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DS Mandloi
K.V.K., Dhar, Madhya Pradesh, India

Praveen Kumar Singh Gurjar
K.V.K., Morena, Madhya Pradesh, India

MK Kureel
College of Agriculture, Khandwa, Madhya Pradesh, India

Rajesh Lekhi
College of Agriculture, Gwalior, Madhya Pradesh, India

KV Singh
K.V.K., Lahar, Bhind, Madhya Pradesh, India

Corresponding Author:
DS Mandloi
K.V.K., Dhar, Madhya Pradesh, India

Influence of bio-fertilizers and level chemical fertilizers on morphological parameters of Onion (*Allium cepa* L.) *cv.* Bhima Red

DS Mandloi, Praveen Kumar Singh Gurjar, MK Kureel, Rajesh Lekhi and KV Singh

Abstract
An experiment entitled "Studies on influence of bio-fertilizers and level chemical fertilizers on growth of Onion (*Allium cepa* L.) *cv.* Bhima Red" was carried out at Agricultural Farm, Krishi Vigyan Kendra, Dhar, M.P. during 2020-21 and 2021-22 with the objectives to study effect of bio-fertilizers application on growth characters. The experiment was conducted in Randomised Block Design with 3 replications. It comprised of 14 treatments of bio-fertilizers and levels of chemical fertilizers.
Morphological parameters like leaf area, leaf area index, Bulb/green top ratio, leaf dry matter, chlorophyll content in leaves and bulb dry matter were recorded and statistically analysed. From the experiment, it may be concluded that the bio-fertilizers and various levels of chemical fertilizers had a significant effect on the growth of the crop. The treatment with 100% RDF + *Azospirillum* + *Azotobactor* + *VAM* was found to be the best treatment among all treatments whereas the minimum effect was observed under treatment with no bio-fertilizer and chemical fertilizer.

Keywords: Onion, morphology, *Allium cepa*, bio fertilizers, VAM, *Azospirillum*, *Azotobacter*

Introduction
Onion, botanically known as *Allium cepa* L. is a biennial herb of the family *Alliaceae*. *Pyaj* is the common name of the crop in Hindi. It is an old-world crop which was domesticated in Iran and Pakistan *i.e.*, Central Asia. Maharashtra is the leading onion growing state in India. Other major onion growing states in India are Karnataka, Gujarat, Bihar, Madhya Pradesh, Andhra Pradesh, Rajasthan, Haryana, Uttar Pradesh and Tamil Nadu. It is one of the most important bulbous vegetables and grown all over the world. It is also used for culinary purpose in everyday cooking. The crop semi-perishable in nature and it can be transported to a long distance without much transit injury losses. It becomes a major cash crop with higher market demand and price due to its culinary, dietary and medicinal values.
Ffter China, India ranks second in area and production of onion. In India, the area and production of onion are 1624 thousand hectare and 26641 thousand MT (Anonymous, 2020-21). In Madhya Pradesh, The area and production of onion are 186.92 thousand hectare and 4548.56 thousand MT (Anonymous, 2020-21). Onion is a good source of ascorbic acid, dietary fiber and it also possesses a high content of flavanoids (mainly quercetin and its conjugates) and sulphur compounds (i.e.thio sulphinate), both contain a high level of antioxidants.
Sustainable increase in crop yield has been obtained with the use of Bio-fertilizers under various agro-climatic conditions during the last few decades.
Onion a seasonal crop has comparatively low storage ability. Sometimes bulbs are to be stored for longer period due to seasonal glut in the market. Significant losses in quality and quantity of onion occur during storage. Organic farming improves the quality of the produce combine with higher nutritive value and better storage life than those grown conventionally with mineral fertilizers. In onion, the information on studies of organic farming using different kinds of organic manure and bio-fertilizers is very meagre. The post-harvest losses, *viz.*, sprouting, rotting and physiological loss in weight pose a great problem.

Materials and Methods
Experimental site and location
The present experiment was conducted at Agriculture farm, Krishi Vigyan Kendra, Dhar

(M.P.). The topography of the field was uniform with proper drainage system.

Climate and weather condition

Dhar belongs to "Malwa Plateau" under 10th Agro-Climatic Zone of Madhya Pradesh as per classification made by National Agricultural Research Project. It is situated in the south-western part of Madhya Pradesh. It lies between the parallels of North latitude 22° 01'14 to 23° 08'49'' North latitude and 74° 28'15 to 75° 42''43 East longitudes and altitude of 588 meter above mean sea level. Dhar enjoys a typical sub-tropical climate consisting of hot dry summers and cool dry winters. The minimum and maximum temperature during crop growth period 2020-21 and 2021-22 varies between 7.36 ^{0}C to 26.71 ^{0}C and from 7.00 ^{0}C to 43.00 ^{0}C, with season's average values of 19.00 ^{0}C and 34.57 ^{0}C, respectively. The morning and evening relative humidity ranged between 12.26 to 87.29% and 11.26 to 76.66% with season's average of 38.14% and 19.01%, respectively. The rainfall of crop growth period 2020-21 was about 266.2 mm and 2021-22 was 221.1 mm which was mostly received between June – July.

Bhima Red was developed by ICAR-Directorate of Onion and Garlic Research (ICAR-DOGR), Pune, Maharashtra and entirely resembles with (B780531, IC No. 561258) has been developed through bulb to row selection method. Bulbs are attractive red in colour with round shape. It can be grown during rabi season also for immediate marketing as it can be stored up to 3 months during rabi. It matures after 115-120days of transplanting. TSS ranges from 10-11%. Bhima Red is a high yielding onion variety. This variety produced bulbs up to 480-520 qt/ha. It was released by ICAR-Directorate on Onion and Garlic Research, Pune12th November, 2014, Pune, Maharashtra

Treatment details

T_0 – Control	T_7 – 75% RDF+ *VAM*
T_1– 100% RDF	T_8– 50% RDF+.*Azospirillum*
T_2 – 100% RDF+*Azospirillum*	T_9 – 50% RDF+ *Azotobactor*
T_3– 100% RDF+*Azotobacter*	T_{10} – 50% RDF+ *VAM*
T_4–100% RDF+*VAM*	T_{11}–100% RDF *Azospirillum*+*Azotobactor*+*VAM*
T_5– 75% RDF+*Azospirillum*	T_{12}–75% RDF+*Azospirillum*+*Azotobactor*+*VAM*
T_6– 75% RDF+*Azotobactor*	T_{13} -50% RDF+*Azospirillum*+*Azotobactor*+*VAM*

Parameters under study

1) Plant height at 30, 60, 90 and 120 DAT
2) No. of leaves per plant at 30, 60, 90 and 120 DAT
3) Length of leaves per plant at 30, 60, 90 and 120 DAT
4) Width of leaves per plant at 30, 60, 90 and 120 DAT
5) Bolting percentage at flowering stage
6) Neck thickness of the bulb at 30, 60, 90 and 120 DAT

