

Original Research Article

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Yield and Quality of *rabi* Onion (*Allium cepa* L.) Influenced by Integrated Nutrient Management

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ABSTRACT

The field experiment was conducted to access the effect of inorganic fertilizers, organic manures and bio-fertilizers on yield and quality of *rabi* onion (*Allium cepa* L.) during *rabi* season. The experiment comprised of 36 treatment combinations and replicated three times, was laid out in split-plot design with three fertility levels (0, 75 and 100% of recommended dose of NPKS) and three treatments of organic manures (control, FYM @ 20 t ha⁻¹ and poultry manure @ 5 t ha⁻¹) were applied in main plots. Four bio-fertilizers (No inoculation, PSB inoculation, *Azospirillum* inoculation and PSB + *Azospirillum* inoculation) were applied in sub plots. The two year results of the study have clearly showed that application of inorganic fertilizers up to 75% RDF significantly increased all the yield parameters (fresh weight of bulb and bulb yield) and quality attributes (total soluble solids, nitrogen, phosphorus, potassium, sulphur and allyl propyl disulphide content in bulb). Similarly, application of poultry manure @ 5 t ha⁻¹ significantly increased all the yield parameters and quality attributes of onion. The significantly maximum values for yield parameters and quality attributes achieved on combined inoculation with PSB + *Azospirillum*. Further it may be concluded that application of 75% RDF of NPKS, poultry manure @ 5 t ha⁻¹ and PSB + *Azospirillum* is worth recommendable for farmers to get significantly better yield and quality of *rabi* onion.

Keywords

Inorganic fertilizers,
Organic manures,
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Introduction

Onion (*Allium cepa* L.) is a biennial or perennial herb belongs to family Alliaceae. It is one of the most important cash vegetable crop among bulb crops and semi-perishable in nature. It can be transported to a long distance without much transit injury losses. The significance of crop further enhances due to its multiple uses. Onion is rich in protein, calcium, phosphorus and carbohydrates (Bhattacharjee *et al.*, 2013). India is second

largest producer of onion after china in the world, cultivating onion over an area of 1320 thousand hectare with total production of 20931 thousand metric tonnes (Anonymous, 2017). In Rajasthan, it is grown over an area of 86.31 thousand hectare with a production of 1435.11 thousand metric tonnes (Anonymous, 2017). The application of different doses of nitrogen increased plant growth and yield of onion. Similarly, phosphorus has its beneficial effect on early root development, plant growth, yield and quality of crop produce.

Potassium plays important role in crop productivity by functioning as an activator of numerous enzymes like pyruvic kinase, cytoplasmic enzymes and therefore, cause pervasive effect on metabolic events. The application of different doses of sulphur improves plant height, number of leaves, bulb diameter, bulb weight and yield of onion (Kumar *et al.*, 2017). The application of organic manures like FYM and poultry manure alone and in combination with NPK have been reported to decrease the bulk density, improve the soil porosity and increase water holding capacity (Yadav, 2015). Further, inoculation biofertilizers mobilize nutrient elements from unavailable to available form through biological processes. These are biologically active strains or products containing active form of microorganisms. Phosphate Solubilizing Bacteria (PSB) when inoculated, secrete antibiotic substances and solubilise the otherwise unavailable insoluble soil phosphorus and then make it available to the plant. The inoculation of PSB bio-fertilizer increases the yield of crops by 10 to 30 per cent. *Azospirillum* inoculation helps the plants to attain better vegetative growth and also in saving inputs of nitrogenous fertilizers by 20-30%. Application of *Azospirillum* had significant effect on nutrient uptake, which may be helpful for increasing the crop production by way of enhancing the soil fertility. Use of biofertilizers not only supplement the nutrients but also improve the efficiency of applied nutrients (Bhati *et al.*, 2018). Studies have also shown that integrated use of chemical fertilizers, organic residues like FYM, compost etc. and biofertilizers resulted in reduced losses of nutrients and environmental pollution. There is meager information on the balanced use of chemical fertilizers along with FYM, poultry manure and biofertilizers for onion crop grown in Rajasthan under semi arid zone IIIA. In last few years, a greater concern regarding use of biofertilizers and

organic sources as alternative/supplements to chemical fertilization has been derived to reduce the high cost that inorganic fertilizers represent in agricultural production.

