Journal of Experimental Agriculture International

Volume 46, Issue 6, Page 610-619, 2024; Article no.JEAI.117149
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Field Experiment on Integrated Nutrient Management in Aggregatum Onion (*Allium cepa* var. *aggregatum*)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jeai/2024/v46i62516

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/117149

Original Research Article

Received: 10/03/2024
Accepted: 14/05/2024
Published: 16/05/2024

ABSTRACT

A field experiment was conducted at the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T. of Puducherry during the summer season of 2023 to investigate the integrated effects of organics and bioenhancers on the growth, bulb yield and quality of aggregatum onion (*Allium cepa* var. *aggregatum*) cv 'Perambalur Local'. The experiment utilized a Randomized Block Design (RBD) with two replications, incorporating two factors *viz.,* fertilizers level (F_1 with 6 levels) and bioenhancers (F_2 with 3 levels), resulting in eighteen treatments in a factorial manner. The study materials included vermicompost, poultry manure, panchagavya and jeevamirtham, in addition to recommended Farm Yard Manure (FYM) and N, P, K fertilizers. Noteworthy observations were made in the treatment receiving Recommended Dose of FYM (RDFYM) + 75% N + Recommended Dose of P (RDP) +

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Cite as: *Selvaprabu, P., & Sundaram, V. (2024). Field Experiment on Integrated Nutrient Management in Aggregatum Onion (Allium cepa var. aggregatum). Journal of Experimental Agriculture International, 46(6), 610–619. https://doi.org/10.9734/jeai/2024/v46i62516*

Recommended Dose of K (RDK) + 25% N through Poultry manure, coupled with the application of jeevamirtham at 500 L ha^{-1} as a soil drench thrice, coinciding with irrigation at planting, 20 and 45 days after planting (DAP). This treatment exhibited significant enhancements in various parameters including maximum plant height at 30 DAP (31.40 cm), leaf girth at 30 DAP (1.94 cm), number of leaves $plant^{-1}$ at 30 DAP (25.80), fresh weight of top (12.26 g), polar (3.17 cm) and equatorial diameter of bulblet (2.94 cm), bulblet weight (9.30 g), number of bulblets $plant^{-1}$ (10.00), maximum bulb yield (43.18 g $plant^{-1}$ and 6.91 t ha^{-1}) and dry matter production of bulbs (788.51 kg ha^{-1}). These findings underscore the efficacy of integrating organic inputs and bioenhancers in optimizing the growth, yield and quality of aggregatum onion.

Keywords: Aggregatum onion; organic farming; bioenhancers; panchagavya; jeevamirtham.

1. INTRODUCTION

Vegetables are considered essential for providing a balanced diet as they constitute phytonutrients, besides nutraceutical compounds. Being rich sources of carbohydrates, proteins, vitamins and minerals, vegetables are regarded as protective foods [1]. Globally, India ranks second in vegetable production next to China, producing 209.14 m MT of vegetables annually, from an area of 11.37 m ha [2]. Aggregatum onion (*Allium cepa* var. *aggregatum*), also known as small onion or country onion or multiplier onion is one of the most important commercial bulbous vegetables of the family Alliaceae, widely cultivated in Maharastra, Madhya Pradesh, Karnataka and Tamil Nadu. Globally, India ranks second in onion production with 31.68 m MT of onion being produced from an estimated area of 1.94 m ha [2]. Onion is considered to be the second most important vegetable crop grown in the world after tomato with multiple uses such as vegetable and condiment, hence become an indispensable part of Indian kitchen [3]. However, the productivity of onion in India is very low (18.64 t ha^{-1}) compared to the world's average productivity of 23.06 t ha^{-1} and imbalance in use of chemical fertilizers is considered one of the prime cause of reduced productivity and a possible alternative is to use organics as substitutes. Organic farming is a holistic approach capable of improving soil fertility and productivity in a sustained way. Further, organic produces fetch better price in the national and international market due to consumer preference, as organic manures not only sustain the productivity but also improves the quality of the produce, besides reducing the cost of cultivation [4,5], thereby enhancing the net profit. Organic substances along with poultry manure, vermicompost and farm yard manure can complement inorganic fertilizers to maintain productivity and natural quality [6]. The present study was hence contemplated to determine the effect of organic sources of nutrients and bioenhancers on growth, yield and quality of aggregatum onion cv. Perambalur Local.

