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Effect of NPK through Chemical Fertilizers Combination with Farm Yard Manure (FYM) and Bio-fertilizers on Yield Attributes of Onion (*Allium cepa* L.) in Jaipur Region of Rajasthan, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted in loamy sand soil of the Horticulture farm, Vivekanand Global University Jaipur, during Rabi season of 2020-21 and 2021-22. The experiment comprises of 32 treatment combinations replicated three times was laid out in split-plot design (SPD) with four

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fertility levels of NPK (0, 50, 75 and 100% of recommended dose of NPK) and two levels of FYM (without FYM and with FYM @ 25 t ha-1) were added in main plots. Four bio-fertilizer levels (No inculcation, N2 fixer Azotobacter, PSB inculcation and N2 fixer Azotobacter + PSB inoculation) were added in sub plots. The treatments comprised of Chemical fertilizers, FYM and biofertilizers with ten treatments Viz., F0- Control, F1-50% of recommended dose of NPK, F2-75% of recommended dose of NPK, F3-100% of recommended dose of NPK, M0- Without FYM, M1- With FYM @ 25 t ha -1, B0- No inoculation, B1- N2 fixer Azotobacter, B2- PSB inoculation and B3- N2 Fixer Azotobacter + PSB inoculation, respectively. The results of the study have clearly shown that application of chemical fertilizer up to 100% RDF increased the entire yield and its attributes viz. (neck length, bulb diameter, number of scales, fresh weight of bulb, volume of bulb). With application of FYM @ 25 t ha-1 yield significantly improved with its attributes. Use of biofertilizers (N2 fixers Azotobacter + PSB inoculation) in combination or alone increased all yield and its attributes. Integrated system approach is not only the liable for attaining fairly high productivity with substantial fertilizer economy but also a concept of soundness leading to sustainable agriculture

Keywords: Azotobacter; biofertilizers; FYM; N2 fixers; PSB inoculation.

1. INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops cultivated extensively in India [1] and It is native of the Central Asia and Mediterranean region and commercially grown in China, India, U.S.A., erstwhile U.S.S.R., Japan, Spain, Turkey, Brazil, Egypt etc it belongs to family Alliaceae [2]. “India is second largest producer of onion after china in the world, cultivating onion over an area of 1173.4 thousand hectare with total production of 203.3 lakh tonnes” [3]. “Onion is considered to be the second most important vegetable crop grown in the world after tomato. Onion is liked for its flavor and pungency in onion is due to presence of a volatile oil ‘allyl propyl disulphide’- organic compound rich in Sulphur” [4]. “The beneficial compound called ‘quercetin’ present in onion is a powerful antioxidant” [5].

“In the world production of onion, India has second place after China. In the foreign exchange point of view, onion ranks first in vegetables” [2]. “Yellow type onion constitutes a bulk (80%) of the world trade particularly in European market, red colored constitutes 20% of the world trade, major share of the market being in the Asian countries” [6]. “In India, only red onions are exported and our export is limited up to 20% of the world trade. India exports the onion to U.A.E., Malaysia, erstwhile U.S.S.R., Kuwait, Sri Lanka, Singapore etc. Maharashtra is the leading producer state of onion in India. It is mainly grown during *Rabi* season and harvested during summer in the month of April and May**.** In India, onion is grown in an area of 1.28 million ha with a production of 23.26 million ton and productivity 18.1 MT/ha as per Anonymous” [7]. “In India, the major onion producing states are Maharashtra, Madhya Pradesh, Karnataka, Gujarat etc. Maharashtra is the highest onion producing state contributing about 30.41 per cent. In Rajasthan, onion occupies an area 64.76 thousand ha with the production 996.73 thousand ton and productivity 15.39 MT/ha” [7]. “In Rajasthan, major onion producing districts are Jodhpur, Sikar, Nagaur, Alwar, Jaipur etc. It is a unique vegetable that is used throughout the year in the from the salador condiment or for cooking with other vegetables. Onion is also used in preparing souyps, sauces, curries, pickles and for flavoring or seasoning food” [8].

