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Effect of graded levels of nitrogen and *Azospirillum* on fruit yield, quality and nutrient uptake in ash gourd (*Benincasa hispida* Cogn.) cv. CO.1

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Abstract
An investigation was undertaken to study the effect of graded levels of nitrogen and *Azospirillum* on yield and quality of ash gourd *(Benincasa hispida* Cogn.) cv. CO.1 in the new area, vegetable unit, Annamalai University, Annamalai nagar during January-May 2016. The doses comprised of 5 levels of nitrogen *viz*., 30, 45, 60, 75 and 90 kg ha^{-1} and in two levels of *Azospirillum* with and without *Azospirillum* (A_1 and A_0 respectively) with a total of 10 treatments replicated thrice in a randomized block design (RBD). The results revealed that the treatment of combined application of nitrogen 75 kg ha^{-1} along with of *Azospirillum* @ 2 kg ha^{-1} of soil application recorded the highest number of fruits per vine, fruit length, fruit weight and fruit yield per plot. Besides, the total soluble solids, dry matter production, NPK uptake and post- harvest soil available nutrients were also higher due to application of 75 kg N ha^{-1} along with *Azospirillum* @ 2 kg ha^{-1} of soil application. In a nutshell, combined application of nitrogen @ 75 kg ha^{-1} along with *Azospirillum* @ 2 kg $ha^{-1}$of soil application could be recommended for obtaining higher yield in ash gourd.

Keywords: Ash gourd, nitrogen, *Azospirillum*, yield, quality, nutrient uptake

Introduction
The family cucurbitaceae consists of a wide range of vegetables either used for salad purpose (Cucumber) or for cooking (All gourds), pickling (West Indian gherkin), or as desert fruit (Musk melon, water melon) or candied or preserved (ash gourd). Among the various cucurbits, genus *Benincasa* is monotypic with the only species, *Benincasa hispida* Cogn. In India, it is commonly called as ashgourd, and is also called by different names such as winter melon, wax gourd, white gourd and white pumpkin. Due to long tap root system, ash gourd is considered as an ideal crop for river bed cultivation. In India, the crop is widely grown in UP and Delhi for preparation of 'Agra petha' and in southern states for use as vegetable. The ash gourd fruits are valued for its medicinal properties, being used as an anthelmintic, antiperiodic and aphrodisiac for lowering blood sugar, against epilepsy, insanity and other nervous diseases.
Nitrogen is considered as one of the essential macronutrients required by the plants for their growth, development and yield (Singh *et al.*, 2003) [15]. The nutrient status of soil in and around Annamalai nagar showed poor nitrogen status and no work has been carried out so far, to find out the optimum dose of nitrogen for ash gourd. Hence it was necessary to carry out a location specific research to find out the optimum quantity of nitrogen required for maximizing the productivity.
Bio-fertilizers or microbial inoculants are eco-friendly, non- bulky, cheap and renewable sources of nutrients for plants. These inoculants render nutrients in available form and in adequate amounts which are otherwise inaccessible to the plants. The application of bio-fertilizers also helps in improving biological activities of soil. Recently, a microbial consortium, containing a mixer of biofertilizers of N-fixers, P- solubilizers and plant growth promoting rhizobacteria (PGPR) has been found topromote the growth of plants better than their individual application (Piyush Pandey and Maheahwari, 2007) [13].
In the background of the above, a study was undertaken to study the effect of graded levels of nitrogen and *Azospirillum* on yield and quality of ash gourd with an aim to study the effect of nitrogen and *Azospirillum* on growth, yield and quality of ash gourd cv. CO.1.

Materials and Methods
The experiment to study the effect of graded levels of nitrogen and *Azospirillum* on yield and quality of ash gourd (*Benincasa hispida* Cogn.) cv.CO-1" was carried out at the vegetable unit, Department of Horticulture, Faculty of Agriculture, Annamalai University during January to May 2016.

Soil characteristics
The experimental plot was analysed for various physico-chemical properties. The pH was 7.81 and EC was 0.76 m mhos cm^{-1}. It contained coarse sand (14.5%), fine-sand (34.7%), silt (29.7 %) and clay (20.81 %). Besides, it contained 216 kg N, 11.49 kg of phosphorus and 270 kg of potassium per ha.
The seeds of ash gourd variety CO.1 were procured from the Vegetable Research Station, Palur of Tamil Nadu Agricultural University.

