Original Research Article

Integrated Plant Nutrient Management on Bulb Quality and Nutrient Uptake of Aggregatum Onion (*Allium cepa* var. *aggregatum*)

ABSTRACT

A field experiment was conducted in the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T. of Puducherry, during the summer season of 2023 in aggregatum onion [*Allium cepa* var. *aggregatum*] cv 'Perambalur Local' with the objective of assessing the impact of soil fertility and integrated plant nutrient management on quality of onion bulbs and the plant response to nutrient uptake. The experiment was conducted in a Randomized Block Design (RBD) with two replications, incorporating two factors: fertilizers (F_1 with 6 levels) and bioenhancers (F_2 with 3 levels), resulting in eighteen treatment combinations distributed in a factorial manner. The study materials included vermicompost, poultry manure, panchagavya, jeevamirtham, as well as recommended farmyard manure (FYM) and N, P, K fertilizers. One of the notable findings was that the application of RDFYM + 75% N + RDP + RDK + 25% N through poultry manure coupled with the application of jeevamirtham at 500 L ha^{-1} as soil drench thrice during irrigation (at planting, 20 and 45 DAP), resulted in the highest Total Soluble Solids (TSS) and ascorbic acid content, measuring 12.64 ^{o}Brix and 15.81 mg 100 g^{-1} respectively. Moreover, this treatment also exhibited the highest uptake of N, P and K by onion bulbs, recording15.27 kg ha^{-1}, 3.38 kg ha^{-1} and 15.27 kg ha^{-1} respectively (F_3B_2). Further, post-harvest soil analysis indicated that the treatment RDFYM + 50% N + RDP + RDK + 50% N through poultry manure, combined with jeevamirtham at 500 L ha^{-1} as a soil drench thrice during irrigation (at planting, 20 and 45 DAP), showed the highest levels of available N, P, and K. The recorded values were 179.60 kg ha^{-1} of N, 12.66 kg ha^{-1} of P, and 171.90 kg ha^{-1} of K (F_5 B_2).

Keywords: Aggregatum onion; Soil fertility; Integrated plant nutrients; Poultry manure; Jeevamirtham.

1. INTRODUCTION

Aggregatum onion (*Allium cepa* var. *aggregatum)* is one of the important commercial bulbous vegetable crops having multivarious uses especially in the South Indian delicacies. Though India is the second largest producer of onion in the world, there is a need for increasing as well as sustaining the productivity of this commercially important vegetable to meet the ever-growing demand. Onion is popularly designated as “Queen of the kitchen” due to its rich flavour, fragrance and unique taste, which is attributable to a volatile compound “allyl-propyl disulphide” contained in it (Yadav *et al.,* 2015). Onion is fairly good in its nutrient status containing carbohydrate (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g) and several vitamins like vitamin A (0.01 mg), vitamin C (11 mg), thiamine (0.08 mg), riboflavin (0.01 mg) and niacin (0.2 mg). It also contains minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg) and potassium (157 mg) in 100 g of bulb (Sharma *et al.,* 2018). Application of chemical fertilizer alone is reported to have resulted in increased crop yield in the initial years but adversely affected the sustainability at a later stage. The cost of chemical fertilizers is also increasing day by day. Reducing the dependence on chemical fertilizers without compromising the sustainability in production is considered as a vital issue in modern agriculture, which could be achieved only through integrated plant nutrient supply system (IPNS). Integrated nutrient management serve as the effective source of manuring in obtaining sustainable productivity without any detrimental effects on soil in an eco-friendly manner. Besides organic manures help in mitigating multiple nutrient deficiencies. Application of organic manures to acidic soil can reduce the soluble and exchangeable aluminium temporarily by forming complex and provides better environment for growth and development by improvement in physical, chemical and biological properties of soil (Jamir *et al.,* 2013). Enhancing productivity and sustaining the yield of crop primarily depends on nutrient availability and nutrient use efficiency. Though many factors are responsible for the existing yield gap in aggregatum onion, the major factor attributable is the poor availability and uptake of nutrients by this short duration crop and such a trend in crop production warrants finding of suitable alternate approach and integrated nutrient management practices with the use of bio compost and bioenhancers is a recent approach towards achieving this objective. The use of manures and compost are helpful in maintaining soil health by increasing organic matter content, besides enhancing the crop productivity (Miglani *et al.,* 2017). Keeping the above facts in view, the present investigation was conducted to study the effect of "Integrated Plant Nutrient Management on Bulb Quality and Nutrient Uptake of Aggregatum Onion (*Allium cepa* var*. aggregatum*)".