Experimental findings

1. Plant height at 30, 60, 90 and 120 DAT

It was recorded that the different treatments of biofertilizers were significantly influenced the plant height at different growth stages. The treatment T_{11} (100% RDF + *Azospirillum* + *Azotobactor* + *VAM*) was found the best treatment among all treatments and it gave the maximum plant height (24.13, 60.67, 82.34 and 83.55 cm) at 30, 60, 90 and 120 DAT in first year, (24.13, 60.53, 80.18 and 81.59 cm) at 30, 60, 90 and 120 DAT second year and (24.13, 60.60, 81.26 and 82.57 cm) at 30, 60, 90 and 120 DAT in pooled. It was at par to all treatments except T_9 and T_{10} at 30 DAT, at par to treatments T_2, T_3, T_4, T_5 and T_{12} at 60 DAT, T_2, T_3, T_4, T_5, T_6, T_7 and T_{12} at 90 DAT and T_2, T_3, T_4, T_5 and T_{12} at 120 DAT. However, the minimum plant height (21.55, 48.19, 74.00 and 77.26 cm) at 30, 60, 90 and 120 DAT in first year, (22.03, 45.71, 75.66 and 75.59 cm) at 30, 60, 90 and 120 DAT second year and (21.79, 46.95, 74.83 and 76.43 cm) at 30, 60, 90 and 120 DAT in pooled was recorded in treatment T_0 (Control).

2. No. of leaves per plant at 30, 60, 90 and 120 DAT

Result reported that the maximum no. of leaves per plant (4.48, 5.56, 8.26 and 9.28) at 30, 60, 90 and 120 DAT in first year, (4.62, 5.81, 8.29 and 9.43) at 30, 60, 90 and 120 DAT second year and (4.55, 5.69, 8.27 and 9.36) at 30, 60, 90 and 120 DAT in pooled was found in treatment T_{11} (100% RDF + *Azospirillum* + *Azotobactor* + *VAM*) and it was the best treatment among all treatments. It was at par to treatments T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_{12} in first year, treatments T_2, T_3, T_4, T_5 and T_{12} in second year and treatments T_2, T_3 and T_{12} in pooled at 30 DAT, at par to all treatments except T_8, T_9, T_{10} and T_{13} in first year, T_2, T_3, T_4, T_5 and T_{12} in second year and treatments T_2, T_3, T_4 and T_{12} in pooled at 60 DAT, at par to treatments T_2, T_3, T_4, T_5, T_6 and T_{12} in first year, treatments T_2, T_3 and T_{12} in second year and T_2, T_3, T_4 and T_{12} in pooled at 90 DAT and at par to all treatments except T_8, T_9 and T_{10} in first year, at par to treatments T_2, T_3, T_4, T_5, T_6, T_7 and T_{12} in second year and T_2, T_3, T_4, T_5, T_6 and T_{12} in pooled at 120 DAT. However, the minimum no. of leaves per plant (3.62, 5.19, 7.15 and 8.38) at 30, 60, 90 and 120 DAT in first year, (3.26, 5.03, 7.12 and 8.29) at 30, 60, 90 and 120 DAT second year and (3.44, 5.11, 7.13 and 8.34) at 30, 60, 90 and 120 DAT in pooled was observed in treatment T_0 (Control).

3. Length of leaves per plant at 30, 60, 90 and 120 DAT

The investigation revealed that the treatment T_{11} (100% RDF + *Azospirillum* + *Azotobactor* + *VAM*) was significantly influenced the length of leaves of onion plant and it gave the maximum length of leaves per plant (22.12, 40.75, 57.10 and 51.42 cm) at 30, 60, 90 and 120 DAT in first year, (22.38, 40.99, 57.00 and 52.04 cm) at 30, 60, 90 and 120 DAT second year and (22.25, 40.87, 57.05 and 51.73 cm) at 30, 60, 90 and 120 DAT in pooled. It was at par to treatments T_2, T_3, T_4 and T_{12} in first year, treatments T_2, T_3, T_4, T_5 and T_{12} in second year and treatments T_3 and T_{12} in pooled at 30 DAT, at par to all treatments except T_9 and T_{10} in first year, at par to all treatments except T_{10} in second year and at par to all treatments except T_8, T_9 and T_{10} in pooled at 60 DAT, at par to all treatments except T_{10} in first year, at par to all treatments except T_1, T_8, T_9 and T_{10} in second year and in pooled at 90 DAT and at par to all treatments except T_9 and T_{10} in first year and second year while at par to all treatments except T_1, T_8, T_9 and T_{10} in pooled at 120 DAT, whereas the minimum length of leaves per plant (19.43, 35.67, 48.67 and 44.30 cm) at 30, 60, 90 and 120 DAT in first year, (19.78, 36.67, 46.93 and 44.73 cm) at 30, 60, 90 and 120 DAT second year and (19.60, 36.17, 47.80 and 44.52 cm) at 30, 60, 90 and 120 DAT in pooled was recorded in treatment T_0 (Control).

4. Width of leaves per plant at 30, 60, 90 and 120 DAT

Result revealed that the maximum width of leaves per plant (0.50, 0.62, 0.65 and 0.67 cm) at 30, 60, 90 and 120 DAT in first year, (0.52, 0.61, 0.65 and 0.67 cm) at 30, 60, 90 and 120 DAT second year and (0.51, 0.61, 0.65 and 0.67 cm) at 30, 60, 90 and 120 DAT in pooled was recorded in treatment T_{11} (100% RDF + *Azospirillum* + *Azotobactor* + *VAM*) and it was found the best treatment among all treatments. It was at par to all treatments except T_9 and T_{10} in first year, at par to treatments T_2, T_3, T_4, T_5, T_6 and T_{12} in second year, treatments T_2, T_3, T_4 and T_{12} in pooled at 30 DAT, at par to treatments T_2, T_3, T_4 and T_{12} in first year, T_2, T_3, T_4, T_5 and T_{12} in second year and T_2, T_3 and T_{12} in pooled at 60 DAT, at par to treatments T_2, T_3 and T_{12} in first, second year and in pooled at 90 DAT and at par to treatments T_2, T_3, T_4, T_5 and T_{12} in first year, treatments T_2, T_3, T_4, T_5, T_6, T_7 and T_{12} in second year and treatments T_2, T_3, T_4 and T_{12} in pooled at 120 DAT. While, the minimum width of leaves per plant (0.41, 0.40, 0.51 and 0.50 cm) at 30, 60, 90 and 120 DAT in first year, (0.35, 0.42, 0.51 and 0.53 cm) at 30, 60, 90 and 120 DAT second year and (0.38, 0.41, 0.51 and 0.51 cm) at 30, 60, 90 and 120 DAT in pooled was found in treatment T_0 (Control).

5. Bolting percentage at flowering stage

It was recorded that the maximum bolting percentage at flowering stage (4.45, 4.47 and 4.46%) in first year, second year and in pooled was recorded in treatment T_{11} (100% RDF + *Azospirillum* + *Azotobactor* + *VAM*) and it was found the best treatment for influencing the bolting percentage in onion. It was at par to treatments T_2, T_3, T_4, T_5 and T_{12} in first year and in pooled and at par to treatments T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_{12} in second year. However, the minimum bolting percentage at flowering stage (3.75, 3.62 and 3.68%) in first year, second year and in pooled was noted in treatment T_0 (Control).

