Effect of *Azotobacter chroococcum* on growth and yeild of leek (*Allium porrum*) c.v Lincoln.

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Leek *(Allium porrum.*L.) is a member of the family *Alliaceae*. It resembles large onion and garlic. The edible portion of leek is pseudostem consisting of the elongated base and lower blade parts of the foliage leaves. It is rich in protein (2.2gm/100gm) and Vitamin A (40 IU). It can be grown on a variety of soil but thrives luxuriantly on medium soils that are rich in organic matter (Pandey and Rai, 2006). The integrated use of biofertilizer and chemical fertilizer can contribute to increase nitrogen content of the soil and the productivity of crop. The microbial inoculants (*Azotobacter chroococcum*) fix the atmospheric nitrogen up to 13-15kg/ha (Sahai, 2004). Apart from nitrogen fixing ability *Azotobacter* is also known to produce plant growth promoting substances like IAA , GA_3 (Mahmaud *et. al,* 1984). These hormones stimulate root growth and development. They also help in better uptake of plant nutrients from chemical fertilizers. Keeping this in view the present investigation was under taken to find out the best treatment combination for better growth and yield of leek.

The experiment was carried out at the Research Farm, Department of Horticulture, Allahabad Agricultural Institute during the winter season of 2007-2008. The soil of experimental site is sandy loam having pH 6.2, organic carbon 0.21%, available Nitrogen (nitrate + ammonical) 55kg/ha, P_2O_5 18 kg/ha and K_2O 112.5 kg/ha. Leek cv. Lincoln was sown on 14th November 2007. The experiment was laid out in RBD with three replications. There were eight treatments *viz.* (i) full N, (ii) biofertilizer (*Azotobacter*), (iii) N (50%) + BF(Azot.) basal,(iv) N (50%) + BF (Azot) basal and foliar, (v) N (60%) + BF (Azot.) basal, (vi) N (60%) +BF (Azot.) basal and foliar, (vii) N (70%) + BF (Azot.) basal and (viii) N (70%) + BF (Azot.) basal and foliar.

Foliar application of *Azotobacter* was done on 60 DAT. The crop was fertilized with uniform basal dose of P_2O_5 and K_2O at 120 and 100 kg/ha through single super phosphate and murate of potash respectively. The crop was raised following all the recommended agronomic practices (Pandey and Rai, 2006) and harvested on March 26, 2008. The carrier based culture of *A. chroococcum* was mixed with sterilized neutral charcoal. In order to study, five plants per plot were selected randomly and observations like plant height, number of leaves per plant, girth of pseudostem, spread of the plant, biomass of fresh harvested plant, yield per plot, Projected yield per hectare and dry weight of whole plant were recorded. The experiment was laid out in RBD with 3 replications. The data recorded during the course of investigation were subjected to statistical analysis as per method of analysis of variance. (Fisher, 1953).

Plant height

It is evident from Table.1 that maximum plant height of 83.77cm was obtained with the combined application of 60% N and 2g *Azotobacter* as basal dose in comparison to control (55.00cm). It is seen in all the cases that soil application yields better result in comparison to soil and foliar application. The differential growth was found maximum in between 20-40 DAT and then it gradually declineed with the progress of development. The height difference in between 60-80 days were lesser than the 40-60 days and it was also greater in between the 20-40 days. Though the result obtained with application of 100% *Azotobacter* is less than the maximum achievement when it was used in combination with urea. Similar observations were noted by (Yumnam, 2006, (Jaythilake, *et al.* 2003) also reported that application of *A. chroococcum.* and *A. brasiliensis* in combination with 50% N results maximum plant height in onion in comparison to the recommended dose of NPK.

Plant spread

It was observed that the plant spread is closely correlated with the plant height (Table 1). Soil application had better spread than soil and foliar application. The plant spread suddenly jumped to maximum range at the period from 40-60 DAT even up to 200% in comparison to 20-40 days span. But the growth was arrested except low development in 60-80 DAT. The plant spread was maximum in case of T_5 (81.20cm) [N (60%) + *Azotobacter* basal] at 80DAT. In all cases even in 100% replacement of urea with *Azotobacter* T_1 yielded better resulted (73.00) than recommended dose of NPK.

