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Effect of bio-fertilizers on yield components, marketable bulb yield and economics of onion (*Allium cepa* L.) under different seedling age

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Abstract
Results of an experiment were conducted during the Rabi seasons of 2019 -20 and 2020-21 at R. V. S. K. V. V., Gwalior with fifteen treatment combinations 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 were tested in split-plot design in onion crop (Cv. Agrifound Light Red) with 3 replications. Pooled data of two years revealed that the maximum value of growth and yield attributes parameters of onion was recorded with 7 weeks age of seedling, Highest pooled marketable bulb yield (331.7 q) was noted with 7th weeks old seedling age which was significantly higher to 6^{h} 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. Highest net income and B: C ratio were recorded under S_2: 7 weeks and BF_5: Arka Microbial Consortium treatments and as well as combination of both treatment.

Keywords: Arka microbial consortium, bio-fertilizer, marketable bulb yield, seedling age, onion

Introduction
Onion (*Allium cepa* L.), a member of Alliaceae family, is one of the most important commercial vegetable crops grown in almost all parts of the world and believed to be originated from Central Asia. India is the second largest producer of onion bulbs in the world, as onions have wider use in the preparation of soups, ketchups, pickles, onion flakes (dehydrated) and also used as salad. Onion is highly valued for its therapeutic properties. It has been used as a food remedy from time immemorial and contain flavonoid quercetin protects against cataracts. Their potent anti-inflammatory properties may also help reduce high blood pressure and protect against blood clots.

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 (Kanton *et al.*, 2002) [3].

Bio-fertilizers are the inoculation of microorganism, which have capability of mobilizing nutrient elements from unavailable to available form through biological processes. It is not only supplement the nutrients but also improve the efficiency of applied nutrients (Somani *et al.*, 1990) [11]. Bio-fertilizers have many benefits such as nitrogen fixation, solubilizing of phosphate, potassium and micronutrients through the production of organic acids and lowering soil pH. It could be produced growth promoting factors, e.g., gibberellins, cytokinins and auxins (Vessey, 2003) [14]. Many studies mentioned positive effects of organic fertilizer with bio-fertilizer on vegetative growth, yield and quality of onion (Singh *et al.*, 2017) [10]. Keeping these views the present study was conducted with this aims to evaluate the impact of bio fertilizers on yield component and yield of onion (*Allium cepa* L.) under different seedling age.

Material and Methods

The present study was conducted during two consecutive Rabi seasons of 2019 -20 and 2020-21 on sandy clay loam soil of horticulture nursery, College of Agriculture, Gwalior having 0.53% 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. Fifteen treatment combinations 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 were tested in split-plot design with 3 replications. All the plots were uniformly fertilized with as per recommended dose i.e. 100: 60: 80: 30:: N: P_2O_5:K_2O:S) in all the treatments 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 grown as per recommended package of practices. The crop was harvested at physiological maturity and yield attributes and yield data of onion crop were recorded at harvest.

Results and Discussion

Growth parameters

The observations recorded on growth parameters of onion indicated that the plant heights, number of leaves/plant, length of leaves were enhanced significantly with the 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 under favourable temperature, the transplanting of 7 weeks older 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 and Singh *et al.*, 2017) [3, 10].

It is revealed from table-1, that the inoculation of different bio-fertilizers recorded significantly higher growth parameters as compared to un-inoculated (control). Maximum value 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) [12] and Kumar *et al.* (2019) [5] in onion.

Table 1: Effect of seedling age and bio fertilizer on growth and yield attributes of onion (Pooled data of two years)

Treatment	Growth parameters			Yield attributes				Marketable bulb yield (q/ha)
	Plant height (cm)	Number of leaves	Length of leave (cm)	Fresh weight of bulb (g)	Dry weight of bulb (g)	Equatorial diameter of bulb (cm)	Neck thickness (cm)	
Seedling age								
S_1: 6 weeks	59.02	12.66	26.83	70.89	9.47	4.83	1.13	318.8
S_2: 7 weeks	60.70	13.04	27.47	80.62	12.25	4.88	1.15	331.7
S_3: 8 weeks	56.00	12.28	25.64	74.16	10.53	4.69	1.10	306.8
SE (m) ±	0.44	0.07	0.16	0.54	0.09	0.03	0.01	2.0
C.D. (5%)	1.43	0.23	0.53	1.75	0.28	0.08	0.03	6.5
Bio Fertilizers combinations (BF)								
BF_1: Un-inoculated (control)	52.00	11.39	23.95	64.88	9.18	4.20	1.03	283.4
BF_2: *Azotobecter*	55.70	12.22	25.86	71.12	10.16	4.63	1.14	305.9
BF_3: *Azotobecter*+ PSB	59.78	13.03	27.18	74.93	10.72	4.95	1.15	320.6
BF_4: Consortia (*Azoto*+ PSB + KMB)	62.50	13.22	27.74	79.57	11.41	5.11	1.16	337.9
BF_5: A. M. Consortium (*Azoto* + PSB + ZSB)	62.89	13.44	28.51	85.60	12.29	5.10	1.15	347.6
SE (m) ±	0.62	0.12	0.24	1.10	0.16	0.06	0.02	3.0
C.D. (5%)	1.76	0.36	0.68	3.12	0.46	0.16	0.04	8.4
Interaction (S X BF)	NS	NS	NS	S*	S*	NS	NS	NS