Materials and Methods

The present investigation was carried out at the Horticulture farm, S.K.N. College of Agriculture, Jobner during *rabi* season for two years, to find out the influence of inorganic fertilizer, organic manure and bio-fertilizers on yield parameters, yield and quality of onion. Geographically, Jobner is situated at 26⁰ 05' North latitude and 75⁰ 20' 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 average rainfall of the locality is approximately 400 to 500 mm; most of which is received in rainy season from July to September. Yearly pan evaporation ranges from 1.3-17.5 mm per day. The soil of the experimental field was loamy sand having 131.7 kg ha⁻¹ available nitrogen, 14.8 kg ha⁻¹ available phosphorous, 149.0 kg ha⁻¹ available potassium and 9.88 kg ha⁻¹ available sulphur. The study was carried out with application three fertility levels (0, 75 and 100% of recommended dose of NPKS) through urea, SSP, MOP and elemental sulphur and three treatments of organic manures (control, FYM @ 20 t ha⁻¹ and poultry manure @ 5 t ha⁻¹) were applied in main plots. Four treatments of bio-fertilizers (No inoculation, PSB inoculation, *Azospirillum* inoculation and PSB + *Azospirillum* inoculation) were applied in sub plots. Experiment was performed in split plot design with three replications. The onion (RO-252) seedling was transplanted at 20 cm row to row and 10 cm plant to plant spacing using 10 kg seed ha⁻¹. The recommended dose of NPKS for onion crop is 100:50:100:60 kg ha⁻¹. Healthy crop of onion was raised following standard agronomic practices. The

observations on yield parameters and quality attributes of onion were recorded with respect to influence of inorganic fertilizers, organic manures and bio-fertilizers effects. The data were statistically analyzed as per the method suggested by Panse and Sukhatme (1985).

Results and Discussion

Yield parameters

Inorganic fertilizers (Effect of fertility levels)

The maximum mean fresh weight of bulb (65.88 g) and bulb yield (305 q ha⁻¹) was obtained under application of 100% RDF which were 63.88 and 63.89 per cent higher over control (Table 1). The results of present study clearly indicate that fresh weight of bulb and bulb yield increased significantly due to application of 100% RDF. However, these yield parameters showed non-significant differences between application of 75% RDF and 100% RDF.

The increase in these parameter due to nitrogen application may be explained on the basis that nitrogen fed to plants might have made their rapid growth and acquired healthy green colour due to increased synthesis of chlorophyll content which in turn resulted in enhanced net assimilation rate due to increased photosynthetic activities. Thus, it also resulted in thickening of scales. Moreover, the nitrogen application might have influenced the availability of other nutrients also especially phosphorus and sulphur and thus better nutrition, ultimately leading to increased yield parameters. The bulb yield, being a function primarily of the cumulative effect of yield attributing parameters, increased significantly with the application of nitrogen fertilization upto 75% RDF. The observed significant increase in bulb yield of onion with increase in application of N might

be due to low initial available N status (131.70 kg ha⁻¹) of the experimental soil. The plant adequately supplied with N had more number of functional leaves and photosynthesizing area which consequently contributed to better growth and development of individual plant. This in turn resulted in production of more yield. The beneficial influence of phosphorus in early stage of growth may be explained by early stimulation of scanty root system through efficient translocation to the roots of certain growth stimulating compounds formed on account of protoplasmic activity of tops in phosphorus fed plants, which enhanced absorption of nitrogen and other nutrients and their utilization. The increase in yield parameters and yield may also be due to functional role of potassium resulting in higher net photosynthetic activity and denser rooting system. The application of sulphur in experiment through various treatments helped to cure deficiency of low initial available sulphur in experimental soil appropriate dose of sulphur might have used for better development and thickening of xylem and collenchyma fibers because of higher rate of protein synthesis and enhanced photosynthetic activity of the plant with increased chlorophyll synthesis. Further, sulphur being an integral constituent of certain amino acids of which nitrogen is also essential constituent, might have helped in increasing net assimilation rate of nitrogen and other nutrients. Thus, it might have resulted in increased yield parameters (Yawalkar *et al.*, 2008). These results are in agreement with findings of Sharma (2014) and Assefa *et al.*, (2015).

Effect of organic manures

The fresh weight of bulb and bulb yield in poultry manure @ 5 t ha⁻¹ and FYM @ 20 t ha⁻¹ was (65.90 and 62.00 g) and (305.08 and 287.03 q ha⁻¹) which witnessed profound increase of (53.18 and 44.12 per cent) and (53.17 and 44.11 per cent), respectively in

pooled analysis over control (Table 1). Data presented in table 1 revealed that the fresh weight of bulb and bulb yield increased significantly with the application of poultry manure @ 5 t ha⁻¹. However, it was statistically at par to FYM @ 20 t ha⁻¹ only in number of scales and yield of residual crop. Poultry manure and FYM having a material which contains better levels of nutrients and water holding capacity and release macro and micro nutrients during the course of microbial decomposition. Organic matter is also a source of energy for soil micro flora which brings the transformation of soil inorganic nutrients in the form that is readily utilized by growing plant and improves the physical properties of the soil.