“Use of organic manure and biofertilizers in conjunction with chemical fertilizers has been found to be promising in not only sustaining higher productivity but also providing stability in crop production” [9-11]. “The farmyard manure seems to act directly for increasing crop yield by accelerating the respiratory process through cell permeability or by hormones through growth action” [11]. “In recent years, use of vermicompost has been advocated in integrated nutrient management (INM) system in vegetable crops. The pioneers of organic farming advise use of vermicompost as an organic manure and substitute for chemical fertilizer” [12]. “Biofertilizers are products containing living cells of different types of microorganism, which have an ability to convert nutritionally important elements to available form through biological processes” Vijaykumar *et al.* [13].

“Further, knowing the deleterious effect of using only chemical fertilizers on soil health, use of chemical fertilizers supplemented with organic waste and biofertilizers will be environmentally

benign. Therefore, biofertilizers are widely accepted as low cost supplements to chemical fertilizers with no deleterious effect on either soil health or environment Bhagyaraj and Suvarna" [14]. "Among biofertilizers, *Azotobacter* strains play a key role in harnessing the atmospheric nitrogen through its fixation in the roots. VAM symbiosis facilitates plant growth through enhancing uptake of several macro and micro nutrients of low mobility in soil, like phosphorus, zinc and copper Dipankar" [15].

"The alternative nutrient sources e.g., organic fertilizers have been applied to reduce the load of chemical fertilizers. In recent years, organic manures and biofertilizers used as an important component of nutrient supply system and to improve crop yield" Shah et al. [16]. Integrated nutrient management is an appropriate approach towards sustainable agriculture. Sustainable agriculture should involve successful management of resources for agriculture to satisfy changing human needs while maintaining or changing the environment and conserving natural resources. Integrated nutrient supply approach for the crop by judicious mixture of organic manure along with the inorganic fertilizers has a number of agronomical and environmental efficiency. Integrated system approach is not only the liable for attaining fairly high productivity with substantial fertilizer economy but also a concept of soundness leading to sustainable agriculture Swaminathan [17].

2. MATERIALS AND METHODS

The present experiment was conducted at Horticulture farm, Vivekanand Global University, Jaipur, during *Rabi* season of 2020-21 and 2021-22 was laid out in split-plot design in both the years with 32 treatment combinations replicated thrice. Jobner in situated at 26.5^0 North latitude, 75.20^0 East longitude and an altitude of 427 meters above mean sea level, in Jaipur district of Rajasthan. This region falls under Agro-climatic zone IIIA (Semi- Arid Eastern Plain) of the state. The climate of Jobner is typically semi-arid characterized by extremes of temperature both in summer and winter with low rainfall and moderate relative humidity. Maximum temperature in summers is as high as 45 ^{0}C and minimum temperature in winters fall around 0 ^{0}C. To find out the effect of conjoint use of NPK through chemical fertilizers with FYM and bio-fertilizers on growth and yield of onion. The soil of experimental field was loamy sand in texture, slightly alkaline in reaction, poor in organic carbon with low available nitrogen, phosphorus and sulphur and medium in potassium status.

The treatments comprised of Chemical fertilizers, FYM and biofertilizers with ten treatments *Viz.,* F_0- Control, F_1-50% of recommended dose of NPK, F_2-75% of recommended dose of NPK, F_3-100% of recommended dose of NPK, M_0-Without FYM, M_1- With FYM @ 25 t ha^{-1}, B_0- No inoculation, B_1- N_2 fixer *Azotobacter* , B_2- PSB inoculation and B_3- N_2 Fixer *Azotobacter* + PSB inoculation, respectively. The treatments of chemical fertilizers, FYM, and bio-fertilizers were applied as per treatment in respective plot. The spacing 15 cm row to row and 10 cm plant to plant was maintained. The seedlings were transplanted in cool evening according to the layout plan. A light irrigation was applied just after the transplanting and subsequent irrigation was given at an interval of 10-12 days depending upon the soil condition. Harvesting of onion was done on last week of May, 2020 and 2021. The data recorded during the course of investigation was subjected to statistical analysis by analysis of variance (ANOVA) using SPSS statistical software version 22. Treatment means were separated using Fisher's Least Significant Difference (LSD) test at 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Yield Attributes