* Significant at 5% level of probability; NS = Non significant

Yield-attributing parameters

This present study indicated that, significant differences were observed among the seedling age levels on fresh and dry weight of bulb in such a way that the 7 weeks of seedling age gave the highest fresh and dry weight of bulb, followed by 8 weeks of seedling age while the lowest was obtained under 6 weeks of seedling age. The dry matter fraction for different age of seedlings varied possibly due to variation of growth patterns and photosynthesis at growing phases. The results of the present study are in agreement with Bhonde *et al.* (2001) [2] who reported that dry matter content of onion bulb was significantly influenced by the age of seedling. This might be due to the fact that the optimum age of seedlings planted had better growth, which resulted in higher production of dry

matter content of bulb. This result is also consistent with the findings of Muhammad *et al.* (2016) [7] who reported that the seedling transplanted at old stage (60 days) have high dry matter percentage as compared to the seedling transplant in early stage and it might be attributed to the fact that as the bulb size decreased quantity of water content also decreased resulting in high percentage of dry matter. The transplanting of optimum age i.e. 7 weeks old seedlings resulted in significantly higher equatorial diameter of bulb (4.88 cm) as well as neck thickness (1.15 cm) in comparison to the transplanting of 6 and 8 weeks old seedling. However, no statically significant difference was observed between 6 and 7 weeks of seedling age (Table 2). This may be absorbed to the fact that 7 weeks old seedlings synthesized much more photosynthates which translocated towards the reproductive organs (bulbs). The similar results have also been obtained by Kanton *et al.* (2002) [3] and Singh *et al.*, (2017) [10]. The increase in growth and yield attributes with 7 weeks old seedling over 6 and 8 weeks old seedlings was owing to quick establishment of seedling, as it has ability to absorb root injury shocks (Upadhyay *et al*., 2001) [13].

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) [2] and Aswani *et al.* (2005) [1].

It is revealed from table-1, that the maximum value of equatorial diameter (5.11 cm) and neck thickness (1.16 cm) was recorded with Consortia (*Azotobecter*+ PSB + KMB) was at par with Arka Microbial Consortium AMC and *Azotobecter*+ PSB treatments. Minimum value of all yield-attributing parameter was notes in Un-inoculated (control) treatment. The probable reason may be that the *Azotobacter* inoculation helped in increasing nitrogen availability, because it is a micro *aerophillic* nitrogen fixer. It colonizes the root mass, fixes nitrogen in loose association with plants and these bacteria induce the plant root to secrete a mucilage which create low oxygen involvement and helps to fix atmospheric nitrogen which refracted in the better yield attributes and PSB and KMB increases the availability of phosphorus and potassium for growth and development of plant. Beneficial effect of bio fertilizers on bulb characters of onion have been reported by Aswani *et al.* (2005) [1] and Waghmode *et al.* (2010) [15].

Table 2: Economics of different treatments of Seedling age and bio fertilizers under onion crop (on polled basis)