6. Neck thickness of the bulb at 30, 60, 90 and 120 DAT

The data gathered on neck thickness of the bulb at 30, 60, 90 and 120 DAT is given in Table 1-6. Its graphical presentation has been shown in Figure 1-6. The ANOVA is given in Appendix-XVIII, XIX, XX and XXI.

It was observed that the treatment T_{11} (100% RDF + *Azospirillum* + *Azotobactor* + *VAM*) was significantly influenced the neck thickness of onion bulb and it gave the maximum neck thickness of the bulb (0.66, 1.10, 1.28 and 1.51 cm) at 30, 60, 90 and 120 DAT in first year, (0.66, 1.33, 1.29 and 1.50 cm) at 30, 60, 90 and 120 DAT second year and (0.66, 1.21, 1.29 and 1.50 cm) at 30, 60, 90 and 120 DAT in pooled. It was at par to all treatments except T_8, T_9 and T_{10} in first year, at par to all treatments except T_9 and T_{10} in second year and at par to treatments T_2, T_3, T_4, T_5, T_6 and T_{12} in pooled at 30 DAT, at par to treatments T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_{12} in first year and at par to treatment T_{12} in second year and in pooled at 60 DAT, at par to treatment T_3 and T_{12} in first year at 90 DAT and at par to all treatments except T_8, T_9 and T_{10} in first year, except treatments T_8, T_9, T_{10} and T_{13} in second year and except treatments T_1, T_8, T_9, T_{10} and T_{13} in pooled at 120 DAT. However, the minimum neck thickness of the bulb (0.54, 0.67, 0.95 and 1.21 cm) at 30, 60, 90 and 120 DAT in first year, (0.54, 0.56, 0.93 and 1.23 cm) at 30, 60, 90 and 120 DAT second year and (0.54, 0.61, 0.94 and 1.22 cm) at 30, 60, 90 and 120 DAT in pooled was recorded in treatment T_0 (Control).

Discussion

Result revealed that the different treatments of biofertilizers were significantly influenced the different morphological parameters (*viz*., plant height, no. of leaves per plant, length of leaves per plant, width of leaves per plant, bolting percentage at flowering stage and neck thickness of the bulb) at different growth stages. The treatment T_{11} (100% RDF + *Azospirillum* + *Azotobactor* + *VAM*) was found the best treatment among all treatments and it gave the maximum morphological parameters at different growth stages. However, the minimum morphological parameters at different growth stages were recorded in treatment T_0 (Control). Application of biofertilizers like *Azospirillum*, *Azotobactor* and *VAM* improves nutrient status of the soil because it is free nitrogen fixers and phosphorus solubilizer. Efficient and healthy strain of *Azotobacter* in rhizosphere, which in turn have resulted in greater fixation of atmospheric nitrogen and consequently use by the plant resulting in vigorous growth of it. Due to the good absorption of nutrients increase the size of bulb and increase neck thickness of bulb. The results are in confirmation with the results achieved by Solanki *et al.* (2019) [3], Vaghela *et al.* (2019) [4], Rathod *et al.* (2020) [1], Singh *et al.* (2020) [2] and Vishvkarma *et al.* (2020a) [5].

Table 1: Effect of bio-fertilizers and chemical fertilizers on plant height at 30, 60, 90 and 120 DAT of onion

Treatments detail	Plant height (cm)											
	Ist Year				IInd Year				Pooled			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T_0 – Control	21.55	48.19	74.00	77.26	22.03	45.71	75.66	75.59	21.79	46.95	74.83	76.43
T_1– 100% RDF	23.28	56.59	78.33	78.81	23.57	58.82	78.70	78.89	23.43	57.70	78.52	78.85
T_2 – 100% RDF + *Azospirillum*	24.06	60.37	80.37	81.75	23.97	60.19	80.08	80.20	24.02	60.28	80.23	80.98
T_3– 100% RDF + *Azotobacter*	24.08	60.42	80.67	82.16	24.05	60.20	80.12	80.60	24.06	60.31	80.39	81.38
T_4–100% RDF + *VAM*	24.03	59.71	79.73	80.28	23.93	60.12	80.00	80.19	23.98	59.92	79.86	80.24
T_5– 75% RDF + *Azospirillum*	24.01	59.38	79.71	79.83	23.81	60.07	79.82	80.18	23.91	59.73	79.76	80.00
T_6– 75% RDF + *Azotobactor*	23.94	58.43	79.67	79.75	23.69	59.74	79.74	79.56	23.82	59.09	79.70	79.65
T_7 – 75% RDF + *VAM*	23.34	58.04	78.75	79.01	23.65	59.11	79.30	79.22	23.50	58.57	79.02	79.11
T_8– 50% RDF +.*Azospirillum*	23.11	53.66	76.63	78.44	23.44	52.18	76.67	76.85	23.27	52.92	76.65	77.65
T_9 – 50% RDF + *Azotobactor*	22.75	49.07	75.67	77.90	22.86	49.77	76.52	76.67	22.81	49.42	76.09	77.29
T_{10} – 50% RDF+ *VAM*	22.64	48.99	75.33	77.27	22.27	49.40	76.48	75.66	22.45	49.20	75.91	76.47
T_{11}–100% RDF + *Azospirillum* + *Azotobactor* + *VAM*	24.13	60.67	82.34	83.55	24.13	60.53	80.18	81.59	24.13	60.60	81.26	82.57

T_{12}–75% RDF + *Azospirillum* + *Azotobactor* + *VAM*	24.09	60.45	81.67	82.59	24.05	60.41	80.14	81.03	24.07	60.43	80.91	81.81
T_{13} -50% RDF + *Azospirillum* + *Azotobactor* + *VAM*	23.11	56.11	78.03	78.78	23.56	58.62	78.52	78.51	23.33	57.37	78.28	78.65
S.Em ±	0.439	0.458	1.330	1.332	0.408	0.532	1.087	1.309	0.300	0.351	0.859	0.934
CD 5%	1.275	1.332	3.867	3.873	1.187	1.546	3.161	3.805	0.851	0.996	2.438	2.650

Table 2: Effect of bio-fertilizers and chemical fertilizers on no. of leaves per plant at 30, 60, 90 and 120 DAT of onion

