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Integrated Nutrient Management on Growth and Yield of *Kharif* Onion (*Allium cepa* L.)

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A B S T R A C T

The field investigation was conducted in *kharif*- 2021 at Agronomy farm, B – Division, Plot No – 5, College of Agriculture, Pune with ten treatments and three replications in RBD. The application of 75% RDF + 1% foliar spray of 19:19:19 at 30 DAT + *Azospirillum* + *PSB* &*KSB* was the significant treatment regarding plant height (69.98 cm), neck thickness (1.68 cm), number of leaves plant^{-1} (11.40), dry matter plant^{-1} (26.26 g), days to maturity (142.33), polar and equatorial diameter (6.70 and 6.93cm), number of scales bulb^{-1} (11.74), fresh weight bulb^{-1} (157.57 g), yield (300.21 q ha^{-1}) and quality(57.28 %) A grade bulbs. Furthermore, net gain was (17.47, 15.33 and 26.14 N, P and K kg ha^{-1}), microbial count of *Azospirillum*, *PSB* and *KSB* was (39.17, 33.56 cfu and 33.31 cfu x 10^7 g^{-1}) and maximum B: C ratio (3.35) was recorded.

Introduction

Onion (*Allium cepa* L.) amid to be crucial spice and vegetable crop of *Alliaceae* family having modified form of stem as the prominent pungent edible part. It is native of Central Asia, although domestication likely took place in Southwest or Central Asian region. It is cultivated in *kharif*, *rangada (late kharif), rabi* and *summer* hence stability in supply is monitored. Onion is commonly known as "Queen of the Kitchen" due to presence of energy, proteins, carbohydrates, vitamins, phosphorus and calcium respectively. Onion is highly nutritive with energy 40 kacl, carbohydrates 9.34 gm, proteins 1.10 gm, dietary fibres 1.7 gm, folates 19 µg, niacin 0.116 mg, pantothenic acid 0.123 mg, pyridoxine 0.120 mg, riboflavin 0.027 mg, thiamin 0.046 mg, vitamin A 2 IU, vitamin C 7.4 mg, vitamin E 0.02 mg, sodium 4mg, potassium 146 mg, calcium 23 mg, copper 0.039 mg, iron 0.021 mg, magnesium 10 mg, manganese 0.129 mg, phosphorus 29 mg and zinc 0.17 mg per 100 gm of fresh onion bulb (Sharma,

2014). These nutritive aspects helps to increasing haemoglobin in blood, elimination of hypertension, reduces heart diseases, cancer, diabetes, cholera disorder and inhibits *E.coli* and *S. aureus* bacterial growth in human body. Onion are also used in households, restaurants, hotels and value addition by pickling, canning, chopping, powdering, dehydrating along with that commercial sale of caramelised onion flavoured products.

Globally Asia is the largest producer of onion. China, India, United States of America, Egypt and Turkey are top five global producers of world. India possess second position with an area of 1.22 million ha and produces 22.82 million tons of onion yearly with average productivity of 16.12 tons and contributes 22.83 % of global production (Anonymous, 2020). Nationally, Maharashtra stands first in onion production with yearly yield of 5355.39 thousand tons and productivity of 15.70 tons ha^{-1} (Anonymous, 2020). Nashik stands first with annual production of 2332.4 thousand tons and productivity of 17.41 tons ha^{-1}.

The initial years of green revolution were highly profitable to farmers, but with course of time the yield got saturated and even decreased in some areas. The application of chemical fertilizers at a massive scale reduced the inherent capacity of soil leading it to become infertile. Lower productivity of onion in India is primarily due to poor nutrient management rather than climate conditions. Hence, in concern to meet the nutrient requirement of crop and bridge the future gap integrated approach is trustworthy.