Treatment	Cost of cultivation (Rs. ha^{-1})			Marketable Bulb yield (q ha^{-1})	Return (Rs. ha^{-1})		B: C ratio
	excluding treatments	Treat cost	Total Cost		Gross*	Net	
Seedling age (S)							
S_1: 6 weeks	91010	0	91010	318.8	318800	227790	3.50
S_2: 7 weeks	91010	0	91010	331.7	331700	240690	3.64
S_3: 8 weeks	91010	0	91010	306.8	306800	215790	3.37
Bio Fertilizers combinations (BF)							
BF_1: Un-inoculated	91010	0	91010	283.4	283400	192390	3.11
BF_2: *Azotobecter*	91010	900	91910	305.9	305900	213990	3.33
BF_3: *Azoto* + PSB	91010	1125	92135	320.6	320600	228465	3.48
BF_4: Consortia (*Azoto* + PSB + KMB)	91010	1200	92210	337.9	337900	245690	3.66
BF_5: A M C (*Azoto* + PSB + ZSB)	91010	2500	93510	347.6	347600	254090	3.72
Interaction (S X BF)							
S_1 X BF_1	91010	0	91010	284.23	284234	193224	3.12
S_1 X BF_2	91010	900	91910	302.60	302600	210690	3.29
S_1 X BF_3	91010	1125	92135	318.63	318633	226498	3.46
S_1 X BF_4	91010	1200	92210	338.03	338033	245823	3.67
S_1 X BF_5	91010	2500	93510	350.28	350283	256773	3.75
S_2 X BF_1	91010	0	91010	292.40	292399	201389	3.21
S_2 X BF_2	91010	900	91910	318.01	318014	226104	3.46
S_2 X BF_3	91010	1125	92135	333.80	333801	241666	3.62
S_2 X BF_4	91010	1200	92210	353.20	353200	260990	3.83
S_2 X BF_5	91010	2500	93510	361.12	361117	267607	3.86
S_3 X BF_1	91010	0	91010	273.52	273517	182507	3.01
S_3 X BF_2	91010	900	91910	297.17	297167	205257	3.23
S_3 X BF_3	91010	1125	92135	309.40	309400	217265	3.36
S_3 X BF_4	91010	1200	92210	322.33	322333	230123	3.50
S_3 X BF_5	91010	2500	93510	331.53	331533	238023	3.55

* On the basis of market rate @1000/-q

Marketable bulb yield

The perusal of mean data of two year indicates that highest pooled marketable bulb yield (331.7 q) was noted with 7th weeks old seedling age which was significantly higher to 6^{h} and 8th weeks old seedling age. Minimum marketable bulb yield (313.8 q) was recorded with 8th weeks old seedling age (Table 1) The Transplanting of optimum age 7th weeks old seedling appeared to have much more root and shoot

developed over the younger and older seedlings. This may be absorbed to the fact that 7th weeks old seedlings 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 bulb yield. The similar results have also been obtained by Kanton *et al.* (2002) [3] Latif *et al.* (2010) [6] and Singh *et al*, (2017) [10].

Under different bio fertilizers, all the biofertilizer 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. Whereas, minimum marketable bulb yield (283.4q) was in Un-inoculated (control). Significant increase in marketable 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.

It is unequivocal that 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, besides these it colonizes the root mass, fixes nitrogen in loose association with plants and these bacteria induce the plant root to secrete a mucilage which create low oxygen involvement and helps to fix atmospheric nitrogen which refrated in the better yield attributes. Similar results have also been reported by Bhonde *et al.* (2001) [2], Waghmode *et al.* (2010) [15] and Kumar *et al.* (2019) [5].

Economics

Cost of cultivation of Rs. 91010/- ha was common for all the treatments. The highest total cost of cultivation (Rs. 93510/ha) was incurred under Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) applied treatments. The major cost components were the labour in weeding revealing the high capital and labour intensive nature of the crop. Similar cost of cultivation of gladiolus was also reported by Pushpalatha *et al*. (2000) [8]. The economic feasibility in terms of net monetary return showed that the highest net income of Rs 2,40,690 and Rs 2,54,090 were recorded under S_2: 7 weeks and BF_5: Arka Microbial Consortium treatments and as well as its treatment combination (interactions) of Rs 2,67,607 in S_2 X BF_5. The highest B: C ratio 3.64 and 3.72 were recorded under S_2: 7 weeks and BF_5: Arka Microbial Consortium treatments and S_2 X BF_5 treatment combination with 3.86 B: C ratio. Similar findings on economics were reported by and Koli and Jayanthi (2018) [4].

Conclusions

The present study showed that, the highest yield of marketable bulb yield of Agrifound Light Red' onion variety were produced at treatment combination of 7 weeks of seedling age with Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) but no significant difference was observed in these parameters Consortia (*Azotobecter*+ PSB + KMB) combinations with same seedling age. However, the combination of 7 weeks of seedling age applied with Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) also gave statistically comparable yield to the highest value and gave more net return and B:C ratio. Therefore, from the present study it can be concluded that, the most economically attractive yield of the onion crop in the study area was obtained by the combinations of inoculation of Arka Microbial Consortium (*Azotobecter* + PSB + ZSB) and 7 weeks of seedling age with low cost of production and higher benefits.

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