No. of leaves per plant												
Treatments detail	**Ist Year**				**IInd Year**				**Pooled**			
	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**
T_0 – Control	3.62	5.19	7.15	8.38	3.26	5.03	7.12	8.29	3.44	5.11	7.13	8.34
T_1– 100% RDF	4.03	5.44	7.48	9.02	3.82	5.30	7.64	8.81	3.93	5.37	7.56	8.92
T_2 – 100% RDF + *Azospirillum*	4.20	5.52	8.00	9.12	4.19	5.44	8.11	9.18	4.20	5.48	8.06	9.15
T_3– 100% RDF + *Azotobacter*	4.37	5.53	8.04	9.18	4.23	5.52	8.14	9.22	4.30	5.52	8.09	9.20
T_4–100% RDF + *VAM*	4.11	5.52	7.95	9.07	4.17	5.42	7.96	9.06	4.14	5.47	7.96	9.07
T_5– 75% RDF + *Azospirillum*	4.10	5.47	7.85	9.06	4.08	5.42	7.82	9.00	4.09	5.44	7.84	9.03
T_6– 75% RDF + *Azotobactor*	4.06	5.46	7.81	9.06	4.00	5.39	7.80	8.98	4.03	5.43	7.81	9.02
T_7 – 75% RDF + *VAM*	4.05	5.44	7.55	9.04	3.92	5.38	7.79	8.84	3.99	5.41	7.67	8.94
T_8– 50% RDF +.*Azospirillum*	3.79	5.41	7.37	8.77	3.60	5.15	7.31	8.73	3.69	5.28	7.34	8.75
T_9 – 50% RDF + *Azotobactor*	3.74	5.28	7.30	8.65	3.58	5.14	7.18	8.69	3.66	5.21	7.24	8.67
T_{10} – 50% RDF+ *VAM*	3.73	5.27	7.19	8.60	3.44	5.10	7.14	8.60	3.59	5.19	7.17	8.60
T_{11}–100% RDF + *Azospirillum* + *Azotobactor* + *VAM*	4.48	5.56	8.26	9.28	4.62	5.81	8.29	9.43	4.55	5.69	8.27	9.36
T_{12}–75% RDF + *Azospirillum* + *Azotobactor* + *VAM*	4.41	5.55	8.08	9.24	4.26	5.59	8.21	9.31	4.33	5.57	8.14	9.28
T_{13} -50% RDF + *Azospirillum* + *Azotobactor* + *VAM*	3.81	5.42	7.40	8.90	3.81	5.16	7.54	8.79	3.81	5.29	7.47	8.85
S.Em ±	0.174	0.074	0.228	0.160	0.208	0.143	0.086	0.209	0.135	0.080	0.122	0.132
CD 5%	0.505	0.214	0.663	0.466	0.604	0.415	0.251	0.607	0.384	0.228	0.346	0.373

Table 3: Effect of bio-fertilizers and chemical fertilizers on length of leaves per plant at 30, 60, 90 and 120 DAT of onion

Length of leaves per plant (cm)												
Treatments detail	**Ist Year**				**IInd Year**				**Pooled**			
	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**
T_0 – Control	19.43	35.67	48.67	44.30	19.78	36.67	46.93	44.73	19.60	36.17	47.80	44.52
T_1– 100% RDF	20.44	39.18	54.97	48.95	20.59	39.70	54.08	49.62	20.52	39.44	54.53	49.29
T_2 – 100% RDF + *Azospirillum*	21.49	40.36	56.26	50.44	21.71	40.46	56.19	50.88	21.60	40.41	56.22	50.66
T_3– 100% RDF + *Azotobacter*	22.05	40.74	56.44	50.59	22.03	40.51	56.34	51.12	22.04	40.63	56.39	50.86
T_4–100% RDF + *VAM*	21.49	40.13	55.92	49.87	21.64	40.09	55.86	50.23	21.57	40.11	55.89	50.05
T_5– 75% RDF + *Azospirillum*	20.89	40.01	55.67	49.83	21.58	40.04	55.50	50.05	21.24	40.03	55.59	49.94
T_6– 75% RDF + *Azotobactor*	20.78	39.69	55.25	49.18	21.16	40.01	55.36	49.96	20.97	39.85	55.31	49.57
T_7 – 75% RDF + *VAM*	20.74	39.63	55.21	49.15	20.88	39.75	54.81	49.75	20.81	39.69	55.01	49.45
T_8– 50% RDF +.*Azospirillum*	20.07	38.70	54.33	48.29	20.25	39.36	53.19	49.34	20.16	39.03	53.76	48.81
T_9 – 50% RDF + *Azotobactor*	20.05	38.04	53.33	46.48	20.11	39.30	52.22	48.01	20.08	38.67	52.78	47.25
T_{10} – 50% RDF+ *VAM*	19.68	36.77	51.33	45.99	19.81	38.00	47.07	47.72	19.74	37.39	49.20	46.86
T_{11}–100% RDF + *Azospirillum* + *Azotobactor* + *VAM*	22.12	40.75	57.10	51.42	22.38	40.99	57.00	52.04	22.25	40.87	57.05	51.73
T_{12}–75% RDF + *Azospirillum* + *Azotobactor* + *VAM*	22.09	40.67	57.03	50.60	22.08	40.77	56.37	51.15	22.09	40.72	56.70	50.88
T_{13} -50% RDF + *Azospirillum* + *Azotobactor* + *VAM*	20.22	39.02	54.60	48.53	20.47	39.70	53.92	49.55	20.35	39.36	54.26	49.04
S.Em ±	0.273	0.807	1.359	1.326	0.311	0.711	0.948	1.002	0.207	0.538	0.828	0.831
CD 5%	0.792	2.346	3.950	3.855	0.905	2.066	2.755	2.913	0.587	1.526	2.351	2.359

Table 4: Effect of bio-fertilizers and chemical fertilizers on width of leaves per plant at 30, 60, 90 and 120 DAT of onion

Width of leaves per plant (cm)												
Treatments detail	**Ist Year**				**IInd Year**				**Pooled**			
	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**
T_0 – Control	0.41	0.40	0.51	0.50	0.35	0.42	0.51	0.53	0.38	0.41	0.51	0.51
T_1– 100% RDF	0.45	0.52	0.55	0.60	0.45	0.53	0.55	0.59	0.45	0.53	0.55	0.59
T_2 – 100% RDF + *Azospirillum*	0.47	0.57	0.62	0.65	0.48	0.58	0.62	0.65	0.48	0.58	0.62	0.65
T_3– 100% RDF + *Azotobacter*	0.48	0.58	0.63	0.65	0.49	0.59	0.63	0.66	0.49	0.59	0.63	0.65

T_4–100% RDF + *VAM*	0.47	0.57	0.58	0.64	0.48	0.57	0.58	0.63	0.48	0.57	0.58	0.63
T_5– 75% RDF + *Azospirillum*	0.47	0.55	0.57	0.63	0.48	0.56	0.57	0.61	0.47	0.56	0.57	0.62
T_6– 75% RDF + *Azotobactor*	0.47	0.54	0.57	0.62	0.48	0.56	0.57	0.61	0.47	0.55	0.57	0.61
T_7 – 75% RDF + *VAM*	0.46	0.53	0.56	0.61	0.46	0.54	0.56	0.60	0.46	0.54	0.56	0.61
T_8– 50% RDF +.*Azospirillum*	0.44	0.48	0.55	0.56	0.45	0.47	0.55	0.58	0.45	0.48	0.55	0.57
T_9 – 50% RDF + *Azotobactor*	0.42	0.44	0.54	0.55	0.44	0.47	0.54	0.57	0.43	0.45	0.54	0.56
T_{10} – 50% RDF+ *VAM*	0.41	0.43	0.52	0.53	0.43	0.45	0.52	0.55	0.42	0.44	0.52	0.54
T_{11}–100% RDF + *Azospirillum* + *Azotobactor* + *VAM*	0.50	0.62	0.65	0.67	0.52	0.61	0.65	0.67	0.51	0.61	0.65	0.67
T_{12}–75% RDF + *Azospirillum* + *Azotobactor* + *VAM*	0.49	0.60	0.64	0.66	0.50	0.59	0.64	0.66	0.49	0.60	0.64	0.66
T_{13} -50% RDF + *Azospirillum* + *Azotobactor* + *VAM*	0.44	0.49	0.55	0.57	0.45	0.50	0.55	0.58	0.45	0.50	0.55	0.57
S.Em ±	0.019	0.021	0.019	0.015	0.018	0.016	0.019	0.025	0.013	0.013	0.014	0.015
CD 5%	0.054	0.060	0.056	0.043	0.053	0.045	0.056	0.074	0.037	0.037	0.039	0.042