The data presented in Table 1 indicate that neck thickness of bulb increased significantly with increasing level of fertility during both the years and in pooled mean. The application of NPK @ 100% RDF had significantly higher mean neck thickness of bulb by 52.71, 19.32 and 4.12over control, 50 and 75% RDF, respectively. It is further evident from data presented in Table 1 that application of FYM @ 25 t ha^{-1} significantly increased the neck thickness of onion to the extent of13.56 per cent over no FYM application. use of different bio-fertilizer alone or in combination differently influenced the neck thickness of onion during both the years of investigation and in pooled analysis. Combined application of *Azotobacter* and PSB was observed to be the most superior treatment with regard to onion neck thickness (1.056 cm) that registered an increase of 25.94, 10.40 and 11.63 percent over control, *Azotobacter* and PSB, respectively. These results are supported by the findings reported by Dhaker et al. [18] who studied the effect of different organic manures on growth and yield of onion.

Table 1. Effect of NPK, FYM and bio-fertilizers on neck thickness

Treatment	Neck thickness (cm)		
	2021-22	2022-23	Pooled mean
Fertilizers			
F_0 = Control	0.752	0.688	0.720
F_1 = 50 % RDF	0.949	0.894	0.922
F_2 = 75 % RDF	1.093	1.019	1.056
F_3 = 100 % RDF	1.137	1.062	1.100
SEm+	0.018	0.020	0.013
CD (p=0.05)	0.053	0.059	0.039
FYM			
M_0 = Control	0.902	0.858	0.880
M_1 = 25 t ha^{-1}	1.063	0.973	1.018
SEm+	0.013	0.014	0.009
CD (p=0.05)	0.038	0.041	0.027
Biofertilizers			
B_0 = Control	0.879	0.798	0.839
B_1 = *Azotobacter*	0.981	0.932	0.957
B_2 = PSB	0.976	0.916	0.946
B_3 = *Azotobacter* + PSB	1.095	1.017	1.056
SEm+	0.018	0.019	0.013
CD (p=0.05)	0.050	0.053	0.036

The data pertaining to neck length (cm) for both years and their pooled mean are presented in Table 2. The data revealed that different levels of fertility, FYM and biofertilizers significantly influenced the neck length during both the years as well as in pooled analysis. Progressive increase in level of fertility from control to 100 % RDF brought about significant improvement in neck length over preceding levels. The maximum neck length (6.96 cm) was recorded with the 100 % RDF which was higher by 41.65, 18.18 and 4.27 per cent over control, 50 and 75% RDF, respectively. However, the 75% and 100% RDF remained at par during both the years and in pooled mean analysis. Application of FYM also had significant effect on neck length during both the years as well as in pooled analysis. Application of FYM @ 25 t ha^{-1} increased the neck length to the extent of 21.69 per cent over no FYM application.

Use of bio-fertilizer alone or in combination was significantly beneficial in terms of neck length of bulb. Use of *Azotobacter* and PSB led to 11.20 and 7.23 per cent increase in neck length of bulb over no inoculation. The effect of combined use of *Azotobacter* along with PSB additive leading to an overall increase of 22.76 percent over to control in necklength of bulb. Table 3. shows that different levels of fertility, FYM and biofertilizers significantly influenced the equatorial diameter of bulb during both the years and in pooled analysis. The maximum mean equatorial diameter (7.15 cm) was observed with 100 % level of fertility followed by 75 % level of fertility (7.00 cm) but these were at par with each other. Minimum equatorial diameter was recorded in control (5.72 cm), which was 12.14, 22.36 and 24.98 per cent lower to 50, 75 and 100 percent RDF, respectively.

