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Devendra Kumar Kurrey
M.Sc. (Ag.) Crop Physiology, Department of Biological Sciences, SHUATS, Allahabad, Uttar Pradesh, India

Mahendra Kumar Lahre
M.Sc. (Ag.) Biotechnology, Department of Plant Molecular Biology and Biotechnology, IGKV. Raipur, Chhattisgarh, India

Gaurav S Pagire
Ph.D. Research Schloar, Plant Physiology, Department of Agricultural Botany, MPKV. Rahuri, Maharashtra, India

Correspondence
Devendra Kumar Kurrey
M.Sc. (Ag.) Crop Physiology, Department of Biological Sciences, SHUATS, Allahabad, Uttar Pradesh, India

Effect of *Azotobacter* on growth and yield of onion (*Allium cepa* L.)

Devendra Kumar Kurrey, Mahendra Kumar Lahre and Gaurav S Pagire

Abstract
Azotobacter is been studied for nitrogen fixation bacteria is soil and effect positively on growth, yield, biochemical properties along with soil quality. Thus present study was carried out to evaluate the response of bio-fertilizer (*Azotobacter*) in case on onion. Doses (T_0: NPK, T_1:33g/m^2, T_2:66g/m^2, T_3:99g/m^2, T_4:132g/m^2, T_5: 166g/m^2, T_6:199 g/m^2) were decided on the basis of nitrogen requirement by the onion crop. The results shows significant increase in germination percent T_5(85%), bulb weight T_5(120.7g), maximum diameter of bulb T_5(6.2cm), bulb dry weight T_5(23.9g), plant dry weight T_5(28.2g), harvest index T_5(69.35%) and plant height T_6(57.3cm), No. of leaves T_6(11.4), chlorophyll- a T_6(0.86mg/g FW), chlorophyll b(0.47 mg/g FW) and carotenoid(0.75 mg/g FW), leaves protein T_6(0.45 mg/g), bulb protein T_6(1.2 mg/g), bulb sulphur T_6(5.64 mg/g).

Keywords: *Azotobacter*, biofertilizer, nitrogen fixation, growth, onion, germination, yield, quality

Introduction
Onion (*Allium cepa* L.) is important bulb crop of India. As a vegetable, it is a low in fat and calories. It also contributes significantly to the human diet and has a therapeutic property. India, the world's second largest producer. The indiscriminate use of chemicals resulted in degradation of soil health, erosion, and loss of organic matter, nitrate pollution and also health hazard for human beings. (Yang *et al.*, 2004) [21], Onion is a source of ascorbic acid and dietary fiber too. It also possesses a high content of flavanoids (mainly quercetin and its conjugates) and sulpher compounds (i.e. thiosulphinates), both of which have a high level of antioxidant activity (Griffiths *et al.*, 2002) [6]. So, application of biofertilizers results in increased mineral and water uptake, root development, vegetative growth and nitrogen fixation also stimulate production of growth promoting substance like vitamin-B complex, Indole acetic acid (IAA) and Gibberellic acids etc. They liberate growth promoting substances and vitamins and help to maintain soil fertility. (Pratap 2012) [15] Sevral studies shows that presence of *Azotobacter* spp. in soils has beneficial effects on plants, i.e, soil physico-chemical and microbiological properties. So, keeping in view the above facts the present experiment was undertaken to find out the most effective dose of *Azotobacter* for growth and yield of onion (*Allium cepa* L.).

Materials and Methods
The study was conducted at Department of Biological Sciences, SHUATS, Allahabad (U.P.), to evaluate the response of bio-fertilizer (*Azotobacter*) in case on onion plantation. Dose decided on the basis of nitrogen percent by *Azotobacter* in provided on powder form requirement by recommended doses on the onion crop. The experiment consists of seven treatment and three replications with RBD design *viz.* T_0 (control NPK 100% RDF), T_1:0.33g/m^2, T_2:0.66g/m^2, T_3:0.99g/m^2, T_4:1.32g/m^2, T_5:1.66g/m^2, T_6:1.99g/m^2). Treatment of *Azotobacter* are applied before transplanting and 30: 60 days after transplanting.

