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Performance of Bottle Gourd (*Lagenaria siceraria* mol.) Plants under Numerous Combined Applications of Mineral Nitrogen Fertilizer Levels and Bio-inoculates

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Abstract

THIS investigation was conducted during the two successive summer seasons of 2022 and 2023 to study the effect of numerous combined applications of mineral nitrogen fertilizer levels (N) as $(NH_4)_2SO_4$ and three different of wild type strains of *Azotobacter chroococcum* (AZO1, AZO2, and AZO3) on growth, yield and quality of bottle gourd plants. It was found that the emergence percentage of bottle gourd seeds was improved after inoculation with AZO3 alone and the majority of combined treatments as compared to the recommended dose (100% N). Plants treated with AZO3 alone gave close results to those treated with 100% N and mixing AZO3 with different doses of N (25, 50, and 75%) made considerable increments in almost vegetative growth traits. Both single and combined treatments decreased significantly the number of male flowers and days taken for flowering initiation. In contrast, the number of female flowers was increased in plants treated with all tested combined treatments. The majority of combined treatments were superior to single treatments for improving all studied fruits, yield, and NPK contents in leaves especially those of mixtures (AZO3 + 50 and 75%N) which gave the best results as compared to other treatments. Finally, it could be concluded that to decrease the hazard effect of mineral fertilizers on environment and human health as well as improve growth, yield and quality of bottle gourd plants, it might be used (AZO3 and AZO1) bio-inoculates alone or in combination with low doses of nitrogen mineral fertilizers in bottle gourd fertilization programs.

Keywords: Bottle gourd, bio-inoculates, mineral fertilizers, vegetative growth, NPK contents, total yield.

Introduction

Bottle gourd (*Lagenaria siceraria* Mol.) is a member of the cucurbitaceae family with 22 chromosomes. It is widely grown throughout the world, in tropical and subtropical regions. A 100 g of this fruit may contain traces of the following minerals: calcium (20 mg), iron (0.7 mg), and phosphorus (10 mg), as well as protein (2000 mg) and carbohydrates (2500 mg). Their seeds contain a great source of vitamins, sterols, antioxidants, important fatty acids, and vitamins A, C, and E (Naafe et al., 2022 and Hassan et al., 2008).

Fertilizers are essential for boosting productivity, which will help solve the problem of food security now and in the future. Applying excessive amounts of chemical fertilizers degrades the physical and chemical characteristics of the soil, reduces microbial activity in the soil, lowers soil humus levels, and increases pollution of the soil, water, and air (Patle et al., 2018). Since mineral fertilizers are becoming more expensive, it is essential to offer alternatives in order to give crops the best and most affordable amount of nutrients.

The term "bio-fertilizer" refers to a material that includes living organisms that, when applied on soil, seed, or plant surfaces, invade the rhizosphere, or inside of the plant, and stimulates growth by making more primary nutrients available to the host plant. The use of bio-fertilizer alone or combined with mineral fertilizers is one of the essential requirements for increasing the yield of vegetable crops (Mandloi et al., 2022 and Rabari et al., 2019).

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Recently, free-living bacteria (*Azotobacter* and *Azospirillum*), symbiotic (*Rhizobium*), and phosphate solubilizers (*Bacillus megaterium*, *B. polymyxa*, and *P. striata*) have become more popular as bio-fertilizers. Because of its inherent capacity to fix atmospheric nitrogen, *Azotobacter* has gained acceptance as a viable substitute for chemical fertilizers (Bageshwar et al., 2017 and Subedi et al., 2019). Increasing yield and crop productivity have been achieved by dressing the soil and inoculating of seed with *Azotobacter* through providing extra nitrogen to the crops (Arjun et al., 2015). So, the present experiment was conducted to study the potential effects of the combined applications of three *Azotobacter chroococcum* bio-inoculates and nitrogen mineral fertilizer levels on growth, yield and quality traits of bottle gourd plants.

Materials and Methods

Field experiments were carried out during the two successive summer seasons of 2022 and 2023 at Sids Experimental Station, Agriculture Research Center (ARC), Beni-Sueif Governorate (latitude 29º 4 and longitude 31º 6), Egypt. The soil texture was clay-loam and the physical and chemical properties of the used soil are listed in Table (1).

Plant material

Seeds of local cultivar of bottle gourd (*Lagenaria siceraria* M) landrace El- Arishy were obtained kindly from Prof. Dr. Samir K. El-Seifi, Department of Horticulture, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt.