Pseudostem girth

The data with respect to pseudostem girth in table 2, revealed that in T_5 [N (60%) + *Azotobacter* basal] pseudostem girth showed the

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maximum at 80 DAT which was 4.00cm followed by T_6 [N (70%) + *Azotobacter* basal] which was 3.60cm. While these were at par with soil along with foliar application of *Azotobacter*. Within first 20 days the parameter did not show any significant change between the treatments. In case of control where recommended dose of NPK was applied a very little change was recorded from 60-80 DAT (2.50cm) which was lesser than T_1 where urea has been totally replenished by *Azotobacter*. (Mahanthesh, *et. al.* 2005) also recorded similar result.

Number of leaves

It was observed that the number of leaves is closely correlated with the pseudostem girth, because the broaden lower portion of leaves *i.e.* leaf sheath form the pseudostem. Hence increase in number of leaves also increased the pseudostem girth. It was better in soil application than soil and foliar application. The number of leaves was maximum in case of T_5 (13.40) [N (60%) + *Azotobacter* basal] closely (12.20) followed by N (70%) + (Azot-B) and minimum were 9.60 in control. In all the cases even in 100% replacement of urea with *Azotobacter* T_1 yields better result (10.20) than with the recommended dose of NPK (control). A similar result in Tomato with the application of 75Kg N along with *Azotobacter* has been reported by Bhadauria (2005) and Mahanthesh (2005) also reported that application of biofertilizer along with chemical nitrogenous fertilizer to increased the number of leaves per plant in onion (*Allium cepa*) cv. Bellary Red.

Biomass of freshly harvested plant

It has been recorded that the maximum growth were achieved in a balanced dose of N (60%) + *Azotobacter* basal and expectedly the biomass on the same treatment was maximum as high as 362g. The biomass growth reaches to the pick point gradually with the reduction of *Azotobacter* with combination of N at 60% then gradually declines with reduction of *Azotobacter* percentage in both basal and basal + foliar application. (Table 3.) In case of onion (Balemi, 2006) recorded that the marketable yield has been increased with the application of *Azotobacter* along with 75% N through chemical fertilizer. While marketable portion of Leek is its vegetative part, so increase in biomass enhance the marketable yield also.

Yield per plot

The effect of *Azotobacter* and optimum dose of nitrogen has increasing effect on yield of leek. It is evident from the table3, that there is significant influence of *Azotobacter* on yield. As leek is a green vegetable in which half portion of leaf blade and the pseudostem is used as vegetable, hence the yield is increase with its biomass. It has been recorded that the maximum growth and biomass were achieved in a balanced dose of N (60%) + *Azotobacter* basal and expectedly the yield on the same treatment was maximum as high as 17.3kg. It has been found that among those treatments in which *Azotobacter* is applied through both soil and foliar application T_5 gives the maximum yield (12.02kg) which is many lees than T_4 but better than control.

Projected yield

Maximum plant biomass and yield per plot along with yield per hectare 421.58q/ha were achieved in T_5 [N (60%) + *Azotobacter* basal]. The yield per plot growth reaches the pick point gradually with the *Azotobacter* (soil application) with combination of N at 60%. Bhadauria, *et al.* (2005) has also shown a similar result in Tomato with *Azotobacter* along with 75kg N. In case of onion Balemi (2006) revealed that the marketable yield increased with the application of *Azotobacter* along with 75% N through chemical fertilizer. While marketable portion of leek is its vegetative part, so increase in biomass enhance the marketable yield also.

Dry weight

Maximum dry weight was recorded in T_5 (27.70g per 100g of fresh weight). The table 3 shows that dry weight growth reaches to the pick point gradually *Azotobacter* soil application with N 60%. Jaytilake *et. al* (2003) showed a similar result in case of onion (*Allium cepa*) cv. N-53. There they used *Azotobacter chroococcum* as biofertilizer and found dry matter accumulation in bulb has been increased significantly.