2. MATERIALS AND METHODS

A field experiment entitled "Field experiment on nutrient management in 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 summer season 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. Panchagavya, an ancient vedic formulation is a blend of five products namely the dung, urine, milk, curd and ghee obtained from indigenous cow. It plays an important role in the overall growth and development of crop plants and increase of yield and profits. It is also eco- friendly [7]. Jeevamrutham is an organic fertilizer capable of enhancing microbial activity in soil and helps in improvement of soil fertility [8]. In the present experiment, panchagavya was applied as foliar spray at 3 per cent concentration on 15, 30 and 45 days after planting, while freshly prepared jeevamirtham was applied in the soil at planting, 20 and 40 days after planting along with irrigation water.The experiment was laid out in a Randomized Block Design with two replications with 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.

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

2.1 Level of Factors

2.1.1 Factor 1 – Fertilisers – 6 (F_0 to F_5)

F_0 - Absolute control
F_1 - RDF (Recommended Dose of Fertilisers)
F_2 - RDFYM + 75 % N + RDP + RDK + 25 % N through Vermicompost
F_3 - RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure
F_4 - RDFYM + 50 % N + RDP + RDK + 50 % N through Vermicompost
F_5 - RDFYM + 50 % N + RDP + RDK + 50 % N through Poultry manure

2.1.2 Factor 2 – Bioenhancers – 3 (B_0 to B_2)

B_0 - Absolute control
B_1 - 3 per cent Panchagavya foliar lspray on 15, 30 and 45th DAP
B_2 - Jeevamirtham 500 L ha^{-1} as soil application, thrice with irrigation *viz*., at planting, 20 and 45 DAP

3. RESULTS AND DISCUSSION

3.1 Effect of organics and Bioenhancers on growth and yield of aggregatum onion

3.1.1 Plant height at 30 DAP (cm)

The effect of fertiliser and bioenhancers observed on plant height of onion at 30 DAP were found to be significantly influenced while, the interaction effect was found insignificant. The application of RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure and Jeevamirtham 500 L ha^{-1} as soil application, thrice with irrigation *viz*., at planting, 20 and 45

DAP (F_3 B_2) has recorded the highest plant height (31.40 cm) in the experiment (Table 2). The treatment F_3 B_1 (30.30 cm) was the next best and was followed closely by F_2 B_2 (29.06 cm). The lowest value was observed in control F_0 B_0 (21.00 cm). The combined application of fertiliser with poultry manure, would have helped in sustained supply of macro and micro nutrients ensuring adequate and progressive release of nitrogen to plant as reported earlier by Datt and Kaur [9] and Marbong and Swaroop [10] in bellary onion. Nitrogen being the main constituent of protoplasm, cell nucleus, amino acid, protein, chlorophyll and many other plant metabolic products, is likely to play a vital role in photosynthesis. Among the bioenhancers used, the soil application of jeevamirtham was found superior to register significant performance with regard to plant height over foliar spraying of 3 per cent panchagavya on 15, 30 and 45 DAP and control and this finding was in conformity to the earlier report of Datt and Kaur [9]. This increase in plant height could be the result of better and continuous availability of plant nutrients, as jeevamirtham is considered to be a rich carrier of beneficial microbes and substances that are capable of promoting metabolic activities related to plant growth and solubility of native nutrients [11].

3.1.2 Leaf girth at 30 DAP (cm)

The differences observed for the leaf girth of onion at 30 DAP were found to be significantly influenced by fertiliser treatments, bioenhancers and their interaction. The leaf girth (1.94 cm) which was significantly superior to rest of the treatments. The treatment F_3 B_1 (1.78 cm) was the second best value, followed by F_2 B_2 (1.70 cm) and F_2 B_1 (1.68 cm). The lowest value was observed in control F_0 B_0 (1.18 cm) for leaf girth at 30 DAP (Table 2) in F_3 B_2 (RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure and jeevamirtham 500 L ha^{-1} as soil application thrice with irrigation *viz*., at planting, 20 and 45 DAP) at all stages of observation and this could be attributed to the better availability and supply of nitrogen in the presence of both poultry manure and jeevamirtham as reported by Chanu et al. [12] in onion. Further, jeevamirtham is also a rich source of carbon, nitrogen, phosphorus, potash and many micronutrients, thus capable of enriching the soil with beneficial microorganisms required for mineralisation, leading to better