The beneficial response of poultry manure and FYM to yield might also be attributed to the availability of sufficient amount of plant nutrients throughout the growth period of crop resulting in better plant vigour and yield. The increased yield and yield parameters with poultry manure might be because of rapid availability and utilization of nitrogen for various internal plant processes for carbohydrates production. Later on these carbohydrates may undergo hydrolysis and get converted into reproductive sugars which ultimately helped in increasing yield. The carbohydrates content due to application of poultry manure might be attributed to balanced C: N ratio and increased activity of plant metabolisms. These results are also in close conformity with the findings of Farooq *et al.*, (2015) and Meena *et al.*, (2015).

Effect of bio-fertilizers

The combined application of PSB and *Azospirillum* observed to be the most superior treatment with regard to fresh weight of bulb (63.87 g) and onion bulb yield (295.71 q ha⁻¹) that registered a quantum increase on per cent basis (46.36, 6.57 and 5.68 per cent) and (46.35, 6.57 and 5.68 per cent) more over

control, PSB and *Azospirillum*, respectively (Table 1). The result of present study (Table 1) clearly indicates that fresh weight of bulb and bulb yield increased significantly due to combined inoculation of PSB + *Azospirillum*. The reason is due to the fact that *Azospirillum* is known to produce antifungal, antibiotic substances that inhibit varieties of soil borne fungal diseases. It can also synthesize the thiamin, riboflavin, pyridoxin, cyanocobalamine, nicotinic acid, pentathenic acid, indole acetic acid and gibberellins or gibberellins like substances resulting in vigorous plant growth and dry matter production which in turn resulted in better fertilization, bulb development and ultimately the higher yield. Further, *Azospirillum* inoculation might have helped in increasing nitrogen availability because it is a micro acrophillic nitrogen fixer. It colonizes the root mass, fixes nitrogen in loose association with plants and these bacteria induce the plant root to secrete mucilage which create low oxygen involvement and help to fix atmospheric nitrogen which reflected in the better yield parameters. Increased activity of plant growth substances like gibberellic acid, indole acetic acid, and dihydrozeatin in *Azospirillum* inoculated plant might have improved the yield. The solubilization effect of PSB is generally due to the production of organic acids by this organism. They are also known to produce amino acids, vitamins, growth promoting substance like indole acetic acid and gibberellic acid which help in better growth of crop and ultimately yield parameters and yields. Biological nitrogen fixation depends appreciably on the available form of phosphorus. So the combined inoculation of nitrogen fixer and PSB may benefit the plant better (by proving both nitrogen as well as phosphorus) than either group of organism alone. Such mutually beneficial synergistic effects have also been reported by Sharma (2014) and Meena *et al.*, (2015).

Quality attributes

Inorganic fertilizers (Effect of fertility levels)

The mean maximum TSS (10.93%) was recorded in 100% RDF followed by 75% RDF (10.64%), being at par with each other. The application of 100% RDF registered an increase of 7.47 and 2.73 per cent over control and 75% RDF, respectively in pooled analysis. Application of 100% RDF showed the significantly highest nitrogen content (0.883 per cent) and registered an increase of 54.37 and 2.79 per cent over control and 75% RDF, respectively in pooled analysis. However, 75% RDF was found statistically at par to 100% RDF. The maximum phosphorus content in bulb (0.493 per cent) was recorded with 100% RDF while, minimum (0.400 per cent) with control. The 100% RDF recorded 23.25 per cent more phosphorus content in bulb over control, being at par to 75% RDF. Significantly highest potassium content (1.195 per cent) was recorded with 100% RDF which registered an increase of 10.44 and 2.75 per cent over control and 75% RDF, respectively. Further, application of 75% RDF was found statistically at par to it. The maximum sulphur content (0.806 per cent) was recorded with the 100 % RDF followed by 75% RDF (0.794), being at par with each other. The minimum was recorded in control (0.649 per cent) which was 22.34 and 24.19 per cent less as compared to 75 and 100% RDF, respectively in pooled analysis. Application of 100% RDF exhibited significantly maximum allyl propyl disulphide content ($7.53 \text{ mg } 100 \text{ g}^{-1}$) among all the treatments and it registered 35.68 and 0.80 per cent increase in it over control and 75 % RDF, respectively, being statistically to par to 75 % RDF (Table 1 and 2).

