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Effect of different bio-fertilizers and organic substances on quality parameters of rabi onion (*Allium cepa* L.)

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Abstract
The present investigation "effect of different bio-fertilizers and organic substances on quality parameters of rabi onion (*Allium cepa* L.)" was carried out at the Horticulture Instructional cum Research Farm, Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Rabi* season of year 2020-21 and 2021-22 with onion cultivar N-53. The experiment was laid down in randomize block design with three replications. The experiment was comprised of nine treatment organic manures and biofertilizers sole and different combination with one control (without organic manures and biofertilizers inoculation). Result revealed that the quality parameters viz., total soluble solids, reducing sugar, non-reducing sugar, total sugar, ascorbic acid content was measured highest in treatment T_9 (Vermicompost + *Azospirillum* + *Azotobacter* + PSB) during both the year and pooled mean. It is therefore concluded that application of full dose of biofertilizers (*Azospirillum* + *Azotobacter* + PSB) along with Vermicompost were recommended to obtain the better quality of onion bulbs.

Keywords: Onion, biofertilizer, *Azospirillum*, *Azotobacter*, PSB and vermicompost

Introduction
Onion (*Allium cepa* L.) is a biennial or perennial herb belongs to family Alliaceae. The place of origin is purported to be in central Asia, and the Mediterranean regions are considered to be the secondary centre of origin. India is the second largest producer of onion in the world, next to China. India produces about 26830 MT of onion from an area of 1639 Mha with productivity of 16.36 metric tonnes. Maharashtra is the leading onion growing state and other important states are Madhya Pradesh, Gujarat, Bihar, Rajasthan, Andhra Pradesh, West Bengal, Haryana and Uttar Pradesh (Anonymous, 2021a) [2]. In Chhattisgarh, onion is cultivated an area about 25.54 Mha and production of 418.12 MT with productivity of 16.37 metric tonnes (Anonymous, 2021b) [3].

It is one of the most important cash vegetable crop, among bulb crops with higher market demand and price due to its culinary, dietary and medicinal values (Anonymous, 2003) [1]. It is especially rich in protein, carbohydrate and ascorbic acid. About 38 kcal. Calories of energy are obtained from 100 g onion. Nutritive value of onion (nutritive value per 100 g onion scales) water (89 g), lipids (0.16 g), carbohydrate (8.6 g), fibre (1.8 g), potassium (157 mg), sulphur (70 mg), phosphorus (33 gm), calcium (20 gm), vitamin C (6.4 gm.), vitamin E (0.26 gm.), vitamin B6 (0.116 gm.), folic acid (19 mcg.), glutamic acid (0.118 g), argentine (0.156 g), lysine (0.055 g) and leucine (0.041 g) (Kumar *et al*., 2019) [4].

Fertilizer application proved to be a great success and production of vegetables crops increasing in our country. But the continuous and liberal use of inorganic fertilizer alone affects soil health and thus resulting in lower yield with poor quality produce (Mamatha, 2006 and Singh *et al*., 2017) [7, 10]. Now a days there is a need to devise alternate ways to collect, process, compost, utilize organic manure like FYM, vermicompost as well as biofertlizers like *Azotobacter*, *Azospirillum*, *Acetobacter*, *Rhizobium*, *Azolla*, Blue green algae and Phosphate solubilizing bacteria for enrich fertility status of the soil (Vachan and Tripathi, 2017) [12]. Use of organic manures and bioferilizers to meet the nutrient requirement of crop would be an inevitable practice in the years to come for sustainable agriculture since, organic manures and bio fertilizers generally improve the soil physical, chemical and biological properties along with conserving the moisture holding capacity of soil and thus resulting in enhanced crop productivity along with maintaining the quality of crop produce (Maheswarappa *et al*., 1999) [6]. Therefore, keeping in view the production of onion with judicial application of organic substances along with bio fertilizers is an integrated way to reduce health hazards, to protect environment as well as enhancing quality of onion crop.

Materials and Methods

The present experiment was conducted at Horticultural Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Rabi* season of year 2020-21 and 2021-22 with onion cultivar N-53. The experiment was comprised of nine treatment organic manures and biofertilizers sole and different combination *i.e.* T_1 : Vermicompost + *Azospirillum*, T_2 : Vermicompost + *Azotobacter*, T_3 : Vermicompost + PSB, T_4 : Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose), T_5 : Vermicompost + *Azospirillum* + PSB (1/2 dose), T_6 : Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose), T_7 : Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose), T_8 : Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose), T_9 : Vermicompost + *Azospirillum* + *Azotobacte*r + PSB and one control T_0 (without organic manures and biofertilizers inoculation). The experiment was laid out in Randomized Block Design with three replications. The schedules of different pre and post-sowing cultural operations carried out timely during the crop season. Quality parameters *i.e.* TSS, ascorbic acid, reducing sugar, non-reducing sugar and total sugar were measured during course of investigation

Results and Discussion

Total soluble solids (TSS %)

The data pertaining to the total soluble solids as significantly influenced by application of biofertilizers and vermicomost during both the year are presented in Table 1.

