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HORTICULTURE

Effects of Salicylic acid (SA) and Azospirillum on growth and bulb yield of Onion (*Allium cepa* L.) cv. Agrifound Light Red

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Abstract

The present investigation was carried out during *Rabi* season of 2014-2015 and laid out in a Randomized Block Design with three replications at Vegetable Research Farm, Department of Horticulture, J.N. Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh).The experimental material for the study was comprised of 18 novel treatments combination of Salicylic acid (SA) and Azospirillum to estimate the best treatment combination in *Rabi* onion under particular region. The growth parameters under present investigation noted under T_{17} recorded maximum plant height (cm) at 30, 60, 90,120 DAT (33.28 cm), (37.58 cm), (45.22 cm) and (48.46 cm) respectively, length of leaves (cm) at 30 DAT (32.57 cm), 60 DAT (36.29 cm) under (T_{17}) and T_{11} (41.75 cm) at 60 DAT and T_{12} (44.15 cm) at 120 DAT respectively, maximum number of leaf at 30 DAT (8.09) in $T_{14,}$ 60,90 DAT (12.99,17.92) in T_{17} and at 120 DAT (19.37) in T_{11} respectively, neck thickness (mm) at 120 DAT (13.71 mm) under $T_{11,}$ dry weight of leaf (g) at 120 DAT (3.92 g). The yield parameters also reported best under T_{17} as average weight of bulb (88.07g), equatorial diameter (67.38mm), polar diameter (60.37mm), double bulb(2.38%)T_{11}, bolting per cent lowest (1.18%), A, B and C grade bulb (on weight basis) (37.22%)T_{5}, (65.09%) and (34.19%) respectively, bulb yield polt^{1}(14.77kg), marketable bulb yield (26.28t/ha.) T_{13}, total bulb yield estimated in T_{16} (30.47 t/ha). T_{11} recorded highest gross monitory return (₹ 450705/ha), net return (₹ 385020/ha) and benefit cost ratio 5.86.

Highlights

- Eighteen novel treatment combinations of Salicylic acid (SA) and Azospirillum to estimate best treatment combination for growth, yield, storage life of onion.
- The application of Salicylic acid @250 mg lit.$^{-1}$ 30, 45& 60 DAT with Azospirillum @5 kg ha^{-1} at 60 DAT enhance the growth and yield of onion.
- The treatment T_{11} Salicylic acid (250 mg lit.$^{-1}$) at 30 DAS, 30,45,60DAT+ Azospirillum (5 kg ha^{-1}) at 30 DAT fetched highest gross monitory return (₹ 450705/ha), net return (₹ 385020/ha) and benefit cost ratio 5.86.

Keywords: Onion (*Allium cepa* L.), Salicylic acid, Azospirillum, onion bulb yield

Onion (*Allium cepa* L.) is one of the most important bulb crops. It is an indispensable item in every kitchen used as salad, culinary purpose for flavoring as spice in pickles, sauce and vegetable. In India, it is cultivated as annual crop for bulb production and as biennial crop for seed production. Onion is an export-oriented crop earning valuable foreign exchange for the country.In India, Maharashtra is one of the leading state in the cultivation of onion, occupied area of 382.0 (000' ha) with production of 5638.0 (000' ha) and its productivity is 14.76 t/ha, as compared to Madhya Pradesh which occupies

area of 88.7 (lakh ha) with production of 1957.0 lakh tones and its productivity is 22.22 t/ha (http://nhb.gov.in, 2011-12).

Salicylic acid (SA), a plant phenol is now considered as a hormone-like endogenous regulator, has defense mechanism against biotic and abiotic stresses (Yalpani *et al*. 1994; Szalai *et al*. 2000). Salicylic acid (SA) is known to affect various physiological and biochemical activities of plants and may play a key role in regulating their growth and productivity (Hayat *et al*. 2010). Salicylic acid is considered to be an endogenous growth regulator of phenolic nature that enhanced the leaf area and dry mass production in corn and soybean (Khan *et al.* 2003). Enhanced germination and seedling growth were recorded in wheat; Fariduddin *et al.* (2003) reported that the dry matter accumulation was significantly increased in Brassica juncea, when

lower concentrations of salicylic acid were sprayed. However, higher concentrations of salicylic acid had an inhibitory effect. Khodary (2004) observed a significant increase in growth characteristic; Eraslan *et al.* (2007) also reported that exogenous application of salicylic acid, enhanced growth, physiological process and antioxidant activity of carrot plants. For sustainable production and productivity as well as quality, organic farming may be the alternative means only few researchers like Yadav *et al.* (2004); Jha *et al.* (2006); studied in this regard to find out the effect of bio-fertilizers in onion. The organic substances and providing favourable environment for plant growth and also improved physical, chemical and biological properties Ngullie *et al*. (2008). Devi and Ado (2005) reported that biofertilizer inoculations of onion on the other hand, increased the yield and saved the fertilizer requirement by 25%, thereby, reduced the cost of cultivation.

