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EFFECT OF GROWTH REGULATOR AND BIOCONTROL AGENT ON GROWTH, BULB YIELD, YIELD CONTRIBURING TRAITS AND ECONOMICS OF ONION (*ALLIUM CEPA* L.) cv. AGRIFOUND LIGHT RED

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Abstract

A field experiment was conducted at Department of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, (M.P.), India; during *Rabi* 2014-15 and 2015-16 to study the empact of gibberellic acid and *Trichoderma viride* on growth, yield and economics of onion (*Allium cepa* L.) cv. Agrifound Light Red. Foliar application of GA_3 100 mg and soil treatment of *T. viride* (10kg ha^{-1}) ($\mathbf{T_{11}}$) was observed significantly maximum, (66.60 cm) plant height (17.82) number of leaves $plant^{-1}$, (61.17 cm) length of leaf, (1.12 cm) width of leaf, (0.09%) bolting percentage, (1.48cm) neck thickness of the bulb, (612.72cm^2) leaf area $plant^{-1}$, (4.09) leaf area index and (1.74) bulb green top ratio over to control ($\mathbf{T_1}$ *i.e.*, GA_3 0 mg + *T. viride* 0). Significantly maximum (43.31g) fresh weight of bulb, (28.10g) dry weight of per 100g bulb, (5.33 cm) diameter of bulb, (6.01 cm) length of bulb and (326.76 q ha^{-1}) bulb yield were recorded in the treatment $\mathbf{T_{11}}$ (GA_3 100 mg and soil treatment of *T. viride* (10kg ha^{-1}). Results on pooled data revealed that the 326.76 q bulb yield $hectare^{-1}$ was recorded significantly maximum under the treatment $\mathbf{T_{11}}$ (GA_3 100 ppm + *T. viride* 10kg ha^{-1} soil treatment) along with net return of Rs. 2,66,592 ha^{-1} and cost benefit ratio 1: 5.43.

Key words : Onion, gibberellic acid, *Trichoderma viride* and economics**.**

Introduction

Onion (*Allium cepa* L.) belongs to the family Alliaceae is one of the most important bulbous vegetable crop grown all over the world. Onion is the oriented crop earning valuable foreign exchange for the country. It is the second after tomato in their importance as a vegetable in the tropics. The demand for onion is worldwide. Onions are found in most marketable of the world thought out the year and can be grown under wide range of agro-climate condition. Irrespective of pries, the demand for remain almost constant in the market as it is primarily, used as seasoning for a wide variety of dishes in many homes almost. It is an indispensable item in every kitchen and used to enhance flavor of different recipes. Nutritive value of onion varies variety to variety, small size onion is more nutritive then big size, its major value is in flavor. Onion ranks medium in caloric low in protein and very low in Vitamins.

The area of onion in Madhya Pradesh is 117.3 thousand hectare, total production is 2826.0 thousand metric tonnes and productivity is about 24.1 metric tonnes per hectare during 2013-14 (Anonymous, 2014). Onion accounts for 70 per cent of our total foreign exchange earnings from the export of fresh vegetables. Government of India has declared onion as an essential commodity. Looking to its importance for domestic consumption as well as export greater attention is needed for its improvement. Onion has recently received considerable attention for its high medicinal value. The application of plant growth regulators give miraculous changes in the performance of optimum dose of nitrogen without compromising with quality & yield aspect of bulb. Gibberellins are natural constituents of plants and are known to participate in the endogenous control of growth activities and a variety of developmental activities. Dormancy, seed germination, stem elongation, flowering, sex expression, and responses to photoperiod and vernalization are some important role of gibberellins in plant. Presently, over 125 different types of gibberellins have been discovered. The most commonly occurring gibberellins is GA_3, which is also called as gibberellic acid.

