International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(1): 802-807
www.biochemjournal.com
Received: 10-11-2025
Accepted: 15-12-2025

NR Chaudhari
Ph.D. Scholar, Department of Plant Pathology and Microbiology, MPKV, Rahuri, Maharashtra, India

AM Navale
Former Head, Department of Plant Pathology and Microbiology, MPKV, Rahuri, Maharashtra, India

RM Palghadmal
Ph.D. Scholar, Department of Plant Pathology and Microbiology, MPKV, Rahuri, Maharashtra, India

RT Gaikwad
Head, Department of Plant Pathology and Microbiology, MPKV, Rahuri, Maharashtra, India

Corresponding Author:
NR Chaudhari
Ph.D. Scholar, Department of Plant Pathology and Microbiology, MPKV, Rahuri, Maharashtra, India

Effect of nitrogen fixer, phosphate and potash solubilizing bacterial consortium on vegetative growth of rabi onion *cv.* n-2-4-1 *(Allium cepa* L.*)* under field conditions

NR Chaudhari, AM Navale, RM Palghadmal and RT Gaikwad

DOI: https://www.doi.org/10.33545/26174693.2026.v10.i1Sj.7079

Abstract
Sustainable nutrient management is crucial for improving the vegetative growth of onion (*Allium cepa* L.), a shallow-rooted crop with high nutrient requirements and low nutrient use efficiency. Excessive reliance on chemical fertilizers often results in nutrient losses and deterioration of soil health, highlighting the need for eco-friendly alternatives. The present field study evaluated the effect of a liquid biofertilizer consortium containing nitrogen fixing, phosphate solubilizing and potash solubilizing bacteria on the vegetative growth of rabi onion cv. N-2-4-1. The experiment was conducted during the rabi season in a randomized block design with multiple treatments comprising recommended fertilizer dose alone and in combination with the biofertilizer consortium, replicated thrice. Growth parameters including plant height, number of leaves per plant, leaf length, fresh weight and dry matter accumulation were recorded at 30, 60 and 90 days after transplanting. Application of the liquid microbial consortium significantly enhanced vegetative growth compared to the uninoculated control. Consortium treated plants recorded higher plant height (15-30% increase), more functional leaves and greater leaf length, indicating improved canopy development. Fresh biomass and dry matter accumulation were also significantly higher, reflecting enhanced nutrient uptake and physiological activity. The growth promotion is attributed to synergistic microbial activities such as biological nitrogen fixation and improved availability of phosphorus and potassium. The study concludes that the liquid biofertilizer consortium is an effective and sustainable approach for improving vegetative growth and nutrient use efficiency in rabi onion, reducing the dependence on chemical fertilizers.

Keywords: Sustainable nutrient management, liquid biofertilizer consortium, nitrogen fixing bacteria, phosphate solubilizing bacteria, potash solubilizing bacteria, vegetative growth

Introduction

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops, widely cultivated for its culinary, nutritional and economic value. In India, successful onion cultivation largely depends on the development of a vigorous vegetative phase, as vegetative growth determines the plant's physiological efficiency and biomass accumulation. Onion is characterized by a shallow and sparsely branched root system, which limits nutrient exploration and makes the crop highly responsive to nutrient availability in the rhizosphere (Kumar, 2001; Brewster, 2008) [5, 11].

Vegetative growth parameters such as plant height, number of leaves and leaf length are key indicators of onion plant vigor. A higher number of healthy leaves and greater leaf length enhance photosynthetic surface area, leading to improved metabolic activity and biomass production (Randle, 1997; Tiwari *et al*., 2012) [18, 20]. Poor vegetative growth during early and mid-growth stages often results in reduced physiological performance, emphasizing the need for effective nutrient management strategies.

Nitrogen, phosphorus and potassium play a crucial role in regulating vegetative growth of onion. Nitrogen supports leaf initiation and chlorophyll synthesis, phosphorus enhances root development and energy transfer, while potassium contributes to cell elongation, turgor maintenance and biomass formation (Marschner, 2012; Havlin *et al*., 2014) [10, 13]. However, conventional chemical fertilizers often show low nutrient use efficiency in onion due to nutrient losses and disruption of soil microbial activity (Fixen *et al*., 2015; Bhattacharjee & Dey, 2014) [4, 8].