Therefore, it is the right time to give more emphasis on the evaluation of organics with chemicals (PGR_S) for growth performance, yield potential and quality improvement. But, there is hardly any precise and conclusive information available on the effect of organics and growth regulators on various physiological processes and productivity potential in Onion. Hence, with this background, the present investigation was aimed to find out the effects of salicylic acid and Azospirillum with novel treatment combination by different time of application of crop cycle to obtain significant results on growth and bulb yield of onion.

Material and Methods

The present investigation entitled "Effects of salicylic acid and Azospirillum on growth and bulb yield of onion (*Allium cepa* L.) cv. Agrifound Light Red was carried out during *Rabi* season of 2014-2015 and laid out in a Randomized Block Design (RBD) with three replications at Vegetable Research Farm, Department of Horticulture, J.N. Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh).The experimental material for the study was comprised of eighteen novel treatments combination of Salicylic acid (SA) and Azospirillum to estimate the best treatment combination in *Rabi* onion under particular region. Jabalpur is situated on 'Kymore Plateau' Agro-climatic region of Madhya Pradesh at 23.91^0 North latitude, 79.5^0 East longitudes and on an altitude of 411.78 meters above the mean sea level.Ten randomly taken plants were used to record data as morpho-physiological parameters i.e., plant height (cm) at 30,60,90 &120 DAT, length of leaves (cm) at 30,60,90&120 DAT number of leaves $plant^{-1}$ at 30,60,90 & 120 DAT, neck thickness of bulb(mm) 30,60,90 &120 DAT, dry weight of leaves (g) at 30,60,90 & 120 DAT. Post-harvest parameters i.e. average weight of bulb (g), bulb equatorial diameter (mm), bulb polar diameter (mm), % A, B,C Grade bulbs (on weight basis), double bulbs (%), bolters (%). Yield attributes parameters i.e. bulb yield $plot^{-1}$, total bulb yield (t/ha.), marketable yield (t/ha), yield economic.

Statistical analysis: Statistical analysis was performed as per methods suggested by Panse & Sukhatme (1985).

Results and Discussion

Growth parameters

Plant height at 30 DAT was significantly influenced by Salicylic acid and Azospirillum, their treatment combinations and different time of applications, It is explicit from the perusal of the (Table 1A), that the application of Salicylic acid (250 mg/Lit.) at 30 DAS, 30 DAT, 45 DAT, 60 DAT and Azospirillum (5 kg /ha) at 60 DAT (T_{17}) was recorded the highest plant height at 30 DAT (33.28 cm) fallowed by T_5

(33.28 cm), T_{11} (33.21 cm), However, (T_{18}) control recorded the lowest plant height (29.82 cm). It is might be due to balancing of internal level of natural auxins through novel plant growth regulator Salicylic acid which is responsible for proper physiological activities in the plant system and optimum nutritional status of plant through Azospirillum application with suitable time of application which response significantly better growth and ultimately improve the plant height. These results are in accordance with the findings of Singh *et al.* (2002) in onion, Chandregowda *et al.* (2007), Sharma (2010) studied that effect of Azospirillum and Nitrogen treatment combinations responded increase in growth and yield as compared to control. Azotobacter inoculation markedly increased growth parameters over control, Chamangasht (2012) revealed that inoculating seeds with the bio-fertilizers significantly increased plant height, the number of leaves, biomass, leaf area index and plant yield, compared with the control in onion, Devi *et al.* (2013) reported that treatment supplemented with Azospirillum increased the plant height, number of leaves, leaf length, leaf area, number of bulbs per hill, bulb length and recorded significantly superior. Plant height at 60 DAT resulted maximum in T_{17} (37.58 cm) fallowed by T_{11} (36.51 cm), T_5 (35.74 cm). However, (T_{18}) control recorded the lowest plant height (33.91 cm). These results are in accordance with the findings of Mehla and Mangat Ram (2006) in garlic, Chandregowda *et al.* (2007), Patel *et al.* (2009) observed that Azospirillum produces bioactive substances which work as growth regulators and also it fixes the atmospheric nitrogen in the soil, enhancing better root growth and plant growth, Chamangasht (2012).Plant height (cm) at 90 DAT recorded maximum under T_{17} (45.22 cm) fallowed by T_5 (47.04 cm), T_{11} (47.01 cm). However, (T_{18}) control recorded the lowest plant height (42.31 cm). The findings are in close harmony with the results of Singh (2001), Devi *et al.* (2013). Plant height at 120 DAT was significantly maximum under T_{17} (48.46 cm) fallowed by T_{11} (48.35 cm). However, (T_{18}) control recorded the lowest plant height (41.08 cm). These findings are in close agreement with the results of Patel *et al.* (2009), Sharma (2010) and Devi *et al.* (2013).