Trichoderma-based preparations are marketed worldwide and used for crop protection of various plant pathogens or increase the plant growth and productivity in diverse cultivated environments; bulb treatment together with foliar application of *Trichoderma viride* improves the yield as well as yield related parameters such as, basal diameter, circumference of bulb. The vital importance to manage the fungal disease in red onion effectively by using plant doctor fungi *Trichoderma viride* or other species without the use of dangerous synthetic fungicides. In case of *T. viride* as biocontrol agent, it worked well under greenhouse conditions but these results are required to be confirmed by on-field study. Amongst the different fungi *Trichoderma* spp. has been reported to have greatest impact on the pathogens (McLean and Stewart, 2000). Therefore, the present experiment was undertaken to find out the effects of GA_3 and *Trichoderma viride* on the growth, yield and economics of onion to optimum dose and maximum efficiency dose for achieving highest yield.

Materials and Methods

A field experiment was conducted at Department of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, (M.P.), India; during *Rabi* 2014-15 and 2015-16 and data presented in two year mean for this manuscript. The experiment was laid out in Randomized Complete Block Design with sixteen treatments and three replications. Ten kg seeds (7.5 kg seeds untreated + 2.5 kg seeds treated with 10g *T. viride*) of onion cv. Agrifound Light Red was sown on the nursery beds on September 2nd, 2014 and September 5th 2015. Healthy seedlings were transplanted in the field during October 17th, 2014 and October 19th, 2015 with row to row 15 cm and plant to plant 10.0 cm space. A recommended dose of 100kg N, 60kg P_2O_5 and 80kg K_2O ha^{-1} along with 20 tonnes FYM ha^{-1} was applied in the form of urea, single super phosphate and murate of potash respectively. One third nitrogen and entire quantity of P, K and FYM was applied prior to sowing. Remaining dose of nitrogen was applied in two splits at 25 and 50 days after transplanting. The crop was sprayed with Trizophos 0.1% and Propenophos 0.2%, to keep the crop free from pest during crop growth period. All the recommended package of practices was followed to raise healthy crop.

The treatment combinations involving four levels of GA_3 *viz*. 0, 50, 100 and 150 ppm (foliar spray was done after 30 DAT) and four methods of application of *Trichoderma viride i.e.* control (without treatment), seed treatment (4g kg^{-1} seed), soil treatment (10kg ha^{-1} before transplanting) and seedling treatment (10g $lit.^{-1}$) were applied at the time of transplanting (by root dipping). Distilled water was spray in control plots. Five plants were randomly selected from each treatment and observations regarding morphological parameter (i.e. plant height (cm), number of leaves $plant^{-1}$, length of leaf (cm), width of leaf (cm), bolting percentage, neck thickness of bulb (cm), leaf area $plant^{-1}$ (cm^2), leaf area index and bulb green top ratio and yield characters *viz*., fresh weight and dry weight of bulb, diameter of bulb (cm), length of bulb (cm) and bulb yield $hectare^{-1}$ (q) were recorded and also estimate the economics of the treatments. Collected data were analyzed statistically using SPAR 2.0 computer programme. The significance of difference between pair of means was tested by the Critical differences (CD) test at 5% level of probability (Panse and Sukhatme, 1985).

Results and Discussion

The result demonstrated that treatment combinations of GA_3 and *Trichoderma viride* had significant influence on all the pre farvest and yield parameters of onion cv. Agrifound Light Red. The plant height, number of leaves $plant^{-1}$, length of leaf (cm), width of leaf (cm), bolting percentage, neck thickness of bulb (cm), leaf area $plant^{-1}$ (cm^2), leaf area index and bulb green top ratio linearly increased up to the maximum vegetative growth stage (120 DAT) and thereafter decreased possibly due to the senescence and drying up of the tips of the leaves. The highest plant height (66.60 cm) were obtained from $\mathbf{T_{11}}$ (GA_3 100 mg + *T. viride* soil treatment 10kg ha^{-1}) followed by $\mathbf{T_{12}}$ (GA_3 100 ppm + *T. viride* seedling dipping 10g lit^{-1}) (65.27cm) at 120 DAT, while the lowest plant height (55.13 cm) were recorded with the control ($\mathbf{T_1}$) (table 1). Results obtained were in agreement with the findings of Islam *et al*. (2007), Patel *et al*. (2010), Islam *et al*. (2013), Nagwa *et al*. (2013) and Govind *et al*. (2015) for GA_3 treatment, Lalitha *et al*. (2012) for use of *T. viride*.

