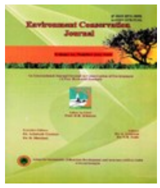
Journal homepage:https://www.environcj.in/

Environment Conservation Journal

ISSN 0972-3099 (Print) 2278-5124 (Online)



Studies on the influence of biofertilizers in combination with inorganic nutrients on growth, yield and quality attributes of onion (*Allium cepa* L.)

Bandi Sai Phanendra ✉

Department of Horticulture, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, R.Sitapur, Odisha

Eggadi Ramesh

Department of Horticulture, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, R.Sitapur, Odisha

Sunna Deepti

Department of Horticulture, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, R.Sitapur, Odisha

Arunabha Pal

Department of Soil Science, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, R.Sitapur, Odisha

ARTICLE INFO

Received : 22 July 2024
Revised : 10 September 2024
Accepted : 18 September 2024

Available online: 03 November 2024

Key Words:
Biofertilizers
Bacillus
Growth
Onion
Pseudomonas
Yield

ABSTRACT

With an increasing population and the food security is at risk, there is decreased crop productivity as soil fertility status is declining. As, the present experiment was conducted in view of understanding the better nutrient acquisition of plants in the presence of biofertilizers on the growth, yield and quality parameters of onion under randomized block design with three replications and ten treatments in order to optimize nutrient uptake for improved agricultural productivity and sustainability, providing valuable insights for more efficient farming practices. The results revealed that the growth parameters such as maximum plant height (72.68cm) and leaf length (63.07 cm) were recorded with the treatment T_2 (100% RDF); number of leaves (10.13) was recorded with treatment T_6 (100% RDF + *Bacillus*); leaf width (17 mm) and neck length (9.78 cm) were recorded with treatment T_5 (100% RDF + *Pseudomonas*); yield parameters such as plant fresh weight (189.33g) was recorded with treatment T_5 (100% RDF + *Pseudomonas*); bulb weight at harvest (170.46g) and yield/m^2 (3.78 kg/m^2) was recorded maximum with treatment T_6 (100% RDF + *Bacillus*). The quality parameters such as ascorbic acid (14.67 mg/100g) and dry matter % (20.32) were also recorded maximum for treatment T_6 (100% RDF + *Bacillus*). As a result, it can be concluded that the combination of 100% RDF + *Bacillus* is best as compared to other treatments as it projected highest B:C ratio (2.98) in view of onion production.

Introduction

Onion (*Allium cepa* L.) is a globally cultivated crop extensively utilized worldwide on a daily basis (Mishra *et al*., 2013). Following tomato, onion ranks as the second most cultivated crop (FAO, 2012), acclaimed for its robust flavor and distinctive aroma, and esteemed as the 'queen of the kitchen' (Selvaraj, 1976; Griffiths *et al*., 2002). It belongs to the Alliaceae family with a chromosome number of 2n = 16, and onion consists of diverse genera with over 500 species, of which merely seven are predominantly cultivated. The genus thrives in various regions across North Africa and Eurasia (Havey, 1993). Despite the absence of geographical origin of wild onion, historical records indicate its cultivation primarily in Central Asia, Afghanistan, Iran, and the southern expanse of the Soviet Union (Jones and Mann, 1963). Still, its extreme diversity was seen in North India, the Middle East, Pakistan, and the Mediterranean area (Hange and Sinhasane, 2023). Onion is a vegetable that is produced in large quantities not only in India but around the world. The total production of onions during the year 2019 was less than 100 million metric tons (MMT), and India contributed 22.8 MMT of onions during 2019, making it the second largest producer of onions in the world. In India, Maharashtra is the leading producer of onion with a share of 28.32% (Nivetha and Uma, 2020), which contributes to 26% of the area and 29% of production, of which 90% was exported. The production of onion in Odisha is 0.3 lakh hectares, which contributed to the production of 3.8 lakh metric tons with a productivity of 11.32 metric tons/ha (GoI, 2018). In the fiscal year 2020-21, APEDA reported that Indian onion exports reached 1,578,016.59 metric tons, valued at Rs. 2,826.50 crores, or 378.49 million USD (APEDA). Onions contain flavonoids and alk (en) yl cysteine sulfoxides, offering anti-inflammatory, anticarcinogenic,

