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Influence of Seedling Age and Bio-fertilizers on Bulb Yield and Nutrient Uptake by Onion (*Allium cepa* L.)

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ABSTRACT: Field experimentation conducted during the Rabiseasons of 2019-20 and 2020-21 at R. V. S. K. V. V., Gwalior to examine the bulb yield and nutrient uptake in onion due to application of bio-fertilizer under different seedling age. There were fifteen treatment combinations comprised of 3 seedling age (6 weeks, 7 weeks and 8 weeks) in main plot and 5 bio-fertilizer (un-inoculated, *Azotobecter*, *Azotobecter* + PSB, Consortia (*Azotobecter* + PSB + KMB) and Arka Microbial Consortium(*Azotobecter* + PSB + ZSB) in subplot. The experiment was laid out under split-plot design and the treatments were triplicated during the experiment. Pooled data of two years revealed that the highest marketable bulb yield (331.7 q) was noted with 7th weeks old seedling age which was significantly higher to ^{6th} and 8th weeks old seedling age. Bio-fertilizer applied treatments recorded significantly higher marketable bulb yield as compared to control. Maximum pooled marketable bulb yield (347.6 q) was recorded with Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) which was significantly higher over rest of the treatments.

The results on nutrient uptake by bulbs indicated maximum of 74.66, 7.08, 35.62 & 9.02 kg ha^{-1} NPKS by application of S @ 45 kg ha^{-1} followed by 30 kg ha^{-1} as gypsum. Similar trend was also observed for total nutrient uptake. Thus, it may be concluded that application of S @ 30 or 45 kg ha^{-1} in the form of gypsum not only increases the bulb yield but also higher uptake of nutrients in onion.

Keywords: Arka Microbial Consortium, Bio-fertilizer, marketable bulb yield, Seedling Age, Onion.

INTRODUCTION

Onion (*Allium cepa* L.*)* is one of the commercial vegetable and spice crops of India which is predominantly cultivated during *Rabi* (60%) followed by 20% each in *Kharif* and late *Kharif* season. Among the various cultural practices followed for the production of onion, planting time is one of the most important factors that greatly influence the growth and yield of onion. The variation in planting time affects the plant vigour and spread, which further affect the yield and quality. If planting time coincides with optimum ecological conditions for better germination, it may lead to better development of plants and ultimately higher yield of good quality. Age of seedling is an important factor that influences the higher bulb yield. Proper age of seedling can produce better yield of bulb (Singh and Chaure, 1999).

Biofertilizers play a very significant role inatmospheric nitrogen fixation and phosphorus solubilization, these also help in stimulating the plant growth hormone providing better nutrient uptake and increased tolerance towards drought and moisture stress. A small dose of bio-fertilizers contains at least 10 million viable cells of specific strains (Rao *et al.,* 2014).

Arka Microbial Consortium is a carrier based product which contains N-fixing, P & Zn solubilizing and plant growth promoting microbes as a single formulation. The novelty of this technology is that farmers need not apply N-fixing, phosphorous solubilizing and growth promoting bacterial inoculants individually. Phosphorus solubilizing bacteria and fungi play a vital role in persuading the insoluble phosphatic compound such as rock phosphate, bone meal and basic slag and particularly the chemically fixed soil phosphorus into available form (Pindi and Satyanarayana, 2012) Onion has a good response to biofertilizers due to root system morphology but the information on effect of inoculation of bio-fertilizers with different seedling age on uptake of nutrients in onion is rather limited so the novelty of

this study is a comparison of different combinations of bio-fertilizers used in different seedling age on bulb yield and nutrient uptake by onion in rabi season.