Inoculant strains

Three different of wild type strains of *Azotobacter chroococcum* namely (AZO1, AZO2 and AZO3) were kindly provided by Prof. DR. Omar F. Dakhly, Genetics Department, Faculty, Agriculture, Minia Univ., Egypt. Modified Ashby's medium (Hegazi and Niemela, 1976) was used to grow *Azotobacter chroococcum*. At the logarithmic growth phase, cultures were centrifuged at 1000 rpm and the cell pellets were washed three times with sterile phosphate buffer (100 mM, pH = 7.0). The washed cells were re-suspended in the same buffer to the final concentration of about 5×10^9 *cfu* ml^{-1}. Different bio-inoculates were prepared immediately before inoculation. The rhizosphere of each plant was injected with about 5 ml /plant of tested bio-inoculates.

Field experiments

Seeds of bottle gourd were sown in 25th and 28th March 2022 and 2023, respectively on rows 5 m long, 2 m wide and in row spacing of 50 cm. One guard ridge separated each treatment. This experiment used a randomized complete block design with three replications. Thirteen treatments were included in each experiment as follow:

- T1: Control (recommended dose of N as a mineral fertilizer at 62 kg N/feddan).
- T2: AZO1 inoculant at 5 ml /plant.
- T3: AZO2 inoculant at 5 ml /plant.
- T4: AZO3 inoculant at 5 ml /plant.
- T5: 25% N + AZO1 inoculant at 5 ml /plant.
- T6: 25% N + AZO2 inoculant at 5 ml /plant.
- T7: 25% N + AZO3 inoculant at 5ml /plant.
- T8: 50% N + AZO1 inoculant at 5 ml /plant.
- T9: 50% N + AZO2 inoculant at 5 ml /plant.
- T10: 50% N + AZO3 inoculant at 5 ml /plant.
- T11: 75% N + AZO1 inoculant at 5 ml /plant.
- T12: 75% N + AZO2 inoculant at 5 ml /plant.
- T13: 75% N + AZO3 inoculant at 5 ml /plant.

Three times; during soil preparation, after four weeks and six weeks of seed sowing, mineral nitrogen fertilizer in ammonium sulphate (20.6% N) form were applied at the recommended dose of 62 kg N/feddan. Equal amounts of 15 m^3 farmyard manure, 150 kg calcium superphosphate (15.5% P_2O_5), and 100 kg elemental sulphur $feddan^{-1}$ were added during soil preparation. K_2O at 48 kg $feddan^{-1}$ was applied in two equal quantities; 20 and 40 days after seed sowing. All other agro-management practices for commercial production of bottle gourd were followed whenever it was necessary due to the recommendations of Egyptian Ministry of Agriculture.

Recorded data

Seed germination

Germinated seeds were counted daily to determine the emergence for the different treatments.

$$\text{Emergence \%} = \frac{\text{Number of germinated seeds /plot}}{\text{Total number of planted seeds}}$$

Vegetative growth and yield traits

After four months of seed sowing, samples of five plants from each plot were taken to determine vegetative growth parameters: vine length (cm), number of leaves per plant, number of branches/plant, leaf area (cm^2), plant fresh weight (kg) and plant dry weight (g), yield components: fruit length (cm), fruit diameter (cm), number of fruit /plant, average weight of fruit (g), yield/plant (kg) and yield /faddan (ton).

Flowering and sex expression parameters

Following emergence, fifteen seedlings were marked at random to record the quantity of male (♂) and female (♀) flowers as well as the number of days it took for flowering initiation.

Chemical constituents

Leaf N, P, and K concentrations were measured on five plants from each plot four months after the seeds were sown. After separating the shoot samples, they were oven dried for 72 hours at 70°C until their weight remained consistent, then finely ground and wet digested. As stated in A.O.A.C. (2000), the Microkjeldahal device was used for measuring total nitrogen. The leaf P content was calculated using Jackson (1967) guidelines. Leaf potassium content was assayed using a Perkin-Elmer Model 52-A Flame Photometer (Page et al., 1982), Total soluble solids TSS (measured by hand refractometer) content in fruit were determined according to methods mentioned by Umiel and Gabelmoii (1971).

Statistical analysis

The obtained data were statistically analysis using MSTAT program (Version 4) according to Gomes and Gomes (1984).

Results and Discussion

Emergence percentage

The effect of different combinations of N mineral fertilizer and bio-inoculates on the emergence percentages of bottle gourd seeds during two successive seasons are shown in Fig. 1. Generally, the results showed that the majority of combined treatments increased the emergency percentages of bottle gourd seeds better than control treatment (100% N).