Corresponding author E-mail: bsaiphanendra@gmail.com
Doi:https://doi.org/10.36953/ECJ.28412876

cardioprotective, and antioxidant benefits (Shon *et al*., 2004; Griffiths *et al*., 2002). Their unique flavor is due to allyl propyl disulfide (Havey, 1993). Versatile in use, onions serve as both a vegetable and a spice for culinary purposes, as they are considered both functional and productive foods (Singh *et al*., 2024). The global population is projected to reach 9.8 billion by 2050 (Ehrlich and Harte, 2015), while arable land decreases due to industrial growth (Macik *et al*., 2020). Excessive use of chemical fertilizers to boost yields depletes soil nutrients and harms microorganisms (Rahman, 2015), where the environmental balance is liable, as the worldwide utilization of agrochemicals cut across the acceptable level where India ranks as the fourth largest producer of agrochemicals globally (Jayakumar *et al*., 2023). This overuse also damages soil fertility (Yadav, 2019) and may not improve crop yields (Sengupta and Banerjee, 2012). Although organic manures are beneficial, they are impractical due to the high costs and large quantities needed. An eco-friendly and affordable alternative to chemical fertilizers is essential. The present study focused on potassium solubilizing bacteria because the Indian soils are showing a gradual decline in K status due to higher permeability of K+ into cell membranes and larger uptake by roots. Also, higher costs of K fertilizers and a lack of awareness among farmers favored less application, which gradually depleted the source of K in the root rhizosphere because potassium is needed more in quantity by crops during their growth period as it involves in many physiological processes like protein synthesis, osmoregulation, and activation of enzymes (Naidu *et al*., 2011), and it also plays a crucial role in enhancing the quality, flavor, nutrition, appearance, and longevity of food crops (Mikkelsen, 2018). Potassium solubilizing bacteria help in solubilizing the potassium by producing organic and inorganic acids, complexolysis, chelation, and exchange reactions (Archana *et al*., 2013; Meena *et al*., 2015). The organic acids produced by these biofertilizers help in the acidification of microbial cells, which in turn release the k+ from minerals and also help in the formation of metal-organic complexes (Kour *et al*., 2020). Potassium solubilization is carried out by a large number of species, including Bacillus, Pseudomonas, and Paenibacillus spp. Kumar *et al*. (2018). Keeping in view of the aforementioned constraints, the work on biofertilizers has been conducted, but limited research has been done on the potassium-solubilizing bacteria and their influence on growth, yield, and quality parameters in onions.

Material and methods

The present investigation was carried out at Post Graduate Research Farm Ranadevi, Department of Horticulture, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, R. Sitapur, Paralakhemundi, Odisha, during the Rabi season in the years 2023-2024. The field is located geographically at 18.77° north latitude and 84.10° east longitude, with an elevation of 58 meters above the mean sea level. The experiment consisted of 10 treatments, viz., two levels of potassium solubilizing bacteria strains at 100% recommended dose of fertilizers (RDF) (Pseudomonas and Bacillus), two levels of potassium solubilizing bacteria strains at 75% RDF (Pseudomonas and Bacillus), and two levels of potassium solubilizing bacteria strains at 50% RDF (Pseudomonas and Bacillus), viz., T1 (Control), T2 (100% RDF), T3 (75% RDF), T4 (50% RDF), T5 (100% RDF + Pseudomonas), T6 (100% RDF + Bacillus), T7 (75% RDF + Pseudomonas), T8 (75% RDF + Bacillus), T9 (50% RDF + Pseudomonas) and T10 (50% RDF + Bacillus), which was laid out in simple RBD with three replications. The seed material of the onion variety "Bhima Sakthi" was collected from Terreglebe Farmers Producer Company Limited, Khargone, Madhya Pradesh. The seedlings were raised in the nursery for transplanting. The raised beds measuring 3m×1.5m×0.15m in size were prepared, and 15kg of vermicompost was mixed in the soil of these beds one month prior to the sowing of onion seeds for nursery raising. Biofertilizers of two strains of 1 liter each were collected, and 500 ml were mixed in 50 kg of vermicompost and mixed thoroughly (Katyayani Organics). After mixing, the mixture was covered by gunny bags in a shady place, watered regularly, and left undisturbed for 7 days. The mixture was applied at the time of transplanting, where the onion seedlings were transplanted. The recommended dose of fertilizers for onions is 110: 40: 60 kg/ha (ICAR-DOGR, Rajgurunagar), and the inorganic fertilizers are calculated according to treatments and their respective areas and then applied in bands between the transplants at the time of transplanting. The fertilizer sources of urea, single superphosphate, and muriate of potash were used, respectively, for nitrogen, phosphorous, and potassium. Intercultural operations like weeding and earthing up were done at 35, 60, and 85 days after transplanting simultaneously, and irrigation was given at 8-10 day intervals till January and 5-7 day intervals from February to April depending upon the soil moisture conditions. The schedules of different pre- and post-sowing cultural operations were carried out timely during the crop season. The vegetative parameters like plant height, leaf length, leaf width and neck length were measured by using a measuring scale (EISCO), number of leaves was counted by hand, neck diameter was measured by using digital vernier calipers (SKADIOO) and yield parameters like fresh weight of the plant, bulb weight at harvest, bulb weight after curing was calculated by using digital weighing balance (SF-400A), equatorial diameter, polar diameter was measured by using digital vernier calipers (SKADIOO), yield (kg/m^2) and quality parameters like ascorbic acid (mg/100g) was determined through the reduction of 2,6-dichlorophenol indophenol, a process conducted via dye titration method, T.S.S (°Brix) were recorded using a digital hand refractometer (ATAGO®), dry matter (%) was determined using the formula outlined by (Dantata *et al*., 2008) and calculated as:

Dry matter content: 100 – moisture content of sample

Where,
Moisture content of sample = [Weight of original sample – Weight of dried sample) / Weight of original sample × 100]

And economic parameters like gross returns, net returns and B:C ratio was calculated according to Yang *et al*., (1989) and all the other parameters (Mahajan *et al*., 2000) were recorded during the investigation.

Results and discussion

Growth parameters

All the observations of different treatments regarding growth parameters were calculated and are depicted in Table 1.

Plant height at 30, 60, and 90 DAT

The information regarding the mean plant height under various nutrient management treatments at 30, 60, and 90 days after transplanting (DAT) is outlined in Table 1, and the mean plant height attributed to different treatments was found to be statistically significant. The plant height at 30 days after transplanting (46.59 cm), at 60 days after transplanting (64.81 cm), and at 90 days after transplanting (72.68 cm) was recorded to be significantly higher with the treatment T2 (100% RDF) compared to other treatments. Vegetative growth is typically boosted by nitrogen and potassium, which enhance auxin production by aiding cell division and elongation (Shen *et al*., 2023). Additionally, potassium helps to loosen cell walls by acidifying the cell apoplast, which leads to cell wall loosening and activates hydrolyzing enzymes (Oosterhuis *et al*., 2014). Auxins affect the size of shoot and root meristems that are crucial for gravitropism and phototropism (Tsukanova *et al*., 2017). These processes lead to increased plant height, with the highest growth observed when 100% Recommended Dose of Fertilizer (RDF) is applied due to urea in NH4+ form that leads to the development of vegetative parameters involving plant height. These results are in close agreement with those of Prasad (2022), SBM *et al*. (2020), and Maassoud *et al*. (2009).

Number of leaves at 30, 60, and 90 DAT

The crop growth period has shown some significant increase in the number of leaves at 30 days after transplanting (5.60) and 60 days after transplanting (9.20) under the treatment T6 (100% RDF + Bacillus), whereas the number of leaves at 90 days after transplanting showed non-significant. Volatile organic compounds (VOCs) from Bacillus spp., a plant growth-promoting bacterium, work synergistically with host plants to regulate physiochemical processes. They enhance photosynthesis and phytohormone production, such as auxin and cytokinin, which promote cell expansion. Bacillus-produced cytokinin aids in cell division, photomorphogenic development, and shoot differentiation, leading to increased meristematic activity and maximum leaf number (Mahapatra *et al*., 2022). Gau *et al*. (2021) and Mounir *et al*. (2020) also reported the maximum number of leaves when potassium biofertilizers are used.