MATERIAL AND METHODS

The trials were conducted according to the split-plot design in three repetitions at the horticulture nursery, College of Agriculture, Gwalior, (26°13′N and 76°14′E) during Rabi seasons of 2019 -20 and 2020-21. The soil of present study was sandy clay loam in texture having0.53% organic carbon, 211.0 kg ha^{-1} available-N, 13.04 kg available P_2O_5 and 338.5 kg K_2O ha^{-1} with pH 7.41.The experimental treatments involved the 3 seedling age (6 weeks, 7 weeks and 8 weeks) in main plot and 5 bio-fertilizer (un-inoculated, *Azotobecter*, *Azotobecter*+ PSB, Consortia (*Azotobecter* + PSB + KMB) and Arka Microbial Consortium (*Azotobecter*+ PSB + ZSB)) in subplot and all the plots were uniformly fertilized with as per recommended dose i.e. 100: 60: 80: 30 : N: P_2O_5 :K_2O :S) through Urea, Di-ammonium Phosphate, Muriate of Potash and bentonite sulphur, respectively. Onion variety ' Agrifound Light Red' was sown on second week of September and six, seven and eight week's old seedlings which having three to five leaves were transplanted as per treatments on pre-marked spacing of 15 x 10 cm in the afternoon during both the years. All bio fertilizers were used in liquid form and prior to transplanting of seedlings it was added as per treatments through root dipping methods. Onion crop was irrigated after planting and later as and when required. The crop was harvested at physiological maturity and the weight of onion bulb was recorded. The bulb and plant samples drawn at harvesting were dried in shade and chaffed into pieces and then kept in oven at 70°C for 12 hours to make free from moisture. After that, the dried samples were ground in a grinder. After mixing well the ground samples were collected for analysis of N, P, K and S. Nitrogen was estimated by Kjeldahl method. For P, K and S estimation bulb samples were digested in a diacid mixture ($HNO_3$and $HClO_4$) and P in the extract was determined by vanadomolybdate yellow colour method and K content was determined by flame photometer method (Jackson, 1973). The uptake of nutrients was calculated as per formula.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient Content (\%)} \times \text{Dry yield (kg ha}^{-1})}{100}$$

RESULTS AND DISCUSSION

A. Growth and yield attributes parameters

It is revealed from results that the growth parameters like plant height and number of leaves and yield attributes parameters i.e. Fresh and dry weight, Polar diameter and neck thickness of onion bulb were significantly influenced due to different seedling age (Table 1). Maximum value was recorded with optimum age of seedling (7 weeks) which was at par with 6 weeks old seedling age, whereas, minimum was recorded in 8 weeks old seedling age in all the parameters. The significantly higher growth parameters under transplanting of 7 weeks old seedlings may be owing to the fact that optimum age of seedlings performer active growth which might have contributed to more vigorous growth and development of plants and thus improvements in the pseudo stem. These results are in consonance with those of other workers (Kanton *et al.*, 2002; Singh *et al.*, 2017). The dry matter fraction for different age of seedlings varied possibly due to variation of growth patterns and photosynthesis at growing phases which may be ascribed that as the bulb size decreased quantity of water content also decreased resulting in high percentage of dry matter. The results of the present study are in agreement with Bhonde *et al.* (2001); Muhammad *et al.* (2016).

Inoculation of different bio-fertilizers recorded significantly higher growth and yield attributes parameters as compared to un-inoculated (control). Maximum value of growth parameters (i.e. plant height and number of leaves $plant^{-1}$) was recorded with Arka Microbial Consortium (AMC) which was at par with Consortia (*Azoto*+ PSB + KMB) and both were significantly superior to rest of the bio fertilizer applied treatment, whereas, minimum was in Un-inoculated (control). This might be due to inoculation with bio fertilizers mixtures provided a more balance nutrition for plants as well as optimum absorption of nutrients by corms accelerated the physiological process and improved the vegetative phenomenon. Improvement in plant height and number and length of leaves with inoculation of bio fertilizers could be attributed to the proper availability of nitrogen fixed by *Azotobacter* as non-symbiotic in the rhizosphere of inoculated corms, while PSB acts as a potent phosphate solubilizer and thus facilitates enhanced phosphorus uptake in roots by which the plants maintain their vegetative growth. Better vigorous growth may also be result of increased meristematic activities and increase in number and size of cells due to effect of growth promoting substances produced by these bio-fertilizers. Similar findings were observed by Taren *et al.* (1994); Kumar *et al.* (2019) in onion.

Under different bio fertilizers, all the bio-fertilizer applied treatments recorded significantly higher yield-attributing parameter i.e. fresh and dry weight, polar diameter and neck thickness of bulb as compared to control. Maximum fresh (85.60 g) and dry weight (12.29 g) of bulb was recorded with Arka Microbial Consortium (AMC) which was significantly higher over rest of the treatments. It might be due to increased

availability of nitrogen and better mobilization, solubilization of phosphate and zinc which leads to better uptake of N and P as well as also increased activity of Zn which is synthesize indole acetic acid and gibberellins or gibberellin like substances resulting in vigorous plant growth and dry matter production which improved the vegetative growth, dry matter accumulation and their partitioning towards the developing bulb. Similar results have also been reported by Bhonde *et al*. (2001); Aswani *et al.* (2005).