It was observed that seeds inoculated with AZO3 alone gave high percentage of emergence (97 and 98%) as compared to those inoculated with the other bio-inoculates (AZO2 and AZO1) and the recommended dose of N mineral fertilizer (100% N). The highest percentages of emergence were found in plants treated with AZO3 + 50% N and AZO3 + 75% N with the same values (98 and 99%) as compared with all other treatments, while the lowest values of emergence percentage were found in plants treated with AZO2 bio-inoculate (94 and 95% during the two tested seasons, respectively). The high percentage of seed germination could be due to the presence of IAA, GA3, vitamins, amino acids, or secondary metabolites, which suppress the growth of antagonists present in soil and on the seed coat, and the release of plant growth-promoting substances around seed rhizospheres (Alghamdi, 2022). Similar results were also reported by Mahato et al. (2009) and Pathak et al. (2013) who reported that *Azotobacter* and PSB were able to make a significant increment at seed germination of tomato and Guava.

Vegetative growth traits

The obtained data in Table 2 showed that mixing AZO3 inoculate with different levels of N mineral fertilizer (25, 50, and 75% N) gave the best results in vine length trait, with a significant increment as compared to 100% N treatment during the two tested seasons. There was no significant difference between plants treated with different bio-inoculates and 100% N in vine length. It was observed that mixing different bio-inoculates with 75% N improve significantly vine length as compared with plant treated with 100% N and all single bio-inoculates treatments during the two seasons.

Data in Table (2) reveal that there were no significant differences between plants treated with 100% N and those treated with AZO3 inoculate in number of leaves/plant during the two tested seasons. The highest values of number of leaves/plant were found in plants treated with 50% N + AZO3 (80.00 and 79.66) during the two seasons, respectively. The data show that almost of N + bio-inoculates combination treatments was better than single treatments in number of leaves/plant trait.

Concerning number of branches/plant trait, there were no significant differences between plant treated with the recommended dose and those treated with the single treatments of bio- inoculates. The highest values of number of branches/plant were exhibited in plants treated with 75% N + AZO3 (7.66 and 7.76) and 50% N + AZO3 (7.33 and 7.40) during the two seasons with a significant increase as compared to the recommended dose (100% N). The lowest values of number of branches/plant were recorded in plants treated with AZO2 inoculate alone (5.66 and 6.01 during the two studied seasons, respectively).

There were no significant variances between plants treated with 100% N and those treated with the two inoculates (AZO1 and AZO3) in leave area trait during tested seasons. The highest values of leaf area were found in plants treated with 75% N+ AZO3 (41.04 and 40.41cm^2) with a significant increment as compared to almost all other treatments.

Results showed that mixing AZO3 bio-inoculate with all N levels (25, 50 and 75% N) gave significant values at plant fresh weight as compared to other tested treatments during the two seasons. The highest values of plant fresh weight were found in plants treated with 75% N + AZO3 (2.601 and 2.387 kg during the two seasons, respectively). The lowest values of plant fresh weight were obtained by AZO2 treatment with a significant decrease (2.060 and 1.999 kg) as compared with other treatments during studied seasons. Regarding plant dry weight trait, the data were compatible with the previous of plant fresh weight.

Generally, data reveal that combined applications were better than that of the single treatments for all tested vegetative growth traits. As well, plants treated with AZO3 alone gave close results to that treated with 100% N as well as, mixing AZO3 with different doses of N (25, 50 and 75% N) made considerable increments in almost tested vegetative growth traits during the two seasons. The increments

of vegetative traits after inoculation with *Azotobacter* bio-inoculate might be due to increase the biological nitrogen fixation process, phosphate solubilization, and secreting phyto-hormones **(**El-Fattah et al., 2013). Furthermore, it may increase the absorption of nutrient as well as the photosynthetic process. Our results were in accordance with that obtained by Patel et al. (2018) and Din et al. (2019) in bottle gourd, Prasad et al. (2009) and Kumar et al. (2012) in bitter gourd.

Flowering traits

The obtained data in Table (3) show that there were significant reductions in number of male flowers in plants treated with different tested bio-inoculates (AZO1, AZO2 and AZO3) as compared to that treated with the recommendation dose of nitrogen mineral fertilizer (100% N) during the two studied seasons. It was also observed that mixing different bio inoculates with different N levels exhibited a significant reduction in number of male flowers as compared with 100% N treatment during the two studied seasons.