The maximum number of leaves $plant^{-1}$ (17.82) were obtained from $\mathbf{T_{11}}$ (GA_3 100 mg + *T. viride* soil treatment 10kg ha^{-1}) followed by $\mathbf{T_{12}}$ (GA_3 100 ppm + *T. viride* seedling dipping 10g lit^{-1}) (17.40) at 120DAT, while the lowest number of leaves $plant^{-1}$ (10.95) were recorded with the control ($\mathbf{T_1}$) (table 1). Similar results have been reported by Islam *et al*. (2007), Patel *et al*. (2010), Sisodia and Nagaich (2011), Islam *et al*. (2013), Nagwa *et al*.

(2013) and Govind *et al.* (2015) for GA_3 treatment, Lalitha *et al.* (2012) for use of *T. viride*.

The length of leaf was significantly increased by the different treatments. The treatment T_{11} (GA_3 100 mg + *T. viride* soil treatment 10kg ha^{-1}) was found significantly superior as compared to other treatments and which was recorded maximum (61.17 cm) length of leaf followed by T_{12} (GA_3 100 ppm + *T. viride* seedling dipping 10g lit^{-1}) (59.97 cm), T_{10} (GA_3 100 ppm + *T. viride* seed treatment 4g kg^{-1}) (59.30 cm) and T_9 (GA_3 100 ppm + *T. viride* without treatment) (58.67 cm) at 120DAT, and which were at par with each other. While, it was recorded lowest (53.20 cm) in treatment T_1 (control) (table 1). These findings are in agreement with the findings of Islam *et al.* (2007), Patel *et al.* (2010) and Nagwa *et al.* (2013) for GA_3 treatment, Lalitha *et al.* (2012) for use of *T. viride*.

It is obvious from the table 1 that the treatment T_{11} was found significantly superior as compared to other treatments and which was recorded maximum 1.12 cm width of leaf followed by T_{12} (1.09 cm) and T_{10} (1.04 cm) at 120 DAT as compared to other treatments, while, it was recorded minimum 0.61 cm in treatment T_1. These findings are in agreement with the findings of Islam *et al.* (2007) and Nagwa *et al.* (2013) for GA_3 treatments, Lalitha *et al.* (2012) for *T. viride* treatments.

The bolting percentage (at flowering stage) was significantly influenced by different treatments. Significantly lowest (0.09%) bolting percentage was recorded in treatment T_{11} followed by T_{12} (0.21%), T_{10} (0.31%) and T_9 (0.40%) and which were at par with each other. While, it was noted maximum (6.73%) bolting percentage in treatment T_1 (table 1). Similar results have been reported by Prajapati *et al.* (2016) for GA_3 treatments.

The neck thickness of the bulb was significantly influenced by various treatments of levels of gibberelic acid and methods of application of *Trichoderma viride*. The significantly minimum (0.92 cm) neck thickness of the bulb was recorded in treatment control (T_1 *i.e.* GA_3 0 ppm + *T. viride* without treatment), while, the highest (1.48 cm) neck thickness of the bulb was recorded with treatment T_{11} (GA_3 100 mg + *T. viride* soil treatment 10kg ha^{-1}) (table 1). These findings are in agreement with the findings of Islam *et al.* (2007) and Sisodia and Nagaich (2011) for GA_3 treatment. The highest plant height, number of leaves $plant^{-1}$, length of leaf width of leaf, bolting percentage and neck thickness of bulb linearly increased up to the maximum vegetative growth stage might be due to the rapid increment and expansion of plant cells for proper plant growth by the increased concentrations of GA_3 and the use of *Trichoderma viride* as bio-control agents induced the accumulation of some enzymes such as chitinase, peroxidase and polyphenol oxidase, which play an important role in plant defense mechanisms against pathogens infection and cleared that the enzymatic activity in treated plants increased than in untreated one which stimulated the plant growth.