B. Bulb yield

The perusal of mean data of two year indicates that highest marketable (331.7 q ha^{-1}) and total bulb yield (334.0 q ha^{-1}) was noted with 7^{th} weeks old seedling age which was significantly higher to 6^{h} and 8^{th} weeks old seedling age. Minimum bulb yields were recorded with 8^{th} weeks old seedling age (Table 1) this may be ascribed that the transplanting of optimum age 7^{th} weeks old seedling appeared to have much more root and shoot developed over the younger and older seedlings and synthesized much more photosynthates which help to increase the vegetative growth of the plant which has improved assimilate availability for storage and led to an increased average bulb weight that gave an advantage to increase the marketable as well as total bulb yield. The similar results have also been obtained by Kanton *et al.* (2002); Latif *et al.* (2010); Singh *et al.* (2017).

Table 1: Effect of seedling age and bio fertilizer on growth, yield attributes and bulb yield of onion (Pooled data of two yearsi. e, 2019-20 & 2020-21)

Treatment	Growth and yield attributes parameters						Bulb yield (q/ha)	
	Plant height (cm)	Number of leaves	Fresh weight of bulb (g)	Dry weight of bulb (g)	Pollar diameter of bulb (cm)	Neck thickness (cm)	Marketable	Total
Seedling age								
S_1 : 6 weeks	59.02	12.66	70.89	9.47	5.47	1.13	318.8	321.9
S_2: 7 weeks	60.70	13.04	80.62	12.25	5.76	1.15	331.7	334.0
S_3: 8 weeks	56.00	12.28	74.16	10.53	5.38	1.10	306.8	313.8
SE (m) ±	**0.44**	**0.07**	**0.54**	**0.09**	**0.04**	**0.01**	**2.0**	**2.1**
C.D. (5%)	**1.43**	**0.23**	**1.75**	**0.28**	**0.13**	**0.03**	**6.5**	**6.7**
Bio Fertilizers combinations (BF)								
BF_1: Un-inoculated	52.00	11.39	64.88	9.18	4.98	1.03	283.4	292.9
BF_2:*Azotobecter*	55.70	12.22	71.12	10.16	5.26	1.14	305.9	311.0
BF_3:*Azotobecter*+ PSB	59.78	13.03	74.93	10.72	5.72	1.16	320.6	323.3
BF_4: Consortia (*Azoto*+ PSB + KMB)	62.50	13.22	79.57	11.41	5.85	1.16	337.9	339.2
BF_5: Arka Microbial Consortium (*Azoto*+ PSB + ZSB)	62.89	13.44	85.60	12.29	5.87	1.14	347.6	349.9
SE (m) ±	**0.62**	**0.12**	**1.10**	**0.16**	**0.08**	**0.02**	**3.0**	**2.1**
C.D. (5%)	**1.76**	**0.36**	**3.12**	**0.46**	**0.22**	**0.04**	**8.4**	**5.9**
Interaction (S × BF)	**NS**	**NS**	**S***	**S***	**NS**	**NS**	**NS**	**NS**

Under different bio fertilizers, all the biofertilizer applied treatments recorded significantly higher bulb yield as compared to control. Maximum marketable bulb yield (347.6 q ha^{-1}) and total bulb yield (349.9 q ha^{-1}) were recorded in Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) inoculated treatments which was significantly higher over rest of the other treatments. Whereas, minimum bulb yields was in Un-inoculated (control). Significant increase in marketable as well as total bulb yield with bio fertilizers inoculated treatment may be due to apart from fixing atmospheric nitrogen, produces plant growth promoting substances and creates metabolic changes in roots. This is turn decrease the activity of oxidative enzymes and increases the development of root hairs thus increasing the endogenous IAA and minerals as well as water uptake. This resulted in increase of root development and overall vegetative growth thereby increasing the marketable bulb yield of onion. On the other side, Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) produce anti fungal antibiotic substances that inhibits various of soil fungi. It can also synthesize and secrete thiamin, riboflavin, cyanocobal amine, indole acetic acid and 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, Similar results have also been reported by Bhonde *et al.* (2001); Waghmode *et al.* (2010); Kumar *et al.* (2019).

