.21	11.61	1.30	5.46	6.58	69.42	11.76	20.71	61.23	15.62	0.47	1.60	43.84	42.46
T_9	73.29	12.96	1.34	5.76	6.92	77.56	12.05	21.97	59.27	15.77	0.64	1.63	51.20	50.28
T_{10}	75.80	13.69	1.38	5.95	7.09	80.57	12.38	24.30	62.38	11.58	0.49	1.84	54.21	52.08
S.E.±	2.14	0.59	0.09	0.29	0.36	2.56	0.22	1.29	1.82	1.08	0.17	0.15	2.17	2.60
CD at 5%	6.33	1.75	0.29	0.88	1.06	7.58	0.64	3.82	NS	3.23	0.54	0.47	6.43	7.71

AGB : A-grade bulbs, BGB : B-grade bulbs, CGB : C-grade bulbs.

cm and 55.14 g for these characters, respectively while only inorganic treatment i.e. T_2 (100:50:50 kg NPK ha^{-1}) has more values *viz;* 4.03 cm, 4.92 cm and 58.91 cm respectively as compare to absolute control. The total bulb yield (t/ha) was highest in T_{10} treatment i.e. 54.21 t/ha followed by T_9 (51.20 t/ha), T_7 (47.42 t/ha) and T_8 (42.84 t/ha) while lowest yield was recorded in T_1 i.e. absolute control (25.75 t/ha) followed by T_2 (29.42 t/ha), and T_4 (33.47 t/ha). The recommended dose of fertilizers i.e. T_3 recorded the yield of 35.28 t/ha. The same trend was also observed for marketable yield (t/ha). The beneficial effect of organic manure on yield and other characters could be attributed to the fact that the decomposition and mineralization of organic manures made the nutrients readily available to the plant (Singh and Asrey 2005) and also had solubilizing effect of fixed form of nutrients in the soil (Kumaran *et al.* 1998).

The maximum increase in total bulb yield was recorded in treatment T_{10} (54.21 t/ha) over the only recommended dose of fertilizer i.e. T_3 (35.28 t/ha) and T_1 (25.76 t/ha) i.e. absolute control which revealed minimum total bulb yield. These results are in close agreement with those of Jayathilake *et al.* (2002), Sharma *et al.* (2002) and Khandelwal (2010). Combination of organic, inorganic and biofertlizers enhances the yield production with better quality (Warade *et al.* 1995, Singh *et al*. 2010). The TSS (^{0}B) was also showed increasing trend from treatment T_1 to T_{10}. It was maximum in T_{10} (12.38 ^{0}B) while minimum in T_1 (10.76 ^{0}B). The total number of marketable bulbs per unit is compared of different sized bulbs which can be graded into A-grade (above 6.5 cm), B-grade (6.5 to 4.5 cm) and C-grade (4.5 to 3.5 cm) size bulbs. The percentage of premature bolters and doubles (twin bulbs) regarded as unmarketable bulbs.

The analysis of soil nutrient status (Table 2) before the treatment application and also after the harvest of the crop revealed that the organic carbon and available nitrogen was found significantly more in poultry manure treated plot alone or in combination with RDF very low organic carbon and available nitrogen content was observed in RDF i.e. T_3 (0.53), T_2 (0.49) and T_1 (0.47) as compared to treatment T_{10} (0.59). Similar trend was observed with available P_2O_5, K_2O and Sulphur. The pH of the RDF treated plot was maximum (8.10) and only

Table 2: Soil nutrient status as influenced by INM treatments in onion (pooled data of three years).

Treatments	PH (1:2.5)	EC (d sm^{-1})	Organic carbon (%)	$CaCO_3$ (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Available Sulphur (mg/kg)	Available Zinc (mg/kg)	Available Boron (mg/kg)
T_1	8.16	0.25	0.47	7.07	155.19	15.33	341.81	7.39	0.40	0.43
T_2	8.15	0.26	0.49	7.08	179.07	18.06	378.54	7.88	0.48	0.45
T_3	8.10	0.31	0.53	7.11	182.69	19.51	387.15	8.55	0.57	0.53
T_4	8.10	0.30	0.53	7.10	181.81	19.95	392.17	8.71	0.59	0.54
T_5	8.10	0.32	0.53	7.16	184.15	21.40	393.54	9.69	0.72	0.58
T_6	8.07	0.32	0.55	7.13	183.22	19.79	398.24	10.58	0.77	0.59
T_7	8.07	0.35	0.56	7.22	184.86	20.62	397.02	10.50	1.09	0.64
T_8	8.07	0.33	0.55	7.17	181.05	19.48	394.83	10.04	0.88	0.60
T_9	8.08	0.34	0.56	7.19	181.30	19.68	395.14	11.32	0.99	0.64
T_{10}	8.07	0.35	0.59	7.31	185.43	20.85	399.30	12.58	1.15	0.72
S.E.±	0.08	0.05	0.02	0.09	2.13	0.89	2.40	0.62	0.12	0.05
CD at 5%	NS	NS	0.06	0.27	6.31	2.63	8.12	1.83	0.35	0.15
Initial values	8.14	0.26	0.49	7.23	175.61	17.96	375.01	7.81	0.63	0.48