The treatment T_{11} was recorded significantly maximum (612.72 cm^2) leaf area $plant^{-1}$ followed by T_{12} (565.68 cm^2) and T_{10} (522.55 cm^2) as compared to other treatments at 120 DAT. While, it was recorded minimum (78.48 cm^2) in treatment T_1 at 120 DAT (table 1). These findings are in agreement with the findings of Abdel (2007) and Sainath *et al.* (2012) for GA_3 treatments, Chauhan *et al.* (2010) and Azarmi *et al.* (2011) for *T. viride* treatments.

It revealed from the results that the leaf area index was significantly influenced by the different treatments. Significantly maximum (4.09) leaf area index was recorded in treatment T_{11} (GA_3 100 mg + soil treatment 10kg ha^{-1} before transplanting) followed by T_{12} (GA_3 100 ppm + *T. viride* seedling dipping 10g lit^{-1}) (3.77) and T_{10} (GA_3 100 ppm + *T. viride* seed treatment 4g kg^{-1}) (3.49) as compared to other treatments at 120 DAT. However, minimum (1.19) leaf area index was recorded in treatment T_1 (control *i.e.* GA_3 0 mg + *Trichoderma viride* 0 without treatment) at 120 DAT (table 1). Results are in agreement with the finding reported by Abdel (2007) for GA_3 treatments and Shadap *et al.* (2015) for *T. viride* treatments.

It is obvious from results that the bulb and green top ratio was significantly influenced by the different treatments. Significantly maximum (1.74) bulb and green top ratio was recorded in treatment T_{11} (GA_3 100 mg + soil treatment 10kg ha^{-1} before transplanting), which was at par with T_{12} (GA_3 100 ppm + *T. viride* seedling dipping 10g lit^{-1}) (1.68), T_{10} (GA_3 100 ppm + *T. viride* seed treatment 4g kg^{-1}) (1.63), T_9 (GA_3 100 ppm + *T. viride* without treatment) (1.58) and T_{15} (GA_3 150 mg+ soil treatment 10kg ha^{-1} before transplanting) (1.55). However, minimum (1.15) bulb and green top ratio were recorded in treatment T_1 (control *i.e.* GA_3 0 mg + *Trichoderma viride* 0 without treatment) (table 1). These findings are in agreement with the findings of Le Guen Le Saos *et al.* (2002) and Kandil *et al.* (2013) for GA_3 treatments.

Growth analytical parameters such as leaf area $plant^{-1}$, leaf area index and bulb /green top ratio as influenced by the application of different levels of gibberellic acid and

Table 1 : Effect of foliar sprays of gibberellic acid and methods of application of *T. viride* on pre harvest parameters.