The cheapest source of nitrogen is urea faces volatilization losses of nitrogen up to 85% in worst cases. Moreover there is plenty of nitrogen in atmosphere which can be utilised when chemical fertilizers are integrated with suitable biofertilizers strains like *Azospirillum* in onion crop. *Azospirillum* is gram-negative free-living nitrogen-fixing rhizosphere bacteria having ability of fixing 20- 40 kg N ha^{-1} and increases vegetative growth by 10 to 30 %. *Azospirillum* plays a crucial role in growth promoting by producing phytohormones like indole 3-acetic acid (IAA), cytokinins, abscisic acid (ABA), ethylene, gibberellic acid and zeatin which ultimately contributes to higher yield. Rapid fixation reactions limits phosphorus availability to plant. Similarly, potassium faces solubility barriers hence 50 % of total applied P and K nutrient remains unutilised in soil. The bacterial inoculants of *PSB* and *KSB* help in solubilizing and mobilising the applied fertilizers which helps in effective uptake of nutrient. The healthy bacterial strain of *PSB* has inherent capacity to bring down inorganic phosphatic fertilizers requirement by 50 to 75 % and increment in vegetable yield by 10 to 30 %. Similarly, *KSB* can bring inorganic fertilizer requirement down by 35 to 50 % with influential increase in yield up to 20 %, respectively. Foliar feeding is an upcoming concept in modern agriculture. The fertilizer use efficiency of foliar grade is 7 times higher as compared to traditional chemical fertilizers. Hence, preferring foliage feeders as an integrative tools can be a trust worthy option.

The most effective integration of chemical fertilizers along with bio inoculants and foliar feeding offers a greater edge in production rather than moving with complete organic or inorganic principle. The RDF for onion is 100:50:50 NPK kg ha^{-1}, but with effective integrated approach fertilizer requirement can be brought down by 25 to 50% and reduction in cost of production. The yearly price trend analysis confirms the onion prices lies between ₹ 1500 to ₹ 4500 q^{-1} which can generate B:C ratio of 1:2.25 in deflated prices an up to 1:3.74 in stable market rates. (Jain and Gupta, 2018). The largest onion market of Asia 'Lasalgaon Agricultural Produce Market Committee (APMC)' and many other onion oriented markets *viz.* Vashi, Kolhapur *etc*. channelized the produce of farmers at MEP (Minimum Export Price) under efficient counsel of World Bank which eternal led the farmers about substantiate producer a fair price.

Conclusively, the inflated rates of fertilizers are clawing benefit cost of producer. Hence, with

integrated nutrient management approach fertilizer use efficiency of applied fertilizers and those stabilised in soil can be utilised by bio inoculants *Azospirillum*, *PSB* and *KSB* along with it foliar spray can be pertinent. Hence, by use of integrally designed treatments estimation of least cost combination of nutrients can be fabricated, which can offer reduction in usage of chemical fertilizers and holds the key in enhancing the productivity as well as quality of produce in an eco-friendly manner.