From the experimental findings, it may be concluded that T_5 (60% urea with *Azotobacter* as basal application) gave the best result in terms of growth and yield. It has been also found that the same treatment is also superior in terms of residual amount of nitrogen and organic carbon in soil than the other treatments. The effect of *Azotobacter chroococcum* on available nitrogen of soil was 255.00kg/ha recorded in T_7 [N (70%) + *Azotobacter* (basal)] whereas available nitrogen was 55kg/ha in the beginning of the experiment.

Table 1: Effect of *Azotobacter* on plant height and spread of leek

Treatments	Plant height (cm)			Plants spread (cm)		
	40DAT	60DAT	80DAT	40DAT	60DAT	80DAT
Full N	41.87	57.47	55.00	34.00	51.60	63.53
(Azot-B+F)	43.20	61.60	69.50	34.20	59.60	73.00
N (50%) + (Azot-B)	46.87	64.67	77.07	40.40	70.80	83.40
N (50%) + (Azot-B+F)	48.60	65.67	78.37	37.80	64.20	78.80
N (60%) + (Azot-B)	52.13	71.00	83.77	45.10	78.40	92.40
N (60%) + (Azot-B+F)	45.53	63.13	75.30	40.20	67.20	81.20
N (70%) + (Azot-B)	46.87	64.40	76.83	41.80	72.40	88.00
N (70%) + (Azot-B+F)	46.40	63.87	76.67	39.70	66.60	80.20
S Em (±)	**0.12**	**0.22**	**0.33**	**0.16**	**0.14**	**0.35**
LSD (0.05)	**0.27**	**0.48**	**0.72**	**0.34**	**0.30**	**0.75**

Table 2: Effect of *Azotobacter* on pseudostem girth and number of leaves of leek

Treatments	Pseudostem girth (cm)			Number of leaves		
	40DAT	60DAT	80DAT	40DAT	60DAT	80DAT
Full N	1.54	2.16	2.50	5.40	7.00	9.60
(Azot-B+F)	1.60	2.28	2.90	5.40	7.40	10.20
N (50%) + (Azot-B)	1.78	2.92	3.00	6.07	8.40	10.40
N (50%) + (Azot-B+F)	1.66	2.40	2.90	5.80	7.80	10.20
N (60%) + (Azot-B)	2.10	3.02	4.00	6.20	8.80	13.40
N (60%) + (Azot-B+F)	1.72	2.76	3.00	6.00	8.20	10.20
N (70%) + (Azot-B)	1.84	2.92	3.60	6.20	8.60	12.20
N (70%) + (Azot-B+F)	1.70	2.48	3.00	5.80	8.00	10.20
S Em (±)	**0.04**	**0.04**	**0.04**	**0.17**	**0.06**	**0.07**
LSD (0.05)	**0.08**	**0.08**	**0.09**	**0.37**	**0.12**	**0.15**

Table 3: Effect of *Azotobacter* on yield attributes and dry matter of leek

Treatments	Biomass of fresh harvested plant (g)	Yield/ plot (kg)	Projected yield (q/ha)	Dry weight of plant (g)
Full N	168.30	8.08	201.94	20.80
Azot (B+F)	191.00	9.17	229.19	21.70
N (50%) + (Azot-B)	270.25	12.97	324.31	23.50
N (50%) + (Azot-B+F)	240.20	11.53	288.23	21.90
N (60%) + (Azot-B)	362.00	17.38	434.41	27.70
N (60%) + (Azot-B+F)	250.40	12.02	300.48	23.40
N (70%) + (Azot-B)	351.32	16.86	421.58	25.80
N (70%) + (Azot-B+F)	248.70	11.94	300.48	22.50
S Em (±)	**3.17**	**0.13**	**3.22**	**0.10**
LSD (0.05)	**6.80**	**0.28**	**6.90**	**0.21**

(Azot.- *Azotobacter*, N-Nitrogen, B-basal, F-foliar, DAT-days after transplanting)

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