Table 2. Effect of organics and bioenhancers on growth of aggregatum onion

Treatment	Plant height at 30 DAP (cm)		Leaf girth at 30 DAP (cm)		Number of leaves plant^{-1} at 30 DAP		Fresh weight of top at harvest (g)	
T_1 - F_0B_0	21.00		1.18		10.94		1.50	
T_2 - F_0B_1	21.20		1.20		13.00		2.10	
T_3 - F_0B_2	23.20		1.30		13.80		3.28	
T_4 - F_1B_0	27.70		1.50		17.30		4.92	
T_5 - F_1B_1	28.30		1.54		19.10		5.34	
T_6 - F_1B_2	28.40		1.62		19.70		6.06	
T_7 - F_2B_0	28.20		1.52		18.20		5.22	
T_8 - F_2B_1	28.56		1.68		21.70		7.26	
T_9 - F_2B_2	29.06		1.70		23.30		8.02	
T_{10} - F_3B_0	28.20		1.54		19.00		5.32	
T_{11} - F_3B_1	30.30		1.78		23.50		9.94	
T_{12} - F_3B_2	31.40		1.94		25.80		12.26	
T_{13} - F_4B_0	23.68		1.44		14.40		2.22	
T_{14} - F_4B_1	25.00		1.46		15.40		3.02	
T_{15} - F_4B_2	25.10		1.46		16.30		3.18	
T_{16} - F_5B_0	24.86		1.44		15.20		2.50	
T_{17} - F_5B_1	26.40		1.48		16.60		4.22	
T_{18} - F_5B_2	26.52		1.48		17.00		4.70	
Factor	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**
Fertilisers	0.33	0.70	0.02	0.04	0.73	1.53	0.11	0.23
Bioenhancers	0.23	0.49	0.01	0.03	0.51	1.08	0.08	0.16
Fertilisers x Bioenhancers	0.57	NS	0.04	0.07	1.26	NS	0.19	0.39

metabolic functions and growth. This, could be the probable reason for better leaf girth and such a finding has already been reported by Kumar et al. [13] and Gore and Sreenivasa [14] in tomato.

3.1.3 Number of leaves plant^{-1} at 30 DAP

The differences observed for number of leaves plant^{-1} of onion at 30 DAP were found to be significantly influenced by fertiliser treatments and bioenhancers while their interaction effect was found insignificant. The application of RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure and jeevamirtham 500 L ha^{-1} as soil application thrice with irrigation water *viz*., at planting, 20 and 45 DAP (F_3 B_2) was found to give the best result in terms of number of leaves plant^{-1} (25.80) as evidenced from Table 2 and the treatment F_3 B_1 (23.50) was the next best, while F_2 B_2 measured 23.30. The lowest value for number of leaves plant^{-1} was recorded in control (F_0 B_0 - 10.94) such an impact of poultry manure in onion had already been established by Adeyeye et al. [15] and Dapaah et al. [16], while Prajapati and Vekariya [17] reported significant influence of jeevamirtham on number of leaves in irrigated onion. The enhanced leaf production under combined application of fertilisers with organic manure and bioenhancers is attributable to the improved availability of essential nutrients, particularly nitrogen helping in better synthesis of various protein components required for leaf development, photosynthesis and metabolic processes of plant growth as suggested by Dapaah et al. [16] in bellary onion. The enhanced supply of macro and micro nutrients could have also contributed for better assimilate synthesis and subsequent translocation to sink as suggested by Prajapati and Vekariya [17].

3.1.4 Fresh weight of top at harvest (g)

The fresh weight of top (leaves) estimated at harvest was found to show significant variation among the fertilisers treatments, bioenhancers studied and their interaction in comparison to control. The treatment which received 25 per cent nitrogen through poultry manure with rest of recommended nitrogen, phosphorus and potash as inorganic fertilizers in combination with soil application of jeevamirtham thrice at 500 L ha^{-1} while planting, 30 and 45 DAP was found to be the best (12.26 g) in terms of fresh weight of top. The treatment F_3 B_1 (9.94 g) recorded the next higher value and was followed by F_2 B_2 (8.02 g) and F_2 B_1 (7.26 g). Regarding fresh weight of top, control (F_0 B_0 - 1.50 g) had the lowest value (Table 2) and such a positive role of integrated application of organic with inorganic sources of nutrients on leaf fresh weight has been observed by Adeyeye et al. [15] and Singh et al. [18]. The release of N, P and K from poultry manure being reasonably fair when compared to vermicompost, could have contributed for production of more number of leaves, resulting in increased fresh weight of top as suggested earlier by Adeyeye et al. [15]. Further, they also suggested that the application of jeevamirtham promoting the beneficial microorganism in the rhizosphere, could have increased phosphorus availability leading to better top growth.