Materials and Methods

The present investigation entitled "Integrated nutrient management on growth and yield of *kharif* onion (*Alliumcepa* L.)" was conducted during *kharif* 2021 at Agronomy farm, B – Division, Plot No – 5, College of Agriculture, Pune. There were ten treatments *viz.*, T_1 (Control), T_2 (100% Recommended Dosage of Fertilizer 100:50:50 NPK kg ha^{-1}), T_3 (75% RDF + 1% foliar spray of 19:19:19 at 30 & 45 DAT), T_4 (75% RDF + 1% foliar spray of 19:19:19 at 30 DAT + *Azospirillum* + *PSB* &*KSB*), T_5 (50% RDF + 1% foliar spray of 19:19:19 at 30 & 45 DAT), T_6 (50% RDF + 1% foliar spray of 19:19:19 at 30 DAT + *Azospirillum* + *PSB* &*KSB*), T_7 (75% RDF + 1% foliar spray of 13:40:13 at 30 & 45 DAT), T_8 (75% RDF + 1% foliar spray of 13:40:13 at 30 DAT + *Azospirillum* + *PSB* &*KSB*), T_9 (50% RDF + 1% foliar spray of 13:40:13 at 30 & 45 DAT) and T_{10} (50% RDF + 1% foliar spray of 13:40:13 at 30 DAT + *Azospirillum* + *PSB* &*KSB*)The soil of the experimental field was clay loam in texture, low in available nitrogen (168.61 kg ha^{-1}), medium in available phosphorus (18.88 kg ha^{-1}) and high in available potassium (378.41 kg ha^{-1}) while medium in organic carbon (0.51 %), neutral in reaction (pH 7.14) and EC was (0.49 dSm^{-1}). Biologically *Azospirillum* count was high (9.10 cfu × 10^7 g^{-1} of soil), *phosphate solubilizing bacteria* count was medium (11.12 cfu × 10^7 g^{-1} of soil) and *potassium solubilising bacteria* was medium (8.10 cfu × 10^7 g^{-1} of soil). The onion variety '*PhuleSamarth'* seed was sown on 25th June - 2021 which was 40 days prior to transplanting. The transplanting was done on 6th August - 2021 at spacing of 30 × 10 cm^2 in ridges and furrow irrigation layout. The 50% N and full dosage of P_2O_5 and K_2O was given as basal dosage, the remaining 50% N was given in two equal splits of 25% each at 30 and 45 DAT, also biofertilizers and foliar sprays were timely initiated as per the treatment details. The seedlings were dipped in a manually prepared mixture of Chlorpyriphos 20% EC (Insecticide) + Carbendazim 50% WP (Systemic Fungicide) both @ 0.2% to control Soil borne fungi and insect pest attack on newly transplanted seedlings of onion. The plant height was measured from the ground level to the tip of longest leaf when leaves were held in vertical position using measuring scale. The neck thickness, polar and equatorial diameter was recorded using standardized Vernier calliper. The yield was calculated by weighing onion bulbs from net plot. Grade wise sorting of bulbs was done with standard of A grade bulbs of size range (> 65 mm or > 6.5 cm), B grade bulb of size range (45 to 65 mm or 4.5 to 6.5 cm) and C grade bulb of size range (< 45 mm or < 4.5 cm), respectively. The available nutrient status after harvest and total uptake was analysed using standard procedures. The microbial count was estimated by using serial dilution agar plate technique. The economics were calculated using standard procedure for estimation of cost of cultivation. The data were analysed statistically as per standard procedure.

Results and Discussion

Growth studies

The growth of onion crop was evaluated in terms of plant height, neck thickness, number of leaves $plant^{-1}$, dry matter $plant^{-1}$ and days to maturity. The results of application of different fertilizer levels along with biofertilizers and foliar sprays revealed that maximum plant height (69.98 cm), neck thickness (1.68 cm) and number of leaves $plant^{-1}$ (11.40) was observed at 84 DAT, Similarly, highest dry matter $plant^{-1}$ (26.26 g) and highest days to maturity (142.33) was recorded with the application of treatment T_4 - 75% RDF + 1% foliar spray of

19:19:19 at 30 DAT + *Azospirillum* + *PSB* &*KSB*. Higher plant height and neck thickness might be dueto appropriate fertilizer dosage and inherent plant growth regulators Indole acetic acid and Indole lactic acid associated with *Azospirillum* which might had promoted root and shoot development in onion plant and had fixed substantial amount of atmospheric nitrogen.

Biofertilizers promoted proliferation and nutrient based establishment of roots leading to profuse vegetative growth. Furthermore, significant increase in number of leaves plant^{-1} is stimulated by higher availability of nitrogen and phosphorus due to healthy biofertilizers strains and cytokinins prompted stimulatory metabolic activities of cell division, expansion and tissue differentiation. The more is the tissue augmentation the higher number of axillary buds are formed in bulb region of modified leaves. These axillary buds are elementary and conclusive parameters for higher number of leaves plant^{-1}. Similarly, increment in dry matter plant^{-1} might be due to appropriate fertility level of N and attainment of atmospheric N to the plant rhizosphere due to *Azospirillum* which promoted higher vegetative growth. Initially applied P and bio inoculants of *PSB* promoted prolific root establishment which induced higher nutrient uptake.