Results revealed that maximum (32.57cm) length of leaf at 30 DAT was recorded under treatment T_{17} fallowed by T_{11} (30.27cm). However, minimum (27.38 cm) length of leaf was noted under (T_{18}). The findings are in close harmony with the results of Singh (2001), Sharma (2010), Chamangasht (2012). It is revealed that maximum (36.34cm) length of leaf at 60 DAT was recorded under treatment T_{17} fallowed by T_{11} (36.29 cm), T_{16} (35.34 cm). However, minimum (29.22cm) length of leaf was noted under (T_{18}).The findings are also relevant with the results of Pankaj and Sharma (2003) resulted that the shoot length significantly increased at 50 and 100 µg /ml of Salicylic acid and Sharma (2010). The maximum (41.75cm) length of leaf at 60 DAT was recorded under treatment T_{11} fallowed by T_{17} (40.39cm) and T_5. However, minimum (37.09cm) length of leaf was noted under (T_{18}). The findings are also relevant with the results of Pankaj and Sharma (2003), Sharma (2010), Waghmode (2010) and Devi *et al.* (2013). The results revealed that maximum (45.12 cm) length of leaf at harvest was recorded under treatment T_{12} fallowed by T_{17} (44.15 cm). However, minimum (35.15 cm) length of leaf was noted under (T_{18}). Similar results have been reported by Sharma (2010), Waghmode (2010) and Devi *et al.* (2013).

The application of T_{14} combination of SA and Azospirillum was recorded the highest number of leaves^{-1} at 30 DAT (8.09) fallowed by T_5 (8.0), T_6 (7.56), T_{11} (7.35). However, (T_{18}) control recorded the lowest number of leaves^{-1} (6.33). Number of leaves^{-1} at 60 DAT was significantly influenced by Salicylic acid, Azospirillum, their treatment combinations and different time of applications. T_{17} was recorded the highest number of leaves^{-1} at 60 DAT (12.99) fallowed by T_{11} (12.08), T_{16} (12.0) and T_{14} (12.0). However, (T_{18}) control recorded the lowest number of leaves^{-1} (8.87). T_{17} was recorded the highest number of leaves^{-1} at 90 DAT (17.92), T_{11} (17.64), T_{15} (17.22).However, (T_{18}) control recorded the lowest number of leaves^{-1} (14.17). Number of leaves^{-1} at 120 DAT was recorded the highest number of leaves^{-1} (19.51) fallowed by T_{11} (19.37), T_{13} (19.34). However, T_{18} control recorded the lowest number of leaves^{-1} at harvest (14.07). The probable reason for increased number of leaf plant^{-1} due to the increased rates of photosynthesis and photosynthates through application of bio-fertilizer and Azospirillum or change in endogenous auxin in turn in apical dominance, these findings are in close agreement with the results of Sharma (2010), Waghmode (2010), Chamangasht (2012), Devi *et al.* (2013) and Mohammad (2014).

Table 1A: Effect of Salicylic acid and Azospirillum on growth parameters of onion growth cv. Agrifound Light Red