Application of FYM also had significant effect on neck length during both the years as well as in pooled analysis. Application of FYM @ 25 t ha^{-1} increased the neck length to the extent of 21.69 per cent over no FYM application. It is also evident from the data that use of bio-fertilizers alone or in combination significantly increased the equatorial diameter of bulb. Use of *Azotobacter* and PSB increased the equatorial diameter to the extend of 16.62 and 13.87 per cent, respectively over control. However, combined application of *Azotobacter* + PSB represented the maximum increase of 22.57 per cent over no inoculation. The use of FYM in improvement of quality and yield of vegetable and spices has been emphasized in recent years still there left a ground to evaluate it performance as short term benefits for onion production along with long term soil rejuvenation in environmentally friendly way [19].

A critical study of the data presented in Table 3 and appendices- 1, 2 indicated that polar

diameter was significantly increased with every increase in level of fertility during both the years as well as in pooled analysis. Application of 50 and 75 %fertility levels represented the polar diameter of 6.57 and 2.75 cm, which was 12.04 and 15.13 per cent higher than control. However, application of 100 % RDF being at par with application of 75% RDF, witnessed the highest polar diameter (6.17 cm) and it registered an increase of 15.13, 12.04 and 8.03 percent over control, 50 and 75%RDF, respectively. Integrated nutrient supply approach for the crop by judicious mixture of organic manure along with the inorganic fertilizers has a number of agronomical and environmental efficiency.

Table 2. Effect of NPK, FYM and bio-fertilizers on equatorial diameter of bulb

Treatment	Equatorial diameter of bulb (cm)		
	2021-22	2022-23	Pooled mean
Fertilizers			
F_0 = Control	5.80	5.65	5.72
F_1 = 50 % RDF	6.54	6.30	6.42
F_2 = 75 % RDF	7.09	6.92	7.00
F_3 = 100 % RDF	7.26	7.05	7.15
SEm±	0.09	0.09	0.06
CD (p=0.05)	0.26	0.26	0.18
FYM			
M_0 = Control	5.85	5.75	5.80
M_1 = 25 t ha^{-1}	7.49	7.21	7.35
SEm±	0.06	0.06	0.04
CD (p=0.05)	0.18	0.18	0.12
Biofertilizers	6.35	6.50	
B_0 = Control	5.91	5.70	5.81
B_1 = *Azotobacter*	6.85	6.69	6.77
B_2 = PSB	6.70	6.52	6.61
B_3 = *Azotobacter* + PSB	7.22	7.01	7.12
SEm+	0.08	0.08	0.06
CD (p=0.05)	0.23	0.24	0.17

Table 3. Effect of NPK, FYM and bio-fertilizers on polar diameter of bulb

Treatment	Polar diameter of bulb (cm)		
	2021-22	2022-23	Pooled mean
Fertilizers			
F_0 = Control	5.45	5.26	5.36
F_1 = 50 % RDF	5.89	5.68	5.79
F_2 = 75 % RDF	6.10	5.90	6.00
F_3 = 100 % RDF	6.28	6.05	6.17
SEm±	0.09	0.09	0.06
CD (p=0.05)	0.26	0.26	0.18
FYM			
M_0 = Control	5.78	5.61	5.70
M_1 = 25 t ha^{-1}	6.08	5.83	5.96
SEm±	0.06	0.06	0.04
CD (p=0.05)	0.18	0.19	0.13
Biofertilizers			
B_0 = Control	5.80	5.59	5.70
B_1 = *Azotobacter*	5.89	5.72	5.81
B_2 = PSB	5.85	5.66	5.76
B_3 = *Azotobacter* + PSB	6.18	5.92	6.05
SEm+	0.08	0.08	0.06
CD (p=0.05)	0.23	0.24	0.16

It may be conferred from the same data (Table 4) that FYM application to onion was found significantly superior in comparison to control. It registered 4.37 per cent more polar diameter over no application of FYM.