Treat. Symb.	Treatment	Plant height (cm) at 120 DAT	No. of leaves plant^{-1} at 120 DAT	Length of leaf (cm) at 120 DAT	Width of leaf (cm) at 120 DAT	Bolting (%)	Neck thickness of bulb (cm)	Leaf area plant^{-1} (cm^2) at 120 DAT	Leaf area index at 120 DAT	Bulb /green top ratio
T_1	GA_3 0 mg+T_0	55.13	10.95	53.20	0.61	6.73	0.92	178.48	1.19	1.15
T_2	GA_3 0 mg+T_1	55.77	11.33	53.73	0.64	4.61	0.99	195.36	1.31	1.20
T_3	GA_3 0 mg+T_2	56.98	12.09	54.50	0.71	2.61	1.09	236.29	1.58	1.24
T_4	GA_3 0 mg+T_3	56.33	11.70	54.15	0.67	3.91	1.04	214.53	1.43	1.22
T_5	GA_3 50 mg+T_0	57.63	12.47	54.85	0.74	2.42	1.12	254.21	1.70	1.28
T_6	GA_3 50 mg+T_1	58.23	12.86	55.27	0.77	2.00	1.16	275.85	1.84	1.31
T_7	GA_3 50 mg+T_2	59.50	13.93	56.23	0.84	0.95	1.23	333.24	2.22	1.39
T_8	GA_3 50 mg+T_3	58.83	13.45	55.78	0.81	1.20	1.19	305.22	2.04	1.35
T_9	GA_3 100 mg+T_0	63.52	16.42	58.67	0.99	0.40	1.37	479.23	3.20	1.58
T_{10}	GA_3 100 mg+T_1	64.43	16.95	59.30	1.04	0.31	1.41	522.55	3.49	1.63
T_{11}	GA_3 100 mg+T_2	66.60	17.82	61.17	1.12	0.09	1.48	612.72	4.09	1.74
T_{12}	GA_3 100 mg+T_3	65.27	17.40	59.97	1.09	0.21	1.45	565.68	3.77	1.68
T_{13}	GA_3 150 mg+T_0	60.03	14.53	56.75	0.87	0.80	1.27	362.19	2.42	1.43
T_{14}	GA_3 150 mg+T_1	60.58	14.92	57.25	0.90	0.67	1.29	388.16	2.59	1.48
T_{15}	GA_3 150 mg+T_2	62.02	15.90	58.23	0.95	0.52	1.34	442.49	2.96	1.55
T_{16}	GA_3 150 mg+T_3	61.32	15.40	57.72	0.93	0.58	1.32	414.41	2.76	1.51
	SEm±	0.34	0.12	0.90	0.006	0.16	0.009	7.85	0.05	0.06
	CD 5%	0.97	0.36	2.61	0.02	0.48	0.03	22.68	0.15	0.19

methods of application of *Trichoderma viride*. The increasing trends in growth analytical parameters under spraying with gibberellic acid may be due to the role of gibberellic acid on enhancing cell division activity, increasing of proline accumulation of plant and increasing of endogenous phytohormones *i.e.* increasing promotion hormones (GA_3 and cytokinins) and reducing ABA content which found that bio-regulators make a shift in hormonal balance characterized by increasing in endogenous phytohormon in plant. The use of *Trichoderma viride* as bio-control agents which play an important role in plant defense mechanisms against pathogens infection and cleared that the enzymatic activity in treated plants increased than in untreated one which stimulated the plant growth as well as growth analytical parameters.

Fresh weight of bulb plant^{-1} was significantly influenced by the different treatments. Significantly maximum (43.31 g) fresh weight of bulb plant^{-1} was recorded in treatment $\mathbf{T_{11}}$ (GA_3 100 mg + soil treatment 10kg ha^{-1} before transplanting) which was at par with $\mathbf{T_{12}}$ (GA_3 100 ppm + *T. viride* seedling dipping 10g lit^{-1}) (41.43 g). However, minimum (26.01 g) fresh weight of bulb plant^{-1} was recorded in treatment $\mathbf{T_1}$ (control *i.e.* GA_3 0 mg + *Trichoderma viride* 0 without treatment) (table 2). These findings are in agreement with the findings of Le Guen Le Saos *et al*. (2002), Islam *et al*. (2007), Patel *et al*. (2010), Sisodia and Nagaich (2011), Govind *et al*. (2015) and Prajapati *et al*. (2016) for GA_3 treatments, Chauhan *et al*. (2010) and Azarmi *et al*. (2011) for *T. viride* treatments.

The data revealed that maximum dry weight of bulb per 100 g fresh weight (28.10 g) was found in treatment $\mathbf{T_{11}}$ (GA_3 100 mg + soil treatment 10kg ha^{-1} before transplanting) followed by $\mathbf{T_{12}}$ (GA_3 100 ppm + *T. viride* seedling dipping 10g lit^{-1}) (26.93 g) and $\mathbf{T_{10}}$ (GA_3 100 ppm + *T. viride* seed treatment 4g kg^{-1}) (25.83 g) as compared to other treatments. While, it was noted minimum (8.92 g) in $\mathbf{T_1}$ (control *i.e.* GA_3 0 mg + *Trichoderma viride* 0 without treatment) (table 2). Results are in agreement with the finding reported by

Table 2 : Effect of foliar sprays of gibberellic acid and methods of application of *T. viride* on yield parameters and economics.