Symb.	Treatments	Plant height (cm)				Length of leaves (cm)				Number of leaves plant^{-1}			
		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_1	Salicylic acid (250 mg/Lit.) at 30 DAS, 30 DAT	31.10	35.78	44.07	46.28	27.11	32.37	38.27	44.00	6.37	9.30	15.54	15.23
T_2	Salicylic acid (250 mg/Lit.) at 30 DAS, 45 DAT	31.28	34.26	42.38	47.04	28.05	33.98	40.25	42.35	7.17	9.35	15.25	16.08
T_3	Salicylic acid (250 mg/Lit.) at 30 DAS, 60 DAT	31.87	32.14	44.69	46.38	29.60	33.01	41.01	41.23	7.11	10.21	14.29	15.27
T_4	Salicylic acid (250 mg/Lit.) at 30 DAS, 30, 45 DAT	30.91	35.07	43.46	47.15	29.78	34.61	41.21	40.85	7.09	10.75	15.26	17.46
T_5	Salicylic acid (250 mg/Lit.) at 30 DAS, 30, 60 DAT	33.28	35.74	47.04	47.10	29.14	34.03	41.28	42.33	8.00	10.82	17.29	17.65
T_6	T_1+ Azospirillum (5 kg /ha) at 30 DAT	30.98	31.57	43.28	48.35	29.98	33.97	41.26	41.19	7.56	10.38	17.10	17.38
T_7	T_2+ Azospirillum (5 kg /ha) at 30 DAT	31.10	35.22	43.21	47.86	28.68	34.15	40.87	42.11	7.13	11.09	16.23	17.35
T_8	T_3+ Azospirillum (5 kg /ha) at 30 DAT	32.02	33.15	44.12	46.97	28.39	31.93	40.35	43.31	7.29	11.00	16.95	18.99
T_9	T_4+ Azospirillum (5 kg /ha) at 30 DAT	31.27	34.29	45.15	47.30	30.00	34.20	42.31	43.09	7.23	11.39	15.51	18.08
T_{10}	T_5+ Azospirillum (5 kg /ha) at 30 DAT	33.01	35.19	46.22	46.27	28.67	34.93	42.76	43.77	7.29	11.43	15.28	16.27
T_{11}	Salicylic acid (250 mg/Lit.) at 30 DAS, 30,45,60 DAT+ Azospirillum (5 kg /ha) at 30 DAT	33.21	36.51	7.01	48.35	31.64	36.29	42.75	42.87	7.35	12.08	17.22	19.37
T_{12}	T_1+ Azospirillum (5 kg /ha) at 60 DAT	32.09	35.19	46.17	47.35	29.24	35.07	42.93	45.12	7.39	10.34	16.09	19.28
T_{13}	T_2+ Azospirillum (5 kg /ha) at 60 DAT	32.48	34.12	46.94	47.08	29.57	33.09	40.49	42.38	7.22	11.54	16.65	19.34
T_{14}	T_3+ Azospirillum (5 kg /ha) at 60 DAT	31.29	34.68	45.19	48.03	29.88	35.19	42.13	43.37	8.09	12.00	16.64	18.33
T_{15}	T_4+ Azospirillum (5 kg /ha) at 60 DAT	33.02	34.86	44.87	45.98	30.27	34.07	40.06	43.91	6.98	11.08	16.44	18.60
T_{16}	T_5+ Azospirillum (5 kg /ha) at 60 DAT	30.97	35.07	46.19	46.57	30.46	35.34	40.39	43.11	7.09	12.0	17.64	19.05
T_{17}	Salicylic acid (250 mg/Lit.) at 30 DAS, 30,45,60 DAT+ Azospirillum (5 kg /ha) at 60 DAT	33.28	37.58	45.22	48.46	32.57	36.34	41.21	44.15	7.05	12.99	17.92	19.51
T_{18}	Control (water spray)	29.82	33.91	42.31	41.08	27.38	29.22	37.09	35.15	6.33	8.87	14.17	14.07
	SEm±	0.64	0.85	1.04	0.74	0.86	0.94	0.53	0.94	0.21	0.13	0.43	0.99
	C.D. (0.05)	1.86	2.46	3.01	2.16	2.50	2.73	1.54	2.71	0.62	0.40	1.26	2.86

Table 1B: Effect of Salicylic acid and Azospirillum on growth parameters of onion growth cv. Agrifound Light Red