Concerning number of female flowers, it was found that single application by bio-inoculates (AZO1, AZO2 and AZO3) gave close results to plants treated with the recommended dose (100% N). The combined treatments of N + bio-inoculates improved the number of female flowers as compared to 100% N treatment during the two seasons. The highest number of female flowers were recorded in plants treated with 75% N + AZO3 (13.33 and 13.34) followed by that treated with 50% N + AZO3 (12.71 and 13.00 during the two seasons, respectively) while the lowest values were obtained in plants treated with AZO1 (10.33 and 10.68 during the two seasons, respectively).

Mixing of mineral and bio-fertilizers enhance the uptake different nutrients which promote faster plant growth leading to increase production of higher number of flowers. Similar results were recorded by Anjanappa et al. (2012) in cucumber and Das et al. (2015) in bottle gourd. The increment of number of female flowers might be due to the high production of phyto-hormones like gibberallic acid, indole acetic acid and dihydrozeatin from the bio-inoculates (*Azotobacter*) which influence positively on the physiological activity of plants which could assist the plants to induce female flowers: thereby it favorably modified the sex ratio (Mulani et al. 2007). Results showed that all bio-inoculate treatments reduced significantly the days taken for flowering initiation as compared to 100% N treatment and almost of other tested treatments. The lowest values of days taken for flowering initiation were recorded in plants treated with AZO3 (51 and 53.33 days during the two studied seasons, respectively). Regarding taken for flowering initiation, it might be possible due to availability nitrogen, phosphorus and potassium in easier and available form through bio-fertilizer (*Azotobacter*) at early stage of life of plant which it helps in foliage growth and early flowering in bottle gourd plants. The reduction in days to male and female flower initiation was due to stimulating effect of phosphorus on growth hormones which induce early flowering (Singh and Asrey, 2005). The results are in accordance with those recorded by Baghel et al. (2018) in bottle gourd, Singh et al. (2018) in cucumber and Kharga et al. (2019**)** in cucumber.

Fruit and yield traits

As presented in Table 4, results showed that there were no significant variances between plants treated with AZO3 and those treated with 100% N in fruit length trait during the two seasons. It was also clearly observed that all of N + N bio-inoculates combined treatments improve fruit length more than single treatments. The maximum fruit length was obtained after treatment with 75% N+AZO3 (63.25 and 63.00cm) with a significant increment more than 100% N (60.00 and 58.67cm, during the two seasons, respectively). The increment in fruit length could be due to the transfer high amount of photosynthesis products to the reproductive organs (Fruit). These results are in accordance with that recorded by jilani et al. (2009) and Ghasem et al. (2014**)** in cucumber.

In the case of fruit diameter, there was a quiet increment in plant treated with 100% N more than that treated with the different bio inoculates. Mixing 75% N + bio-inoculates gave the highest values of fruit diameter as compared to all other treatments. Inoculation with AZO3 alone or in combination with different N levels was the best among all other tested bio- inoculates in fruit diameter traits. It might be due to the great availability of nitrogen elements which resulted from mineral and N bio-fertilizer that induced protein formation which help to generate more meristem cells and enhance cell division that finally led to increase fruit diameter (Mandloi et al., 2022). Similar results are in line with Das et al. (2015) in bottle gourd.

Regarding the number of fruit/plant, there was no significant difference between 100% N and all tested bio-inoculates treatments during the two studied seasons. The maximum number of fruit/plant was recorded in plant treated with 75% N +AZO3 (3.35 and 3.67, during the two studied seasons, respectively). Generally, mixing N with different bio-inoculates affected positively the number of fruit/plant as shown in Table 4. Compared to conventional treatments with single or less balanced nutrient sources, the balanced combination of mineral and bio-fertilizer components assures a synergistic impact, delivering optimal nutrition and stimulating powerful plant growth, ending in longer vines which reflecting on increasing number of flowers and therefore number of fruit/plant (Tomar et al., 2024). Similar results were mentioned by

Pravallika and Deepanshu (2020), Nadoda et al. (2020) and Pathak et al. (2022) in bottle gourd.

Concerning the average weight of fruit, the obtained data show that plants treated with the recommended dose (100% N) exhibited a slight increment as compared to those inoculated with different tested bio-inoculates during the two seasons as well as, almost of combinations treatments were superior to single treatments. Mixing AZO3 with different N levels gave the best results and exhibited high increment in average weight of fruit during the two tested seasons. The maximum average weight of fruit was recorded in plants treated with 75% N+AZO3 (783.67 and 758.00 g, during the two seasons, respectively.