Table 5: Effect of bio-fertilizers and chemical fertilizers on bolting percentage at flowering stage of onion

Treatments detail	**Bolting percentage at flowering stage**		
	Ist Year	**IInd Year**	**Pooled**
T_0 – Control	3.75	3.62	3.68
T_1– 100% RDF	4.11	4.26	4.19
T_2 – 100% RDF + *Azospirillum*	4.39	4.41	4.40
T_3– 100% RDF + *Azotobacter*	4.40	4.42	4.41
T_4–100% RDF + *VAM*	4.33	4.35	4.34
T_5– 75% RDF + *Azospirillum*	4.30	4.32	4.31
T_6– 75% RDF + *Azotobactor*	4.15	4.32	4.24
T_7 – 75% RDF + *VAM*	4.12	4.32	4.22
T_8– 50% RDF +.*Azospirillum*	4.08	4.16	4.12
T_9 – 50% RDF + *Azotobactor*	3.82	3.96	3.89
T_{10} – 50% RDF+ *VAM*	3.81	3.86	3.83
T_{11}–100% RDF + *Azospirillum* + *Azotobactor* + *VAM*	4.45	4.47	4.46
T_{12}–75% RDF + *Azospirillum* + *Azotobactor* + *VAM*	4.42	4.45	4.44
T_{13} -50% RDF + *Azospirillum* + *Azotobactor* + *VAM*	4.08	4.18	4.13
S.Em ±	0.102	0.101	0.072
CD 5%	0.297	0.295	0.204

Table 6: Effect of bio-fertilizers and chemical fertilizers on neck thickness of the bulb at 30, 60, 90 and 120 DAT of onion

Neck thickness of the bulb (cm)												
Treatments detail	**Ist Year**				**IInd Year**				**Pooled**			
	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**
T_0 – Control	0.54	0.67	0.95	1.21	0.54	0.56	0.93	1.23	0.54	0.61	0.94	1.22
T_1– 100% RDF	0.61	0.96	1.09	1.41	0.61	0.93	1.05	1.42	0.61	0.95	1.07	1.41
T_2 – 100% RDF + *Azospirillum*	0.63	1.03	1.19	1.47	0.64	1.04	1.16	1.46	0.64	1.03	1.18	1.46
T_3– 100% RDF + *Azotobacter*	0.64	1.03	1.20	1.48	0.65	1.05	1.17	1.47	0.65	1.04	1.18	1.47
T_4–100% RDF + *VAM*	0.63	1.03	1.18	1.46	0.63	1.03	1.16	1.44	0.63	1.03	1.17	1.45
T_5– 75% RDF + *Azospirillum*	0.62	1.01	1.12	1.45	0.63	1.01	1.09	1.44	0.63	1.01	1.10	1.45
T_6– 75% RDF + *Azotobactor*	0.62	0.99	1.11	1.43	0.63	0.99	1.09	1.44	0.62	0.99	1.10	1.44
T_7 – 75% RDF + *VAM*	0.61	0.97	1.10	1.43	0.63	0.93	1.07	1.42	0.62	0.95	1.09	1.43
T_8– 50% RDF +.*Azospirillum*	0.57	0.91	1.02	1.35	0.60	0.84	1.00	1.36	0.59	0.88	1.01	1.36
T_9 – 50% RDF + *Azotobactor*	0.57	0.88	1.00	1.33	0.58	0.73	0.98	1.32	0.58	0.81	0.99	1.32
T_{10} – 50% RDF+ *VAM*	0.57	0.84	0.96	1.26	0.57	0.67	0.94	1.24	0.57	0.76	0.95	1.25
T_{11}–100% RDF + *Azospirillum* + *Azotobactor* + *VAM*	0.66	1.10	1.28	1.51	0.66	1.33	1.29	1.50	0.66	1.21	1.29	1.50
T_{12}–75% RDF + *Azospirillum* + *Azotobactor* + *VAM*	0.65	1.05	1.22	1.50	0.65	1.15	1.18	1.49	0.65	1.10	1.20	1.49
T_{13} -50% RDF + *Azospirillum* + *Azotobactor* + *VAM*	0.60	0.92	1.05	1.38	0.61	0.86	1.02	1.36	0.60	0.89	1.03	1.37
S.Em ±	0.021	0.055	0.029	0.049	0.022	0.067	0.030	0.036	0.015	0.043	0.021	0.031
CD 5%	0.062	0.160	0.084	0.144	0.064	0.195	0.089	0.105	0.043	0.123	0.060	0.087