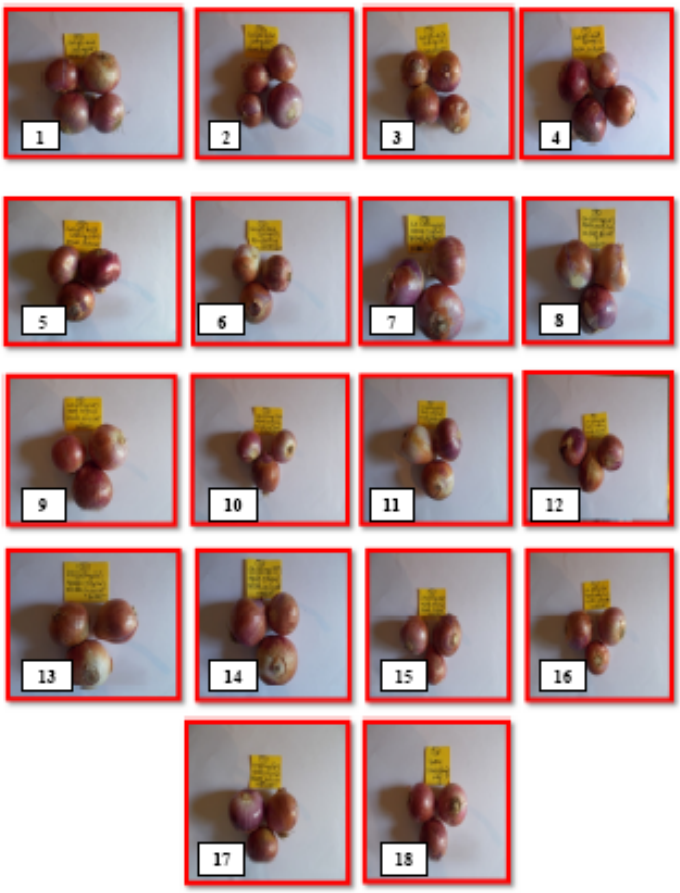
Symb.	Neck thickness (mm)				Dry weight of leaves (g)			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T_1	9.58	13.90	12.58	11.24	1.28	2.11	2.23	2.95
T_2	10.10	12.38	12.30	11.20	1.32	2.15	2.20	2.16
T_3	11.03	13.22	11.05	12.30	1.37	2.39	2.64	2.09
T_4	10.28	13.00	12.39	11.00	1.30	2.00	2.30	2.37
T_5	11.20	14.09	12.33	12.93	1.48	2.08	2.90	3.08
T_6	10.83	14.68	13.00	12.36	1.30	2.31	2.76	3.00
T_7	11.42	13.97	13.20	12.15	1.38	2.79	2.70	3.03
T_8	10.37	14.10	13.32	12.10	1.20	2.14	2.19	3.01
T_9	12.07	13.91	13.28	12.30	1.55	2.46	2.83	3.26
T_{10}	10.90	13.24	13.36	12.39	1.37	2.21	2.34	3.28
T_{11}	11.24	15.94	13.98	13.20	1.62	2.98	2.91	3.87
T_{12}	10.44	15.21	14.07	10.55	1.31	2.24	2.64	3.92
T_{13}	11.09	15.00	13.59	12.81	1.87	2.19	2.07	3.00
T_{14}	11.29	14.61	13.35	12.97	1.30	2.23	2.00	3.20
T_{15}	10.87	15.23	13.34	12.50	1.25	2.16	2.39	3.64
T_{16}	10.00	16.28	13.23	13.71	1.11	2.13	3.03	3.43
T_{17}	11.74	15.34	13.13	12.39	1.14	2.06	2.95	3.92
T_{18}	11.18	13.12	11.62	10.09	1.14	2.07	1.93	2.18
SEm±	0.34	0.32	0.23	0.30	0.02	0.02	0.03	0.24
C.D. (0.05)	1.00	0.93	0.66	0.88	0.06	0.06	0.09	0.71

Table 2: Effect of Salicylic acid and Azospirillum on yield parameters of onion cv. Agrifound Light Red

Treatments	Average weight of bulb (g)	Equatorial diameter (mm)	Bulb polar diameter (mm)	Double bulbs (%)	Bolters (%)	A Grade bulb (%)	B Grade bulb (%)	C Grade bulb (%)	Bulb yield plot^{-1}	Total bulb yield (t/ha)	Marke table bulb yield (t/ha)
T_1	67.30	51.26	53.08	12.09	3.24	23.55	33.08	33.08	6.87	23.29	22.07
T_2	65.41	54.31	51.34	10.01	4.29	30.02	42.33	42.33	6.95	24.11	21.37
T_3	69.83	54.04	52.22	10.03	4.96	34.41	43.29	43.29	7.00	24.25	22.34
T_4	74.08	55.28	49.32	9.44	6.11	35.38	47.66	47.66	8.65	23.69	22.47
T_5	75.21	56.83	51.31	5.21	3.16	37.22	51.03	50.78	10.29	24.55	21.77
T_6	70.00	55.14	52.19	7.36	4.39	32.79	43.23	43.25	11.03	25.19	22.74
T_7	70.09	55.41	53.10	4.97	5.65	30.07	48.71	48.71	12.61	24.38	24.97
T_8	76.38	54.09	52.19	6.59	5.64	33.28	37.49	37.45	13.22	26.22	25.17
T_9	72.22	55.13	51.41	8.57	5.03	34.08	42.06	42.06	13.68	26.08	25.31
T_{10}	72.38	55.62	51.10	10.13	3.66	28.00	58.21	58.21	13.29	25.31	25.27
T_{11}	83.69	62.38	56.64	2.38	1.57	34.28	48.28	49.28	12.43	28.41	26.54
T_{12}	77.91	60.36	56.65	5.51	3.24	29.65	58.73	58.73	13.28	28.78	24.98
T_{13}	78.88	63.10	55.38	7.81	4.56	36.29	50.99	51.00	12.95	26.37	27.09
T_{14}	75.09	61.22	56.19	7.30	1.48	31.22	61.47	65.10	13.29	26.78	25.00
T_{15}	76.05	59.08	55.67	5.68	4.28	30.89	58.17	58.17	13.63	28.13	26.07
T_{16}	78.07	62.04	55.87	5.29	2.61	36.89	57.23	57.23	13.81	30.47	25.09
T_{17}	88.07	67.38	60.37	4.27	1.18	36.14	65.09	61.47	14.77	29.20	26.28
T_{18}	61.57	44.93	44.18	41.08	9.21	21.01	34.19	34.19	8.22	21.07	20.97
SEm±	0.74	1.37	1.00	0.35	0.40	1.33	1.54	1.49	1.10	1.20	0.56
C.D. (0.05)	2.14	3.97	2.91	1.01	1.16	3.84	4.45	4.31	3.18	3.47	1.61