In the case of yield/plant trait, data in Table 4 show that there were no significant differences between plants treated with 100% N and those treated with different bio-inoculates. During the two tested seasons, almost of N + bio-inoculates combined treatments gave a clear improvement in yield/plant as compared to the single treatments. The maximum values of yield/plant were recorded in plants treated with 75% N + AZO3 in both seasons (92.42 and 2.60 kg, respectively) followed by that of 50% N + AZO3 (2.39 and 2.42 kg) during the two seasons.

Regarding total yield/feddan, considerable increments were observed in plants treated with the combined treatments as compared to those treated with the single treatments. Mixing AZO3 bio-inoculate with different N levels gave the best results as compared with all other treatments. The highest values of yield/feddan were recorded in plants treated with 75% N + AZO3 in both seasons (9.95 and 10.40 tons) as compared with the recommended dose (7.83 and 8.00 tons, during the two tested seasons, respectively). Generally, data in Table 4 reveal that the majority of combined treatments were superior to the single treatments at improvement of all studied fruit and yield traits in bottle gourd plants practically, these of N + AZO3 with gave the best results as compared to all other treatments.

The increase in fruit average weight, yield/plant and total yield/feddan may be attributable to the beneficial effects of bio-fertilizers, which provide ideal conditions surrounding the root rhizosphere and improve nutrient absorption (Patton et al. 2002). The results obtained are in line with the findings of Patel et al. (2020) in bottle gourd and Anjanappa et al. (2012) in cucumber.

Leaf NPK contents and TSS in fruit

The presented results in Table (5) show that there were no significant differences between plants treated with 100% N and those treated tested bio-inoculates in the N content in the leaves during all studied seasons. The highest values of N content were recorded by 75% N + AZO3 treatment during all studies seasons (2.11 and 2.07%, respectively) followed by 50% N + AZO3 **(**2.08 and 2.06%, respectively) as compared with 100% N and all other treatments. Almost of the tested combined treatments were better than single treatments for increasing N content in leaves during all tested seasons. One the other hand, there was a considerable increase in P content values in plants treated with all tested treatments as compared with the recommended dose (100% N). The two treatments; 75% N + AZO3 (0.38 and 0.38%) and 50% NMF+AZO3 (0.36 and 0.37%) gave the best values of P content in leaves during all studied seasons, respectively.

The present results in Table (5) showed the superiority of all tested combination treatments for increasing of K content in leaves during all seasons as compared to single treatments. It was observed that mixing different levels of N (25, 50 and 75%) with AZO3 bio-inoculate gave the best results of K content in leaves as compared to the recommended dose and other tested treatments during the two tested seasons.

Generally, data show that almost of N + bio-inoculates combination treatments improved considerably N, P and K contents in the leaves of bottle gourd plant as compared to the recommended dose (100% N) during the two tested seasons. This improvement could be attributed to the role of biofertlizer on the enhancement of nutrients availability and modification of root growth morphology resulting in more efficient absorption of available nutrients **(**Jagnow et al., 1991 and El-Seginy, 2006).

According to data in Table 5, it was clearly observed that all tested treatments induced significantly TSS in fruit of bottle gourd as compared with the recommended dose (100% N). The best values of TSS were obtained after being treated with 25% N + AZO3 (7.07 and 7.08%) followed by 25% N + AZO2 (7.06 and 7.07%) during studied seasons, respectively. The minimum values of TSS were found in plants treated with the recommendation dose (5.69 and 5.71%) during studied seasons, respectively. The increment of TSS may be due to the increment of carbohydrates production during photosynthesis as well as, improvement of physiological and biochemical processes in plant system (Pathak et al., 2022). Das et al. (2015) reported that quality trait like TSS was increased by application of bio-fertilizers. The obtained results were comparable to those of Nadoda et al. (2020) in bottle gourd and Sayed et al. (2015) in cucumber.

Conclusions

Finally, it could be concluded that to decease the hazard effect of mineral fertilizer on environment and human health as well as, improve growth, yield and quality of bottle gourd plants it might be use

(AZO3 and AZO1) bio-inoculates alone or in combination with low doses of nitrogen mineral fertilizers in bottle gourd fertilization programs.

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Conflicts of interest

We wish to confirm that there are no known conflicts of interest associated with this publication.