Leaf length at 30, 60, and 90 DAT

The leaf length per plant was observed to be significant, and the maximum leaf length at 30 DAT (41.46 cm), 60 DAT (56.94 cm), and 90 DAT (63.07 cm) were recorded under the treatment T2 (100% RDF) compared to other treatments. The increase in auxin production leads to rapid cell division and elongation, which have resulted in positive shoot growth as mentioned in plant height, and these processes lead to an increase in the leaf length of the plant, where leaf length is the measure of height from the divergence of leaves from the tip of the plant. The results are in close agreement with Verma *et al*. (2021), Vachan *et al*. (2017), and Dikshit (2015).

Leaf width at 30, 60, and 90 DAT

The maximum leaf width was recorded under treatment T5 (100% RDF + Pseudomonas) with (8.93 mm) at 30 DAT, (16.20 mm) at 60 DAT, and (17.00 mm) at 90 DAT, showing significant improvement compared to other treatments. Potassium (K+) enhances photosynthesis by regulating sunlight interception and the photosynthetic rate per leaf area. Higher soil potassium levels increase leaf size and number by boosting osmotic potential and cell turgor pressure. Gibberellic acid (GA) and potassium work synergistically, which helps to redistribute potassium in plants, and Pseudomonas biofertilizers produce more GA than Bacillus biofertilizers (Oosterhuis *et al*., 2014). Similar findings have been reported with Dikshit (2015).

Neck diameter at 30, 60, and 90 DAT

The maximum neck diameter was recorded under treatment T6 (100% RDF + Bacillus), with 7.48 mm at 30 DAT, 18.57 mm at 60 DAT, and 19.17 mm at 90 DAT recorded under treatment T7 (75% RDF + Pseudomonas), which showed significant improvement compared to other treatments. Before the bulbing stage, as the leaf canopy is developing, approximately 74% of the shoot's dry matter growth is allocated to the leaf blades, with the remaining portion distributed to the stem bases and leaf sheaths (Brewster, 2008). These findings are in close agree-

Table 1: Effects of inorganic nutrients and biofertilizers on growth parameters of onion