Data pertaining to effect of different bio-fertilizers on polar diameter presented in Table 4 indicated that polar diameter was increased appreciably by using the bio-inoculants in comparison to no inoculations. Microbial inoculation with *Azotobacter* + PSB was the best treatment in improving the polar diameter. The increase in polar diameter due to *Azotobacter* +PSB was 6.23, 4.22 and 5.13percentovercontrol, *Azotobacter* and PSB, respectively.

Table 4. Effect of NPK, FYM and bio-fertilizers on number of scales per bulb

Treatment	Number of scales per bulb		
	2021-22	2022-23	Pooled mean
Fertilizers			
F_0 = Control	6.37	4.81	5.59
F_1 = 50 % RDF	7.17	5.23	6.20
F_2 = 75 % RDF	7.77	5.45	6.61
F_3 = 100 % RDF	8.17	5.60	6.89
SEm±	0.10	0.09	0.07
CD (p=0.05)	0.30	0.26	0.19
FYM			
M_0 = Control	7.03	5.16	6.10
M_1 = 25 t ha^{-1}	7.71	5.38	6.55
SEm±	0.07	0.06	0.05
CD (p=0.05)	0.21	0.19	0.14
Biofertilizers			
B_0 = Control	7.03	5.14	6.09
B_1 = *Azotobacter*	7.43	5.27	6.35
B_2 = PSB	7.34	5.21	6.28
B_3 = *Azotobacter* + PSB	7.68	5.47	6.58
SEm+	0.09	0.08	0.06
CD (p=0.05)	0.27	0.24	0.18

Table 5. Effect of NPK, FYM and bio-fertilizers on fresh weight of bulb (g)

Treatment	Fresh weight of bulb (g)		
	2021-22	2022-23	Pooled mean
Fertilizers			
F_0 = Control	38.77	37.76	38.26
F_1 = 50 % RDF	47.57	46.64	47.10
F_2 = 75 % RDF	55.06	53.89	54.47
F_3 = 100 % RDF	57.04	55.93	56.48
SEm±	0.63	0.66	0.46
CD (p=0.05)	1.88	1.95	1.32
FYM			
M_0 = Control	43.75	42.55	43.15
M_1 = 25 t ha^{-1}	55.47	54.55	55.01
SEm±	0.45	0.46	0.32
CD (p=0.05)	1.33	1.38	0.93
Biofertilizers			
B_0 = Control	45.45	44.05	44.75
B_1 = *Azotobacter*	50.40	49.65	50.03
B_2 = PSB	48.85	48.80	48.83
B_3 = *Azotobacter* + PSB	53.74	51.71	52.73
SEm+	0.57	0.62	0.42
CD (p=0.05)	1.62	1.76	1.19

Data pertaining to the effect of integrated nutrient management on number of scales per bulb are presented in Table 5. Application of different levels of fertility had significant influence on number of scales per bulb in both years as well as pooled analysis. With the increase in levels of fertility from control to 100% RDF, a significant increase in number of scales per bulb was observed. The application of NPK @100% RDF increase the mean number of scales per bulb by 23.17, 18.25 and 10.91 percent over control, 50 and 75% RDF, respectively. Data further revealed that application of FYM significantly increased the number of scales during both years and in pooled analysis. The FYM applied @ 25 tha^{-1}increased the mean number of scales by 6.87 per cent over no FYM application.

It is also clear from the data that use of bio-fertilizers *viz. Azotobacter* and PSB alone or in combination significantly increased the number of scales per bulb. Use of *Azotobacter* and PSB increased the number of scales per bulb to the extent of 4.35 and 3.12 percent, respectively over control. However, combined application of *Azotobacter and* PSB represented the maximum increase of 8.05 percent over control.