Treatments
There were 10 treatment combinations replicated thrice in a randomized block design with a plot size of 2.0 x 1.5 m. The treatment comprised of 30:60:80 kg NPK ha^{-1}alone (T_1), 30:60:80 kg NPK ha^{-1} + *Azospirillum* @ 2 kg ha^{-1} of soil (T_2), 45:60:80 kg NPK ha^{-1} alone (T_3), 45:60:80 kg NPK ha^{-1} + *Azospirillum* @ 2 kg ha^{-1} of soil application (T_4), 60:60:80 kg NPK ha^{-1} alone (T_5), 60:60:80 kg NPK ha^{-1} + *Azospirillum* @ 2 kg ha^{-1} of soil application (T_6), 75:60:80 kg NPK ha^{-1} alone (T_7), 75:60:80 kg NPK ha^{-1} + *Azospirillum* @ 2 kg ha^{-1} of soil application (T_8), 90:60:80 kg NPK ha^{-1} alone (T_9) and 90:60:80 kg NPK ha^{-1} + *Azospirillum* @ 2 kg ha^{-1} of soil application (T_{10}).

Field preparation and imposition of treatments
During field preparation, 25 t ha^{-1} of FYM was incorporated. Plots were earmarked for each treatment with an area of 18 m^2 and then beds were formed at a spacing of 1.5 m within each plot. Pits of size 30 cm^3 were made at a spacing of 2 × 1.5 m. Five seeds were sown in each pit and thinned to two healthy seedlings per pit. The crop was raised by following the recommended cultural practices (Veeraragathatham *et al*., 1988) [20].

Fertilizer application
The required quantity of nitrogen was applied in two split doses as per treatments, the first dose at the time of sowing followed by top dressing at 30 days after sowing. The entire phosphorus and potassium were applied as basal during the time of sowing. The fertilizers were applied in the form of urea, single super phosphate and muriate of potash.

***Azospirillum* application**
Lignite based inoculum of *Azospirillum brasilense* was obtained from the Department of Agricultural microbiology, Faculty of Agriculture, Annamalai University and applied mixing with farmyard manure at the time of pitting.

Observations recorded
Observations were recorded on number of fruits per vine, single fruit weight (kg), fruit length (cm), fruit girth (cm), fruit yield per vine (kg), fruit yield per plot (kg), estimated fruit yield (t ha^{-1}).
Total soluble solids (°Brix) and ascorbic acid content (mg $100g^{-1}$) were estimated by a hand refractrometer and by A.O.A.C. method (1975) [1] respectively.

Plant nutrient analysis
The plant samples collected from the individual treatment at the time of harvest were dried in an oven at 60° C, powdered in a Wiley mill and analysed for total nutrient content.
The total nitrogen content in Ashgourd was estimated by the micro kjeldahl method suggested by Yoshida *et al.* (1972) [21] and expressed as percentage on oven dry basis and expressed as kg ha^{-1}. The total phosphorous uptake in the plants was estimated by using triple acid digestion method described by Jackson (1973) [6] with photoelectric calorimeter and expressed as kg ha^{-1}. The total potassium uptake in the plants was estimated using triple acid digestion method described by Jackson (1973) [6] with flame photometer and expressed as kg h^{-1}.

Post-harvest soil nutrient status
Soil samples were collected from the experimental plots at a depth of 20-30 cm after the completion of harvest of the crop and used for analysis. The available nitrogen was estimated by alkaline permanganate method (Subbiah and Asija, 1956) [17] and was expressed in kg ha^{-1}. The available phosphorous was estimated by calorimetric method suggested by Olsen *et al*. (1954) [10] and was expressed in kg ha^{-1}. The available potassium was estimated by flame photometer using the neutralized triple acid extract as suggested by Piper (1996) and was expressed in kg ha^{-1}.

Statistical analysis
The data recorded during the investigation were statistically analyzed following the standard procedures given by Panse and Sukhatme (1978) [11] and using AGRISTAT software in a personal computer. Whenever the results were found significant, critical differences (CD) were worked out at 5 per cent level of probability.