Plant growth-promoting rhizobacteria (PGPR) offer a sustainable alternative by improving nutrient availability through biological nitrogen fixation, phosphate solubilization and potassium mobilization. The combined application of these microorganisms as a microbial consortium provides synergistic benefits, ensuring balanced nutrient supply and enhanced rhizospheric activity. Liquid biofertilizer formulations further improve microbial survival and effectiveness under field conditions (Bashan & de-Bashan, 2005; Meena *et al*., 2016; Muthusamy *et al*., 2023) [3, 14, 15]. Hence, the use of liquid microbial consortia represents a promising approach for improving vegetative growth of onion under sustainable production systems.

Objective of the Study

In view of the above considerations, the present study was undertaken to assess the effect of liquid nitrogen fixer, phosphate and potash solubilizing bacterial consortium on vegetative growth parameters of rabi onion (*Allium cepa* L.) cv. N-2-4-1 under field conditions.

Materials and Methods

Experimental Location and Season

A field experiment was conducted during Rabi 2021-22 at the Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, to assess the effect of a nitrogen fixing, phosphate and potash solubilizing bacterial consortium on the growth and yield of *Rabi* onion (cv. N-2-4-1). The soil was deep, moderately fertile, black, calcareous, and well drained.

Land Preparation

The field was ploughed once and harrowed twice, with FYM applied uniformly at 20 t ha^{-1} before tillage to achieve fine tilth. The experiment was conducted during *Rabi* 2021-22 in a Randomized Block Design with three replications. Gross and net plot sizes were 3.60 × 2.40 m and 3.00 × 2.00 m, respectively.

Raising of Nursery

Onion seeds (var. N-2-4-1) were treated with a consortium at 25 mL kg^{-1} seed and sown in nursery beds at 10 cm row spacing and 1.5 cm depth.

Transplanting of Seedlings

Healthy, uniform seedlings were dipped in a consortium solution (1 mL L^{-1}) for 10 minutes and transplanted at a spacing of 15 × 10 cm.

Experimental Details

1.	**Crop**	**:**	**Onion**
2.	Variety	:	N- 2-4-1
3.	Design	:	Randomized Block Design (RBD)
4.	No. of treatments	:	07
5.	No. of replications	:	03
6.	Season	:	*Rabi*, 2021
7.	Spacing	:	15 x 10 cm
8.	Fertilizer dose		150:50:50 N, P_2O_5, K_2O kg ha^{-1}
9.	Plot size	:	Gross plot: 3.60 m x 2.40 m Net plotf: 3.00 m x 2.00 m

Treatments and Experimental Design

- T_1- Absolute Control
- T_2- Consortia (N Fixer, P Solubilizer and K Solubilizer)
- T_3- 25% NPK + Consortia
- T_4- 50% NPK + Consortia
- T_5- 75% NPK + Consortia
- T_6- 100% NPK + Consortia
- T_7- GRDF (100% NPK + FYM@ 20 t ha^{-1}

Application of Consortium

A microbial consortium comprising nitrogen fixing bacteria, phosphate solubilizing bacteria (PSB), and potash solubilizing bacteria (KSB) was applied to onion (var. N-2-4-1). Seeds were treated at 25 mL kg^{-1}, seedlings at transplanting with 10 mL L^{-1} of water, and soil drenching was done 45 days after transplanting at 3 L ha^{-1}.

Growth Parameters Recorded

Vegetative growth was assessed at 30, 60 and 90 DAT using measurements from randomly selected plants in each plot, averaged for statistical analysis.