Furthermore, applied K and *KSB* regulated higher synthesis, transportation and storage of photo assimilates in the form of carbohydrates and starch in the bulb scales of onion. This storage of accumulated matter leads to thickening of scales ultimately leading to higher bulb weight and diameter of bulb. All these nutritive aspects provoked higher photosynthesis and eventually lower respiration accelerated progressive increment regarding plant height (cm), neck thickness (cm), number of leaves plant^{-1}, number of scales bulb^{-1}, diameter and fresh weight of bulb which ultimately helped in significant increase in dry matter plant^{-1}. The days required for maturity was found non-significant among all treatments. These findings are in close conformity with outcomes revealed by Yogita and Ram (2012); Vachan and Tripathi (2015); Kaur and Singh (2017); Kumar *et al.*, (2018); Deshmukh *et al.,* (2019) in onion crop.

Yield and quality studies

The evaluation of yield was done by taking polar diameter, equatorial diameter, number of scales bulb^{-1}, fresh weight bulb^{-1} and yield into consideration. The significant increase in polar and equatorial diameter (6.70 and 6.93 cm), number of scales bulb^{-1} (11.74), fresh weight bulb^{-1} (157.57 g), yield (300.21 q ha^{-1}) was observed with application of T_4 - 75% RDF + 1% foliar spray of 19:19:19 at 30 DAT + *Azospirillum* + *PSB* &*KSB*.

The superiority in yield attributed might be due to the cytokinins secreted by *Azospirillum* stimulated higher cell division and cell expansion in the axillary bud region leading to formation of numerous scales. Simultaneously, the applied K through foliar sprays, fertilizers and significant K availability to the onion plants might had led to higher synthesis, transportation and storage of photo assimilates. The scales are crucial part for storage of assimilated material. Hence, the storage of starch and carbohydrates in scale region had thicken the scales and plant growth regulator triggered higher number of scales. Furthermore, N improved green colour and improvement in chlorophyll content biosynthesis, which in turn led to improved photosynthetic productivity and equates to a higher net assimilation rate activities. Ultimately deposition of starch and carbohydrates justifies higher scale thickness and *Azospirillum* associated cytokinins might had induced numerous modified leaves due to axillary buds which justifies the significant increase in number of scales bulb^{-1}. Hence, increase in number and thickness of scale in conclusive reason for higher polar and equatorial diameter, fresh weight and yield of onion crop. Furthermore, these significant characters are leading to higher percentage of A grade bulbs (57.28 %), respectively. These results are in corroboration with outcomes recorded by Shinde *et al.,* (2013); Dhaker *et al.*, (2017); Mahala *et al.,* (2018); Nirala *et al.,* (2019); Kumar *et al.,* (2019) in onion.

Table.1 Plant height and Neck thickness of onion as influenced by different treatments

Tr. No	Plant height (cm)				Neck thickness (cm)			
	28 DAT	56 DAT	84 DAT	At harvest	28 DAT	56 DAT	84 DAT	At harvest
T_1	21.87	31.38	41.14	34.48	0.90	1.09	1.21	1.06
T_2	36.36	55.88	65.65	60.65	0.93	1.33	1.53	1.39
T_3	31.24	45.65	53.74	48.55	0.93	1.31	1.41	1.34
T_4	37.27	57.67	69.98	62.50	0.94	1.52	1.68	1.51
T_5	26.64	36.13	46.13	38.51	0.93	1.29	1.37	1.25
T_6	28.08	39.94	50.65	42.39	0.91	1.31	1.43	1.30
T_7	29.72	44.74	52.79	47.06	0.93	1.32	1.40	1.30
T_8	37.16	57.05	68.97	60.77	0.94	1.48	1.58	1.44
T_9	25.04	33.52	44.48	37.14	0.92	1.24	1.37	1.23
T_{10}	26.04	38.66	49.39	40.79	0.95	1.29	1.41	1.28
S.Em. ±	1.42	0.66	1.47	0.62	0.07	0.04	0.05	0.03
C.D. @5%	4.23	1.98	4.38	1.86	NS	0.14	0.18	0.11
General Mean	29.94	44.06	54.29	47.28	0.93	1.32	1.44	1.31