Results and Discussion
The results of the experiment on "Studies on the effect of graded levels of nitrogen and *Azospirillum* on yield and quality of ash gourd (*Benincasa hispida* Cogn.) cv. CO.1" are discussed hereunder.
The yield and quality of ash gourd in India is not commensurating with the introduction of new varieties. Fertilizer application is one of the important factors in the crop management, governing the successful production of this crop. There is a possibility to reduce the quality of inorganic nitrogen with the application of biofertilzers like *Azospirillum* which have received considerable attention in recent years in the production of horticultural crops (Amirthalingam, 1988) [2].
The data on fruit length and girth revealed the superiority of the treatment which received 75: 60: 80 kg NPK ha^{-1}plus *Azospirillum* @ 2 kg ha^{-1} as compared to the lowest recorded in the control. The same trend was observed for number of fruits per vine and single fruit weight (Table 1 and 2). As regard to fruit yield per vine, the highest (17.38 kg) was recorded in the treatment of 75: 60: 80 kg NPK ha^{-1} plus *Azospirillum* @ 2 kg ha^{-1} of soil application (Table 3). This might be due to better nutritional status of the plant being favoured by increased photosynthetic activity. It may also be attributed to the increase in the number of cells as well as elongation of individual cells and also due to better translocation of soluble ions under optimum level of nitrogen. *Azospirillum* also has exerted a dominant role in increasing the fruit length andother yield attributes. This might be due to properly colonized roots, which have enhanced water and nutrient uptake for soils and also by increasing the biological nitrogen fixation (Okon, 1984) [9].
The results reported by Mangal *et al*. (1977) [8] and Xu and Cheng (1989) [19] in watermelon, Janakiraman (1996) [7] in gherkin and Selvakumar (1998) [14] in cucumber are in agreement with the results obtained in the present study.

Table 1: Effect of graded levels of nitrogen and *Azospirillum* on number of fruits per vine and single fruit weight (kg) in ashgourdcv. CO.1

Treatment	Number of fruits vine^{-1}	Single fruit weight (kg)
T_1 - 30:60:80 kg NPK ha^{-1}	2.21	2.93
T_2 - 30:60:80 kg NPK ha^{-1} + *Azospirillum*	2.66	3.23
T_3 - 45:60:80 kg NPK ha^{-1}	3.13	3.55
T_4 - 45:60:80 kg NPK ha^{-1} + *Azospirillum*	3.27	3.67
T_5 - 60:60:80 kg NPK ha^{-1}	4.31	4.31
T_6 - 60:60:80 kg NPK ha^{-1} + *Azospirillum*	4.90	4.68
T_7 - 75:60:80 kg NPK ha^{-1}	4.45	4.38
T_8 - 75:60:80 kg NPK ha^{-1} + *Azospirillum*	5.37	5.00
T_9 - 90:60:80 kg NPK ha^{-1}	3.84	4.01
T_{10} - 90:60:80 kg NPK ha^{-1} + *Azospirillum*	3.72	3.94
S. Ed	0.16	0.11
CD (p=0.05)	0.49	0.34

Table 2: Effect of graded levels of nitrogen and *Azospirillum* on fruit length (cm) and fruit girth (cm) in ashgourdcv. CO.1

Treatment	Fruit length (cm)	Fruit girth (cm)
T_1 - 30:60:80 kg NPK ha^{-1}	14.94	28.14
T_2 - 30:60:80 kg NPK ha^{-1} + *Azospirillum*	17.05	31.07
T_3 - 45:60:80 kg NPK ha^{-1}	19.18	34.02
T_4 - 45:60:80 kg NPK ha^{-1} + *Azospirillum*	19.87	34.97
T_5 - 60:60:80 kg NPK ha^{-1}	24.76	41.80
T_6 - 60:60:80 kg NPK ha^{-1} + *Azospirillum*	27.56	45.70
T_7 - 75:60:80 kg NPK ha^{-1}	25.45	42.77
T_8 - 75:60:80 kg NPK ha^{-1} + *Azospirillum*	29.69	48.65
T_9 - 90:60:80 kg NPK ha^{-1}	22.65	38.85
T_{10} - 90:60:80 kg NPK ha^{-1} + *Azospirillum*	21.19	37.90
S. Ed	0.17	2.19
CD (p=0.05)	2.15	6.58