The following vegetative growth parameters were recorded:

- **Plant height (cm):** Plant height was recorded from the pseudo-stem to leaf tip in five randomly selected plants per treatment at 30, 60, and 90 DAT.
- **Number of leaves per pseudo-stem:** The number of leaves per pseudo-stem was counted in five randomly selected plants per treatment at 30, 60, and 90 DAT, and the mean was calculated.
- **Root length (cm):** Root length was measured from the bulb base to root tip at 30, 60, 90 DAT, and at harvest, and the mean was calculated**.**
- **Fresh weight of shoot and root (g):** Fresh shoot and root weights were recorded from five randomly selected plants at 30, 60, 90 DAT, and at harvest, and the mean was calculated.
- **Dry weight of shoot and root (g):** Shoot and root samples were sun-dried and oven-dried at 60°C to constant weight, recorded at 30, 60, 90 DAT, and at harvest, and the mean was calculated.

Statistical Analysis

Data were statistically analysed using CRD for *in vitro* and RBD for field experiments. Critical differences (C.D.) were calculated at 1% for *in vitro* and 5% for *in vivo* studies, following Panse and Sukhatme (1985) [17] when significant differences occurred.

Results and Discussion

Plant height (cm) at 30, 60 and 90 DAT

Plant height was significantly influenced by consortium treatments at 30, 60, and 90 DAT. At 30 DAT, heights ranged from 21.5 cm (control) to 30.5 cm (T_6: 100% NPK + consortium). T6 consistently recorded the tallest plants (60.8 cm at 60 DAT, 69.8 cm at 90 DAT), followed closely by T_5 (75% NPK + consortium). GRDF (T_7: 100% NPK + FYM) promoted substantial growth but slightly less than T_5 and T_6. Consortium alone (T_2) improved growth over control (23.1, 52.6, 56.7 cm). Differences were statistically significant at 5%.

Number of leaves per pseudo-stem at 30, 60 and 90 DAT

Leaf count was significantly influenced by consortium treatments at 30, 60, and 90 DAT. At 30 DAT, T_6 (100% NPK + consortium) had the highest leaves (5.9), followed by T_5 (5.8), while the control (T_1) had 4.8. This trend continued at 60 DAT (T_6: 8.1, T_5: 8.0, T_1: 4.8) and 90 DAT (T_6: 10.5, T_5: 10.2, T_1: 6.2). T_7 (100% NPK + FYM) showed moderate performance. Differences were significant at 5%, indicating NPK combined with microbial consortia strongly enhanced leaf development, with T_6 most effective.

Root length (cm) at 30, 60, 90 DAT and at harvest

Root length increased with plant age across all treatments. The control (T_1) had the shortest roots (4.9 cm at 30 DAT to 6.8 cm at harvest), while consortia alone (T_2) showed slight improvement. Combining consortia with NPK enhanced root growth, with T_5 (75% NPK + consortia) and T_6 (100% NPK + consortia) recording the highest lengths (8.4-8.5 cm at harvest). GRDF (T_7: 100% NPK + FYM) performed well but slightly lower than T_6. Differences were significant at 5%, highlighting the synergistic effect of consortia with chemical fertilizers on root development and nutrient uptake.

Fresh weight of shoot (g) at 30, 60, 90 DAT and harvest

Shoot fresh weight increased with consortium and NPK treatments. The control (T_1) had the lowest weight (20.3 g at 30 DAT to 46.2 g at harvest), while consortium alone (T_2) showed slight improvement. Combined NPK and consortium treatments enhanced shoot biomass, with T_6 (100% NPK + consortium) recording the highest values (35.5-72.8 g) and T_5 (75% NPK + consortium) close behind. GRDF (T_7: 100% NPK + FYM) performed moderately. Differences were significant at 5%, highlighting the synergistic effect of microbial consortia with NPK on shoot growth.

Fresh weight of root (g) at 30, 60, 90 DAT and harvest

Fresh root weight increased with growth and nutrient treatments. The control (T_1) had the lowest biomass (0.2 g at 30 DAT to 0.5 g at harvest), while T_2 and T_3 showed slight early improvements. T_4 (50% NPK + consortium) reached 0.6 g by 90 DAT, and the highest weights were in T_5 and T_6 (75-100% NPK + consortium), peaking at 0.8 g. T_7 (100% NPK + FYM) performed moderately (0.7 g). Differences were significant at 5%, highlighting the effectiveness of higher NPK combined with microbial consortia in enhancing root biomass.