Table 3: Economics of different treatments of Salicylic acid and Azospirillum for onion

Treat.	Pod yield (t/ha)	Expenditure (₹/ha)	Gross monitory return (₹/ha^{-1})	Net monitory return (₹/ha^{-1})	Benefit: Cost ratio
T_1	23.29	64760	345435	280675	4.33
T_2	24.11	64760	360165	295405	4.54
T_3	24.25	64760	360375	295615	4.56
T_4	23.69	64960	346035	281075	4.32
T_5	24.55	64960	360825	295865	4.55
T_6	25.19	65385	375285	309900	4.10
T_7	24.38	65385	360570	295185	4.51
T_8	26.22	65385	390330	324945	4.96
T_9	26.08	65585	390120	324535	4.94
T_{10}	25.31	65585	375465	309880	4.72
T_{11}	28.41	65885	420615	354730	5.38
T_{12}	28.78	65385	421170	355785	5.44
T_{13}	26.37	65385	390555	325170	4.97
T_{14}	26.78	65385	391170	325785	4.98
T_{15}	28.13	65685	420195	354510	5.39
T_{16}	30.47	65685	450705	385020	5.86
T_{17}	29.20	65885	315105	250845	3.90
T_{18}	21.07	64260	290180	224295	3.40



It was obvious from the data presented in (Table1B) indicate that the maximum (12.07mm) neck thickness at 30 DAT recorded in T_9 fallowed by T_{17} (11.74 mm), T_{11} (11.24 mm). While, minimum (11.18 mm) neck thickness at 30 DAT recorded under T_{18}.The maximum (16.26 mm) neck thickness at 60 DAT recorded in T_{16} fallowed by followed by T_{11} (15.94 mm), T_{17} (15.34). While, minimum (13.12mm) neck thickness at 30 DAT recorded under T_{18}. The maximum (14.07mm) neck thickness at 90 DAT recorded in T_{12} fallowed by T_{11}(13.98mm).While, minimum (11.62mm) neck thickness at 30 DAT recorded under T_{18}.The maximum (13.71mm) under T_{16} fallowed by T_{11}(13.20) and (T_5) while, minimum (10.09mm) neck thickness at 30 DAT recorded under T_{18}. These findings are in close agreement with the results of Waghmode (2010), Chamangasht (2012), Abumoslem Bideshki *et al.* (2013), Devi *et al.* (2013) and Jamir *et al.* (2013).

The maximum (1.87g) dry weight of leaves at 30 DAT was recorded (Table 1B) under treatment T_{13} followed by T_{11} (1.62 g). However, minimum (1.14g) dry weight of leaves at 30 DAT was recorded under T_{18}. The maximum (2.98 g) dry weight of leaves at 60 DAT was recorded under treatment T_{11} (2.33 g) followed by T_9.However, minimum (2.07g) dry weight of leaves at 60 DAT was recorded under T_{18}.The maximum (3.03 g) dry weight of leaves at 90 DAT was recorded under treatment T_{16} fallowed by T_{17} (2.95), T_{11}(2.91g). However, minimum (1.93g) dry weight of leaves was recorded under T_{18}. The maximum (3.92 g) dry weight of leaves at 120 DAT was recorded under treatment T_{17} fallowed by T_{12} (3.92 g), T_{11} (3.87g).However, minimum (2.18g) dry weight of leaves at harvest was recorded under T_{18}. These findings are in close agreement with the results of Ibrahim *et al.* (2005) revealed that the Salicylic acid increased bulb size, fresh and dry weights in onion, Sharma (2010) studied that effect of Azospirillum and Nitrogen treatment combinations responded increase in growth and yield as compared to control. Azotobacter inoculation markedly increased growth parameters over control, Sridevi *et al.* (2010) reported the effect of Arbuscular mycorrhizae fungi and Azospirillum on onion, these two beneficial microbes played a vital role in supplying N and P to the onion and found enhanced the growth and yield over the untreated control.