Table 3: Effect of graded levels of nitrogen and *Azospirillum* on fruit yield per vine (kg), fruit yield per plot (kg) and fruit yield per ha (t) in ashgourdcv. CO.1

Treatment	Fruit yield vine^{-1}(kg)	Fruit yield plot^{-1} (kg)	Fruit yield (t ha^{-1})
T_1 - 30:60:80 kg NPK ha^{-1}	4.38	23.70	12.08
T_2 - 30:60:80 kg NPK ha^{-1} + *Azospirillum*	6.24	33.43	16.91
T_3 - 45:60:80 kg NPK ha^{-1}	8.11	43.14	21.74
T_4 - 45:60:80 kg NPK ha^{-1} + *Azospirillum*	8.72	46.37	23.32
T_5 - 60:60:80 kg NPK ha^{-1}	13.05	69.02	34.56
T_6 - 60:60:80 kg NPK ha^{-1} + *Azospirillum*	15.51	81.19	40.99
T_7 - 75:60:80 kg NPK ha^{-1}	13.66	72.25	36.16
T_8 - 75:60:80 kg NPK ha^{-1} + *Azospirillum*	17.38	91.69	45.84
T_9 - 90:60:80 kg NPK ha^{-1}	11.18	59.29	29.73
T_{10} - 90:60:80 kg NPK ha^{-1} + *Azospirillum*	10.57	56.08	28.15
S. Ed	0.63	3.25	1.62
CD (p=0.05)	1.89	9.75	4.87

Quality attributes (Table 4)

In any vegetable, the quality of the produce is very important. The highest amount of total soluble solids will be an added advantage in the consumer preference. In the present study, the total soluble solids was significantly influenced by the various levels of nitrogen and *Azospirillum*. The highest total soluble solids was registered from the fruits harvested from the plant fertilized with both nitrogen @ 75 kg ha^{-1} and *Azospirillum* @ 2 kg ha^{-1} of soil. It may be due to the mobilization of photosynthates from the leaves and also synthesis of auxins produced by *Azospirillum* (Tien *et al*., 1979). Similar trend was observed with ascorbic acid content of the fruits with a record of 57.26 mg 100g^{-1}.

Table 4: Effect of graded levels of nitrogen and *Azospirillum* on TSS (°Brix) and ascorbic acid content (mg 100g^{-1}) in ashgourdcv. CO.1

Treatment	TSS (°Brix)	Ascorbic acid content (mg 100^{-1}g)
T_1 - 30:60:80 kg NPK ha^{-1}	3.30	45.82
T_2 - 30:60:80 kg NPK ha^{-1} + *Azospirillum*	3.70	47.32
T_3 - 45:60:80 kg NPK ha^{-1}	4.12	49.02
T_4 - 45:60:80 kg NPK ha^{-1} + *Azospirillum*	4.22	49.62
T_5 - 60:60:80 kg NPK ha^{-1}	5.18	53.44
T_6 - 60:60:80 kg NPK ha^{-1} + *Azospirillum*	5.70	55.56
T_7 - 75:60:80 kg NPK ha^{-1}	5.30	54.06
T_8 - 75:60:80 kg NPK ha^{-1} + *Azospirillum*	6.12	57.26
T_9 - 90:60:80 kg NPK ha^{-1}	4.76	51.74
T_{10} - 90:60:80 kg NPK ha^{-1} + *Azospirillum*	4.64	51.74

S. Ed	0.14	0.64
CD (p=0.05)	0.44	1.90

Plant analysis (Table 5)

Mineral nutrition is basic to crop production, since all physiological and biochemical processes are controlled by nutrient elements. It is well known that only 50 percent of the applied nitrogen is used by plants and the rest is lost by denitrification or leaching. Nutrient supply is generally considered to be the most important factor limiting growth and productivity.