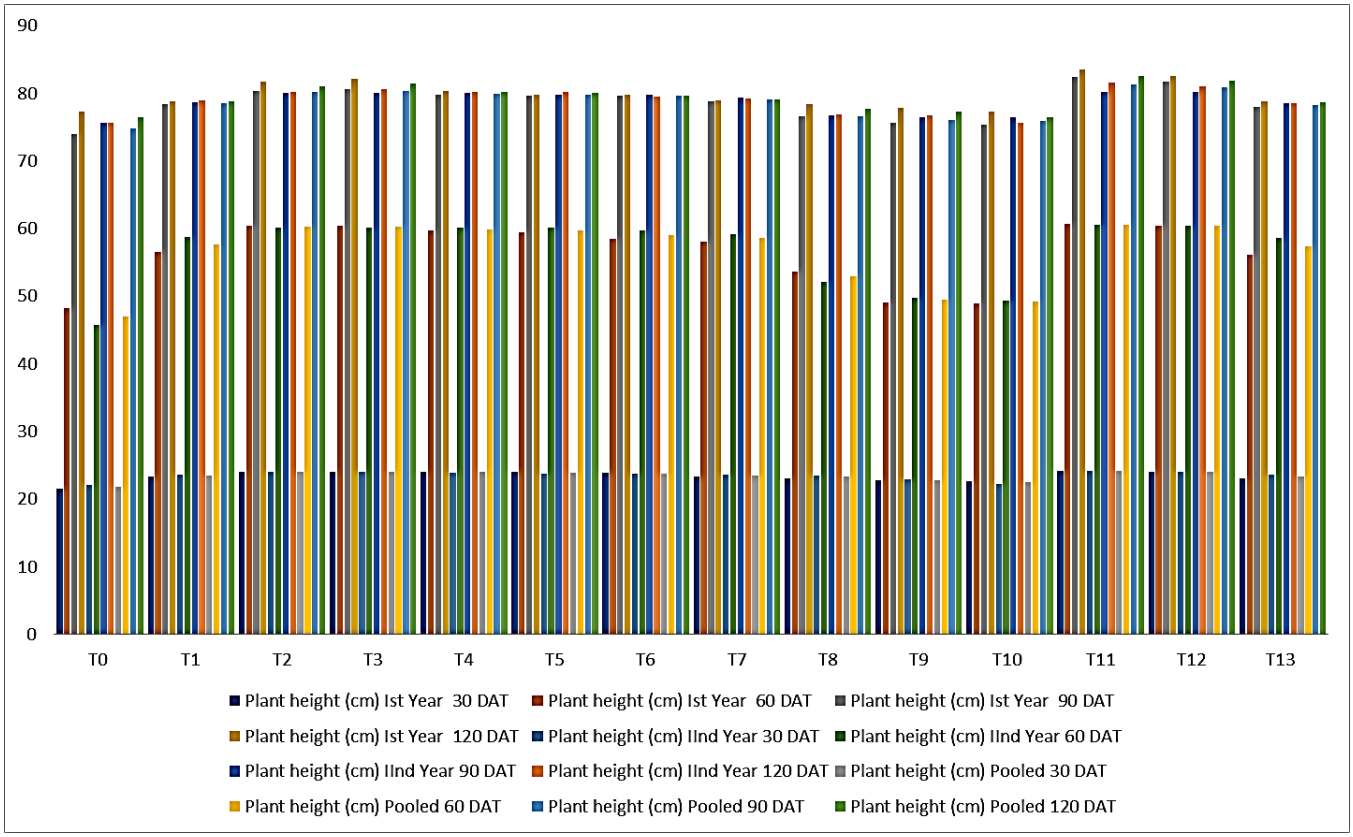

Fig 1: Effect of bio-fertilizers and chemical fertilizers on plant height (cm) at 30, 60, 90 and 120 DAT of onion

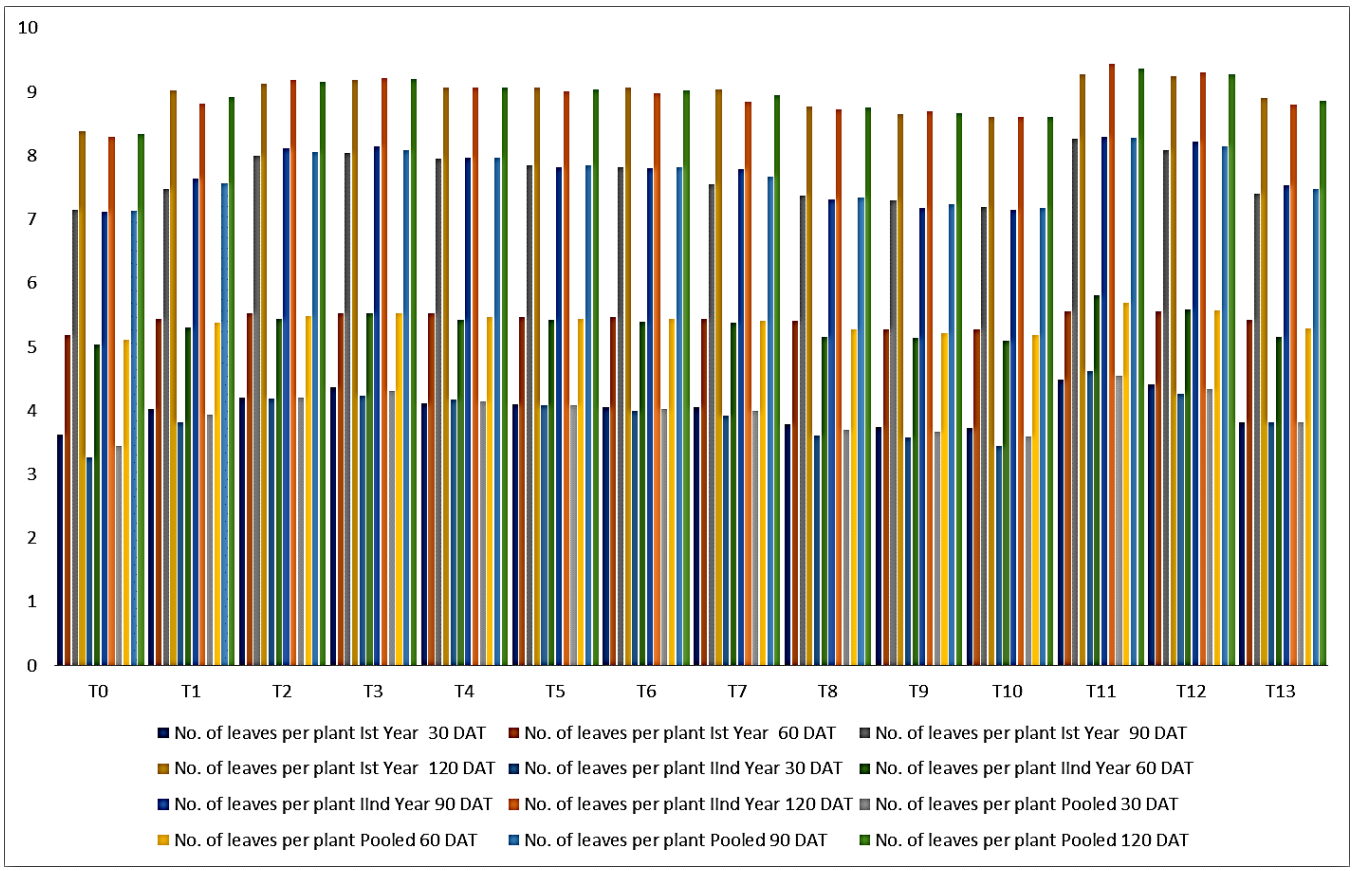

Fig 2: Effect of bio-fertilizers and chemical fertilizers on no. of leaves per plant at 30, 60, 90 and 120 DAT of onion