3.1.5 Bulb diameter (cm)

Significant differences in polar as well as equatorial diameter of onion bulbs were observed in the present study among fertiliser treatments, bioenhancers used as well as for their interaction effect. The highest polar as well as the equatorial diameter of bulblet as evident from Table 3 was observed in treatment F_3 B_2 (3.17 cm and 2.94 cm). The second best value was recorded in F_3 B_1 (3.11 cm and 2.89 cm). The lowest value for polar as well as the equatorial diameter of bulblet was recorded in control (F_0 B_0 - 2.02 cm and 1.16 cm) with integrated application of fertilizer and poultry manure as already reported in onion by Anand et al. [19]. This might be due to the ability of the beneficial biota in poultry manure in improving the nutrient availability besides enhancing the essential nutrient content in the soil [20]. Moreover, poultry litter is also considered to be a good source of primary, secondary and micro nutrients, which might have resulted in higher nutrient availability coupled with better uptake of nutrients leading to improved bulb growth as supported by Amanullah et al. [21]. Of the bioenhancers tried, the use of jeevamirtham has outperformed the foliar application of panchagavya and such a positive influence of jeevamirtham on bulb diameter has been reported earlier by Datt and Kaur [9]. This is attributable to the improved translocation of nutrients, water and establishment of favourable conditions for bulb development. Earlier studies by Chakraborty and Sarkar [22] revealed the presence of macro and micro nutrients, beneficial microbes, growth promoting substances *viz.,* IAA, GA, cytokinin and ascorbic acid in jeevamirtham and all of which could have contributed for the improvement of bulb diameter in onion when applied along with fertilizers.

Table 3. Effect of organics and bioenhancers on yield parameters of aggregatum onion

Treatment	Polar diameter of bulblet (cm)		Equatorial diameter of bulblet (cm)		Bulblet weight (g)		Number of bulblets plant^{-1}		Bulb yield plant^{-1} (g)		Bulb yield (t ha^{-1})		Dry matter production of bulbs (kg ha^{-1})	
T_1 - F_0B_0	2.02		1.16		3.48		5.00		19.32		1.69		253.73	
T_2 - F_0B_1	2.12		1.50		3.72		5.20		19.43		2.88		254.50	
T_3 - F_0B_2	2.13		1.63		3.84		5.80		21.85		3.13		256.50	
T_4 - F_1B_0	2.54		2.06		6.02		6.60		31.28		4.70		595.01	
T_5 - F_1B_1	2.63		2.25		6.22		7.00		35.07		4.87		595.02	
T_6 - F_1B_2	2.65		2.34		6.28		7.20		39.27		5.17		595.03	
T_7 - F_2B_0	2.56		2.08		6.08		6.80		33.23		4.35		645.20	
T_8 - F_2B_1	2.67		2.56		6.50		7.20		39.62		5.56		645.25	
T_9 - F_2B_2	2.81		2.55		7.04		7.60		40.36		5.66		646.50	
T_{10} - F_3B_0	2.57		2.17		6.10		7.00		33.65		4.90		787.00	
T_{11} - F_3B_1	3.11		2.89		7.36		8.80		41.10		5.79		788.50	
T_{12} - F_3B_2	3.17		2.94		9.30		10.00		43.18		6.91		788.51	
T_{13} - F_4B_0	2.20		1.79		3.92		6.20		22.53		3.76		422.51	
T_{14} - F_4B_1	2.34		1.90		4.22		6.40		26.26		4.08		422.66	
T_{15} - F_4B_2	2.37		1.98		4.44		6.40		27.02		4.12		423.50	
T_{16} - F_5B_0	2.22		1.79		4.14		6.20		25.87		3.94		474.75	
T_{17} - F_5B_1	2.40		1.98		4.56		6.40		28.52		4.17		475.71	
T_{18} - F_5B_2	2.50		2.04		5.94		6.40		29.58		4.18		476.75	
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)**	**SEd**	**CD (p=0.05)**
Fertilisers	0.03	0.07	0.03	0.06	0.08	0.17	0.09	0.20	0.32	0.68	0.06	0.13	0.17	0.35
Bioenhancers	0.02	0.05	0.02	0.04	0.06	0.12	0.07	0.14	0.23	0.48	0.04	0.09	0.12	0.25
Fertilisers x Bioenhancers	0.05	0.12	0.05	0.10	0.14	0.30	0.16	0.35	0.56	1.17	0.11	0.22	0.29	0.61