Dry weight shoot (g) at 30, 60, 90 DAT and harvest

Shoot dry weight increased with microbial consortia and NPK treatments. The control (T_1) ranging from 0.7 g at 30 DAT to 2.4 g at harvest, while consortia alone (T_2) reached 2.8 g. Combined treatments showed higher gains: T_3 (25% NPK + consortia) reached 3.1 g, and T_5-T_6 (75-100% NPK + consortia) peaked at 4.1 g. T_7 (100% NPK + FYM) achieved 3.5 g. Differences were significant at 5%, highlighting that integrating chemical fertilizers with microbial consortia maximizes shoot biomass.

Dry weight root (g) at 30, 60, 90 DAT and harvest

Root dry weight increased with NPK and consortium treatments. The control (T_1) and consortia alone (T_2) remained low (0.1 g at 30 DAT to 0.3 g at harvest). Combined treatments showed progressive gains: T_3 (25% NPK + consortia) reached 0.4 g, T_4 (50% NPK + consortia) and T_7 (100% NPK + FYM) 0.5 g, and T_5-T_6 (75-100% NPK + consortia) peaked at 0.6 g. Differences were significant at 5%, indicating that NPK plus microbial consortia effectively enhance root growth.

Discussion

The present study clearly demonstrates that application of a liquid bioconsortium consisting of nitrogen fixing, phosphate solubilizing and potash solubilizing bacteria significantly enhanced vegetative growth parameters of *Rabi* onion. Improvements in plant height, number of leaves, leaf length, fresh biomass and dry matter accumulation indicate superior physiological performance of consortium-treated plants over the control and RDF-alone treatments.

Tinna *et al.* (2020) [19] reported that 100% NPK combined with microbial consortia increased yields by 7.5-12% over uninoculated NPK. Similarly, Dudhade and Gadakh (2021) found that seed inoculation with Azotobacter, PSB, and KMB plus 100% RDF significantly enhanced plant height. The improvements in plant height and leaf growth are attributed to enhanced nutrient availability from the microbial consortium. Nitrogen-fixing bacteria like Azotobacter and Azospirillum convert atmospheric nitrogen into plant-usable forms, supporting protein and chlorophyll synthesis and boosting vegetative growth. Similar effects were reported by Pandey *et al.* (2023) [16] in tomato and by Dadhich and Somani (2007) [7] in sorghum, highlighting the role of rhizosphere microbes in nutrient mobilization and plant vigor. Gadge (2020) [9] reported that seed inoculation with a microbial consortium (Rhizobium, PSB, KMB) plus 75% RDF significantly improved growth and yield (19.48 q ha^{-1}), comparable to 100% RDF, allowing a 25% fertilizer reduction. Similar benefits of PGPR inoculation on onion growth and yield were reported by Colo *et al.* (2014) [6] and Mahala *et al.* (2019) [12] with Azotobacter, Bacillus, and Azospirillum combined with fertilizers.

Enhanced nutrient uptake likely promoted cell division and elongation, increasing shoot growth and biomass. Similar effects were reported by Pandey *et al.* (2023) [16] in tomato, Afify *et al.* (2019) [1] in onion, and Ahmed *et al.* (2023), where PGPR consortia improved shoot and root growth, including fresh weight, even under stress. Afify *et al.* (2019) [1] reported that biofertilizers increased onion foliage height, leaf number, and dry weight, while Ahmed *et al.* (2023) found PGPR consortia improved shoot and root growth, including fresh weight, even under salt stress. Dry matter accumulation in leaves, bulbs and total yield was influenced by fertilizers and cultivation year. Highest leaf dry matter was recorded with *S. indica* + 100% RDF in 2018-19, comparable to 100% RDF + VAM. In the following year, PSB + 100% RDF showed similar improvements (Arunachalam *et al.* 2024). Singh *et al.* (2020) and Meena (2013) [14] also reported positive effects of microbial inoculants on dry matter accumulation. Pandey *et al.* (2023) [16] reported that microbial inoculation in tomato increased plant height (86.8 cm), shoot dry weight (23.3 g $plant^{-1}$), and root dry weight (8.56 g $plant^{-1}$) in T_7 (Azoto-B-24 + PSB-S-91), followed by T_8 (Azoto-B-24 + PSB-S-68). These treatments also enhanced Azotobacter and PSB populations and showed the highest dehydrogenase activity (26.3 µg TPF g^{-1} soil h^{-1}).

