Yield and economic response of onion (*Allium cepa* L) to combined inorganic (NPK) and organic (biomix and humic acid) fertilization

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ABSTRACT

Intensive cultivation and excessive chemical fertilizer use contribute to soil degradation, environmental concerns and high production costs in agriculture. Addressing the limited information on balanced nutrient management in onion cultivation, this two-year factorial randomized block design experiment investigated the effects of three recommended doses of fertilizers (RDF) levels (80%, 100%, 120% NPK) combined with six organic treatments (control, various rates of biomix and humic acid) on onion (cv Baswant-780) yield and economics in Parbhani, Maharashtra. Pooled data revealed that the highest bulb yields (24.56 and 24.24 tonnes/ha) were achieved with 120 per cent RDF combined with either 10 kg per hectare humic acid or 15 kg per hectare biomix, with both treatments being statistically at par. Economically, treatment 120 per cent RDF + 10 kg per ha humic acid yielded the highest net return (Rs 154,913.62/ha), while treatment 120 per cent RDF + 15 kg/ha biomix) recorded the superior benefit-cost ratio (2.38). These findings underscore that integrating 120 per cent RDF with optimal organic sources (either 10 kg/ha humic acid or 15 kg/ha biomix) significantly enhances onion bulb yield and profitability. This study advocates for the adoption of such integrated nutrient management practices to foster sustainable and economically viable onion cultivation.

Keywords: Onion; biomix; humic acid; yield; economics; benefit-cost ratio

INTRODUCTION

Onion (*Allium cepa* L) is a perennial (often biennial) monocotyledonous bulbous crop belonging to the Amaryllidaceae family and one of the most important crops of vegetables and spices grown under a wide range of climatic conditions worldwide (Brewster 1994, McCallum et al 2001).

In a variety of flavoured salads and soups, onion is used in both the green and mature stages for salad and spice. It is very popular in food and commonly used in almost all regions of the world for cooking and has been used throughout history in various cultures and rituals; it is therefore called the Kitchen Queen (Brewster 1994).

Onion consumption has a high demand for elasticity income. Therefore, with economic growth and urbanization, increased demand for onions is expected. Onions are part of millions of people diets around the world, are in constant demand throughout the year and have a significant effect on global food security. The United Nations Food and Agriculture Organization (FAO) recorded that in terms of total annual world production, onion ranks second among horticultural crops, next to tomatoes (Anon 2021).

Over several years, numerous possible health and nutritional benefits resulting from onion consumption have been studied. Onions provide flavour and contain health-related properties of useful phytochemicals, including different sulphur-containing compounds such as alkenyl cysteine sulphoxides, anti-oxidant compounds that are likely to be used to protect against fungi and insects, create the distinctive odour, flavour and lachrymatory (tear stimulating) properties of onions along with their breakdown products (Brewster 1994).

Intensive cultivation and the excessive use of chemical fertilizers have led to soil degradation and unstable crop yields (Lal 2015). Additionally, modern agricultural practices are contributing to environmental concerns (Tilman et al 2002, Pretty 2008). In recent years, there has been growing interest in using organic sources such as biomix and humic acid as alternatives, supplements or complements to chemical fertilizers. This shift aims to improve soil health, promote sustainable farming and reduce the high costs associated with inorganic fertilizers in horticultural production.

The bioagents are playing important role in plant disease management, pest management and boosting the plant growth. Department of Pathology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra introduced biocontrol in the Marathwada region and developed an experimental product 'biomix' during 2005. Later on, an improved biomix was formulated by adding some bio- fungicides, bio-pesticides and growth promoting bio-agents (Borase et al 2021).

Humic acid improves soil fertility and increases the availability of nutrient elements by holding them on mineral surface. The humic substances are mostly used to remove or decrease the negative effects of chemical fertilizers from the soil and have a major effect on plant growth (Ghabbour and Davies 2001).

Limited information exists regarding the balanced application of chemical fertilizers with organic sources like biomix and humic acid in onion cultivation. Therefore, this study was conducted to investigate the effects of biomix and humic acid on onion crop.

MATERIAL and METHODS

The investigations were done during late kharif season for two consecutive years 2020-21 and 2021-2022 at the experimental farm of Department of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra on onion variety Baswant-780 developed by Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra.