2. MATERIALS AND METHODS

The experiment on Aggregatum Onion (*Allium cepa* var*. aggregatum*)" was carried out in the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T. of Puducherry, India, during the summer season of 2023. Aggregatum onion type 'Perambalur Local' collected from farmer's field in Padalur village of Perambalur district of Tamil Nadu (India) was used for the study. The treatment materials for the study comprised of vermicompost, poultry manure, panchagavya and jeevamirtham, besides recommended FYM and N, P, K fertilisers. The experiment was laid out in a Randomized Block Design with two replications constituting eighteen treatments (Table 1) in a factorial way (FRBD) and the study comprised of 2 factors *viz*., Fertiliser (Factor 1) and Bioenhancers (Factor 2). There were six levels for Factor 1 and three levels for Factor 2, forming 18 treatment combinations.

The soil of the experimental area belongs to Kottucherry series, having the textural class of sandy soil with a pH of 7.15, electrical conductivity of 0.35 dSm^{-1}, organic carbon of 0.39 per cent, available nitrogen 140 kg ha^{-1}, available phosphorus of 9.59 kg ha^{-1} and potassium availability of 133.33 kg ha^{-1}.

Table 1. Treatment particulars

Sl. No.	Treatment	Treatment Particulars
1.	T_1 - F_0B_0	Absolute control

2.	T_2 - F_0B_1	3 % Panchagavya foliar spray on 15, 30 and 45th DAP
3.	T_3 - F_0B_2	Jeevamirtham 500L ha^{-1} as soil application thrice with irrigation *viz*., at planting, 20th and 45th DAP
4.	T_4 - F_1B_0	RDF
5.	T_5 - F_1B_1	RDF + 3 % Panchagavya foliar spray on 15, 30 and 45th DAP
6.	T_6 - F_1B_2	RDF + Jeevamirtham 500L ha^{-1} as soil application thrice with irrigation *viz*., at planting, 20th and 45th DAP
7.	T_7 - F_2B_0	RDFYM + 75 % N + RDP + RDK + 25 % N through Vermicompost
8.	T_8 - F_2B_1	RDFYM + 75 % N + RDP + RDK + 25 % N through Vermicompost + 3% Panchagavya foliar spray on 15, 30 and 45th DAP
9.	T_9 - F_2B_2	RDFYM + 75 % N + RDP + RDK + 25 % N through Vermicompost + Jeevamirtham 500L ha^{-1} as soil application thrice with irrigation *viz*., at planting, 20th and 45th DAP
10.	T_{10} - F_3B_0	RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure
11.	T_{11} - F_3B_1	RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure + 3 % Panchagavya foliar spray on 15, 30 and 45th DAP
12.	T_{12} - F_3B_2	RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure + Jeevamirtham 500L ha^{-1} as soil application thrice with irrigation *viz*., at planting, 20th and 45th DAP
13.	T_{13} - F_4B_0	RDFYM + 50 % N + RDP + RDK + 50 % N through Vermicompost
14.	T_{14} - F_4B_1	RDFYM + 50 % N + RDP + RDK + 50 % N through Vermicompost + 3 % Panchagavya foliar spray on 15, 30 and 45th DAP
15.	T_{15} - F_4B_2	RDFYM + 50 % N + RDP + RDK + 50 % N through Vermicompost + Jeevamirtham 500 L ha^{-1} as soil application thrice with irrigation *viz*., at planting, 20th and 45th DAP
16.	T_{16} - F_5B_0	RDFYM + 50 % N + RDP + RDK + 50 % N through Poultry manure
17.	T_{17} - F_5B_1	RDFYM + 50 % N + RDP + RDK + 50 % N through Poultry manure + 3% Panchagavya foliar spray on 15, 30 and 45th DAP
18.	T_{18} - F_5B_2	RDFYM + 50 % N + RDP + RDK + 50 % N through Poultry manure + Jeevamirtham 500L ha^{-1} as soil application thrice with irrigation *viz*., at planting, 20th and 45th DAP

A fertilizer dose of 60:60:30 kg NPK ha^{-1} along with 25 t ha^{-1} of FYM (Crop Production Guide of Horticultural Crops - 2020) was taken as the reference for fertiliser application. The reduced level of N fertiliser was compensated with vermicompost in T_7 to T_9 and T_{13} to T_{15} and by poultry manure in T_{10} to T_{12} and T_{16} to T_{18}. The quantity of vermicompost and poultry manure applied in each plot were calculated to compensate the requirement based on the N content in vermicompost (1.50 per cent) and poultry manure (3.03 per cent). The post harvest soil and plant samples collected were analysed for nutrient content as indicated in Table 2.