Table.2 Number of leaves plant^{-1}, Dry matter plant^{-1} and Days to maturity of onion as influenced by different treatments

Tr. No	Number of leaves plant^{-1}				Dry matter plant^{-1} (g)				Days to Maturity
	28 DAT	56 DAT	84 DAT	At harvest	28 DAT	56 DAT	84 DAT	At harvest	
T_1	5.90	6.80	8.00	6.93	2.90	6.17	8.65	9.24	137.67
T_2	7.20	8.27	10.07	9.40	5.35	10.00	20.03	20.92	140.33
T_3	6.60	7.48	9.67	9.07	5.06	9.71	18.84	19.31	139.67
T_4	7.78	8.77	11.40	10.27	6.72	12.75	25.08	26.26	142.33
T_5	6.13	7.17	8.87	7.73	4.17	7.88	13.55	14.34	138.67
T_6	6.50	7.42	9.20	7.93	4.72	8.90	14.73	15.23	139.00
T_7	6.53	7.45	9.47	8.40	4.93	9.24	17.67	18.74	139.67
T_8	7.60	8.33	10.93	10.20	6.49	12.52	21.98	23.67	141.67
T_9	6.07	7.06	8.60	7.67	3.64	7.45	13.62	14.01	139.33
T_{10}	6.33	7.26	8.93	7.93	4.53	8.42	14.37	14.82	138.33
S.Em. ±	0.36	0.18	0.48	0.29	0.43	0.87	1.64	1.18	1.15
C.D. @5%	1.07	0.55	1.42	0.87	1.30	2.61	4.89	3.51	NS
General Mean	6.67	7.60	9.51	8.55	4.85	9.31	16.85	17.65	139.67

Table.3 Yield and quality attributes of onion as influenced by different treatments

Tr. No	Diameter (cm)		No. of scales bulb^{-1}	Fresh weight bulb^{-1} (g)	Yield (q ha^{1})	AGB (%)	BGB (%)	CGB (%)
	Polar	Equatorial						
T_1	3.91	4.15	7.27	32.35	94.62	29.47	62.04	8.49
T_2	5.34	5.52	10.47	133.57	274.21	51.18	26.98	21.85
T_3	5.07	5.49	10.27	110.22	251.12	42.32	42.27	15.40
T_4	6.70	6.93	11.74	157.57	300.21	57.28	31.47	11.59
T_5	4.65	4.84	9.20	91.72	147.19	35.31	54.78	9.91
T_6	4.90	5.25	9.53	97.25	182.51	38.42	46.78	14.81
T_7	4.94	5.38	10.20	106.49	241.19	41.06	41.47	17.47
T_8	6.50	6.90	11.33	156.38	296.79	53.98	31.59	14.43
T_9	4.46	4.45	9.07	82.61	141.23	33.84	56.45	9.72
T_{10}	4.70	5.07	9.27	93.32	175.36	37.60	51.42	10.98
S.Em. ±	0.45	0.47	0.31	7.72	3.46	0.35	0.58	0.60
C.D. @5%	1.34	1.40	0.96	21.26	10.30	1.05	1.73	1.80
General Mean	5.12	5.40	9.83	106.15	210.45	42.05	44.52	13.46

Table.4 Nitrogen balance of onion as influenced by different treatments

Tr. No.	Initial N + Added N (kg ha^{-1})	Total N uptake (kgha^{-1})	Available N after harvest (kg ha^{-1})	Net gain or loss (kg ha^{-1})
T_1	168.61	61.47	93.03	-75.59
T_2	268.61	107.90	176.21	7.60
T_3	243.61	105.34	156.08	-12.53
T_4	243.61	120.96	186.08	17.47
T_5	218.61	81.75	142.20	-26.41
T_6	218.61	93.42	159.23	-9.38
T_7	243.61	102.74	153.32	-15.29
T_8	243.61	117.12	182.70	14.09
T_9	218.61	78.70	148.18	-20.43
T_{10}	218.61	87.88	159.12	-9.49
General Mean	228.61	95.73	155.61	-12.99