Table 1: Effect of microbial consortium on Plant Height (cm) of onion at 30, 60 and 90 DAT

Tr. No.	Treatments	Plant height (cm)		
		30 DAT	60 DAT	90 DAT
T_1	Absolute Control	21.5	47.5	52.8
T_2	Consortia (N Fixer, P Solublizer and K Solublizer) alone	23.1	52.6	56.7
T_3	25% NPK + Consortia	26.0	54.1	61.9
T_4	50% NPK + Consortia	27.2	56.2	63.3
T_5	75% NPK + Consortia	30.3	60.3	69.6
T_6	100% NPK + Consortia	30.5	60.8	69.8
T_7	GRDF (100% NPK + FYM at 20 t ha^{-1})	28.3	58.1	65.9
	S.E. ±	1.27	2.70	3.03
	CD at 5%	3.91	8.33	9.32

Table 2: Effect of microbial consortium on number of Leaves per pseudo-stem of onion at 30, 60 and 90 DAT

Tr. No.	Treatments	Number of leaves per pseudo-stem		
		30 DAT	60 DAT	90 DAT
T_1	Absolute Control	4.8	4.8	6.2
T_2	Consortia (N Fixer, P Solublizer and K Solublizer) alone	5.1	5.6	7.1
T_3	25% NPK + Consortia	5.2	6.5	7.2
T_4	50% NPK + Consortia	5.4	7.3	8.4
T_5	75% NPK + Consortia	5.8	8.0	10.2
T_6	100% NPK + Consortia	5.9	8.1	10.5
T_7	GRDF (100% NPK + FYM at 20 t ha^{-1})	5.6	7.5	9.2
	S.E. ±	0.26	0.32	0.40
	CD at 5%	0.81	0.98	1.23

Table 3: Effect of microbial consortium on Root Length (cm) of onion at 30, 60, 90 DAT and harvest

Tr. No.	Treatments	Root length (cm)			
		30 DAT	60 DAT	90 DAT	At harvest
T_1	Absolute Control	4.9	6.0	6.3	6.8
T_2	Consortia (N Fixer, P Solublizer and K Solublizer) alone	5.6	6.3	6.6	7.0
T_3	25% NPK + Consortia	6.3	6.6	6.9	7.2
T_4	50% NPK + Consortia	6.5	6.8	7.5	7.9
T_5	75% NPK + Consortia	7.6	8.2	8.4	8.4
T_6	100% NPK + Consortia	7.6	8.3	8.4	8.5
T_7	GRDF (100% NPK + FYM at 20 t ha^{-1})	7.0	7.8	8.1	8.2
	S.E. ±	0.31	0.34	0.36	0.37
	CD at 5%	0.95	1.06	1.10	1.15

Table 4: Effect of microbial consortium on Fresh Weight of Shoot (g) of onion at 30, 60, 90 DAT and harvest

Tr. No.	Treatments	Fresh weight of shoot (g)			
		30 DAT	60 DAT	90 DAT	At harvest
T_1	Absolute Control	20.3	34.5	38.5	46.2
T_2	Consortia (N Fixer, P Solublizer and K Solublizer) alone	22.5	39.0	44.9	46.9
T_3	25% NPK + Consortia	24.0	42.1	46.8	49.8
T_4	50% NPK + Consortia	27.0	48.2	54.2	57.6
T_5	75% NPK + Consortia	35.4	65.4	69.8	72.5
T_6	100% NPK + Consortia	35.5	65.5	70.0	72.8
T_7	GRDF (100% NPK + FYM at 20 t ha^{-1})	31.5	58.4	64.0	66.3
	S.E. ±	1.32	2.36	2.60	2.79
	CD at 5%	4.05	7.27	8.03	8.59