3.1.6 Bulblet weight (g)

Bulb weight is one of the primary yield determinants in onion and it was found to vary significantly with fertiliser treatments given, bioenhancers used and their interaction in the present study. It was observed again that, the application of RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure and Jeevamirtham 500 L ha^{-1} as soil drench, thrice with irrigation *viz*., at planting, 20 and 45 DAP (F_3 B_2) had shown maximum bulblet weight of 9.30 g. The treatment F_3 B_1 (7.36 g) was the next best and was followed closely by F_2 B_2 (7.04 g). The lowest value was observed in control F_0 B_0 (3.48 g) (Table 3). The present findings on the role of poultry manure in improving onion bulblet weight is found to corroborate with the earlier result of Akhil and Singh [23] and Mahala et al*.* [24]. Among the bioenhancers, the use of jeevamirtham has recorded improved bulblet weight and was found to be in conformity to the earlier findings of Datt and Kaur [9]. weight and is found to be in conformity to earlier findings by Datt and Kaur [9]. Jeevamirtham application as soil drench would have enhanced the solubility and availability of plant nutrients, besides being a rich carrier of beneficial microbes and plant growth promoting substance. This characteristics of jeevamirtham is capable of improving the plant metabolic activities and offer biotic resistance in plants resulting in better vigour and translocation of nutrients to the sink as suggested by Gopal and Gurusiddappa, [11].

3.1.7 Number of bulblets $plant^{-1}$

The study revealed the presence of significant differences among the various fertiliser and bioenhancers used as well as their interaction on number of bulblets $plant^{-1}$ in aggregatum onion. The application of inorganic and organic sources of nutrient in appropriate proportion in the treatment receiving RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure and Jeevamirtham 500 L ha^{-1} as soil application, thrice with irrigation *viz*., at planting, 20 DAP and 45 DAP (F_3 B_2) has lead to the production of more number of bulblets $plant^{-1}$ (10.00) which was significantly superior to rest of the treatments. The treatment F_3 B_1 (8.80) was the second best value, followed by F_2 B_2 (7.60). The lowest value for number of bulblets $plant^{-1}$ was observed in control (Table 3), the improved availability of nutrients from the inorganic fertilisers under the influence of poultry manure besides improvement in physicochemical as well as biological properties of the soil and such a report had been published earlier by Sitaula et al*.* [25]. Among the bioenhancers used jeevamirtham 500 L ha^{-1} as soil application thrice with irrigation *viz*., at planting, 20 and 45 DAP was found superior in producing maximum number of bulblets $plant^{-1}$ and the ability of jeevamirtham in improving the availability of nitrogen, phosphorous, potassium and beneficial microbes in the rhizosphere as reported by Manoj et.al*.* [26] could be attributed for this.