TREATMENTS	Plant height (cm)			Number of leaves			Leaf length (cm)			Leaf width (mm)			Neck diameter (mm)			Neck length (cm)	Fresh weight of plant (g)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT		
T_1 (Control)	30.68^{bc}	49.73^{c}	57.39^{d}	4.47^{c}	6.73^{b}	7.80^{a}	27.29^{c}	46.29^{a}	51.01^{cd}	6.40^{c}	11.53^{c}	13.73^{c}	5.48^{c}	11.36^{c}	14.63^{c}	6.24^{c}	82^{f}
T_2 (100% RDF)	46.59^{a}	64.81^{a}	72.68^{a}	5.60^{a}	9.07^{a}	9.40^{a}	41.46^{a}	56.94^{bc}	63.07^{a}	8.40^{a}	15.87^{ab}	16.67^{ab}	7.32^{ab}	16.95^{ab}	18.35^{ab}	8.48^{ab}	158^{c}
T_3 (75% RDF)	39.91^{ab}	54.62^{bc}	62.62^{bcd}	5.27^{abc}	7.47^{ab}	8.60^{a}	34.57^{abc}	47.04^{bc}	53.74^{bcd}	7.20^{ab}	12.67^{cd}	14.33^{bc}	6.26^{bc}	12.48^{bc}	15.68^{abc}	7.25^{bc}	122^{d}
T_4 (50% RDF)	37.65^{bc}	56.48^{abc}	62.44^{bcd}	4.80^{abc}	8.33^{ab}	8.87^{a}	35.67^{ab}	49.85^{abc}	53.90^{bcd}	7.40^{ab}	12.93^{bcd}	15.40^{abc}	6.29^{bc}	14.89^{abc}	17.34^{abc}	7.92^{bc}	115de
T_5 (100% RDF + Pseudomonas)	43.23^{ab}	61.30^{ab}	71.42^{ab}	5.33^{ab}	9.13^{a}	9.93^{a}	40.11^{ab}	52.68^{ab}	62.45^{ab}	8.93^{a}	16.20^{a}	17.00^{a}	7.36^{ab}	16.60^{ab}	18.37^{ab}	9.78^{a}	189^{a}
T_6 (100% RDF + Bacillus)	43.73^{ab}	59.17^{ab}	68.33^{abc}	5.60^{a}	9.20^{a}	10.13^{a}	39.07^{ab}	51.11^{ab}	59.79^{abc}	8.67^{a}	14.93^{abc}	16.87^{a}	7.48^{a}	16.88^{ab}	18.87^{a}	8.10^{ab}	183^{a}
T_7 (75% RDF + Pseudomonas)	40.97^{ab}	57.63^{abc}	65.81^{abcd}	5.27^{abc}	8.47^{ab}	9.67^{a}	34.45^{abc}	50.87^{ab}	56.76^{abcd}	8.47^{a}	14.67^{abcd}	16.20^{abc}	7.36^{ab}	17.64^{a}	19.17^{a}	8.23^{ab}	169^{b}
T_8 (75% RDF + Bacillus)	43.57^{ab}	60.90^{ab}	68.09^{abc}	5.00^{abc}	8.40^{ab}	9.13^{a}	38.89^{ab}	52.51^{ab}	59.06^{abc}	8.60^{a}	14.73^{abc}	14.93^{abc}	7.08^{ab}	14.97^{abc}	18.16^{abc}	8.80^{ab}	159^{c}
T_9 (50% RDF + Pseudomonas)	41.10^{ab}	52.99^{bc}	61.30^{cd}	4.93^{abc}	6.93^{b}	8.47^{a}	37.99^{ab}	46.38^{bc}	52.98^{cd}	7.93^{ab}	11.93^{cd}	14.53^{bc}	6.93^{ab}	14.13^{abc}	15.56^{abc}	7.46^{bc}	112^{e}
T_{10} (50% RDF + Bacillus)	36.85^{bc}	50.01^{c}	60.07^{cd}	4.53^{bc}	7.00^{b}	8.60^{a}	32.67^{bc}	42.91^{c}	49.20^{d}	6.47^{c}	12.13^{cd}	15.00^{abc}	5.88^{bc}	13.07^{bc}	15.21^{bc}	7.31^{bc}	109^{e}
S.E.m ±	2.48	2.73	2.71	0.25	0.53	0.78	2.40	2.20	2.69	0.59	0.95	0.70	0.44	1.34	1.08	0.53	2.65
SE (d)	3.50	3.87	3.84	0.36	0.75	1.10	3.40	3.11	3.81	0.83	1.34	0.99	0.63	1.90	1.52	0.75	3.75
CD at 5%	7.16	7.91	7.85	0.73	1.54	NS	6.95	6.35	7.78	1.70	2.74	2.03	1.28	3.89	3.11	1.53	7.67
CV	10.604	8.34	7.23	8.59	11.43	-	11.48	7.66	8.29	12.99	11.94	7.88	11.38	15.64	10.88	11.49	3.28

ment with Prasad (2022).

Neck length The maximum neck length (9.78 cm) was recorded as significant under the treatment T5 (100% RDF + Pseudomonas), followed by treatment T8 (8.80 cm). Gibberellic acid (GA) is crucial for stem elongation in plants. Both Bacillus and Pseudomonas biofertilizers produce GA, but Pseudomonas generates higher amounts, ranging from 116.1 to 485.8 µg/ml, surpassing Bacillus (Sharma *et al*., 2018). Dikshit (2015) has reported similar findings with his work on biofertilizers.

Fresh weight of the plant

At the time of harvest, the treatment T5 (100% RDF + Pseudomonas) significantly recorded the maximum fresh weight (189 g) of the plant, followed by treatment T6 (183 g). Biofertilizers convert inorganic potassium into organic forms, enhancing nutrient uptake crucial for chlorophyll, storage proteins, and phospholipids (Frageria and Stone, 2007). Plants absorb nitrogen, where some of it is lost through denitrification and volatilization, while microbes use the rest to produce VOCs (volatile organic compounds) and phytohormones. The influx of K+ ions increases turgor pressure in guard cells, which helps in opening stomata for CO_2 intake there by boosting carbohydrate synthesis in the mesophyll cells of chloroplast. Gibberellic acid (GA) aids in K+ remobilization, contributing to increased fresh weight in treatment T5 (Oosterhuis *et al*., 2014). SBM *et al*. (2020) also reported the maximum fresh weight of the plant in their findings with the use of biofertilizers.