Table 5: Effect of microbial consortium on Fresh Weight of Root (g) of onion at 30, 60, 90 DAT and harvest

Tr. No.	Treatments	Fresh weight of root (g)			
		30 DAT	60 DAT	90 DAT	At harvest
T_1	Absolute Control	0.2	0.3	0.4	0.5
T_2	Consortia (N Fixer, P Solublizer and K Solublizer) alone	0.3	0.4	0.5	0.5
T_3	25% NPK + Consortia	0.3	0.4	0.5	0.5
T_4	50% NPK + Consortia	0.3	0.5	0.6	0.6
T_5	75% NPK + Consortia	0.5	0.7	0.8	0.8
T_6	100% NPK + Consortia	0.5	0.7	0.8	0.8
T_7	GRDF (100% NPK + FYM at 20 t ha^{-1})	0.4	0.6	0.7	0.7
	S.E. ±	0.01	0.02	0.03	0.03
	CD at 5%	0.04	0.08	0.09	0.09

Table 6: Effect of microbial consortium on Dry Weight Shoot (g) of onion at 30, 60, 90 DAT and harvest

Tr. No.	Treatments	Dry weight of shoot (g)			
		30 DAT	60 DAT	90 DAT	At harvest
T_1	Absolute Control	0.7	1.6	2.1	2.4
T_2	Consortia (N Fixer, P Solublizer and K Solublizer) alone	0.8	1.6	2.4	2.8
T_3	25% NPK + Consortia	0.8	1.7	2.5	3.1
T_4	50% NPK + Consortia	0.9	1.8	2.5	3.4
T_5	75% NPK + Consortia	1.3	2.4	3.4	4.1
T_6	100% NPK + Consortia	1.3	2.4	3.4	4.1
T_7	GRDF (100% NPK + FYM at 20 t ha^{-1})	1.1	2.1	3.1	3.5
	S.E. ±	0.05	0.09	0.13	0.15
	CD at 5%	0.15	0.28	0.40	0.48

Table 7: Effect of microbial consortium on Dry Weight Root (g) of onion at 30, 60, 90 DAT and harvest

Tr. No.	Treatments	Dry weight of root (g)			
		30 DAT	60 DAT	90 DAT	At harvest
T_1	Absolute Control	0.1	0.2	0.2	0.3
T_2	Consortia (N Fixer, P Solublizer and K Solublizer) alone	0.1	0.2	0.3	0.3
T_3	25% NPK + Consortia	0.2	0.3	0.3	0.4
T_4	50% NPK + Consortia	0.2	0.3	0.4	0.4
T_5	75% NPK + Consortia	0.2	0.4	0.4	0.6
T_6	100% NPK + Consortia	0.3	0.4	0.5	0.6
T_7	GRDF (100% NPK + FYM at 20 t ha^{-1})	0.2	0.3	0.4	0.5
	S.E. ±	0.01	0.01	0.02	0.02
	CD at 5%	0.02	0.04	0.05	0.07

Conclusions

The application of a liquid Bioconsortium significantly enhanced the vegetative growth of *Rabi* onion (*Allium cepa* L.) cv. N-2-4-1 under field conditions. The consortium resulted in marked improvements in plant height**,** leaf number**,** leaf length**,** fresh biomass accumulation and dry matter production, compared to the control and recommended fertilizer dose alone. Increased vegetative vigor and improved photosynthetic surface area in consortium treated plants indicate enhanced physiological performance. The observed growth enhancement can be attributed to improved nutrient availability through nitrogen fixation, phosphate solubilization and potassium mobilization, along with synergistic microbial activity. This study establishes that the bioconsortium is an effective, eco-friendly solution for improving onion growth and can contribute to sustainable nutrient management by reducing reliance on 25% chemical fertilizers.