The quality parameters *viz*., TSS and ascorbic acid content in bulbs were analysed as proposed by (Tigchelaar, 1986: Sadasivam and Balasubraminan1987).

Table 2. Details of analytical methods employed for soil and plant analysis

Sl. No.	Analysis	Methodology	Reference
I. Soil Analysis			
A	**Physico - chemical properties**		
1	Soil reaction (1:2.5)	Using glass electrode in the ELICO (LI 120) pH meter	Jackson (1973)
2	Electrical conductivity (1:2.5)	Using ELICO (CM 180) conductivity meter	Jackson (1973)
B	**Chemical properties**		
1	Organic carbon	Chromic acid wet digestion Method	Walkley and Black (1934)
2	Available nitrogen	Alkaline permanganate Method	Subbiah and Asija (1956)
3	Available phosphorous	Using 0.5 M $NaHCO_3$ of pH 8.5	Olsen *et al*. (1954)
4	Available potassium	Flame photometric method	Stanford and English (1949)
II. Plant Analysis			
1	Total nitrogen	Kjeldahl's method	Bremner (1965)
2	Total phosphorous	Vanadomolybdate yellow colour method using diacid Extract	Jackson (1973)
3	Total potassium	Flame photometric method using the neutralised diacid extract	Jackson (1973)

3. RESULTS AND DISCUSSION

3.1 Effect of organics and bioenhancers on quality parameters in aggregatum onion

3.1.1 Quality parameters

In view the increased awareness of the consumers on quality aspects of vegetables, the present study with different fertilizer treatments and bioenhancers revealed the existence of significant influence of various fertilisers treatments, bioenhancers used and their interaction effect of the factors studied for total soluble solids and ascorbic acid content. The highest value for TSS (12.64 ºBrix, which differed significantly from rest of the treatments) and ascorbic acid content (15.81 mg 100 g^{-1} of bulbs) was recorded for F_3 B_2 (Table 3). This treatment involving the application of inorganic fertilizer with 25 per cent reduction in N fertilizer duly compensated with the application of poultry manure has recorded the highest total soluble solids as well as ascorbic acid content in bulbs of onion and this was found to be in conformity with the earlier findings of Kumar *et al.* (2018) and Akhil and Singh (2022) for total soluble solids and Kumar *et al.* (2018) and Vishwaraj *et al.* (2022) for ascorbic acid content. The increase in total soluble solids with the combined application of fertilisers and poultry manure is attributed to the effective translocation of sucrose from the photosynthesizing tissue to the storage tissue as reported by Kumar *et al.* (2018), besides the enhanced metabolic activities under integrated nutrient application as recorded by Dilpreet *et al.* (2016). The increase in ascorbic acid content is attributed to the better nutrient availability, improved plant metabolic function and enhanced enzyme activity as reported by Vishwaraj *et al*. (2022). The improved quality parameters *viz.,* total soluble solids and ascorbic acid observed with soil application of the bioenhancer jeevamirtham is likely to be the result of quick build up of soil fertility, resulting in increased availability and uptake of nutrients, improved beneficial biota in the rhizosphere and growth promoting substances arising out of soil application of jeevamirtham, as suggested by Chakraborty and Sarkar (2019) and Reddy and Menon (2021).

Table 3. Effect of nutrients on total soluble solids (ºBrix) and ascorbic acid content (mg 100 g^{-1}) in aggregatum onion cv. Perambalur Local

Treatment	Total soluble solids (ºBrix)		Ascorbic acid content (mg 100 g^{-1})	
T_1 - F_0B_0	8.85		9.26	
T_2 - F_0B_1	9.83		10.13	
T_3 - F_0B_2	10.29		10.37	
T_4 - F_1B_0	11.22		12.84	
T_5 - F_1B_1	11.44		13.58	
T_6 - F_1B_2	11.65		13.83	
T_7 - F_2B_0	11.37		13.21	
T_8 - F_2B_1	11.88		14.69	
T_9 - F_2B_2	11.80		15.06	
T_{10} - F_3B_0	11.20		13.34	
T_{11} - F_3B_1	11.78		15.56	
T_{12} - F_3B_2	12.64		15.81	
T_{13} - F_4B_0	10.38		10.87	
T_{14} - F_4B_1	10.86		11.98	
T_{15} - F_4B_2	10.65		12.10	
T_{16} - F_5B_0	10.65		11.61	
T_{17} - F_5B_1	11.21		12.47	
T_{18} - F_5B_2	11.06		12.72	
Factor	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**
Fertilisers	0.15	0.31	0.06	0.12
Bioenhancers	0.11	0.22	0.04	0.09
Fertilisers x Bioenhancers	0.26	0.54	0.10	0.22