inorganic fertilizer i.e. T_2 (8.15) and in absolute control i.e. T_1 (8.16) as compared to other treatments and it was minimum in T_{10} (8.07). The EC (d sm^{-1}) was minimum in absolute control (0.25), inorganic fertilizer (0.26) and RDF (0.31) as compared to treatment T_{10} (0.35). The $CaCO_3$ percentage were also maximum in T_{10} (7.31) and minimum in T_1 (7.07). From these studies it is clearly seen that use of inorganic fertilizers along with farmyard manure, poultry manure, vermicompost and biofertilizers results in significant improvement in available N, P, K and S status of the soil. Similar is the case with zinc and boron nutrients. The availability was increased by the use of organic, inorganic and biofertilizers as an integrated nutrient management system for onion crop. Similar findings were also reported by Siag and Yadv (2004) and Shanti *et.al.* (2005).

As regards storage studies in onion bulbs influenced by various INM treatments, the treatment T10 recorded the maximum losses *viz;* 11.13, 15.80, 23.49, 31.54, 38.78 and 45.62 as compare to absolute control i.e. T_1 *viz;* 7.30, 10.00, 16.38, 20.81, 26.00 and 30.77 percentage total storage losses at 30, 60, 90, 120, 150 and 180 days after storage, respectively (Table 3). From the above studies, it is revealed that the increased level of nutrient applications is responsible for increasing the total losses in onion after six months of storage period. The nitrogenous applications observed to increases the total losses while the minimum losses were observed in absolute control treatment. Similar findings were also reported by Mukeshkumar (2000).

The total nutrient uptake of N, P, K, S, Zn and B by onion crop was significantly influenced by various treatments (Table 4). Total nitrogen uptake (94.00 kg ha^{-1}) was maximum in treatment T_{10} and which was at par with T_9 (90.11 kg ha^{-1}), T_8 (82.42 kg ha^{-1}) and T_7 (86.73 kg ha^{-1}) and minimum in treatment T_1 (58.33 kg ha^{-1}) i.e. absolute control. The recommended dose of fertilizers recorded the nitrogen uptake of 71.10 kg ha^{-1}. The total P uptake (16.52 kg ha^{-1}) was recorded

Table 3: Total storage losses (%) in onion as influenced by different INM treatments (pooled data of three years).

Treatment	Total storage losses after days					
	30	60	90	120	150	180
T_1	7.30	10.00	16.38	20.81	26.00	30.77
T_2	8.97	12.85	19.92	25.25	29.47	34.05
T_3	7.98	15.28	22.65	26.03	34.24	40.21
T_4	8.03	12.36	18.39	21.91	29.86	38.08
T_5	8.63	13.25	22.14	27.65	32.76	39.75
T_6	8.48	14.31	21.56	30.75	34.85	39.60
T_7	8.99	14.17	20.01	25.58	32.96	39.40
T_8	8.19	12.88	18.69	26.46	31.87	38.70
T_9	9.29	13.28	22.23	28.48	35.38	41.46
T_{10}	11.13	15.80	23.49	31.54	38.78	45.62
S.E.±	1.86	1.90	2.88	2.64	2.66	2.53
CD at 5%	NS	NS	NS	6.60	7.90	7.55