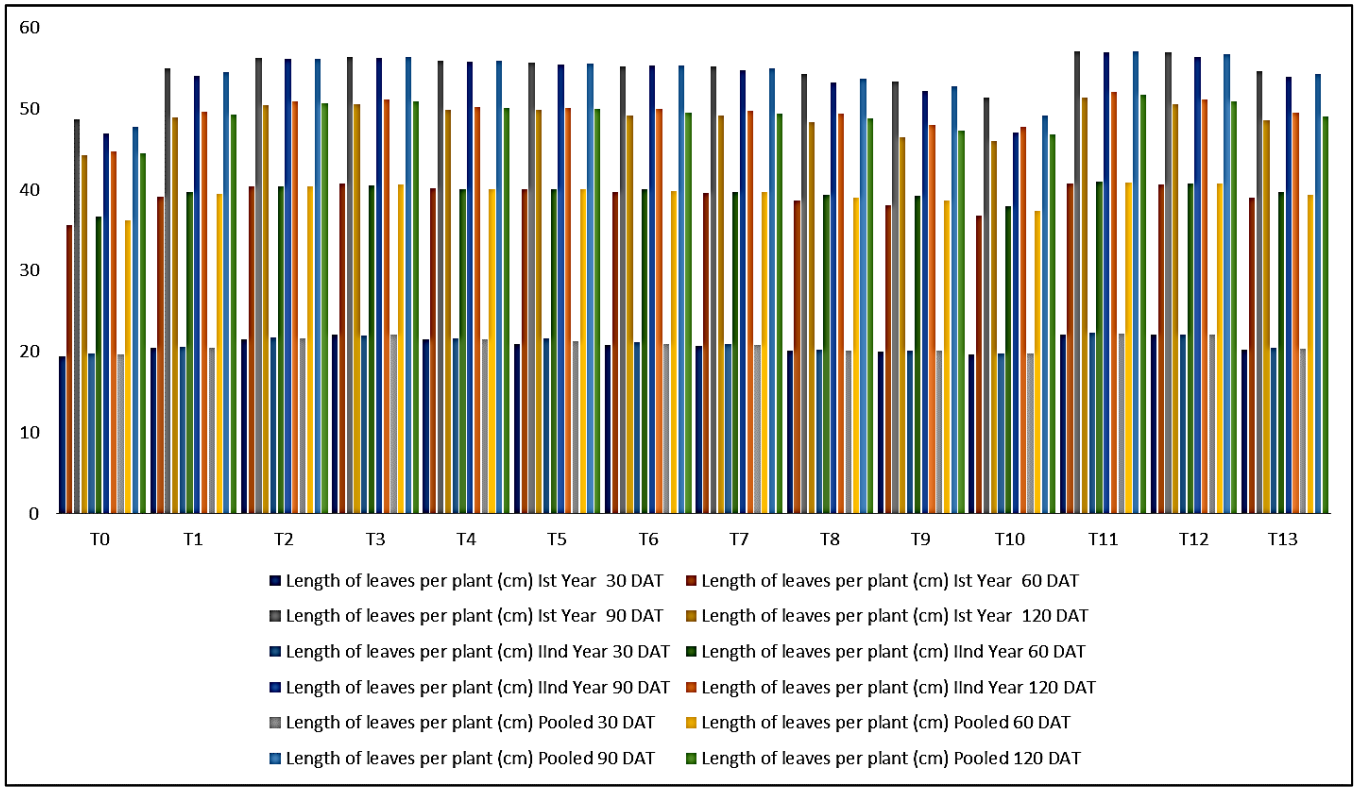

Fig 3: Effect of bio-fertilizers and chemical fertilizers on length of leaves per plant (cm) at 30, 60, 90 and 120 DAT of onion

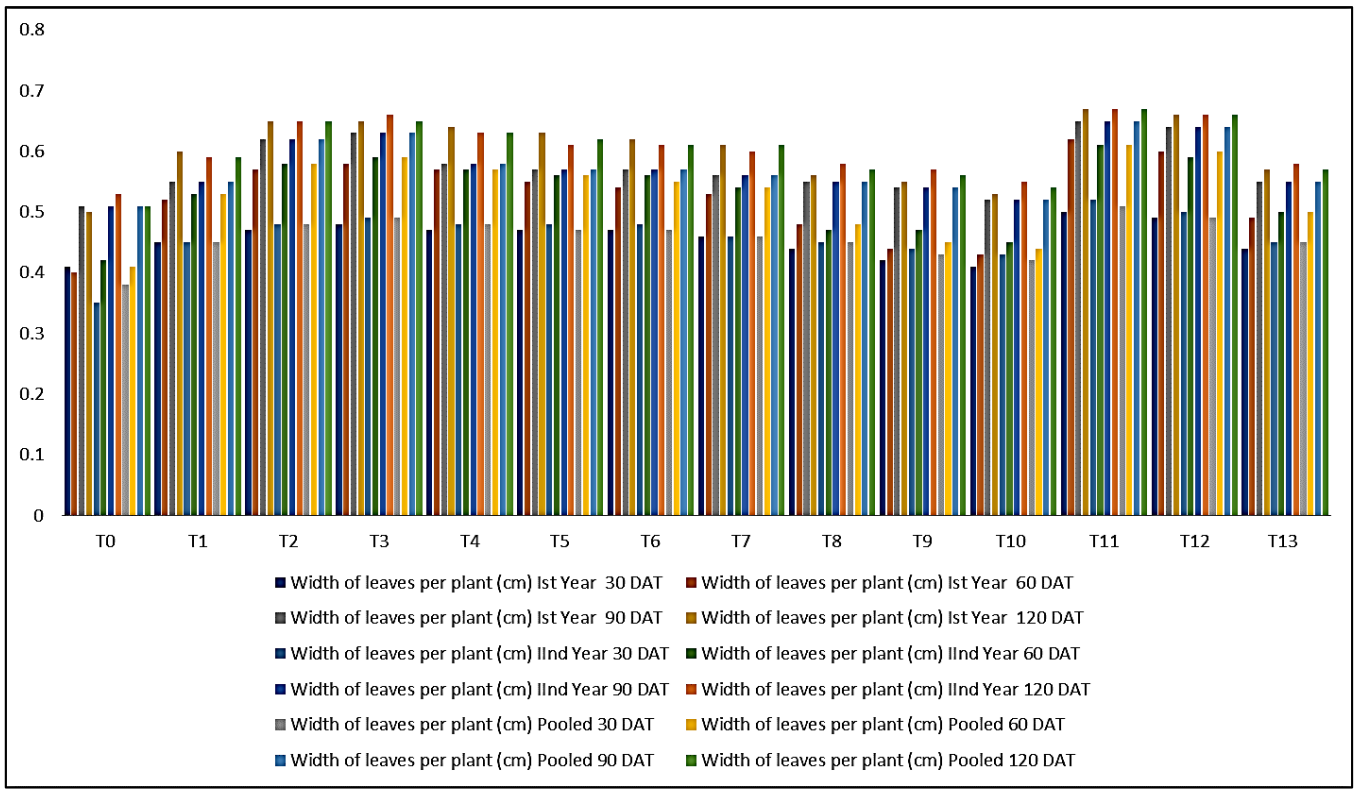

Fig 4: Effect of bio-fertilizers and chemical fertilizers on width of leaves per plant (cm) at 30, 60, 90 and 120 DAT of onion