The application of biofertilizer and vermicompost significantly increased the total soluble solids during first year. The highest total soluble solids was measured under treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (13.63%) which was statistically at par with T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (12.57%) and T_5 [Vermicompost + *Azospirillum* + PSB (1/2 dose)] (12.17%), T_8 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose)] (11.93%), T_6 [Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)] (11.68%) and T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (11.60%). However, the lowest plant height was recorded under treatment T_0 [Control] (9.27%).

During the second year of experiment, the maximum total soluble solids was measured with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (12.90%) which was significantly superior over all the treatment but statistically at with T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (12.40%), T_5 [Vermicompost + *Azospirillum* + PSB (1/2 dose)] (12.33%), T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (12.07%), T_6 [Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)] (11.87%), T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (11.79%) and T_3 : Vermicompost + PSB (11.39%). However, the minimum total soluble solid was recorded under treatment T_0 [Control] (9.65%).

According to pooled mean data, the maximum total soluble solids were recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (13.27%). Treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] were statistically at par with T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (12.49%), T_5 [Vermicompost + *Azospirillum* + PSB (1/2 dose)] (12.25%), T_8 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose)] (12.00%), T_6 [Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)] (11.78%), T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (11.70%) and T_3 [Vermicompost + PSB] (11.36%). However, the minimum total soluble solid was recorded (9.46%) under treatment T_0 [Control].

The beneficial effect of biofertilizers may be attributed to increase the activity of microbes which might have resulted in release of more amounts of gibberellins, auxins and cytokinins. These growth hormones, in turn accelerate the physiological process like synthesis of carbohydrates and might have other proximate substances. The results are in confirmation with the view of Manna *et al*. (2014) [8] in onion. Similar results were also reported by Setty (1988) [9] in Garlic and Thimmiah in Onion (1989) [11].

Ascorbic Acid (mg/100 g)

Data on effect of bio-fertilizer and vermicompost on ascorbic acid content in bulb of the onion was perusal in Table 1. The data showed that the various levels of bio-fertilizer and vermicompost differed significantly with respect to ascorbic acid content in onion bulb.

The first year mean data indicate that the maximum ascorbic acid in bulb was recorded treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (13.49 mg). This was statistically at par with treatments T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (12.98 mg), T_8 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose)] (12.68 mg), T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (12.60 mg) and T_6 [Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)] (12.41 mg). Treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] were significantly superior over all other treatment including control. However, the minimum ascorbic acid in bulb was recorded under treatment T_0 (10.70 mg) which was statistically inferior as compared to all other treatments and it also happened to be control.

Mean data during the second year of investigation revealed, the maximum ascorbic acid in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (13.92 mg) which was statistically at par with treatment T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (12.84 mg), T_8 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose)] (12.65 mg), T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (12.31 mg) and T_6 [Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)] (12.30 mg). However, the minimum ascorbic acid in bulb was recorded under treatment T_0 [Control] (10.49 mg).

In case of pooled mean, the maximum ascorbic acid in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (13.71 mg) which was significantly superior as compared to all other treatments but remained statistically at par with treatment T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (12.91 mg), T_8 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose)] (12.67 mg), T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (12.46 mg) and T_6 [Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)] (12.36 mg). However, the minimum ascorbic acid in bulb was recorded (10.60 mg) under treatment T_0 and this was also happened to be control. Similar results were also reported by Kumar *et al*. (2017) [5].

Reducing sugar (%)

Significant differences were exhibited among different treatments with respect to the reducing sugar in bulb during first year, second year and pooled mean (Table 2).

During the first year, the maximum reducing sugar in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (4.95%). This was statistically at par with treatments T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (4.92%), T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (4.84%), T_6 [Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)] (4.71%), T_8 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose)] (4.37%) and T_5 [Vermicompost + *Azospirillum* + PSB (1/2 dose)] (4.15%). However, the minimum reducing sugar in bulb was recorded under treatment T_0 [Control] (3.78%).

Data on second year of investigation revealed that the maximum reducing sugar in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (5.16%).This was significantly superior as compared to other treatments but remained at par with treatment T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (4.91%), T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (4.56%), T_6 [Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)] (4.54%) and T_8 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose)] (4.49%), However, the minimum reducing sugar in bulb was recorded under treatment T_0 [Control] (3.70%).

In case of pooled mean, the maximum reducing sugar in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (5.06%) which was statistically at par with treatments T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (4.94%), T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (4.70%), T_6 [Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)] (4.63%) and T_8 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose)] (4.43%). However, the minimum reducing sugar in bulb was recorded under treatment T_0 [Control] (3.74%). Similar results were also reported by Kumar *et al*. (2017) [5].

Non-reducing sugar (%)

Non-significant differences were exhibited among the treatments with respect to non-reducing sugar in bulb under different treatments during first year, second year and pooled mean which can be seen in Table 2.

Mean data during the second year of investigation revealed, the maximum non-reducing sugar in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (9.67%) followed by T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (9.39%) and T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (9.23%). However, the minimum non-reducing sugar in bulb was recorded under treatment T_0 [Control] (7.95%).