Treat. Symb.	Treatment	Fresh weight of bulb (g)	Dry weight of bulb (g)	Diameter of bulb (cm)	Length of bulb (cm)	Bulb yield hectare^{-1} (q)	Gross income (Rs/ha)*	Expenditure (Rs/ha)	Net income (Rs/ha)	B: C ratio
T_1	GA_3 0 mg+T_0	26.01	8.92	3.60	3.97	193.70	193700	54208	139492	3.57
T_2	GA_3 0 mg+T_1	29.09	9.91	3.95	4.16	212.52	212520	54216	158304	3.92
T_3	GA_3 0 mg+T_2	33.03	13.20	4.65	4.41	242.83	242830	56208	186622	4.32
T_4	GA_3 0 mg+T_3	31.06	11.30	4.32	4.30	227.26	227260	54308	172952	4.18
T_5	GA_3 50 mg+T_0	35.04	15.27	4.81	4.78	260.08	260080	56188	203892	4.63
T_6	GA_3 50 mg+T_1	35.70	16.57	4.86	4.91	268.68	268680	56196	212484	4.78
T_7	GA_3 50 mg+T_2	36.17	19.20	4.94	5.17	275.98	275980	58188	217792	4.74
T_8	GA_3 50 mg+T_3	36.03	17.75	4.88	5.04	274.44	274440	56288	218152	4.88
T_9	GA_3 100 mg+T_0	39.39	24.73	5.19	5.54	299.06	299060	58168	240892	5.14
T_{10}	GA_3 100 mg+T_1	40.28	25.83	5.23	5.57	303.99	303990	58176	245814	5.23
T_{11}	GA_3 100 mg+T_2	43.31	28.10	5.33	6.01	326.76	326760	60168	266592	5.43
T_{12}	GA_3 100 mg+T_3	41.43	26.93	5.28	5.60	311.29	311290	58268	253022	5.34
T_{13}	GA_3 150 mg+T_0	36.61	20.40	4.99	5.29	277.53	277530	60148	217382	4.61
T_{14}	GA_3 150 mg+T_1	37.27	21.15	5.05	5.38	282.23	282230	60156	222074	4.69
T_{15}	GA_3 150 mg+T_2	38.60	23.55	5.16	5.50	293.98	293980	62148	231832	4.73
T_{16}	GA_3 150 mg+T_3	38.04	22.40	5.11	5.43	288.70	288700	60248	228452	4.79
	SEm±	0.85	0.38	0.05	0.26	7.98	-	-	-	-
	CD 5%	2.48	1.11	0.15	0.76	23.06	-	-	-	-

Sisodia and Nagaich (2011) and Govind *et al*. (2015) for GA_3 treatments, Chauhan *et al*. (2010) and Azarmi *et al*. (2011) for *T. viride* treatments.

The highest fresh weight and dry weight of bulb plant^{-1} might be due to the rapid increment and expansion of plant cells for proper plant growth by the increased concentrations of GA_3, and the use of *Trichoderma viride* as bio-control agents induced the accumulation of some enzymes such as chitinase, peroxidase and polyphenol oxidase which play an important role in plant defense mechanisms against pathogens infection and indicated that the enzymatic activity in treated plants increased than in untreated one which stimulated the plant growth which ultimately fresh weight of bulb plant^{-1}.