3.2 Effect of organics and bioenhancers on post harvest soil properties of aggregatum onion

The differences observed for post harvest soil pH was found significant only for bioenhancers studied whereas, post harvest soil EC assessed was found to show significant variation only among fertilizer treatments (Table 4). The marginal reduction in soil pH (F_1B_0 - 7.28) over the initial soil pH observed with soil application of jeevamirtham might be the result of cow's urine used as an important ingredient. Acidic nature of freshly prepared jeevamirtham has been recorded earlier by Kaur (2020). However, this is found to be in controversy to the report of Chakraborty and Sarkar (2019). The treatment receiving 50 per cent

N through poultry manure was found to record higher (F_5B_2 - 0.453 dSm^{-1}) EC over the initial value and this might be the effect of soluble salts present in poultry manure and such a finding has been reported already by Singh *et al.* (1992). Significant differences among fertilizer treatments and bioenhancers tried could be observed for organic carbon content with maximum values observed in F_4B_2 (0.43 per cent) and it was found to be on par with F_4B_1 (0.43 per cent).This is in accordance with earlier findings of Rani and Jha (2018) and Brar *et al.* (2019), who proposed that the addition of organic matter either as solid manure or liquid manure could be responsible for a slight increase in soil organic carbon content over the initial value. Significant variation with regard to the post harvest soil N, P and K status could be observed among the fertilizer treatments, bioenhancers studied as well as their interaction in (Table 4). The post harvest available N, P and K was found to be the highest in the treatment RDFYM + 50 % N + RDP + RDK + 50 % N through Poultry manure and jeevamirtham 500 L ha^{-1} as soil drench thrice with irrigation *viz.,* at planting, 20 and 45 DAP (F_5 B_2 - 179.60 kg ha^{-1} of N, 12.66 kg ha^{-1} of P and 171.90 kg ha^{-1} of K). The available nutrient content was found to be higher over the initial soil value in all the treated plots except control. The highest values with regard to all the three major nutrients were observed in plots with higher replacement of inorganic 'N' through organic 'N'. This is found to be in agreement with the findings of Meena *et al.* (2019) and could be the result of slow and sustained decomposition of organic matter in releasing nutrients to the soil solution. The conjunctive use of organic manure with in organic fertiliser could have led to the build up of active pool of NPK as suggested by Ramesh *et al.* (2017) and enhanced beneficial microbial population from the liquid manure as proposed by Brar *et al.* (2019).

Table 4. Effect of organics and bioenhancers on post harvest soil properties in aggregatum onion cv. Perambalur Local

Treatment	pH		EC (dSm^{-1})		Organic carbon (per cent)		Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
T_1 - F_0B_0	7.24		0.306		0.37		129.80		8.94		123.77	
T_2 - F_0B_1	7.22		0.310		0.41		134.20		9.16		127.78	
T_3 - F_0B_2	7.10		0.323		0.39		136.50		9.23		128.49	
T_4 - F_1B_0	7.28		0.324		0.37		150.45		10.30		144.00	
T_5 - F_1B_1	7.22		0.328		0.40		154.45		10.39		147.25	
T_6 - F_1B_2	7.05		0.339		0.40		158.30		11.02		151.73	
T_7 - F_2B_0	7.15		0.349		0.39		160.30		11.38		154.86	
T_8 - F_2B_1	7.13		0.358		0.42		164.31		11.40		159.65	
T_9 - F_2B_2	7.11		0.367		0.42		165.20		11.42		160.09	
T_{10} - F_3B_0	7.19		0.360		0.37		165.45		11.50		159.67	
T_{11} - F_3B_1	7.15		0.364		0.41		169.85		11.61		162.29	
T_{12} - F_3B_2	6.93		0.380		0.41		171.10		11.72		163.71	
T_{13} - F_4B_0	7.16		0.427		0.40		169.21		11.79		162.27	
T_{14} - F_4B_1	7.15		0.439		0.43		173.00		12.01		166.05	
T_{15} - F_4B_2	6.86		0.445		0.43		175.20		12.08		165.06	
T_{16} - F_5B_0	7.08		0.434		0.37		171.01		11.34		167.20	
T_{17} - F_5B_1	7.09		0.442		0.42		175.89		12.10		170.20	
T_{18} - F_5B_2	6.93		0.453		0.41		179.60		12.66		171.58	
Factor	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**
Fertilisers	0.09	NS	0.01	0.02	0.01	0.02	0.09	0.19	0.09	0.19	0.09	0.19
Bioenhancers	0.06	0.13	0.01	NS	0.01	0.01	0.06	0.13	0.06	0.13	0.06	0.13
Fertilisers x Bioenhancers	0.15	NS	0.02	NS	0.02	NS	0.15	0.33	0.15	0.33	0.15	0.33