Results and Discussion
The results of the experiments are presented separately under the following results, The maximum seed germination percentage was observed in T_5(85%) in followed by T_4(83%). whereas the minimum was observed in T_1(71%). Similarly 90% germination was observed under 50% *Azotobacter* (Mahato *et al.*, 2009) [12] cumin 80% (Rezai *et al.*, 2005) [16].
However, in a studies on effect of *Azotobacter* inoculation on seed germination of onion found that combined inoculation with *Azotobacter chroococcum and Azospirillum brasilense* found increased germination (96.5%) over un inoculated control (85.5%) (Musmade and Konde 1987) [13].
The maximum plant height was observed in T_6 (57.3cm) followed by T_5(55.8 cm). Similarly there was increase in plant height 59.67cm (Bhandari *et al.*, 2012) [4] in case of garlic and onion

plant height 61.39 cm (Singh *et al*., 2007) [17]. It suggests that plant height was significantly influenced due to nitrogen amendment with *Azotobacter* inoculation (Balemi *et al.*, 2007) [1].

The maximum number of leaves was noted in the T_6(11.4), followed by T_5(11.1), and the minimum number of leaves was observed in T_1(10.5). Similarly case of onion for number of leaves per plant was (8.67) in *Azotobacter* inoculation (Balemi *et al*., 2007) [1]. The number of leaves per plant was (9.1) recorded on organic and inorganic combination on onion (Pratap *et al*., 2012) [15] while number increases for onion to 12.08 (Singh *et al*. 2007) [17].

The average weight of bulb (g/bulb) was observed in T_5(120.7 g) followed by T_6(112.3 g).Similarly for observed fresh weight of bulb (175.67 g) (Yadav *et al*., 2015) [20] Maximum weight of bulb (66.98 g) on onion in organic substances (Banjare *et al*., 2015) [2]. Maximum bulb weight (67.45g). (Ghanti and Sharangi 2009) [5].

The Maximum bulb diameter (cm) was observed in T_5(6.2cm) followed by T_6 and T_4(5.8cm) Similarly result was recorded for bulb equatorial diameter (5.23 cm) on onion in organic substances (Banjare *et al.*, 2015) [2], maximum diameter of bulb (4.60 cm) in organic and in organic combination. (Yadav *et al*., 2015) [20], average diameter of bulb (5.34 cm) (Bhandari *et al.*, 2012) [4].

The maximum bulb dry weight was observed in treatment T_5(23.9g) followed by T_6(22.2g). However, maximum dry weight of plant (7.65g) of the *Azotobacter* treatment on garlic (Pratap *et al*., 2012) [15]. In a study on dipping the root zone of onion during the transplantation in *azatobacter* slurry showed 8 to 10% increase in bulb dry weight (Balemi *et al*., 2007) [1]. There is also a significant increase in dry matter accumulation in onion bulb when applied in form of fertilizer (*Azotobacter chroococcum)* along with organic fertilizers in different combinations (Jaytilake *et al*., 2003).

The maximum harvest index was noted in treatment T_5 (66.71%). followed by T_6(66.42%) coincides with the harvest index 66.9% for combined treatment with organic manure (Jaytilake *et al.*, 2006), further in case of sesame plant HI was increased by 66% in comparison to control (Kushwaha 2010) [11]. However in case of Wheat there was no significant difference between Harvest index (35.7 -36.8%) when compare with NPK dose (Soleimanzadeh and Gooshchi, 2013) [19].

Chlorophyll "a and b" and carotene was observed maximum in T_6(0.863mg/g, 0.75mg/gram and 0.47.4mg/gm) which was significantly differ from rest of the treatments in a study on cabbage against BF+f states 2% and 3% increment over control for chlorophyll a" and b" (Jain and Boswal, 2015) [8].

However result estimated after 15 and 30 days of sowing (0.020 and 0.022 mg/g) amount of total chlorophyll content (Belhekar and Bhosale, 2010) [3] for fresh leaves of onion was less in comparison of mature leaf for *Azotobacter* treated soil but was higher to control states the positive effect of biofertilizer on chlorophyll content.

The maximum leaf & bulb protein content was observed in T_6(0.45mg/g and 1.2 mg/g) which was approximately 40 % and 30% more in comparison to control. In a study on onion protein was increased by 56% in *Azotobacter* combination comparison to control (Parab *et al*., 2013) [14]. This confirms increase in protein content. may be due to biofertilizer as over recommended doses of 50% NPK in combination with organic and biofertilizer increases protein content (Singh and Pandey, 2010) [18].

The maximum sulfur content was observed in treatment T_6(5.64ppm) which was significantly high from control. *Azotobacter* treatment improved sulphur content in onion by 0.682% when compare to organic 0.655% (Indira and Singh, 2014) [7] and even if use in combination with inorganic an organic (Bhandari *et al.*, 2012) [4].