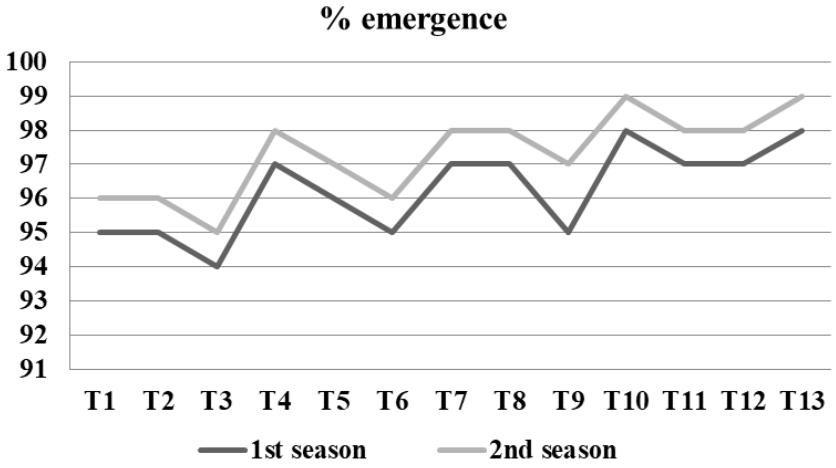

Fig. 1. Effect of different combinations of N mineral fertilizer and bio-inoculates on emergence percentages of bottle gourd seeds during two successive seasons.

TABLE 1. Physical and chemical profile of the used soil at 0-30 cm depth used during the two seasons of 2022 and 2023.

Constituents	Value	
	1st season	2nd season
Sand (%)	22.20	22.22
Silt (%)	31.70	31.71
Clay (%)	46.10	46.07
Soil type	Clay loam	Clay loam
Organic matter (%)	1.58	1.57
$CaCo_3$ (%)	2.09	2.10
pH (1:2.5)	7.79	7.77
E.C. (m mhos/cm)	1.04	1.05
Total N (%)	0.08	0.08
Available P (%)	29.15	29.24
Available K^+ (mg/100g)	3.19	3.22
Available Ca^{++} (mg/100g)	30.71	30.10
Available Na^+ (mg/100g)	2.38	2.37
Available micronutrients (EDTA, ppm):		
Fe	8.57	8.59
Cu	2.03	2.01
Zn	2.64	2.65
Mn	8.27	8.10

TABLE 2. Effect of different combinations of N mineral fertilizer and three different of wild type strains of *Azotobacter chroococcum* on some vegetative parameters of bottle gourd (*Lagenaria siceraria*) during two successive seasons of 2022 and 2023.

Treatments	Vine length (cm)		No. leaves/plant		NO. branches/plant		Leaf Area (cm2)		Plant fresh weight (kg)		Plant dry weight (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% N	226.66	245.00	75.33	76.00	6.37	6.45	39.70	38.70	2.326	2.313	329.33	327.30
AZO1	209.00	234.33	74.68	72.33	6.23	6.28	39.09	37.36	2.230	2.213	322.70	319.00
AZO2	198.66	229.66	73.67	74.68	5.98	6.01	37.36	37.96	2.060	1.999	321.70	320.70
AZO3	219.66	225.00	76.33	76.66	6.28	6.32	39.02	37.92	2.304	2.217	352.33	352.00
25% N+AZO1	221.66	221.00	75.33	73.00	6.33	6.38	38.65	37.59	2.049	2.025	294.70	356.70
25% N+AZO2	223.67	222.66	76.33	77.00	6.00	6.07	37.97	37.89	2.094	2.081	305.00	319.70
25%N+AZO 3	253.00	262.33	78.00	77.00	7.09	7.08	38.54	38.58	2.508	2.451	353.70	326.00
50% N+AZO1	237.66	243.00	75.66	76.00	7.01	7.03	38.72	37.97	2.195	2.201	304.00	293.30
50% N+AZO2	239.00	253.33	76.33	75.33	6.68	6.34	38.70	38.85	2.227	2.250	301.00	325.00
50% N+AZO3	299.33	296.67	80.00	79.66	7.33	7.40	39.19	39.31	2.540	2.452	364.70	344.30
75% N+AZO1	282.33	286.33	76.66	77.33	7.08	7.09	37.49	36.89	2.219	2.220	310.33	322.00
75% N+AZO2	305.33	313.66	79.33	79.00	6.71	6.90	37.61	37.89	2.441	2.314	316.00	342.70
75% N+AZO3	312.66	317.33	79.00	79.00	7.66	7.76	41.04	40.41	2.601	2.387	364.00	343.30
LSD0.05	**19.00**	**21.74**	**2.75**	**2.96**	**0.72**	**0.54**	**1.67**	**1.37**	**0.20**	**0.13**	**26.68**	**26.85**

100% N: the recommended dose of nitrogen mineral fertilizer

TABLE 3. Effect of different combinations of N mineral fertilizer and three different of wild type strains of *Azotobacter chroococcum* on some flowering traits of bottle gourd (*Lagenaria siceraria*) during two successive seasons of 2022 and 2023.