C. Nutrient uptake by onion

Nutrient (N, P & K) uptake by onion bulb and leaves significantly differ in various seedling age treatment and maximum total N (80.41 kg ha^{-1}), P (16.92 kg ha^{-1}) and K (91.09 kg ha^{-1}) were observed with 7 weeks old seedling age which was significantly higher as compared to total N-uptake by 6 and 8 weeks old seedling. This increase in uptake may be ascribed to greater dry matter production with this age of seedling which may be ascribed that 7 weeks old over 6 and 8 weeks old seedlings has ability to absorb root injury shocks and owing to quick establishment in soil and thus more uptake of nutrients. Similar findings were also reported by (Upadhyay *et al*., 2001).

Under different bio fertilizers inoculated treatments, all the inoculated treatments recorded significantly higher N, P & K uptake as compared to un-inoculated. Maximum total N (87.70 kg ha^{-1}) uptake was observed in Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) inoculated treatments which was significantly higher over rest of the other treatments. Maximum total P (87.70 kg ha^{-1}) uptake was observed in Consortia (*Azoto*+ PSB + KMB) closely followed by Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) and both were significantly superior over rest of other inoculated treatments. Maximum total K (96.71 kg ha^{-1},) uptake was observed in Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) closely followed by Consortia (*Azoto*+ PSB + KMB) with 95.20 kg ha^{-1} K-uptake and both were recorded significantly higher total K uptake as compared to rest of other inoculated treatments. It is clear from result (Table 2) that the inoculation by mixture of two or more bio-fertilizer treatments recorded significantly higher N, P & K uptake as compared to single bio-fertilizer inoculation treatments. Inoculation by mixture of Biofertilizers i.e. Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) and Consortia (*Azoto* + PSB + KMB) play a very significant role in atmospheric nitrogen fixation and phosphorus, potassium/zinc solubilization, these also help in stimulating the plant growth hormone providing better nutrient uptake (Rao *et al.,* 2014).

Table 2: Effect of seedling age and bio fertilizer on nutrient uptake by onion (Pooled data of two years).

Treatment	N-Uptake (kg ha^{-1})			P-Uptake (kg ha^{-1})			K-Uptake (kg ha^{-1})		
	Bulb	**Leaves**	**Total**	**Bulb**	**Leaves**	**Total**	**Bulb**	**Leaves**	**Total**
Seedling age									
S_1 : 6 weeks	50.28	24.20	74.48	12.43	3.05	15.48	54.42	29.04	83.47
S_2: 7 weeks	54.27	26.14	80.41	13.56	3.36	16.92	59.18	31.91	91.09
S_3: 8 weeks	41.85	20.31	62.16	10.46	2.52	12.98	45.51	24.55	70.06
SE (m) ±	**0.69**	**0.36**	**1.03**	**0.19**	**0.05**	**0.23**	**0.65**	**0.29**	**0.92**
C.D. (5%)	**2.25**	**1.18**	**3.36**	**0.61**	**0.15**	**0.75**	**2.13**	**0.94**	**3.00**
Bio Fertilizers combinations (BF)									
BF_1: Un-inoculated (control)	35.78	17.33	53.11	8.92	2.13	11.05	39.06	20.95	60.01
BF_2:*Azotobecter*	45.66	22.10	67.76	10.93	2.60	13.53	47.47	25.52	72.99
BF_3:*Azotobecter*+ PSB	47.72	23.20	70.93	12.56	3.12	15.67	53.75	29.02	82.77
BF_4: Consortia (*Azoto*+ PSB + KMB)	55.41	26.83	82.24	14.26	3.54	17.80	61.82	33.38	95.20
BF_5: Arka Microbial Consortium (*Azoto*+ PSB + ZSB)	59.42	28.28	87.70	14.08	3.49	17.57	63.08	33.63	96.71
SE (m) ±	**1.07**	**0.53**	**1.58**	**0.31**	**0.08**	**0.38**	**1.33**	**0.70**	**2.02**
C.D. (5%)	**3.06**	**1.50**	**4.48**	**0.87**	**0.23**	**1.09**	**3.79**	**1.99**	**5.74**
Interaction (S × BF)	**S***	**S***	**S***	**S***	**S***	**S***	**S***	**S***	**S***

Interaction effect of seedling age and bio fertilizers on nutrient uptake. It is clear from Table 3, that the seedling age of 7th week resulted significantly maximum total N uptake with Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) followed by Consortia (*Azoto* + PSB + KMB) while in the case of P & K it is higher with Consortia (*Azoto* + PSB + KMB) followed by Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) and both were comparable with other.