3 3.3. Effect of organics and bioenhancers on nutrient uptake by onion bulbs

3.3.1 Nitrogen, phosphorus and potassium uptake by bulbs (kg ha^{-1})

The study of nutrient uptake by onion bulbs revealed significant differences among the fertiliser treatments, bioenhancers used as well as their interaction for 'N' uptake by bulbs, while the interaction effect was found insignificant for 'P' uptake of bulbs. The differences observed with regard to 'K' uptake of onion was significant only for the various fertilizer treatments used whereas, the bioenhancers used as well the interaction effect on bulbs did not show any significant variation in (Table 5). The study of nutrient uptake by bulbs which is dependent on the concentration of nutrients becomes important as it is considered to be a function of nutrient availability in soil solution. While, all the fertilizer plots were superior to control for this trait, the maximum uptake of 15.27 kg ha^{-1}, 3.38 kg ha^{-1} and 15.27 kg ha^{-1} of N, P and K respectively by onion bulbs was also observed with RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure along with application of jeevamirtham 500 L ha^{-1} as soil drench thrice with irrigation *viz*., at planting, 20 and 45 DAP (F_3B_2). The increased nutrient uptake under poultry manure treated plots has already been reported by Mahala *et al.* (2018). Significant influence of bioenhancers on nutrient uptake of onion bulbs was observed only for 'N' and 'P' in the present study. This influence of enhanced nutrient uptake by onion bulbs with the use of solid and liquid manures might be the result of breakdown of complex nitrogenous compounds to nitrate nitrogen by the action of microorganisms present in it. Increase in P could be due to greater solubilization of native P from the soil due to action of various organic acids liberated on decomposition of organics. Increased K uptake could be ascribed to the improved soil properties due to the action of organics, leading to better penetration of roots, thereby resulting in greater uptake of K as reported earlier by Ramesh *et al.* (2017). Further, the enhanced uptake of P and K by onion bulbs might also be the result of increased availability of these to nutrients as they are also available from the added poultry manure over and above the recommended dose P and K.

Table 5. Effect of organics and bioenhancers on nutrient uptake by bulbs (kg ha^{-1}) in aggregatum onion cv. Perambalur Local

Treatment	'N' uptake (kg ha^{-1})		'P' uptake (kg ha^{-1})		'K' uptake (kg ha^{-1})	
T_1 - F_0B_0	4.54		0.91		4.52	
T_2 - F_0B_1	4.58		0.97		4.58	
T_3 - F_0B_2	4.64		1.03		4.67	
T_4 - F_1B_0	10.96		2.32		11.25	
T_5 - F_1B_1	11.08		2.44		11.31	
T_6 - F_1B_2	11.19		2.56		11.37	
T_7 - F_2B_0	12.01		2.58		12.26	
T_8 - F_2B_1	12.14		2.65		12.32	
T_9 - F_2B_2	12.29		2.72		12.41	
T_{10} - F_3B_0	14.97		3.23		14.96	
T_{11} - F_3B_1	15.14		3.31		15.41	
T_{12} - F_3B_2	15.27		3.38		15.27	
T_{13} - F_4B_0	7.69		1.56		7.78	
T_{14} - F_4B_1	7.76		1.65		7.83	
T_{15} - F_4B_2	7.77		1.73		7.86	
T_{16} - F_5B_0	8.69		1.85		8.88	
T_{17} - F_5B_1	8.60		1.90		8.94	
T_{18} - F_5B_2	8.92		1.95		9.01	
Factor	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**
Fertilisers	0.02	0.03	0.02	0.03	0.18	0.37
Bioenhancers	0.01	0.02	0.01	0.02	0.13	NS
Fertilisers x Bioenhancers	0.03	0.06	0.03	NS	0.31	NS

5. CONCLUSION

The study emphasizes the significance of optimizing soil fertility and nutrient management techniques, particularly through the judicious use of organic amendments such as poultry manure and bioenhancers like jeevamirtham, to enhance the quality attributes and nutrient uptake efficiency of aggregatum onion crops. Such integrated approaches hold promise for improving agricultural sustainability and crop productivity in onion cultivation systems.

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