Table.5 Phosphorous balance of onion as influenced by different treatments

Tr. No.	Initial P + Added P (kg ha^{-1})	Total P uptake (kgha^{-1})	Available P after harvest (kg ha^{-1})	Net gain or loss (kg ha^{-1})
T_1	18.88	13.55	8.77	-10.11
T_2	68.88	39.30	27.14	8.26
T_3	56.38	36.16	23.39	4.51
T_4	56.38	45.18	34.21	15.33
T_5	43.88	25.38	23.43	4.55
T_6	43.88	27.84	30.36	11.48
T_7	56.38	32.36	22.43	3.55
T_8	56.38	44.16	32.88	14.0
T_9	43.88	21.00	20.80	1.92
T_{10}	43.88	27.38	29.40	10.52
General Mean	48.88	31.23	25.28	6.40

Table.6 Potassium balance of onion as influenced by different treatments

Tr. No.	Initial K + Added K (kg ha^{-1})	Total Kuptake (kg ha^{-1})	Available K after harvest (kg ha^{-1})	Net gain of loss (kg ha^{-1})
T_1	378.41	46.24	291.20	-87.21
T_2	428.41	92.02	364.11	-14.30
T_3	415.91	80.82	341.45	-36.96
T_4	415.91	101.15	404.55	26.14
T_5	403.41	62.42	311.22	-67.19
T_6	403.41	68.55	391.71	13.3
T_7	415.91	74.61	332.64	-45.77
T_8	415.91	98.71	402.70	24.29
T_9	403.41	55.91	306.54	-71.87
T_{10}	403.41	65.52	386.63	8.22
General Mean	408.41	74.58	353.28	-25.13

Table.7 Microbial count of *Azospirillum*, *PSB* and *KSB* in onion as influenced by different treatments

Tr. No.	Microbial count (cfu x 10^7 g^{-1} of soil)		
	Azospirillum	***P.S.B***	***K.S.B***
T_1	9.19	9.49	10.46
T_2	12.77	12.37	12.37
T_3	11.17	12.36	12.30
T_4	39.17	33.56	33.31
T_5	10.60	11.07	11.12
T_6	32.16	31.32	28.82
T_7	10.94	11.45	12.22
T_8	38.28	33.01	32.78
T_9	9.25	10.63	10.70
T_{10}	29.59	29.57	28.11
S.Em. ±	0.55	0.33	0.60
C.D. @5%	1.65	0.98	1.80
General Mean	20.31	19.48	19.22
Initial microbial count	9.10	11.12	8.10

Table.8 Economics of onion as influenced by different treatments

Tr. No.	Gross monetary returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net Monetary returns (₹ ha^{-1})	B:C Ratio
T_1	224504	121226	103278	1.85
T_2	675198	212342	462856	3.17
T_3	611737	200676	411061	3.04
T_4	793716	236860	556856	3.35
T_5	356198	151231	204967	2.35
T_6	438227	168759	269468	2.59
T_7	579048	195019	384029	2.96
T_8	763045	231358	531687	3.29
T_9	339847	148625	191222	2.28
T_{10}	426652	166820	259832	2.55
General Mean	520817	183291	337525	2.74

Chemical studies

The nutrient use efficiency was estimated by analysing Total nutrient uptake, Available nutrient in soil after harvest of onion and net gains or losses equations. The application of T_4 - 75% RDF + 1% foliar spray of 19:19:19 at 30 DAT + *Azospirillum* + *PSB* & *KSB* recorded maximum total nutrient uptake N (120.96 kg ha^{-1}), P (45.18 kg ha^{-1}) and K (101.15 kg ha^{-1}). In spite of higher uptake the available nutrient status was also significantly superior with available N, P and K (186.08, 34.21 and 404.55 kg ha^{-1}). Furthermore, the comparative study of initial nutrient status and available nutrient status after