Yield parameters

All observations of the different treatments concerning yield parameters were calculated and are presented in Table 2.

Bulb weight at harvest

The average bulb weight at harvest was recorded significantly under various treatments, whereas the maximum bulb weight after harvest (170 g) was recorded under the treatment T6 (100% RDF + Bacillus), followed by treatment T5 (162 g). Bacteria-produced phytohormones aid in cell processes like cell division, cell differentiation, and cell-wall formation with deposits of hemicelluloses and celluloses. Potassium (K+) is essential for carbohydrate and protein synthesis (Oosterhuis *et al*., 2014), while nitrogen supports enzymes, chlorophyll, nucleic acids, and protein storage that are crucial for photosynthesis (Zheng, 2009). K+ also facilitates solute and carbohydrate transport from source tissues to sink tissues, which leads to increased carbohydrate storage and plant weight. The results are in close agreement with Gau *et al*. (2021), who had obtained similar findings when treated with biofertilizers.

Equatorial diameter

The equatorial diameter of the bulb was recorded significantly highest (64.75 mm) under the treatment T6 (100% RDF + Bacillus). As bulb scales initiate, leaf blades continue to expand, marking a transition period while photosynthate allocation shifts to storage scales (Brewster, 2008). Bacillus spp. produce growth-promoting substances like gibberellic acid (GA) and cytokinins, stimulating root and shoot growth (Radhakrishnan *et al*., 2017). Bacillus spp. also reduces ethylene levels and enhances plant growth with 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase (Radhakrishnan *et al*., 2017). Pseudomonas spp. not only synthesizes IAA (indole acetic acid) but also degrades it by serving as a nutritive substrate, thereby eliminating the inhibitory effects of exogenous IAA levels and thus increasing the equatorial diameter in treatment T6 compared to treatment T5 (Tsukanova *et al*., 2017). The results are in close agreement with those of Prasad (2022) and Gau *et al*. (2021).

Polar diameter

The polar diameter of the bulb was recorded as significantly highest (51.11 mm) under the treatment T5 (100% RDF + Pseudomonas). After bulb initiation, photosynthates from leaf blades are transported to the roots, where phytohormones promote shoot cell division and elongation (Brewster, 2008). Gibberellic acid (GA) influenced neck length in Pseudomonas-treated plants, with a slight enhancement in root system elongation, contributing to the increased polar diameter in treatment T5 compared to T6. Gau *et al*. (2021) and Mounir *et al*. (2020) also reported similar findings with those of treatments applied through biofertilizers.

Bulb weight after curing

The treatment T6 (100% RDF + Bacillus) significantly recorded the maximum bulb weight after curing (144 g). The treatments with biofertilizers facilitate increased carbohydrate accumulation from source to sink by aiding K+ in phloem translocation and sink deposition by increasing dry matter accumulation rates. Thus bulbs treated with biofertilizers (T6, T5, T8) exhibit greater resilience against water loss compared to T2. Mounir *et al*. (2020) also obtained similar results in their experiment when treated with biofertilizers.

Yield (kg/m^2)

The maximum yield per meter square (3.78 kg/m^2) recorded significantly under the treatment T6 (100% RDF + Bacillus). Onion crops require a diverse array of nutrients for optimal growth and high yields. The quantitative evaluation of crop productivity, growth characteristics, and yield-contributing factors significantly impacts bulb yield. Utilizing biofertilizers has improved nutrient uptake by enhancing growth and yield traits, leading to increased bulb production. Higher potassium levels enhance nutrient translocation and photosynthesis by boosting carbohydrate synthesis. Prasad (2022), Fawaz *et al*. (2020), and Maassoud *et al*. (2009) obtained similar

Table 2: Effects of inorganic nutrients and biofertilizers on yield and quality parameters of onion