The experiment was laid out in factorial randomized block design with three different levels of recommended doses of fertilizers (RDF), F_1 {RDF 80% (80:40:40 NPK kg/ha)}, F_2 {RDF 100% (100:50:50 NPK kg/ha)} and F_3 {RDF120% (120:60:60 NPK kg/ha)} with six levels of organic sources viz S_0 (Control), S_1 (Biomix 10 kg/ha), S_2 (Biomix 12.5 kg/ha), S_3 (Biomix 15 kg/ha), S_4 (Humic acid 5 kg/ha) and S_5 (Humic acid 10 kg/ha) comprising eighteen treatments replicated thrice. The onions were transplanted on 20.08.2020 and 21.08.2021 with 15 cm row to row and 10 cm plant to plant spacing.

Nitrogen was applied as per treatment through urea, half as basal dose and remaining half in two equal splits at 10 and 30 days after transplanting. Phosphorus and potassium were applied through single super phosphate and muriate of potash respectively, just before transplanting.

The different levels of biomix were mixed with 5 liters of water for drenching purpose. Similarly, different levels of humic acid were mixed with water for drenching. Recommended package of practices was applied to grow a good crop.

The expenditure incurred on different inputs and labour cost were recorded as per the current market rate. The cost of cultivation of each treatment was worked out by considering the present price of inputs, charges for cultivation, labour, land and other charges, required for each treatment. Bulb yield was calculated per plot. The total value of crop was calculated as per prevailing market rates of produce during harvest period and gross returns were calculated by multiplying the total yield with prevailing price of produce. Net return was worked out by subtracting the cost of cultivation from gross return.

The benefit-cost ratio was calculated by using the following formula:

$$\text{Benefit-cost ratio} = \frac{\text{Gross monetary return (Rs)}}{\text{Cost of cultivation (Rs)}}$$

The statistical analysis was done as per Panse and Sukhatme (1985).

RESULTS and DISCUSSION

Effect of treatments on onion yield: As per pooled data (Table 1), F_3S_5 (RDF 120%/ha + humic acid 10 kg/ha) and F_3S_3 (RDF 120%/ha + biomix 15 kg/ha) resulted in maximum bulb yield of 24.56 and 24.24 tonnes per ha respectively, which were at par. Minimum yield was recorded in F_1S_0 (RDF 80%/ha + control),

F_1S_1 (RDF 80%/ha + biomix 10 kg/ha) and F_1S_2 (RDF 80%/ha + biomix 12.5 kg/ha) with 20.09, 20.49 and 20.82 tonnes per ha respectively, the three treatments being at par.

Effect of treatments on economics of onion cultivation: Data given in Table 2 depict that highest net return was recorded under treatment F_3S_5 (RDF 120%/ha + humic acid 10 kg/ha) (Rs 154,913.62/ha) followed by F_3S_3 (RDF 120%/ha + biomix 15 kg/ha) (154,220.12/ha) and the lowest under treatment F_1S_0 (RDF 80%/ha + control) (Rs 107,606.17/ha) followed by F_1S_1 (RDF 80%/ha + biomix 10 kg/ha) (Rs 115,742.49/ha). However, highest B-C ratio was recorded in treatment F_3S_3 (RDF 120%/ha + biomix 15 kg/ha) (2.38) followed by F_3S_5 (RDF 120%/ha + humic acid 10 kg/ha) (2.35). On the other hand, lowest B-C ratio was recorded in F_1S_0 (RDF 80%/ha + control) (1.95) followed by F_2S_0 (RDF 100%/ha + control) (2.03).

Garde et al (2022a) reported that onion bulbs grown with 120 per cent recommended dose of fertilizers (RDF) showed higher chlorophyll content (63.44 SPAD value), ascorbic acid content (11.71 mg/100 g), total soluble solids (12.23%), reducing sugars (2.33%), non-reducing sugars (5.27%) and total sugars (7.60%). Among the organic sources, humic acid (10 kg/ha) resulted in the highest mean chlorophyll content (59.66 SPAD value), total soluble solids (11.91%), reducing sugars (2.29%), non-reducing sugars (5.03%) and total sugars (7.32%). However, the highest ascorbic acid content (10.89 mg/100 g) was observed with biomix (15 kg/ha). In storage studies spanning five months at ambient temperatures, the mean minimum physiological loss in weight (18.47%) was recorded under NPK (80:40:40 kg/ha), while the maximum total soluble solids were observed in NPK (120:60:60 kg/ha). Similarly, for organic treatments during the five-month storage, the mean minimum physiological loss in weight (18.55%) was noted under biomix (15 kg/ha) and the mean maximum total soluble solids were found in the humic acid treatment (10 kg/ha).