Treatments	No. male flowers		No. female flowers		Days taken for flowering initiation	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% N	83.33	83.00	10.85	11.33	57.00	58.00
AZO1	79.00	78.33	10.58	10.87	52.33	54.00
AZO2	79.00	79.33	10.33	10.68	52.00	54.67
AZO3	77.70	77.00	10.65	11.00	51.00	53.33
25% N+AZO1	77.90	78.00	11.66	12.00	54.33	56.68
25% N+AZO2	78.34	77.00	11.33	11.70	53.00	54.00
25%N+AZO3	77.00	76.33	12.66	12.80	53.67	55.00
50% N+AZO1	77.68	77.00	12.66	11.67	55.33	56.33
50% N+AZO2	79.70	80.33	11.66	11.72	54.00	55.68
50% N+AZO3	78.70	78.70	12.71	13.00	56.33	57.33
75% N+AZO1	80.70	81.00	12.33	12.70	56.00	58.333
75% N+AZO2	80.00	77.79	12.33	12.00	56.33	57.33
75% N+AZO3	78.67	77.34	13.33	13.34	55.00	57.33
LSD0.05	**2.16**	**2.22**	**1.40**	**1.78**	**1.92**	**1.82**

100% N: the recommended dose of nitrogen mineral fertilizer.

TABLE 4. Effect of different combinations of N mineral fertilizer and three different of wild type strains of *Azotobacter chroococcum* on some fruit and yield traits of bottle gourd (*Lagenaria siceraria*) during two successive seasons of 2022 and 2023.

Treatments	Fruit length (cm)		Fruit diameter (cm2)		No. fruits/plant		Average weight of fruit(g)		Yield/plant (kg)		Yield/feddan (ton)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% N	60.00	58.67	9.57	10.10	2.67	3.00	685.67	711.33	1.95	2.08	7.83	8.00
AZO1	54.33	55.12	8.47	7.80	2.67	2.33	650.00	671.67	1.78	1.73	6.70	7.12
AZO2	54.00	55.23	8.50	8.50	2.00	2.17	663.33	680.00	1.57	1.68	6.27	6.87
AZO3	58.67	60.00	9.27	9.50	2.67	2.33	684.67	691.67	1.84	2.01	7.04	7.29
25% N+AZO1	59.33	58.67	8.73	8.43	2.67	3.00	672.67	751.33	2.06	2.17	8.22	8.52
25% N+AZO2	57.33	57.67	9.27	8.83	2.33	3.00	682.33	698.00	1.62	1.75	6.47	7.00
25%N+AZO3	60.33	60.67	9.73	10.27	3.00	2.33	713.67	732.67	2.04	2.13	8.35	8.67
50% N+AZO1	59.33	59.00	8.37	9.00	2.67	2.67	675.00	715.67	1.96	2.02	8.16	8.30
50% N+AZO2	59.67	61.33	9.84	9.73	2.67	3.00	763.00	722.67	1.82	1.76	7.02	7.80
50% N+AZO3	62..00	62.67	10.07	10.30	3.00	3.33	773.00	750.00	2.39	2.42	8.53	9.65
75% N+AZO1	61.00	59.67	10.17	10.83	2.67	2.67	736.00	752.67	2.09	2.26	8.48	9.04
75% N+AZO2	61.67	62.33	10.20	10.73	3.33	3.33	723.67	743.67	2.02	1.96	7.40	8.09
75% N+AZO3	63.25	63.00	10.23	10.87	3.35	3.67	783.67	758.00	2.42	2.60	9.95	10.40
LSD0.05	**3.14**	**3.21**	**1.19**	**1.10**	**1.40**	**1.11**	**73.31**	**63.00**	**1.00**	**0.81**	**2.87**	**3.23**

100% N: the recommended dose of nitrogen mineral fertilizer

TABLE 5. Effect of different combinations of N mineral fertilizer and three different of wild type strains of *Azotobacter chroococcum* on leaves NPK and fruits TSS% in bottle gourd (*Lagenaria siceraria*) during two successive seasons of 2022 and 2023.