Conclusion

Present study may conclude that *Azotobacter* influences positively on various growth, yield and biochemical parameter in comparison to control. However among different treatments T_5 and T_6 show optimum results.

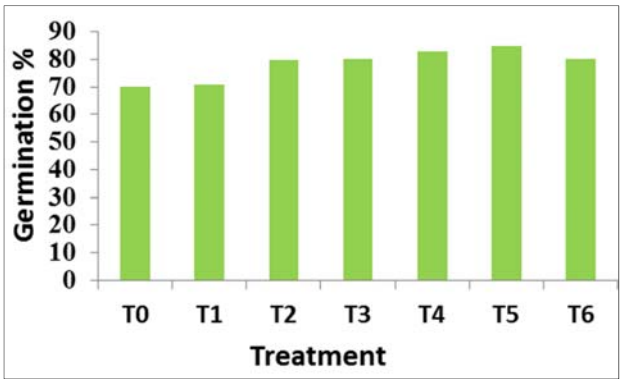

Fig 1: Effect of different doses of *Azotobacter* on the germination percentage of onion seed

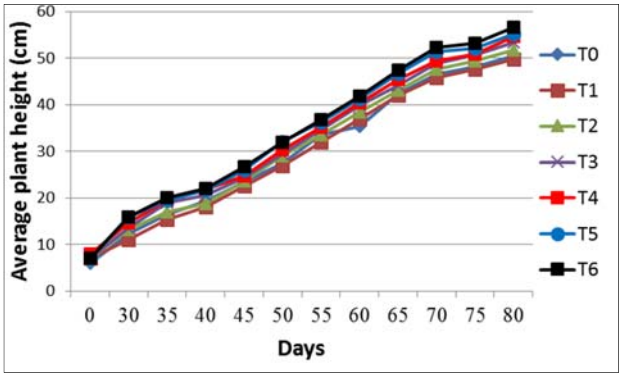

Fig 2: Effect of different doses of *Azotobacter* on average plant height (cm) of onion

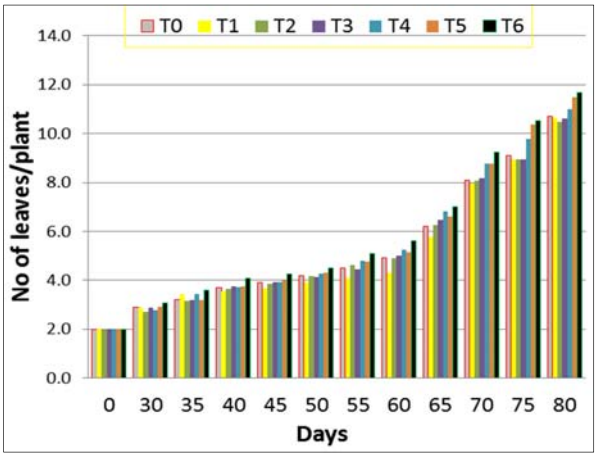

Fig 3: Effect of different doses of *Azotobacter* on number of leaves/plant of onion

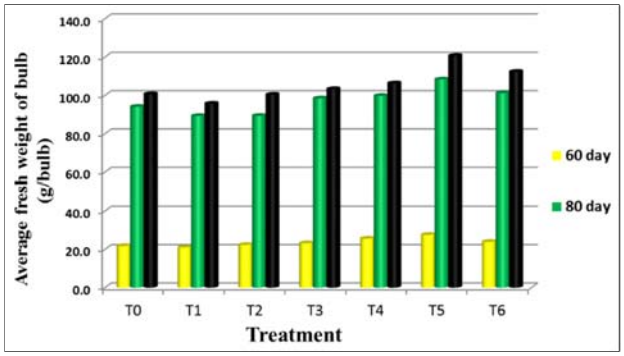

Fig 4: Effect of different doses of *Azotobacter* on fresh weight of bulb (g/bulb) of onion

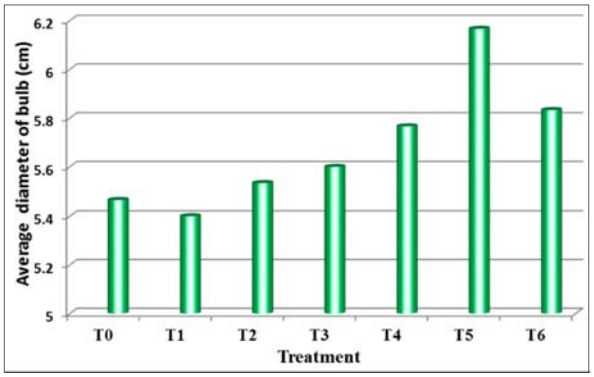

Fig 5: Effect of different doses of *Azotobacter* on average diameter of bulb (cm) of onion