Yield and its components characters

All the treatments significantly increased the weight of fruits except control as the data shown in (Table2).The maximum (88.07g) average weight of bulb was recorded with treatment T_{17} followed by T_{11} SA (83.69g), T_{13} (78.88g), T_{16} (78.07g).Whereas, minimum (61.57g) average weight of bulb at harvest was noted under (T_{18}). It is might be due to better source sink relationship and higher photosynthetic activity which would have improved due to timely availability of nutrients through Azospirillum and PGR hence, better harvest of sunlight. Application of Azospirillum and SA along also might have contributed for better uptake of all essential nutrients and production of growth promoting substances which might be responsible for enhancement of these parameters. Similar results have been reported by Similar results have been reported by Siva kumar *et al.* (2002) studied found that 100 ppm Salicylic and are 50 ppm mepiquat chloride application has increased the content of chlorophyll, Kalarani *et al.*(2002) it is concluded that among the different concentrations of salicylic acid, 100 ppm SA was optimum for enhancing the tomato productivity and quality of fruits, Ibrahim *et al.* (2005) revealed that the Salicylic acid increased bulb size, fresh and dry weights in onion and Sridevi *et al.* (2010).

The maximum (67.38mm) equatorial diameter of bulb was recorded with treatment (T_{17}) followed by T_{11} (62.38mm), T_{13} (63.10 mm), T_{16} (62.04 mm), T_{14} (61.22). However, minimum (44.93mm) equatorial diameter of bulb noted under (T_{18}). Similar results have been reported by Kalarani *et al.* (2002), Ibrahim *et al.* (2005) revealed that the Salicylic acid increased bulb size, fresh and dry weights in onion. Application of salicylic acid and Azospirillum significantly increased the polar diameter of bulb in all the treatments under study. Application of salicylic acid and Azospirillum significantly increased the polar diameter of bulb in all the treatments under study except control. The maximum (60.37 mm) polar diameter of bulb was recorded with treatment T_{17} followed by T_{12} (56.65 mm), T_{11}(56.64 mm), T_{14} (56.19 mm), T_{16} (55.87mm) all these treatments were

found significantly superior over all the other treatments. However, minimum (42.20mm) polar diameter of bulb estimated in control (T_{18}).Similar results have been reported by Kalarani *et al.* (2002) and Abumoslem Bideshki *et al.* (2013).

It is revealed that the application of (T_{11}) SA (250 mg/lit.) at 30 DAS, 30 DAT, 45 DAT, 60 DAT+ Azospirillum (5 kg /ha) at 30 DAT was recorded the lowest double bulbs per cent (2.38 %) fallowed by T_{17} (4.27%), T_{16} (5.29%), T_5 (5.21%).However, (T_{18}) control recorded the highest double bulbs per cent (41.08 %). The results revealed that the application of Salicylic acid and Azospirillum under T_{17} was recorded the lowest bolters per cent (1.18%) fallowed by T_{14} (1.48%), T_{11} (1.57%). However, (T_{18}) control recorded the highest bolters per cent (9.21%). (T_{17}) was recorded the lowest bolters per cent (1.18%) fallowed by (T_{14}) T_3+ Azospirillum (5 kg /ha) at 60 DAT (1.48%), (T_{11}) SA (250 mg/lit.) at 30 DAS, 30 DAT, 45 DAT, 60 DAT+ Azospirillum (5 kg /ha) at 30 DAT (1.57%). However, (T_{18}) control recorded the highest bolters per cent (9.21%).

The results revealed that maximum (37.22%) A Grade bulbs (%) was recorded under treatment T_5 fallowed by T_{16} (36.89%), T_{13} (36.29%), T_{17} (36.14%).On the other hand minimum (21.01%) A Grade bulb (%) was noted under (T_{18}). The results revealed that maximum (65.09%) B Grade bulbs (%) was recorded under treatment T_{17} fallowed by T_{14} (61.47%), T_{12} (58.73%).On the other hand minimum (34.19%) B Grade bulb (%) was noted under (T_{18}). The results revealed that maximum (33.08%) B Grade bulbs (%) was recorded under treatment T_1 fallowed by T_8 (37.45%), T_2 (42.33%), T_6 (43.25%). On the other hand minimum (34.19%). Maximum C Grade bulb (%) was noted under (T_{18}). Similar results have been reported by Sridevi *et al.* (2010) and Abumoslem Bideshki *et al.* (2013).