The higher uptake may be due to more bulb yield and dry matter found in this treatment combination and absorption and utilization of nutrients in mixture of bio-fertilizer which may be ascribed that available nitrogen and phosphorus content may be due to increased biological nitrogen fixation and phosphate and potassium solubilization by micro-organisms. Similar results have also been reported by Bhonde *et al.* (2001); Waghmode *et al.* (2010); Kumar *et al.* (2019).

Table 3: Interaction effect of seedling age and bio fertilizer on nutrient uptake by onion (Pooled data of two years).

Bio Fertilizers (BF)	Seedling Age (S)			MEAN (BF)
	Total N uptake (kg ha^{-1})			
	S_1:6 weeks	S_2:7 weeks	S_3: 8 weeks	
BF_1: Un-inoculated	52.17	52.21	54.95	**53.11**
BF_2:*Azotobecter*	68.40	72.68	62.20	**67.76**
BF_3:*Azo*+ PSB	70.60	82.81	59.37	**70.93**
BF_4: Consortia (*Azo*+ PSB + KMB)	88.03	95.76	62.94	**82.24**
BF_5: A M C (*Azo* + PSB + ZSB)	93.17	98.57	71.36	**87.70**
MEAN(S)	**74.48**	**80.41**	**62.16**	
	(S*BF)1		**(S*BF)2**	
SEm (±)	**2.49**		**2.46**	
CD (P=0.05)	**7.09**		**7.13**	
	Total P- uptake (kg ha^{-1})			
BF_1: Un-inoculated	10.71	11.07	11.37	**11.05**
BF_2:*Azotobecter*	13.18	15.01	12.41	**13.53**
BF_3:*Azo*+ PSB	15.33	18.59	13.10	**15.67**
BF_4: Consortia (*Azo*+ PSB + KMB)	19.14	20.67	13.58	**17.80**
BF_5: A M C (*Azo* + PSB + ZSB)	19.02	19.26	14.43	**17.57**
MEAN(S)	**15.48**	**16.92**	**12.98**	
	(S*BF)1		**(S*BF)2**	
SEm (±)	**0.60**		**0.59**	
CD (P=0.05)	**1.72**		**1.70**	
	Total K- uptake (kg ha^{-1})			
BF_1: Un-inoculated	57.88	59.81	62.32	**60.01**
BF_2:*Azotobecter*	71.24	79.73	68.00	**72.99**
BF_3:*Azo*+ PSB	80.89	98.70	68.72	**82.77**
BF_4: Consortia (*Azo*+ PSB + KMB)	103.45	109.67	72.48	**95.20**
BF_5: A M C (*Azo* + PSB + ZSB)	103.86	107.51	78.76	**96.71**
MEAN(S)	**83.47**	**91.09**	**70.06**	
	(S*BF)1		**(S*BF)2**	
SEm (±)	**3.19**		**3.00**	
CD (P=0.05)	**9.07**		**8.60**	

CONCLUSION

From the results, it can be concluded that Inoculation by mixture of bio-fertilizers i.e. Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) and Consortia (*Azoto* + PSB + KMB) in 7 weeks old seedling found to be effective for higher marketable bulb yield and uptake of nutrients by onion bulb and leaves. These treatments of seedling age and bio fertilizer also recorded fresh and dry weight of bulb. Therefore Inoculation by mixture of bio-fertilizers i.e. Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) and Consortia (*Azoto* + PSB + KMB) in 7 weeks old seedling of Agri found Light Red had significant effect on bulb yield and uptake of nutrients by onion under the agro-climatic conditions of Gwalior district of Madhya Pradesh.

FUTURE SCOPE

1. Multi-location experiments are required to recommend and use the output sustainably.
2. Similar field and economic feasibility studies need to be carried out for a number of seasons in different soils.
3. Various varieties under different seedling age under different agro-ecological condition to understand their yield performance.
4. Nutritional quality analysis also need further study.

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Conflicts of Interest. The authors declare no conflict of interest.

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