The result of present study clearly indicate that total soluble solids, N, P, K, S content, Allyl propyl disulphide content in bulb

increased significantly due to application of 100% RDF (Table 1 and 2). However, this treatment was found statistically at par with 75% RDF.

The influence of nitrogen fertilization on N, P, K and S content of bulb appeared to be due to improved nutritional environment both in the root zone and the plant system. Thus, adequate supply of N, P, K and S early in the crop season increased the availability of nutrients to the root zone coupled with increased metabolic activity at cellular level.

It might have increased the nutrient uptake and accumulation in the vegetative plant parts. The higher nutrient content in bulb also seems to be due to higher functional activity of root for longer duration under this treatment. The increase in N, P, K and S content in bulb were also observed by Sharma *et al.*, (2003) and Soni (2005).

Application of NPKS significantly increased the TSS in onion bulb. TSS content significantly increased with the nitrogen application which helped in vigorous vegetative growth and imparted deep green colour to the foliage which favoured photosynthetic activity of the plants so there was greater accumulation of food material *i.e.*, carbohydrates in the bulb leading to increase TSS content.

Similarly, S content and allyl propyl disulphide content in onion bulb were increased with increasing level of NPK and sulphur. The increased sulphur and allyl propyl disulphide content in bulb might be due to increased concentration of sulphur in soil solution with increasing levels of sulphur fertilization. Similar results were also reported by Mishu *et al.*, (2013) on onion. These results are also in accordance with the findings of Tripathy *et al.*, (2013), Diriba-Shiferaw *et al.*, (2014) and Sharma (2014).

Table.1 Yield parameters and quality attributes of onion as influenced by integrated nutrient management (pooled)

Treatments	Fresh weight of bulb (g)	Bulb yield (q ha ⁻¹)	TSS (%)	Allyl propyl disulphide (mg 100 g ⁻¹)
Inorganic fertilizers				
0% RD of NPKS	40.20	186.10	10.17	5.55
F ₁ (7 75% RD of NPKS)	64.84	300.18	10.64	7.47
100% RD of NPKS	65.88	305.00	10.93	7.53
SEm ₊	0.76	3.12	0.12	0.08
CD (P=0.05)	2.19	8.96	0.33	0.23
Organic manures				
Control	43.02	199.17	9.92	5.44
FYM @ 20 t ha ⁻¹	62.00	287.03	10.67	7.39
Poultry Manure @ 5 t ha ⁻¹	65.90	305.08	11.14	7.72
SEm ₊	0.76	3.12	0.12	0.08
CD (P=0.05)	2.19	8.96	0.33	0.23
Bio-fertilizers				
No-inoculation	43.64	202.05	10.33	6.28
PSB inoculation	59.93	277.47	10.52	6.91
<i>Azospirillum</i> inoculation	60.44	279.81	10.58	6.98
PSB + <i>Azospirillum</i> inoculation	63.87	295.71	10.89	7.25
SEm ₊	0.73	3.51	0.11	0.07
CD (P=0.05)	2.04	9.81	0.30	0.21

Table.2 Quality attributes of onion as influenced by integrated nutrient management (pooled)

Treatments	N content in bulb (%)	P content in bulb (%)	K content in bulb (%)	S content in bulb (%)
Inorganic fertilizers				
0% RD of NPKS	0.572	0.400	1.082	0.649
F ₁ (7 75% RD of NPKS)	0.859	0.481	1.163	0.794
100% RD of NPKS	0.883	0.493	1.195	0.806
SEm ₊	0.010	0.005	0.012	0.006
CD (P=0.05)	0.028	0.013	0.033	0.017
Organic manures				
Control	0.549	0.326	1.069	0.629
FYM @ 20 t ha ⁻¹	0.857	0.509	1.158	0.793
Poultry Manure @ 5 t ha ⁻¹	0.908	0.539	1.212	0.828
SEm ₊	0.010	0.005	0.012	0.006
CD (P=0.05)	0.028	0.013	0.033	0.017
Bio-fertilizers				
No-inoculation	0.623	0.410	1.096	0.670
PSB inoculation	0.794	0.471	1.146	0.760
<i>Azospirillum</i> inoculation	0.816	0.468	1.151	0.772
PSB + <i>Azospirillum</i> inoculation	0.853	0.485	1.194	0.799
SEm ₊	0.011	0.004	0.012	0.007
CD (P=0.05)	0.031	0.012	0.034	0.019

Effect of organic manures

A further review of the data (Table 1) revealed that application of poultry manure @ 5 t ha⁻¹ and FYM @ 20 t ha⁻¹ significantly increased the nitrogen content of bulb to the extent of 65.39 and 56.10 per cent over control in pooled analysis. The significantly maximum nitrogen content was recorded with poultry manure @ 5 t ha⁻¹. Application of poultry manure and FYM also had significant effect on phosphorus content (Table 1) in bulb during both the years and in pooled analysis. The significantly maximum phosphorus content 0.539 per cent was recorded under application of poultry manure 5 t ha⁻¹ with the tune of 5.89 and 65.34 per cent more over FYM and control, respectively.