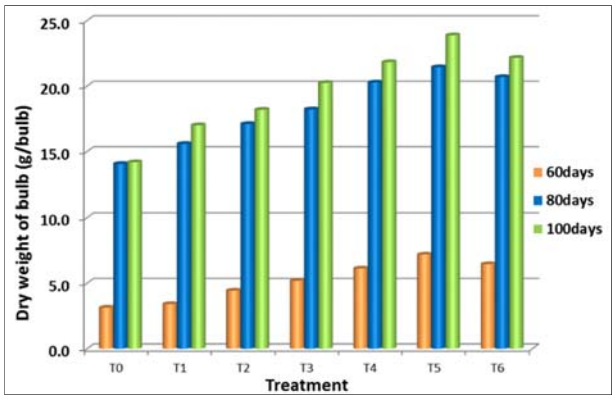

Fig 6: Effect of different doses of *Azotobacter* on dry weight of bulb (g/bulb) of onion

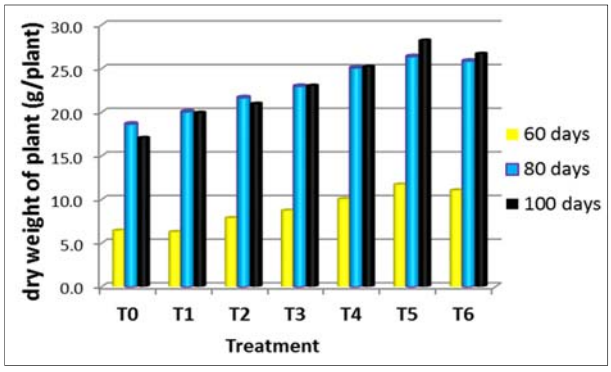

Fig 7: Effect of different doses of *Azotobacter* on dry weight of plant (g/plant) of onion

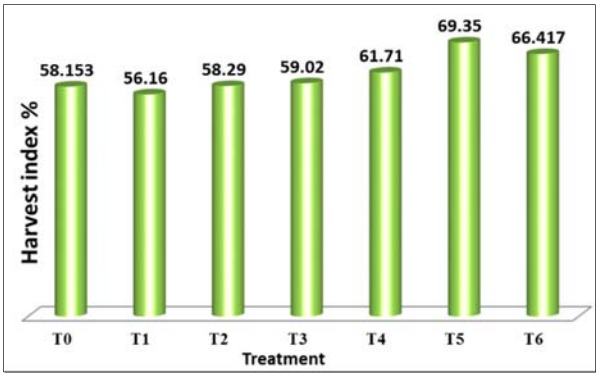

Fig 8: Effect of different doses of *Azotobacter* on harvest index of onion

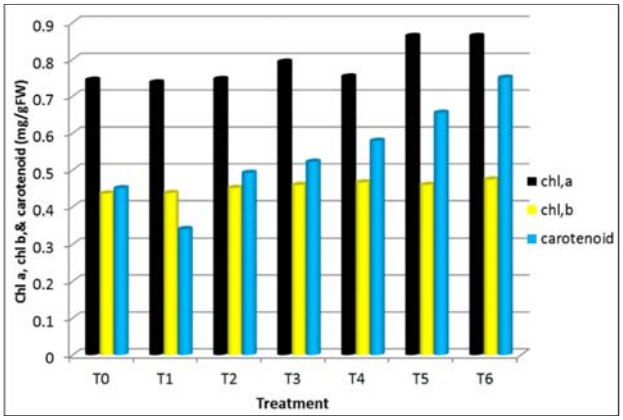

Fig 9: Effect of different doses of *Azotobacter* on chlorophyll a and b content, and Carotenoid content (mg/g FW) of onion