harvest revealed that the net gain with illustrated treatment was (17.47, 15.33 and 26.14 N, P and K kg ha^{-1}), respectively. The significance in all the chemical might be due to the root zone owning to better development of nutritional environment nearby rhizosphere. *Azospirillum* might have fixed higher amount of nitrogen in soil which ultimately increased uptake of nitrogen. Similarly, *PSB* and *KSB* stimulated higher solubilisation of phosphorus and potassium which ultimately increased uptake of nutrient. The foliar sprays has 100 % solubility and seven times higher utilisation as compared to application of straight fertilizers alone. Furthermore, the reduction in recommended dosage of fertilizer as per experimental demand by 25% might have been satisfied by bio inoculants by microbial actions associated with atmospheric nitrogen and relying on feldspar and mica to generate low molecular weight organic acids which are core substances to provide utilisable K in ample quantity as onion requires higher K. Eventually all these factors of appropriate fertilizer dosage, biofertilizers and timely application of foliar spray enhanced total nutrient uptake. Secondly, Available nutrient in soil after harvest of onion was also inflated, this might be due to combined application of inorganic fertilizer levels along with biofertilizers and foliar sprays enriched the soil nutrient status and hence residual N, P_2O_5 and K_20 was higher. Similarly, macro nutrients present in fertilizers was available for the nutrition of crop and by application of biofertilizers (*Azospirillum*, *PSB* and *KSB*) it might had increased the available NPK content in soil by atmospheric N fixation and relying on inherent P and K based minerals for satisfying demand of potassium and phosphorous by formation of microbial colonies associated with these minerals. Hence, there is surplus availability of N, P and K in soil. These results are in close alignment with Ngullie *et al.*, (2010); Chopra *et al.*, (2017); Deshpande *et al.*, (2019) regarding onion crop.

Biological studies

The higher microbial count regarding treatment T_4, T_6, T_8 and T_{10}might be due to extrinsic treatment based application of *Azospirillum*, *PSB* and *KSB* at the time of transplanting acted as microbial colony inoculant and the recommended dosages of fertilizers were altered by 25 and 50% which created shortage between requirement and applied availability.

The diminution in applied fertilizers is the ultimate factor in accretion of microbial colonies the reason being for satisfying the demand of N, P and K which is not completely fulfilled by altered RDFs the *Azospirillum*, *PSB* and *KSB* plays prominent role to satisfying the demand. *Azospirillum* fixed atmospheric N, *PSB* solubilised potassium by utilising mica and feldspar and *KSB* solubilised phosphorous by utilising apatite and rock phosphate inherently present in soil. Hence in pursuit of making availability of nutrients to meet crop demand multiplication of biofertilizers is seen. Similar outcomes were reported by Talwar *et al.*, (2017); Vaghela (2018) and Ranjan *et al.*, (2019) in onion crop.

Economic studies

The maximum gross monetary return (793716 ₹ ha^{-1}) and net monetary returns (556856 ₹ ha^{-1}) as well as B:C ratio (3.35) was obtained with the application of treatment T_4 -75% RDF + 1% foliar spray of 19:19:19 at 30 DAT +*Azospirillum* + *PSB*&*KSB* than all other treatments. The indicative increase in monetary returns is due the higher bulb yield as compared to all other treatments, along with that percentage of A grade bulb production was also elevated which has 49% higher market value as compared to B grade bulbs and was thrice the value of C grade bulbs. Hence, all these market-oriented parameters are influential in increasing net monetary return (₹ ha^{-1}). These monetary returns are in close corroboration with outcomes reported by Mehta *et al.*, (2017); Singh *et al.*, (2017) and Vachan and Tripathi (2018) regarding onion crop.

On the basics of present investigation regarding onion crop the application of 75% RDF + 1% foliar spray of 19:19:19 at 30 DAT + *Azospirillum* + *PSB*

&*KSB* was found superior in respect to growth, yield and quality attributes of onion. Furthermore, total nutrient uptake, available nutrient status after harvest and net gain of macro nutrients was also found superior in comparison to rest of the treatments. Conclusively, the illustrated treatment also recorded higher outcomes regarding net monetary returns (556856 ₹) and B:C ratio (3.35), respectively.

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