Garde et al (2022b) observed that onion bulbs produced with RDF (120% - 120:60:60 NPK kg/ha) exhibited superior bulb attributes. These included a higher polar diameter (6.48 cm), equatorial diameter (8.29 cm), number of scales per bulb (8.76) and bulb volume (73.21 cc). Among the organic sources, humic acid (10 kg/ha) led to higher values for these same bulb attributes: polar diameter (6.06 cm), equatorial diameter (7.80 cm), number of scales per bulb (7.99) and bulb volume (72.59 cc). Furthermore, onions grown with RDF (120%) also showed superior root parameters, specifically a higher number of roots per bulb (146.49) and longer root length (20.63 cm). Within the organic treatments, humic acid (10 kg/ha) again resulted in the maximum number of roots per bulb (143.98) and root length (19.53 cm).

Sajid et al (2012) reported that various levels of humic acid significantly influenced growth and yield parameters of onion cultivars. The cultivar Parachinar Local consistently showed higher neck height (7.5 cm), plant height (80.9 cm), bulb weight (94.2 g), yield per plot (22.9 kg) and total yield (36.1 tonnes/ha). Similarly, applying 2 kg per ha of humic acid significantly increased neck height (7.6 cm), plant height (75.3 cm), bulb weight (96.4 g), yield per plot (22.4 kg) and total yield (35.86 tonnes/ha), while survival percentage showed a non-significant response. The interaction between onion cultivars and humic level indicated that Parachinar Local, when fertilized with 2 kg per ha of humic acid, demonstrated the best performance for most of the growth and yield parameters. It was concluded that the combination of onion cultivar Parachinar Local and humic acid application at 2 kg per ha resulted in higher growth and yield for onion.

Yadav et al (2023) assessed the impact of humic acid and ascorbic acid on the growth and yield of onion bulb. They found that the maximum plant height (39.44 cm), number of leaves per plant (10), bulb length (5.93 cm), bulb diameter (5.47 cm), bulb fresh weight (88.20 g), bulb dry weight (13.88 g) and bulb yield per plot (6.39 kg) were achieved with the spray of humic acid 70 ppm + ascorbic acid 40 ppm. These results were higher compared to the minimum values obtained in the control group.

Bekele (2020) evaluated the effectiveness of foliar application of humic substances (HFA), consisting of 22.5 per cent total humic and fulvic acid with 7.1 per cent water soluble potassium oxide, on onion. The results revealed that onion marketable yield was significantly improved by several treatments. These included the application of recommended rates of nitrogen, phosphorus and potassium (RNPK – 46 N, 46 P_2O_5 and 51 K_2O kg/ha) alone and various foliar applications of HFA. Specifically, treatments involving 1.875 l per ha and 2.5 l per ha HFA with RNPK as well as 1.875 l per ha HFA with half RNPK, all led to significant yield improvements. Among these, the foliar

Table 1. Effect of different levels of RDF with organic sources on bulb yield of onion

Treatment	Bulb yield (tonnes/ha)		
	2020-21	2021-22	Pooled mean
F_1S_0: RDF 80%/ha + control	20.30	19.89	20.09
F_1S_1: RDF 80%/ha + biomix 10 kg/ha	20.69	20.28	20.49
F_1S_2: RDF 80%/ha + biomix 12.5 kg/ha	20.96	20.68	20.82
F_1S_3: RDF 80%/ha + biomix 15 kg/ha	21.42	21.08	21.25
F_1S_4: RDF 80%/ha + humic acid 5 kg/ha	21.00	20.77	20.89
F_1S_5: RDF 80%/ha + humic acid 10 kg/ha	21.75	21.32	21.53
F_2S_0: RDF 100%/ha + control	21.77	20.69	21.23
F_2S_1: RDF 100%/ha + biomix 10 kg/ha	22.07	21.12	21.59
F_2S_2: RDF 100%/ha + biomix 12.5 kg/ha	22.56	21.79	22.18
F_2S_3: RDF 100%/ha + biomix 15 kg/ha	23.03	22.57	22.80
F_2S_4: RDF 100%/ha + humic acid 5 kg/ha	22.68	21.93	22.31
F_2S_5: RDF 100%/ha + humic acid 10 kg/ha	23.48	22.89	23.19
F_3S_0: RDF 120%/ha + control	22.62	21.80	22.21
F_3S_1: RDF 120%/ha + biomix 10 kg/ha	23.18	22.22	22.70
F_3S_2: RDF 120%/ha + biomix 12.5 kg/ha	23.95	23.37	23.66
F_3S_3: RDF 120%/ha + biomix 15 kg/ha	24.69	23.78	24.24
F_3S_4: RDF 120%/ha + humic acid 5 kg/ha	23.99	23.48	23.74
F_3S_5: RDF 120%/ha + humic acid 10 kg/ha	25.10	24.01	24.56
SEm±	0.26	0.24	0.25
$CD_{0.05}$	0.77	0.71	0.74