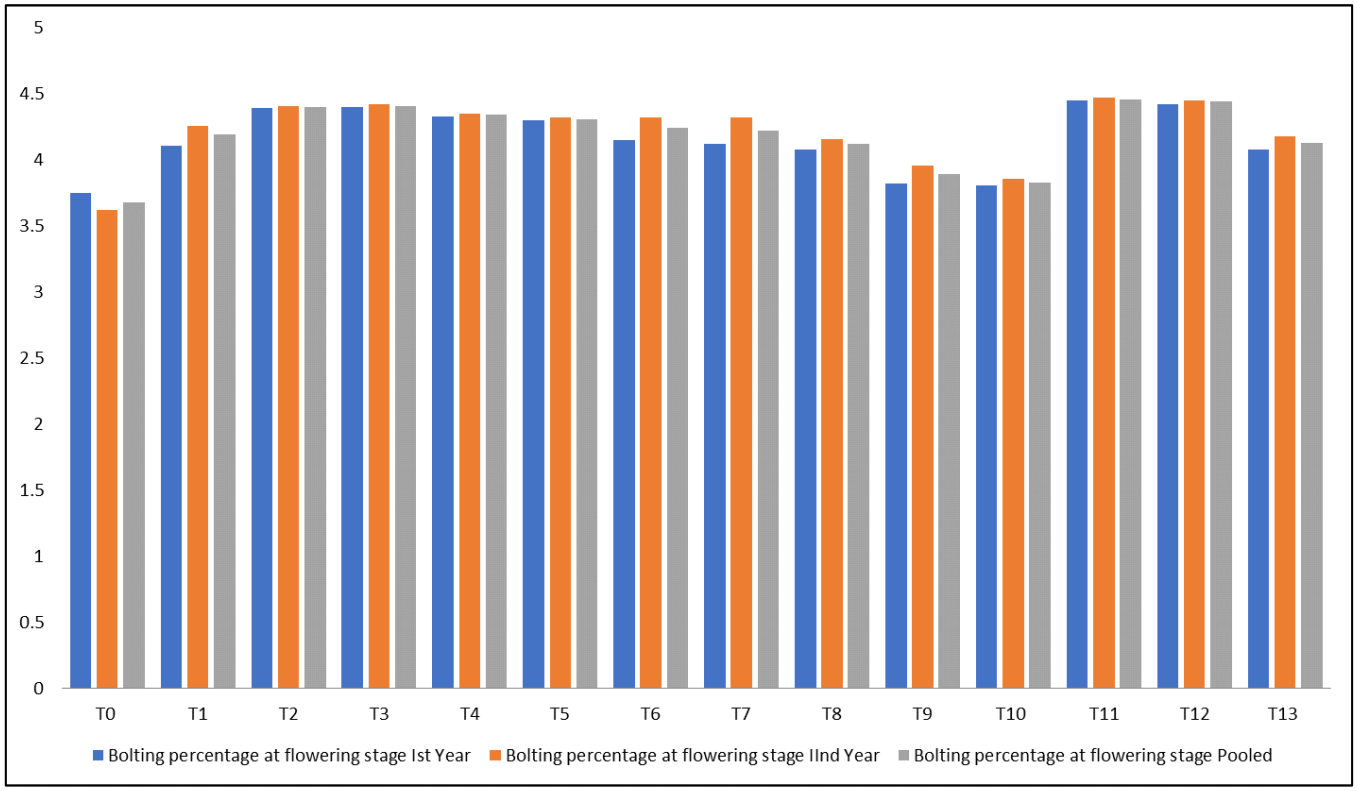

Fig 5: Effect of bio-fertilizers and chemical fertilizers on bolting percentage at flowering stage of onion

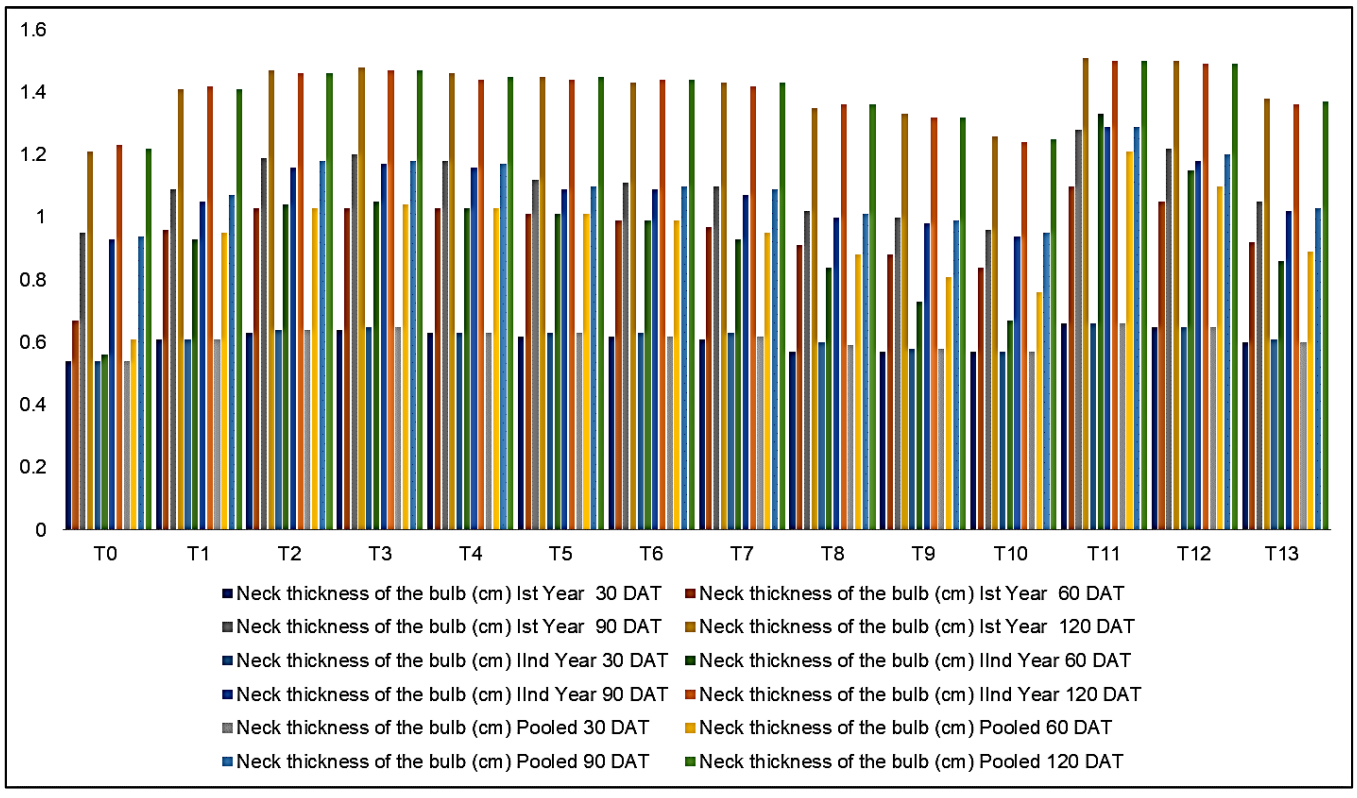

Fig 6: Effect of bio-fertilizers and chemical fertilizers on neck thickness of the bulb (cm) at 30, 60, 90 and 120 DAT of onion

Conclusion

The maximum morphological parameters (*viz*., plant height, no. of leaves per plant, length of leaves per plant, width of leaves per plant, bolting percentage at flowering stage and neck thickness of the bulb) at different growth stages were recorded in treatment T_{11} (100% RDF + *Azospirillum* + *Azotobactor* + *VAM*), whereas the minimum morphological parameters at different growth stages were recorded in treatment T_0 (Control).

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