It is obvious from table 2 that the significantly maximum (5.33 cm) diameter of bulb was recorded in treatment $\mathbf{T_{11}}$ (GA_3 100 mg + *T. viride* soil treatment 10kg ha^{-1}) which was at par with $\mathbf{T_{12}}$ (GA_3 100 ppm + *T. viride* seedling dipping 10g lit^{-1}) (5.28 cm), $\mathbf{T_{10}}$ (GA_3 100 ppm + *T. viride* seed treatment 4g kg^{-1}) (5.23 cm) and $\mathbf{T_9}$ (GA_3 100 ppm + *T. viride* without treatment) (5.19 cm). However, minimum (3.60 cm) diameter of bulb was recorded in treatment $\mathbf{T_1}$ (control). Results are in agreement with the finding reported by Islam *et al*. (2007), Patel *et al*. (2010) and Sisodia and Nagaich (2011) for GA_3 treatment, Gupta and Gupta (2013) and Naguleswaran *et al*. (2014) for use of *T. viride*.

Treatment $\mathbf{T_{11}}$ (GA_3 100 mg + *T. viride* soil treatment 10kg ha^{-1}) was observed maximum (6.01 cm) length of bulb followed by $\mathbf{T_{12}}$ (GA_3 100 ppm + *T. viride* seedling dipping 10g lit^{-1}) (5.60 cm) and $\mathbf{T_{10}}$ (GA_3 100 ppm + *T. viride* seed treatment 4g kg^{-1}) (5.57 cm), while, it was noted minimum (3.97 cm) in treatment $\mathbf{T_1}$ (control). The treatment $\mathbf{T_{11}}$, $\mathbf{T_{12}}$, $\mathbf{T_{10}}$, $\mathbf{T_9}$, $\mathbf{T_{15}}$, $\mathbf{T_{16}}$, $\mathbf{T_{14}}$ and $\mathbf{T_{13}}$ were found statistically at par (table 2). These findings are in agreement with the findings of Islam *et al*. (2007) and Patel *et al*. (2010) for GA_3 treatment, Gupta and Gupta (2013) and Naguleswaran *et al*. (2014) for use of *T. viride*.

It was apparent from the results (table 2) that the treatments $\mathbf{T_{11}}$ (GA_3 100 mg + *T. viride* soil treatment 10kg ha^{-1}) recorded significantly maximum (326.76 q ha^{-1}) bulb yield, which was statistically at par with $\mathbf{T_{12}}$ (311.29 q ha^{-1}) and $\mathbf{T_{10}}$ (303.99 q ha^{-1}), while, bulb yield $hectare^{-1}$ was observed minimum (193.70 q ha^{-1}) in the treatment $\mathbf{T_1}$ (control). Likewise, maximum bulb diameter, bulb length and bulb yield showed upward trend with the increase in GA_3 concentrations, which could be due to the rapid cell division and elongation leading to longer bulb formation. The findings of the present study revealed that judicious use of fertilizers, organic manures, and chemical pesticides supplemented with biopesticide are effective to increase yield as well as quality of the onion bulb. These findings are in agreement with the findings of Islam *et al*. (2007), Patel *et al*. (2010), Sisodia and Nagaich (2011), Islam *et al*. (2013), Nagwa *et al*. (2013) and Govind *et al*. (2015) for GA_3 treatment, Gupta and Gupta (2013) and Naguleswaran *et al*. (2014) for use of *T. viride*.

It is evident from the results (table 2) that the treatment $\mathbf{T_{11}}$ (GA_3 100 ppm + *T. viride* 10kg ha^{-1} soil treatment) was obtaind maximum net return of Rs 2,66,592 ha^{-1} and cost benefit ratio 1: 5.43 followed by $\mathbf{T_{12}}$ (GA_3 100 ppm + *T. viride* 10g $lit.^{-1}$ seedling dipping) gave the net return of Rs 2,53,022 ha^{-1} along with cost benefit ratio 1: 5.34. However, the lowest bulb yield of 193.70 q ha^{-1}, net return of Rs 1,39,492 ha^{-1} and cost benefit ratio 1: 3.57 was noted in control $\mathbf{T_1}$ (GA_3 0 ppm + *T. viride* without treatment). The high return was clearly due to the maximum bulb yield $hectare^{-1}$ in the treatment. Similar results of plant growth regulators have also been detailed by Bhardwaj *et al*. (1995), Baloch *et al*. (2014) and Thomson *et al*. (2015).

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