3.1.8 Bulb yield $plant^{-1}$ (g)

The existence of significant differences for bulb yield among the fertiliser treatments, bioenhancers used and their interaction was noticed in the present study. The maximum bulb yield of 43.18 g $plant^{-1}$ and 6.91 t ha^{-1} (Table 3) was observed in treatment receiving RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure and Jeevamirtham 500 L ha^{-1} as soil application, thrice with irrigation *viz*., at planting, 20 and 45 DAP (F_3 B_2). The treatment F_3 B_1 (41.10 g $plant^{-1}$ and 5.79 t ha^{-1}) was the second best value and was found to be on par with F_2 B_2 (40.36 g $plant^{-1}$ and 5.66 t ha^{-1}). The lowest value for this trait was observed in control F_0 B_0 (19.32 g $plant^{-1}$ and 1.69 t ha^{-1}). The presence of poultry manure in treatment F_3 (RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure) acts as good soil amendment by adding nutrients as well as beneficial microorganisms [20]. The application of inorganic fertilizers with the combination of poultry manure is also reported to increase the uptake of both macro and micro nutrients resulting in better growth and yield of crop as suggested by Amanullah et al*.* [21]. Among the two bioenhancer tried, jeevamirtham was found to be superior in terms of bulb yield and this could be the result of improved population of beneficial microbes including bacteria, yeast, fungi, actinomycetes and photosynthetic bacteria, besides enhanced soil enzyme activity contributing to such an yield increase of onion bulbs as suggested by Nitin and Purohit [27] and Pathak and Shukla [28]. Application of jeevamirtham could have also helped in rapid build up of soil fertility resulting in better growth and yield as proposed by Kaur et al*.* [29]. The study of interaction effect of present study revealed the treatment F_3 B_2 (RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure and jeevamirtham 500 L ha^{-1} as soil application thrice with irrigation *viz.,* at planting, 20 and 45 DAP) to be superior which is

attributable to the presence of poultry manure and jeevamirthum along with fertilisers.

3.1.9 Dry matter production (kg ha^{-1}) of bulbs

The yield of onion is greatly influenced by the number and size of leaf as well as bulbs. Increase in dry matter content of onion bulb is the result of improved growth and physiological function, which gets reflected in fresh yield of onion bulbs. Considering the above fact, the dry matter production of onion bulb under various treatments were assessed in the present study and significant influence of different fertilizers treatments, bioenhancers used and their interaction were noted. The treatment F_3 B_2 had the highest dry matter production of onion bulb (788.51 kg ha^{-1}). The treatment F_2 B_2 (787.50 kg ha^{-1}) was the next best and was found to be on par with F_3 B_0 (787.00 kg ha^{-1}). The lowest dry matter production of onion bulb was recorded in control F_0 B_0 (253.73 kg ha^{-1}). The maximum dry matter production of onion bulb (788.51 kg ha^{-1}) observed with the application of inorganic and organic sources of nutrients in right proportion in the treatment receiving RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure and Jeevamirtham 500 L ha^{-1} as soil application, thrice with irrigation *viz*., at planting, 20 and 45 DAP (F_3 B_2) is attribuable to the increased number of leaves, enhanced photosynthesis and better translocation and storage of assimilates in the bulbs, as well as better soil physiochemical and biological properties as reported earlier by Dapaah et al*.* [16]. The use of jeevamirtham as bioenhancers through soil application was also found to perform better over the application of panchagavya, which was found to be in line with the report of Nitin and Purohit [27]. The increase in dry weight of bulb in response to the addition of poultry manure is attributed to the increased number of leaves, enhanced photosynthesis and better translocation and storage of assimilate to the bulbs, leading to better soil physiochemical and biological properties as reported earlier by Dapaah et al*.* [16] and Meena et al*.* [30]. The application of jeevamirtham is reported to increase the availability of nutrient for early growth, besides containing beneficial microbes and growth promoting substances, thus resulting in efficient metabolic activities and biotic stress tolerance. Such contribution from jeevamirtham is also found to be responsible for better dry weight accumulation of bulb as suggested by Kaur et al*.* [29] and Nitin and Purohit [27]. The interaction effect was also found to contribute beneficially on soil amendment.

4. CONCLUSION AND RECOMMENDATIONS

The results of the experiment clearly revealed the significance of applying RDFYM + 75 % N + RDP + RDK + 25 % N through Poultry manure and jeevamirtham 500 L ha^{-1} as soil application, thrice with irrigation *viz.,* at planting, 20 and 45 DAP in terms of growth and yield parameters in aggregatum onion. In short-duration aggregatum onion cultivation, adopting a combination of solid (poultry manure) and liquid (jeevamirtham) can significantly enhance yield and reduce the cost of cultivation. The combined application of poultry manure and jeevamirtham enriches the soil with beneficial microorganisms, enhancing nutrient cycling and improving soil structure. Poultry manure supplies essential nutrients, while jeevamirtham complements the nutrient supply. As a result, onion plants efficiently take up nutrients and assimilates produced during photosynthesis are effectively transported to the bulbs. Additionally, this practice enhances onion plant resilience to stressors such as drought, pests and diseases. Farmers cultivating short-duration aggregatum onion varieties can benefit from this sustainable approach.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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