minimum in treatment T_1 i.e. absolute control and maximum (36.90 kg ha^{-1}) in treatment T_{10} followed by T_9 (35.26 kg ha^{-1}). The minimum potassium uptake by onion was observed in treatment T_1 (54.52 kg ha^{-1}) and it was maximum in treatment T_{10} (93.62 kg ha^{-1}). This may be because of application of inorganic fertilizers with organic sources which are responsible for increasing nutrient use efficiency by the crop. Uptake of nutrients increased with increasing availability of nutrients and also with nitrogen use efficiency. Similar results were also reported by Sharma *et al* (2000) and Shanti *et al.* (2005). The maximum (29.13 mg kg^{-1}) sulphur uptake by onion was recorded in treatment T_{10} and minimum (19.93 mg kg^{-1}) in treatment T_1. The treatment T_6 (25.81 mg kg^{-1}), T_7 (27.45 mg kg^{-1}), T_8 (26.27 mg kg^{-1}) and T_9 (28.36 mg kg^{-1}) were at par with treatment T_{10} for sulphur uptake. From these studies it was indicated that uptake of sulphur increased with application of organic, inorganic and biofertilizers in combinations. These results are in close agreement with those of Siag and Yadav (2004) and Mukeshkumar *et.al.* (2000). The Zinc uptake was minimum in T_1 (356.98 g/ha) and maximum in T_{10} (424.60 g/ha). Similar is case with boron uptake and it was lowest in T_1 (117.67 g/ha) and highest in T_{10} (169.83 g/ha). All other treatments are within the treatment of T_1 and T_{10}. Similar

Table 4: Effect of different INM treatments on total uptake of nutrients (pooled data of three years).

Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	S uptake (mg kg^{-1})	Zinc uptake (g/ha)	Boron uptake (g/ha)
T_1	58.33	16.92	54.52	19.93	356.98	117.67
T_2	63.98	19.24	59.24	20.84	364.92	121.47
T_3	71.10	24.56	67.65	23.98	386.36	132.33
T_4	68.92	23.05	67.85	23.59	368.19	125.15
T_5	75.45	26.40	79.70	25.44	353.63	146.89
T_6	78.06	27.06	81.07	25.81	377.23	147.06
T_7	86.73	22.81	84.45	27.45	409.28	156.30
T_8	82.42	29.94	80.75	26.27	408.91	156.51
T_9	90.11	35.26	88.56	28.36	400.95	162.53
T_{10}	94.00	36.90	93.62	29.13	424.60	169.83
S.E.±	3.95	2.02	3.29	1.14	13.76	4.26
CD at 5%	11.69	6.00	9.74	3.40	40.61	12.88

report was also observed by Shanti *et al.* (2005).

It is evident from three years studies that judicious use of organic, inorganic and biofertilizers as integrated nutrient management system would be useful for enhancing the yield and uptake of various nutrients in onion. Considering the yield contributing characters, storage losses and soil nutrient status, it can be concluded that application of 110:40:60:40 kg NPKS + 7.5 t FYM + 2.5 t PM + 2.5 t VC ha^{-1} + biofertlizers (5 kg each of Azospirillum and Phosphobacteria) should be given to onion crop for obtaining higher yields and sustaining the soil health in vertisols of Western Maharashtra conditions.

सारांश

प्याज में 100:40:60:40 किलोग्राम नत्रजन, फास्फोरस, पोटाश, गन्धक + 7.5 टन गोबर की खाद + 2.5 टन मुर्गी की खाद + 2.5 टन वर्मी कम्पोस्ट + बायोफर्टिलाजर (5 किलोग्राम एजोस्पाइरिलम + 5 किलोग्राम फास्फोबैक्ट्रिया) प्रति हेक्टेयर प्रयोग करने से पूर्ण निन्त्रक (25.76 टन/हेक्टेयर) की तुलना में 54.21 टन/हेक्टेयर उपज प्राप्त हुई। इससे स्पष्ट होता है कि अकार्बनिक उर्वरकों तथा कार्बनिक उर्वरकों के साथ जैव उर्वरकों का प्रयोग प्याज उत्पादन बढ़ाने का सबसे उत्तम साधन हैं। नियंत्रक की तुलना में कुल कन्द उत्पादन में ज्यादा वृद्धि एककृत पोषक तत्व प्रबंधन से प्राप्त हुआ। अनेकों शोध परिक्षण जिनमें कार्बनिक, अकार्बनिक तथा जैव उर्वरक सम्लित थे। मृदा पोषक स्थिति भी प्रभावित हुयी। कुल भंडारण नुकसान में भी वृद्धि पोषक स्तर बढ़ाने से वृद्धि दर्ज की गयी तथा यह पूर्ण नियंत्रक में सबसे कम था। नत्रजन, फास्फोरस, पोटाश, गन्धक, जिन्क तथा बोरान की ग्राहयता भी एकीकृत पोषक तत्व द्वारा प्रबंधन पद्धति प्रभावित हुई। सभी स्रोतों से प्राप्त पोषक तत्व उपज एवं उपज घटक प्रभावित हुआ तथा पश्चिम महाराष्ट्र की वर्टिसोल मृदा भी प्रभावित हुई।

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