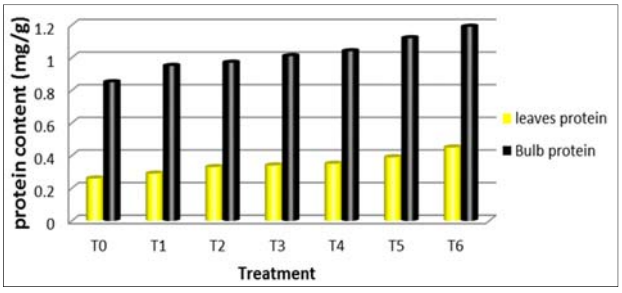

Fig 10: The effect of different doses of *Azotobacter* on leaves & bulb protein content (mg/g) of onion

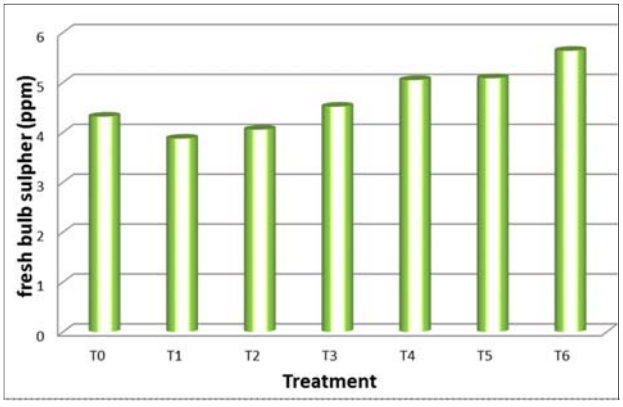

Fig 11: The effect of different doses of *Azotobacter* on fresh bulb sulphur content (ppm)

Table 1: Soil characteristics of the experimental site

Particulars	Sand	Silt	Clay	Textural class	Soil pH	EC(dsm^{-1} at 25^0 C)	Organic carbon	Available nitrogen (k ha^{-1})	Available phosphorus (k ha^{-1})	Available potassium (k ha^{-1})
Value (0-30cm depth)	48.15%	20.30%	30.50%	Sandy Loam	7.5	0.703 dsm^{-1}	0.38%	198.2	18	332

Table 2: Effect of different doses of *Azotobacter* on growth and yield parameter of onion

Treatments	Treatment amount g/m^2	Germination % 12 DAS	Plant Height (Cm)	No. of Leaves Per plant	Fresh weight of bulb(g)	Diameter of bulb (cm)	Dry weight of bulb (g/bulb)	Dry weight of plant (g/plant)	Harvest index (%)
T_0	Control	70	52.7±0.36	10.7±0.1	100.7	5.5	14.2	17.1	58.153
T_1	0.33	71	50.7±0.15	10.5±0.04	95.7	5.4	17.0	19.9	56.16
T_2	0.66	79.7	52.5±0.2	10.6±0.04	100.4	5.5	18.2	21.0	58.29
T_3	0.99	80	53.7±0.5	10.5±0.12	103.3	5.6	20.3	23.0	59.02
T_4	1.32	83	54.8±0.5	10.8±0.04	106.3	5.8	21.8	25.2	61.71
T_5	1.66	85	55.8±0.2	11.1±0.04	120.7	6.2	23.9	28.2	69.35
T_6	1.99	80	57.3±0.27	11.4±0.03	112.3	5.8	22.2	26.7	66.42
	F test	S	S	S	S	S	S	S	S
	SE.d±	3.53	0.25	0.18	2.48	0.09	0.12	0.12	0.41
	C.D At 5%	7.68	0.54	0.40	5.41	0.19	0.26	0.27	0.89

Table 3: Effect of different doses of *Azotobacter* on biochemical parameter of onion

Treatment	Treatment amount g/m^2	Chlorophyll a(mg/g FW)	Chl. b(mg/g FW)	Carotenoid (mg/g FW)	Leaves Protein (mg/g)	Bulb Protein(mg/g)	Bulb Sulphur(ppm)
T_0	Control	0.744	0.436	0.45	0.26	0.85	4.32
T_1	0.33	0.737	0.437	0.341	0.29	0.95	3.88
T_2	0.66	0.746	0.451	0.492	0.33	0.97	4.06
T_3	0.99	0.793	0.459	0.522	0.34	1.01	4.52
T_4	1.32	0.753	0.466	0.579	0.35	1.04	5.05
T_5	1.66	0.863	0.459	0.655	0.39	1.12	5.09
T_6	1.99	0.863	0.474	0.75	0.45	1.2	5.64
	F test	S	S	S	S	S	S
	SE.d±	0.01	0.00	0.01	0.06	0.01	0.04
	C.D At 5%	0.01	0.00	0.01	0.13	0.03	0.08

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