The maximum (14.77kg) bulb yield plot^{-1} at 30 DAT recorded in T_{17} followed by T_{16} (13.81 kg), T_9 (13.68 kg), T_{15} (13.63 kg), T_{14} (13.29%). While, minimum (10.55 kg) bulb yield plot^{-1} recorded under T_{18}.These findings are in line with the results obtained by Muthuramalingam *et al.* (2001) in onion, Saishankar (2001) revealed that Salicylic acid increase in yield and yield components due to these chemicals in green gram, Sanaa *et al.* (2001) reported that higher concentrations of salicylic acid resulted in higher yield in bean, Ibrahim *et al.* (2005) revealed that the Salicylic acid increased bulb size, fresh and dry weights in onion, Amin *et al.* (2007) reported that combination between indole-3-butyric acid and salicylic acid concentrations showed significant increase on most growth characters, yield and its quality, total soluble sugars, total free amino acids, total phenols and total indoles of onion plants, Tilak *et al.*(2008) reported that increase in bulb yield of onion when seeds were inoculated with Azospirillum in absence of nitrogen over control, Patel *et al.* (2009) observed that Azospirillum produces bioactive substances which work as growth regulators and also it fixes the atmospheric nitrogen in the soil, enhancing better root growth, plant growth and finally yield in okra, Lalita Kumari and Swarajya lakshmi (2009) reported that garlic crop inoculated with Azospirillum also recorded higher yield compared to control, Waghmode (2010) concluded that application of gibberellic acid (100 ppm) along with biofertilizer (Azospillium + PSB 6 kg/ha and VAM @ 10 kg/ha) was effective in increasing yield, Sridevi *et al.* (2010) and Jamir *et al.* (2013).

The maximum (30.47t/ha) total bulb yield was recorded under treatment (T_{16}) followed by T_{17} (29.20 t/ha), T_{12} (28.78 t/ha), T_{11} (28.41t/ha).All the treatments found to be significantly superior over control. However, minimum (21.07 t/ha) total bulb yield was recorded under (T_{18}). These findings are in line with the results obtained by Muthuramalingam *et al.* (2001), Ibrahim *et al.* (2005), Sanaa *et al.* (2001), Tilak *et al.* (2008), Patel *et al.* (2009), Lalita Kumari and Swarajya lakshmi (2009), Waghmode (2010), Sharma (2010), Sridevi *et al.* (2010). The maximum (27.09 t/ha) marketable bulb yield was recorded with treatment T_{13} followed by T_{17} (26.28 t/ha), T_{11} (26.54 t/ha), T_{15} (27.48 t/ha).Whereas, minimum (20.97 t/ha) marketable bulb yield (t/ha) was noted under (T_{18}). These findings are in line with the results obtained by Muthuramalingam *et al.* (2001), Sharma and Kamalesh (2000), Amin *et al.* (2007),Tilak *et al.* (2008),Waghmode (2010), Sharma (2010), Sridevi *et al.* (2010) and Jamir *et al.* (2013).

It is revealed from the data (Table 3) that the treatment (T_{11}) SA (250 mg/Lit.) at 30 DAS, 30 DAT, 45 DAT, 60 DAT+ AZSP (5 kg /ha) at 30 DAT fetched highest gross monitory return (₹ 450705/

ha), net return (₹ 385020/ha) and benefit cost ratio 5.86 fallowed by (T_{12}) T_1+ Azospirillum (5 kg /ha) at 60 DAT estimated gross monitory return (₹ 421170/ha), net return (₹ 355785/ha), benefit cost ratio 5.44. However, minimum gross income (₹ 290180/ha), net return (₹ 224295/ha) with benefit cost ratio 3.40 was recorded under control (T_{18}).The different times of application of Salicylic acid with Azospirillum proved its superiority over control. These findings are in line with the results obtained by Jawadagi *et al.* 2012, Jamir *et al.* (2013) and Devi *et al.* (2013).

Conclusion

The present study concluded that the application of plant growth regulator (Salicylic acid) @250 mg/lit. 30, 45, 60 day after transplanting with bio-fertilizer (Azospirillum) @5 kg/ha at 60 DAT should be suggest for onion growers to enhance the growth and yield of onion cv. Agrifound Light Red.

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