Table 2. Effect of different levels of RDF with organic sources on economics of onion cultivation

Treatment	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B-C ratio
F_1S_0: RDF 80%/ha + control	113,189.02	220,795.18	107,606.17	1.95
F_1S_1: RDF 80%/ha + biomix 10 kg/ha	109,405.52	225,148.01	115,742.49	2.06
F_1S_2: RDF 80%/ha + biomix 12.5 kg/ha	109,364.02	229,107.03	119,743.01	2.09
F_1S_3: RDF 80%/ha + biomix 15 kg/ha	109,225.02	233,553.75	124,328.74	2.14
F_1S_4: RDF 80%/ha + humic acid 5 kg/ha	112,209.02	229,415.00	117,205.99	2.04
F_1S_5: RDF 80%/ha + humic acid 10 kg/ha	111,929.02	236,644.53	124,715.52	2.11
F_2S_0: RDF 100%/ha + control	114,547.13	232,972.50	118,425.37	2.03
F_2S_1: RDF 100%/ha + biomix 10 kg/ha	110,763.63	237,063.75	126,300.12	2.14
F_2S_2: RDF 100%/ha + biomix 12.5 kg/ha	110,722.13	243,547.50	132,825.37	2.20
F_2S_3: RDF 100%/ha + biomix 15 kg/ha	110,583.13	250,571.25	139,988.12	2.26
F_2S_4: RDF 100%/ha + humic acid 5 kg/ha	113,567.13	245,021.25	131,454.12	2.16
F_2S_5: RDF 100%/ha + humic acid 10 kg/ha	113,287.13	254,758.31	141,471.18	2.25
F_3S_0: RDF 120%/ha + control	115,907.63	243,888.75	127,981.12	2.10
F_3S_1: RDF 120%/ha + biomix 10 kg/ha	112,124.13	249,200.06	137,075.93	2.22
F_3S_2: RDF 120%/ha + biomix 12.5 kg/ha	112,082.63	259,970.36	147,887.73	2.32
F_3S_3: RDF 120%/ha + biomix 15 kg/ha	111,943.63	266,163.75	154,220.12	2.38
F_3S_4: RDF 120%/ha + humic acid 5 kg/ha	114,927.63	260,857.50	145,929.87	2.27
F_3S_5: RDF 120%/ha + humic acid 10 kg/ha	114,647.63	269,561.25	154,913.62	2.35

application of 1.875 l of HFA combined with RNPK fertilizers provided the most significant boost to onion marketable yield.

CONCLUSION

This study investigated the combined effects of varying recommended doses of fertilizers (RDF) and organic sources (biomix and humic acid) on onion yield and economic returns in a two-year trial. The findings demonstrate that a balanced approach combining high levels of chemical fertilizers with organic amendments can significantly enhance onion bulb yield. Specifically, the treatment integrating 120 per cent RDF with 10 kg per hectare of humic acid and the treatment combining 120 per cent RDF with 15 kg per hectare of biomix consistently resulted in the highest bulb yields, both being statistically at par.

Economically, the highest net return was achieved with the 120 per cent RDF plus 10 kg per hectare humic acid treatment. However, the most favourable benefit-cost ratio was observed in the treatment combining 120 per cent RDF with 15 kg per hectare of biomix followed closely by the 120 per cent RDF with 10 kg per hectare humic acid treatment. This suggests that while both top treatments maximize yield and profitability, the biomix application offers a slightly better return on investment.

These results are supported by previous research indicating the positive impacts of higher RDF levels and organic amendments like humic acid and biomix on various onion growth, quality and yield parameters as well as their role in mitigating physiological loss during storage. Therefore, for sustainable and economically viable onion production, farmers in the region should consider adopting integrated nutrient management strategies that include a higher recommended dose of fertilizers complemented by organic sources such as humic acid at 10 kg per hectare or biomix at 15 kg per hectare.

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