Treatments	Equatorial diameter (mm)	Polar diameter (mm)	Bulb weight at harvest (g)	Bulb weight after curing (g)	Yield per m^2 (kg/m^2)	Total soluble solids (°Brix)	Ascorbic acid (%)	Dry matter (%)
T_1 (Control)	45.38^{c}	37.13^{d}	71^{f}	41^{f}	1.57^{e}	12.23^{a}	9.87^{c}	10.57^{d}
T_2 (100% RDF)	62.13^{b}	45.93^{abc}	138^{c}	115^{c}	3.06^{abcd}	13.67^{ab}	13.60^{ab}	18.23^{b}
T_3 (75% RDF)	55.13^{abc}	45.41^{abc}	110^{d}	82^{d}	2.45^{bcde}	13.87^{a}	12.80^{ab}	14.63^{c}
T_4 (50% RDF)	52.24^{abc}	40.11$_{cd}$	101de	72de	2.25^{cde}	13.50^{ab}	11.20^{bc}	10.43^{d}
T_5 (100% RDF + Pseudomonas)	63.87^{a}	51.11^{a}	162^{ab}	132^{ab}	3.61^{a}	13.60^{ab}	14.13^{a}	19.87^{ab}
T_6 (100% RDF + Bacillus)	64.75^{a}	50.58^{ab}	170^{a}	144^{a}	3.78^{a}	13.07^{ab}	14.67^{a}	20.32^{a}
T_7 (75% RDF + Pseudomonas)	59.20^{b}	43.29^{abcd}	142^{c}	115^{c}	3.15^{abc}	13.37^{ab}	12.80^{ab}	18.51^{b}
T_8 (75% RDF + Bacillus)	61.79^{b}	45.57^{abc}	150^{bc}	123^{bc}	3.32^{ab}	14.03^{a}	13.07^{ab}	18.96^{ab}
T_9 (50% RDF + Pseudomonas)	49.56^{bc}	42.54^{bcd}	96^{e}	66^{e}	2.14^{de}	13.13^{ab}	12.00^{abc}	13.50^{c}
T_{10} (50% RDF + Bacillus)	46.01^{c}	39.69$_{cd}$	99de	69de	2.20^{cde}	14.03^{a}	12.27^{abc}	14.15^{c}
S.E.m ±	3.94	2.45	4.35	4.29	0.30	0.46	0.36	0.53
SE (d)	5.57	3.46	6.15	6.07	0.42	0.64	0.51	0.75
CD at 5%	11.80	7.08	12.58	12.41	0.86	NS	1.04	1.54
CV	12.19	9.60	6.08	7.74	18.78	-	4.91	5.79

results with those of treatments applied with biofertilizers.

Quality parameters

Total soluble solids (°Brix)

The data pertaining to the mean total soluble solids of different treatments were non-significant, where the maximum TSS (14.03) was recorded under the treatment T8 (75% RDF + Bacillus). These results are supported by similar findings with Gupta *et al*. (2023).

Ascorbic acid content

The treatment T6 (100% RDF + Bacillus) significantly recorded maximum ascorbic acid content (14.67) compared to other treatments. Vitamin C production in onions relies on photosynthesis in leaves, which then moves to roots. Ascorbic acid is transported from older to newer leaves or synthesized in young tissue without direct sunlight. The highly active, immature tissue in the center of the onion bulb is the most potent in terms of vitamin C (Murphy, 1941). Biofertilizers with increased K+ concentration enhance the translocation of photosynthates and vitamins, resulting in higher ascorbic acid levels. Gupta *et al*. (2023), Kumar *et al*. (2021), and Dilpreet *et al*. (2016) have also reported similar findings in work with biofertilizers.

Dry matter (%)

The dry matter percentage (%) under different treatments was recorded as significant, whereas the maximum dry matter percentage (20.32) was recorded with treatment T6 (100% RDF + Bacillus). From the above findings, it is concluded that bulb weight after curing was highest in treatments with biofertilizers. Bulbs exhibited resilience against water loss due to the accumulation of photosynthates, which also contributed to higher dry matter percentages. Prasad (2022) also obtained similar findings in his experiments conducted with biofertilizers.

Conclusion

Based on the results of the current experiment, it can be concluded that the application of T6 (100% RDF + Bacillus) resulted in the highest bulb yield among all the treatments, followed by treatments T7 (75% RDF + Pseudomonas) and T8 (75% RDF + Bacillus), which showed better bulb yield per m^2 than T2 (100% RDF).

Conflict of interest

The authors declare that they have no conflicts of interest.

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