It is evident from the data given in Table 6 fresh weight of bulb influenced significantly due to application of different level so fertility during both the years as well as in pooled analysis. Progressive increase in level of fertility to the soil rendered significantly higher fresh weight of bulb upto 100% RDF. The maximum mean fresh weigh t of bulb (56.48g) was obtained at this level, which was 47.62, 42.37 and 23.11percent higher over control, 50 and 75% RDF, respectively.

Application of FYM @ 25 t ha^{-1} significantly increased the fresh weight of bulb during both the years and in pooled mean (Table 6). Recording the fresh weight of bulb 55.01 g it witnessed profound increase of 21.56 per cent in pooled analysis, over no FYM application. The beneficial effect of organic manures on yield might be due to additional supply of plant nutrients and improved chemical, physical and biological properties of soil [20]. Our result was in close conformity with the findings of Bhati et al [20,21] who reported that higher levels of inorganic and organic fertilizers resulted in a higher bulb yield of onion [22].

Table 6. Interaction effect of NPK and FYM on fresh weight of bulb (g)

RDF levels	**FYM levels**	
2021-22	**M_0 = Control**	**M_1 = 25 t ha^{-1}**
F_0 = Control	34.19	43.35
F_1 = 50 % RDF	41.95	53.19
F_2 = 75 % RDF	48.56	61.56
F_3 = 100 % RDF	50.30	63.78
SEm+	0.90	
CD (p=0.05)	2.66	
2022-23		
F_0 = Control	33.09	42.42
F_1 = 50 % RDF	40.87	52.40
F_2 = 75 % RDF	47.23	60.55
F_3 = 100 % RDF	49.02	62.84
SEm+	0.92	
CD (p=0.05)	2.76	
Pooled mean		
F_0 = Control	33.64	42.89
F_1 = 50 % RDF	41.41	52.79
F_2 = 75 % RDF	47.89	61.06
F_3 = 100 % RDF	49.66	63.31
SEm+	0.65	-
CD (p=0.05)	1.87	-

It is also evident from the data (Table 7**)** that fresh weight of bulb was significantly improved due to all the inoculation treatments during each year of study as well as in pooled analysis. Inoculation with *Azotobacter* and PSB significantly increased the fresh weight of bulb to the tune of 11.79 and 9.11 per cent, respectively over control, while maximum fresh weight of bulb (52.73g) was obtained with the combined application of *Azotobacter* and PSB. Which was significantly 17.82, 5.40 and 7.99 per cent over control, *Azotobacter* and PSB, respectively.

Fresh weight of bulb was also significantly affected due to combined effect of different dose of fertility and application of FYM during both the years as well as in pooled analysis (Table 7). A perusal of pooled data presented in Table 7 revealed that application of 100 % RDF integrated with FYM @ 25 t ha^{-1} (F_3 M_1) recorded the significantly highest fresh weight of bulb(63.78 g) among all the treatment combinations. However, it was found statistically compatible with F_2 M_1 (61.56 g). These two treatment combinations significantly increased the fresh weight of bulb to the level of 55.57, 47.12, 42.02, 26.79, 22.70 per cent, respectively over F_1M_1, F_3M_0, F_2M_0, $F_0M_1$and F_1M_0 combinations, respectively. The increment in yield attributes in response to increased application of the fertilizers is attributable to the role of different nutrients in the plant in terms of enhancing photosynthetic rate and cell division, elongation and vegetative growth Gererufael et al. [20].

The results (Table 8) showed that volume of bulb was significantly affected by different levels of fertility in both years of study as well as pooled analysis. The mean data for both the years clearly indicate that 100 % RDF had maximum volume of bulb (57.33 cc) followed by 75 % (53.43 cc) and 50 % (48.00 cc) RDF. The mean volume of bulb with thetreatment100 % RDF was 37.73, 28.36 and 15.32 per cent more over control, 50 and 75%RDF, respectively. Volume of bulb was also influenced significantly by application of FYM in comparison to control. It registered 7.49 per cent more volume of bulb over no application of FYM (Table 8).