A review of data (Table 1 and 2) indicates that application of poultry manure @ 5 t ha⁻¹ significantly registered highest K content in bulb with tune of 13.38 and 4.66 per cent over control and FYM, respectively in pooled analysis. Application of poultry manure and FYM also had significant effect on sulphur content during both the years as well as pooled analysis. Application of poultry manure @ 5 t ha⁻¹ significantly increased the sulphur content to maximum level at the tune of 31.64 per cent in pooled analysis, over control. Data given in same table also indicating that application of poultry manure @ 5 t ha⁻¹ and FYM @ 20 t ha⁻¹ significantly increased the allyl propyl disulphide content in onion bulb to the extent of 41.91 and 35.85 per cent over control in pooled analysis, respectively. Although, the significantly maximum allyl propyl disulphide content was recorded with poultry manure only.

The significantly increasing trend in TSS, N, P, K, S content, allyl propyl disulphide content in bulb were registered with application of poultry manure @ 5 t ha⁻¹ and FYM @ 20 t ha⁻¹, respectively over control

(Table 1 and 2). The beneficial effect of poultry manure and FYM in increasing the content of N, P, K and S in bulb and leaves might be attributed to direct supply of nutrients. Moreover, poultry manure and FYM after decomposition might have released macro and micro nutrients, which increases the availability of nutrients to the soil, plant system and thus increased the nutrient content in plants. The higher nutrient availability enhanced photosynthesis and their translocation to different plant parts resulting into higher concentration of nutrients. The nutrient content and other quality attributes were increased significantly with application of poultry manure and FYM. Similar findings have been earlier reported by Choudhary *et al.*, (2013), Meena *et al.*, (2014), Meena *et al.*, (2015).

Effect of bio-fertilizers

The maximum N content of 0.853 per cent was obtained with the combined inoculation of PSB + *Azospirillum* which led to an increase of 36.92, 7.43 and 4.53 per cent over control, PSB and *Azospirillum* alone, respectively. Microbial inoculation with PSB + *Azospirillum* led to an increase of 18.29, 2.97 and 3.63 per cent higher P content over control, PSB and *Azospirillum*, respectively.

The maximum K content of 1.194 per cent was achieved with the combined inoculation of PSB + *Azospirillum* which had an increase of 8.94, 4.19 and 3.74 per cent over control, PSB and *Azospirillum*, respectively. Use of PSB and *Azospirillum* alone led to 13.43 and 15.22 per cent increase in sulphur content in bulb over no inoculation, respectively. However, the effect of combined use of PSB along with *Azospirillum* led significant effect on overall increase of sulphur content in bulb 19.25 per cent in in pooled analysis (Table 1 and 2) over no inoculation. Use of PSB and *Azospirillum* increased the allyl propyl

disulphide content to the tune of 10.03 and 11.15 per cent over no inoculation, respectively whereas, combined use of PSB + *Azospirillum* represented the significantly maximum increase in allyl propyl disulphide content (15.45%) over control.

The maximum total soluble solids, N, P, K, S content, allyl propyl disulphide content in bulb were recorded by the use of PSB + *Azospirillum* inoculation and minimum in no inoculation (Table 1 and 2). *Azospirillum* might have fixed higher amount of nitrogen in soil and made available to the plants resulted in better uptake of N by plants. Phosphobacteria would have caused more mobilization and solubilization of insoluble P in the soil and improved the availability of phosphorus which might have caused an increase in uptake of phosphorus by plants.

The improvement in growth habit might have helped in increased photosynthetic rate and more photosynthates mobilization. Similarly, quality attributes might have improved due to higher photosynthetic rate, better source sink relationship, better nutrients uptake, besides excellent physiological and biochemical activities. Similar results were reported by Sharma (2014) and Meena *et al.*, (2015).

On the basis of results emerging out from the present investigation, It can be concluded that application of 75% RDF of NPKS, poultry manure @ 5 t ha⁻¹ and PSB + *Azospirillum* is worth recommendable for farmers to get significantly better yield, quality of *rabi* onion.

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