Treatments	N (%)		P (%)		K (%)		TSS (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% N	1.73	1.72	0.30	0.31	3.08	3.09	5.69	5.71
AZO1	1.71	1.70	0.33	0.34	3.04	3.06	6.40	6.57
AZO2	1.66	1.68	0.31	0.32	2.94	2.98	6.23	6.23
AZO3	1.70	1.72	0.35	0.35	3.07	3.09	6.40	6.63
25% N+AZO1	1.75	1.67	0.32	0.33	3.24	3.29	6.93	7.01
25% N+AZO2	1.69	1.72	0.36	0.35	3.19	3.26	7.06	7.07
25%N+AZO3	1.77	1.77	0.36	0.36	3.30	3.32	7.07	7.08
50% N+AZO1	1.94	1.97	0.34	0.36	3.27	3.29	6.93	6.77
50% N+AZO2	1.71	1.79	0.31	0.33	3.21	3.28	6.73	6.87
50% N+AZO3	2.08	2.06	0.36	0.37	3.32	3.34	6.87	6.76
75% N+AZO1	2.06	2.04	0.33	0.35	3.30	3.31	6.17	6.30
75% N+AZO2	2.00	2.00	0.32	0.34	3.27	3.31	6.17	6.19
75% N+AZO3	2.11	2.07	0.38	0.38	3.39	3.40	6.17	6.27
$LSD_{0.05}$	**0.10**	**0.09**	**0.02**	**0.02**	**0.21**	**0.19**	**0.45**	**0.40**

100% N: the recommended dose of nitrogen mineral fertilizer

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أداء نباتات اليقطين في ظل العديد من الإضافات المشتركة لمستويات من الأسمدة النيتروجينية المعدنية واللقاحات الحيوية

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الملخص

أجري هذا البحث خلال الموسمين الصيفيين المتتاليين لعامي 2022 و2023 لدراسة تأثير العديد من الإضافات المشتركة لمستويات من السماد المعدني النيتروجيني (سلفات الامونيوم) وثلاثة لقاحات حيوية جديدة (AZO1، AZO2 وAZO3) على نمو وإنتاجية وجودة نباتات اليقطين. أظهرت النتائج أن نسب إنبات بذور اليقطين قد تحسنت بعد التلقيح بلقاح AZO3 بصوره منفردة وكذلك بأغلب المعاملات المركبة عند مقارنتها بالجرعة الموصي بها من السماد المعدني النتروجيني (100% N)، وأظهرت النتائج أيضاً أن النباتات المعاملة بلقاح AZO3 بصوره منفردة قد أعطت نتائج قريبة من تلك المعاملة بالكونترول (100% N) كما أن خلط AZO3 بمستويات مختلفة من السماد النيتروجيني المعدني (25 ، 50، 75%) قد أحدث زيادات كبيرة في جميع صفات النمو والمجموع الخضري المدروسة تقريباً عند مقارنتها بالجرعة الموصي بها من السماد المعدني النتروجيني خلال موسمي الدراسة. أدت جميع المعاملات الفردية والمركبة إلى حدوث انخفاض معنوي في عدد الأزهار المذكرة والأيام التي استغرقت لبدء التزهير مقارنة بمعاملة الكونترول، على العكس من ذلك فإنه قد حدثت زيادة في عدد الأزهار المؤنثة في النباتات المعالجة بجميع المعاملات المركبة التي تم اختبارها. تفوقت غالبية المعاملات المركبة على المعاملات المنفردة في تحسين جميع صفات انتاج وجودة الثمار المدروسة وكذلك محتوى أوراق نبات اليقطين من العناصر الكبرى NPK ،وعلى العكس، فقد اعطت النباتات المعاملة بلقاح AZO3 مخلوطاً بجميع مستويات السماد النيتروجيني المعدني أفضل نتائج عند مقارنتها بجميع المعاملات الأخرى. وأخيرًا، فانه يمكن التوصية بأنه لتقليل التأثير الخطير للأسمدة الكيماوية على البيئة وصحة الإنسان وكذلك تحسين نمو وإنتاجية وجودة نباتات اليقطين، فانه يمكن استخدام اللقاحات الحيوية (AZO3 وAZO1) بمفردها أو عن طريق خلطها بجرعات منخفضة من الأسمدة المعدنية النيتروجينية في برامج تسميد اليقطين.