Data from Table 8 further indicate that inoculation of biofertilizers had significant effect on volume of bulb during both the years as well as pooled analysis. The highest mean volume of bulb was observed under inoculation with *Azotobacter* + PSB (53.61 cc) which was significantly superior over control (46.20 cc), *Azotobacter* (50.40 cc) and PSB (50.18 cc). It is in close conformity with the findings of Warade et al [23].

Table 7. Effect of NPK, FYM and bio-fertilizers on volume of bulb (cm3)

Treatment	Volume of bulb (cm^3)		
	2021-22	**2022-23**	**Pooled mean**
Fertilizers			
F_0 = Control	42.09	41.16	41.63
F_1 = 50 % RDF	48.55	47.45	48.00
F_2 = 75 % RDF	54.05	52.81	53.43
F_3 = 100 % RDF	57.65	57.01	57.33
SEm+	0.85	0.93	0.63
CD (p=0.05)	2.53	2.75	1.82
FYM			
M_0 = Control	48.41	47.88	48.15
M_1 = 25 t ha^{-1}	52.76	51.33	52.05
SEm+	0.60	0.66	0.44
CD (p=0.05)	1.79	1.95	1.29
Biofertilizers	8.24	9.15	
B_0 = Control	46.09	46.31	46.20
B_1 = *Azotobacter*	50.49	50.31	50.40
B_2 = PSB	50.34	50.01	50.18
B_3 = *Azotobacter* + PSB	55.42	51.80	53.61
SEm+	0.62	0.67	0.46

Table 8. Effect of NPK, FYM and bio-fertilizers on bulb yield per hectare (q)

Treatment	Bulb yield per hectare (q)		
	2021-22	2022-23	Pooled mean
Fertilizers			
F_0 = Control	169.89	164.08	166.98
F_1 = 50 % RDF	215.11	211.63	213.37
F_2 = 75 % RDF	252.57	244.34	248.45
F_3 = 100 % RDF	259.63	253.67	256.65
SEm±	3.58	3.92	2.66
CD (p=0.05)	10.64	11.65	7.69
FYM			
M_0 = Control	190.28	183.39	186.84
M_1 = 25 t ha^{-1}	258.31	253.47	255.89
SEm±	2.53	2.77	1.88
CD (p=0.05)	7.52	8.24	5.44
Biofertilizers			
B_0 = Control	213.77	205.58	209.68
B_1 = *Azotobacter*	226.92	222.62	224.77
B_2 = PSB	226.14	218.08	222.11
B_3 = *Azotobacter* + PSB	230.36	227.44	228.90
SEm+	2.36	2.57	1.75
CD (p=0.05)	6.69	7.28	4.91

Data presented in Table 9 revealed that bulb yield of onion was significantly influenced by application of different levels of fertility during both the years as well as in pooled analysis. Progressive increase in levels of fertility to the soil rendered significantly higher yield of onion bulbs upto 100 % RDF. The maximum mean bulb yield of 259.63 q ha^{-1} was obtained at this level which was 53.70, 20.29 and 3.30 per cent higher in comparison to control, 50 and 75 % RDF, respectively. It was followed accompanied by 75 and 50 % RDF which also witnessed 48.79 and 16.44 improvement in bulb yield of onion respectively, over control in pooled analysis. It is in close conformity with the findings of Muthuramalingam et al [24].