Data on second year of investigation revealed that the maximum non-reducing in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (9.43%) followed by T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (9.21%) and T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (9.00%). However, the minimum non-reducing sugar in bulb was recorded under treatment T_0 [Control] (7.37%).

In case of pooled mean, the maximum non-reducing sugar in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (9.55%) followed by T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (9.30%) and T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (9.12%). However, the minimum non-reducing sugar in bulb was recorded under treatment T_0 [Control] (7.66%). Similar results were also reported by Kumar *et al*. (2017) [5].

Total sugar (%)

The present investigation revealed that the total sugar in bulb was found to be non-significant during first year, second year and pooled mean with respect to the combined effect biofertilizers and vermicompost (Table 2).

The first year of investigation, the maximum total sugar in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (14.62%) followed by T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (14.23%) and T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (14.15%). However, the minimum total sugar in bulb was recorded under treatment T_0 [Control] (11.73%).

Based on second year mean data, the maximum total sugar in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (14.59%) followed by T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (13.96%) and T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (13.77%). However, the minimum total sugar in bulb was recorded under treatment T_0 [Control] (11.15%).

In case of pooled mean, the maximum total sugar in bulb was recorded with treatment T_9 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB] (14.61%) followed by T_7 [Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)] (14.09%) and T_4 [Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)] (14.00%). However, the minimum total sugar in bulb was recorded under treatment T_0 [Control] (11.44%).

The increased total sugar in bulb was could be due to more translocation of photosynthates from leaves (source) to bulb (sink). Similar results were also reported by Kumar *et al*. (2017) [5].

Table 1: Effect of different bio-fertilizers and organic substances on TSS and ascorbic acid content of rabi onion.

Treatments	TSS (%)			Ascorbic acid (mg/100g)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_0 : Control	9.27	9.65	9.46	10.70	10.49	10.60
T_1 : Vermicompost + *Azospirillum*	11.10	11.02	11.06	11.03	11.19	11.11
T_2 : Vermicompost + *Azotobacter*	10.37	10.38	10.38	10.87	10.90	10.89
T_3 : Vermicompost + PSB	11.33	11.39	11.36	10.78	10.83	10.81
T_4 : Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)	11.60	11.79	11.70	12.60	12.31	12.46
T_5 : Vermicompost + *Azospirillum* + PSB (1/2 dose)	12.17	12.33	12.25	11.42	11.30	11.36
T_6 : Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)	11.68	11.87	11.78	12.41	12.30	12.36
T_7 : Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)	12.57	12.40	12.49	12.98	12.84	12.91
T_8 : Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose)	11.93	12.07	12.00	12.68	12.65	12.67
T_9 : Vermicompost + *Azospirillum* + *Azotobacter* + PSB	13.63	12.90	13.27	13.49	13.92	13.71
SEm (±)	0.76	0.62	0.69	0.65	0.70	0.68
CD (5%)	2.25	1.85	1.99	1.94	2.07	1.94

Table 2: Effect of different bio-fertilizers and organic substances on reducing sugar, non-reducing sugar and total sugar of rabi onion.

Treatments	Reducing sugar (%)			Non-reducing sugar (%)			Total sugar (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_0 : Control	3.78	3.78	3.78	7.95	7.37	7.66	11.73	11.15	11.44
T_1 : Vermicompost + *Azospirillum*	3.93	4.05	3.99	8.57	8.62	8.60	12.50	12.67	12.59
T_2 : Vermicompost + *Azotobacter*	4.06	4.09	4.08	8.45	8.43	8.44	12.51	12.52	12.52
T_3 : Vermicompost + PSB	3.82	3.97	3.90	8.42	8.40	8.41	12.24	12.37	12.31
T_4 : Vermicompost + *Azospirillum* + *Azotobacter* (1/2 dose)	4.84	4.56	4.70	9.39	9.21	9.30	14.23	13.77	14.00
T_5 : Vermicompost + *Azospirillum* + PSB (1/2 dose)	4.15	4.30	4.23	8.60	8.76	8.68	12.75	13.06	12.91
T_6 : Vermicompost + *Azotobacter* + *Azospirillum* (1/2 dose)	4.71	4.54	4.63	8.85	8.87	8.86	13.56	13.41	13.49
T_7 : Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/2 dose)	4.92	4.91	4.92	9.23	9.00	9.12	14.15	13.91	14.03
T_8 : Vermicompost + *Azospirillum* + *Azotobacter* + PSB (1/3 dose)	4.37	4.49	4.43	8.88	8.88	8.88	13.25	13.37	13.31
T_9 : Vermicompost + *Azospirillum* + *Azotobacter* + PSB	4.95	5.16	5.06	9.67	9.43	9.55	14.62	14.59	14.61
SEm (±)	0.28	0.26	0.27	0.90	0.78	0.84	1.04	1.47	1.27
CD (5%)	0.84	0.77	0.78	NS	NS	NS	NS	NS	NS

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