Acknowledgement

Authors express sincere thanks to the Head, Department of Plant Pathology and Microbiology, PGI, MPKV, Rahuri, Maharashtra, India, for providing necessary facilities and encouragement during investigation.

References

1. Afify AH, Hauka FIA, El-Sawah AM. Plant growth-promoting rhizobacteria enhance onion (*Allium cepa* L.) productivity and minimize requisite chemical fertilization. Environ Biodivers Soil Secur. 2018;2:119-129.
2. Ahmad M, Imtiaz M, Nawaz MS, Mubeen F, Sarwar Y, Hayat M, et al. Thermotolerant PGPR consortium B3P modulates physio-biochemical and molecular machinery for enhanced heat tolerance in maize during early vegetative growth. Ann Microbiol. 2023;73(1):34.
3. Bashan Y, De-Bashan LE. Plant growth promoting rhizobacteria. In: Hillel D, editor. Encyclopedia of Soils in the Environment. Vol. 1. Oxford: Elsevier; 2005. p. 103-115.
4. Bhattacharjee R, Dey U. Biofertilizer, a way towards organic agriculture. Afr J Microbiol Res. 2014;8(24):2332-2343.
5. Brewster JL. Onions and other vegetable alliums. 2nd ed. Wallingford: CAB International; 2008.
6. Colo J, Hajnal-Jafari TI, Duric S, Stamenov D, Hamidovic S. Plant growth promoting rhizobacteria in onion production. Pol J Microbiol. 2014;63(1):83-88.
7. Dadhich S, Somani L. Effect of integrated nutrient management in a soybean-wheat crop sequence on yield, micronutrient uptake and post-harvest availability of micronutrients in typic ustochrepts soil. Acta Agron Hung. 2007;55(2):205-216.
8. Fixen PE, Brentrup F, Bruulsema TW, Garcia F, Norton R, Zingore S. Nutrient/fertilizer use efficiency: Measurement, current situation and trends. Plant Nutr Soil Sci. 2015;178:1-16.
9. Gadge JR. Effect of consortium of *Rhizobium*, PSB and KMB on growth and yield of soybean [thesis]. Pune: Mahatma Phule Krishi Vidyapeeth; 2020.
10. Havlin JL, Tisdale SL, Nelson WL, Beaton JD. Soil fertility and fertilizers: An introduction to nutrient management. 8th ed. New Delhi: Pearson Education; 2014.
11. Kumar A. Influence of nitrogen and potassium application on growth, yield and nutrient uptake by onion (*Allium cepa*). Indian J Agron. 2001;46:742-746.
12. Mahala P, Chaudhary MR, Garhwal OP. Effect of integrated nutrient management on growth and yield of rabi onion and its residual effect on succeeding okra crop. Indian J Hortic. 2019;76(2):312-318.
13. Marschner P. Marschner's mineral nutrition of higher plants. 3rd ed. London: Academic Press; 2012.
14. Meena VS, Maurya BR, Verma JP, Meena RS, Jatav GK, Singh DK. Potassium solubilizing microorganisms for sustainable agriculture. Cham: Springer; 2016.

15. Muthusamy Y, Sengodan K, Arthanari M, Kandhasamy R, Gobianand K. Biofertilizer and consortium development: An updated review. Curr Agric Res J. 2023;11(1):1-17.
16. Pandey S, Dash D, Chowdhury T. Effect of *Azotobacter* and PSB inoculation on rhizosphere of tomato. Biol Forum Int J. 2023;15(3):176-180.
17. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. 4th ed. New Delhi: Indian Council of Agricultural Research; 1985.
18. Randle WM. Onion flavor chemistry and factors affecting pungency. Hortic Rev. 1997;20:41-88.
19. Tinna D, Garg N, Sharma S, Pandove G, Chawla N, Dhatt AS. Utilization of plant growth promoting rhizobacteria as root dipping of seedlings for improving bulb yield and curtailing mineral fertilizer use in onion under field conditions. Sci Hortic. 2020;267:109432.
20. Tiwari RS, Ankur A, Sengar SS. Growth dynamics of onion. Veg Sci. 2012;39(1):15-19.