Table 9. Interaction effect of NPK and FYM on bulb yield per hectare (q)

RDF levels	FYM levels	
2021-22	**M_0 = Control**	**M_1 = 25 t ha^{-1}**
F_0 = Control	144.12	195.65
F_1 = 50 % RDF	182.49	247.73
F_2 = 75 % RDF	214.26	290.87
F_3 = 100 % RDF	220.25	299.00
SEm±	5.06	
CD (p=0.05)	15.05	
2022-23		
F_0 = Control	137.52	190.64
F_1 = 50 % RDF	177.37	245.88
F_2 = 75 % RDF	205.07	283.61
F_3 = 100 % RDF	213.61	293.74
SEm±	5.55	16.48
CD (p=0.05)	16.48	
Pooled mean		
F_0 = Control	140.82	193.15
F_1 = 50 % RDF	179.93	246.81
F_2 = 75 % RDF	209.67	287.24
F_3 = 100 % RDF	216.93	296.37
SEm±	3.75	
CD (p=0.05)	10.88	

Table 10. Interaction effect of NPK and FYM on bulb yield per hectare (q)

RDF levels	FYM levels	
2021-22	**M_0 = Control**	**M_1 = 25 t ha^{-1}**
F_0 = Control	144.12	195.65
F_1 = 50 % RDF	182.49	247.73
F_2 = 75 % RDF	214.26	290.87
F_3 = 100 % RDF	220.25	299.00
SEm+	5.06	
CD (p=0.05)	15.05	
2022-23		
F_0 = Control	137.52	190.64
F_1 = 50 % RDF	177.37	245.88
F_2 = 75 % RDF	205.07	283.61
F_3 = 100 % RDF	213.61	293.74
SEm+	5.55	16.48
CD (p=0.05)	16.48	
Pooled mean		
F_0 = Control	140.82	193.15
F_1 = 50 % RDF	179.93	246.81
F_2 = 75 % RDF	209.67	287.24
F_3 = 100 % RDF	216.93	296.37
SEm+	3.75	
CD (p=0.05)	10.88	

It is clear from the data presented in the same table that application of FYM @ 25 t ha^{-1} significantly enhanced the bulb yield of onion as compared with control. It is further evident from the data that use of different biofertilizers alone or in combination differentially influenced the bulb yield of onion during both the years of investigation and in pooled analysis. Use of *Azotobacter* and PSB remaining at par with each other significantly increased the bulb yield of onion to the extent of 7.20and 5.93 per cent respectively, over control. However, combined application of *Azotobacter* and PSB observed to be the most superior treatment with regard to onion bulb yield (228.44 q ha^{-1}) that registered a quantum increase of9.17, 1.84 and 3.06 q ha^{-1} over control, *Azotobacter*, and PSB, respectively. It is in close conformity with the findings of Ange [25].

Interactive effect of different levels of fertility and FYM application on bulb yield during both years as well as pooled data was also significant (Table 10). The data revealed that irrespective of FYM application the increasing level of fertilizers upto 75% RDF brought significant improvement in bulb yield of onion. Irrespective of fertility levels, the FYM application @ 25 t ha^{-} recorded significant higher bulb yield over control. In general, the combined application of F_2M_1 (75% RDF+25tha^{-1}FYM) remain significantly higher over other rest of treatments. However, this treatment combination was statistically at par with F_3M_1 (100% RDF+25t ha^{-1} FYM). Integrated nutrient supply approach for the crop by judicious mixture of organic manure along with the inorganic fertilizers has a number of agronomical and environmental efficiency. The present trend of increase in bulb yield in K application of nitrogen is in close conformity with the findings of Vachhani and Patel [26-30].

4. CONCLUSION

Maximum neck thickness, neck length, bulb diameter (equatorial and polar), number of scales per bulb, fresh weight of bulb, volume of bulb and bulb yield per hectare was recorded with 100% RDF fertility level. yield attributes viz. neck thickness, neck length, bulb diameter (equatorial and polar) number of scales per bulb, fresh weight of bulb, volume of bulb and bulb yield per hectare were significantly enhanced with the application of FYM. the combined application of biofertilizers viz. *Azotobacter* + PSB exhibited the maximum increase in yield attributes although inoculation with *Azotobacter* and PSB alone significantly increased the yield attributes over no inoculation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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