Different levels of nitrogen had a positive influence on nitrogen uptake. Application of 75 kg N ha^{-1} resulted in the maximum uptake of nitrogen (91.56 kg ha^{-1}). Higher nitrogen level leads to higher nitrogen uptake by improving nitrogen availability in the rhizosphere which facilitates better uptake of nitrogen which was reported earlier in watermelon (Hedge, 1987) [5], in gherkin (Janakiraman, 1996) [7] and in cucumber.

Phosphorus content was significantly influenced by the combined application of nitrogen and *Azospirillum* (43.27 kg ha^{-1}). The highest phosphorus uptake in nitrogen treatments could be due to the enhanced vegetative growth. Similar findings were reported by Hedge (1987) [5] in watermelon, Janakiraman (1996) [7] in gherkin and cucumber.

Different levels of nitrogen and application of *Azospirillum* and their combined application had a significant influence in the potassium uptake. The highest potassium uptake was recorded in T_8 (83.69 kg ha^{-1}). The higher potassium content in the plants might be due to the interaction of nitrogen and potassium as reported by Stalin *et al.* (1993) [16].

Table 5: Effect of graded levels of nitrogen and *Azospirillum* on nutrient uptake (kg ha^{-1}) in ashgourdcv. CO.1

Treatment	Nutrient uptake (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
T_1 - 30:60:80 kg NPK ha^{-1}	63.22	15.98	51.89
T_2 - 30:60:80 kg NPK ha^{-1} + *Azospirillum*	67.29	19.88	56.42
T_3 - 45:60:80 kg NPK ha^{-1}	71.34	23.80	60.97
T_4 - 45:60:80 kg NPK ha^{-1} + *Azospirillum*	72.68	25.07	62.49
T_5 - 60:60:80 kg NPK ha^{-1}	82.10	34.16	73.11
T_6 - 60:60:80 kg NPK ha^{-1} + *Azospirillum*	87.49	39.35	79.14
T_7 - 75:60:80 kg NPK ha^{-1}	83.44	35.45	74.61
T_8 - 75:60:80 kg NPK ha^{-1} + *Azospirillum*	91.56	43.27	83.69
T_9 - 90:60:80 kg NPK ha^{-1}	78.05	30.26	68.56
T_{10} - 90:60:80 kg NPK ha^{-1} + *Azospirillum*	76.73	28.97	67.04
S. Ed	1.36	1.31	1.52
CD (p=0.05)	4.09	3.94	4.57

Post-harvest soil analysis (Table 6)

The post-harvest nutrient status showed a significant influence on the available soil nitrogen and phosphorus content, whereas the potassium content was not significantly influenced. However, the higher available soil nitrogen, phosphorus and potassium was recorded when 75 kg N ha^{-1} along with *Azospirillum* was applied. The reason may be the combined application enriched the soil and hence the residual N, P_2O_5 and K_2O nutrients were higher, and another reason may be the NPK present in the fertilizer was available for crop nutrition and by the application of *Azospirillum* in turn might have increased the available NPK content in soil.

It may finally be concluded that application of nitrogen @ 75bkg ha^{-1} along with *Azospirillum* @ 2 kg ha^{-1}, be the best treatment to enhance yield and quality of ash gourd cv. CO.1.

Table 6: Effect of graded levels of nitrogen and *Azospirillum* on post-harvest analysis (kg ha^{-1}) in ashgourdcv. CO.1

Treatment	Post-harvest soil nutrient status (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
T_1 - 30:60:80 kg NPK ha^{-1}	224.86	10.17	266.98
T_2 - 30:60:80 kg NPK ha^{-1} + *Azospirillum*	219.35	9.69	258.29
T_3 - 45:60:80 kg NPK ha^{-1}	213.86	9.23	251.62
T_4 - 45:60:80 kg NPK ha^{-1} + *Azospirillum*	212.06	9.09	249.43
T_5 - 60:60:80 kg NPK ha^{-1}	199.22	8.01	233.58
T_6 - 60:60:80 kg NPK ha^{-1} + *Azospirillum*	191.91	7.41	225.00
T_7 - 75:60:80 kg NPK ha^{-1}	197.42	7.89	231.69
T_8 - 75:60:80 kg NPK ha^{-1} + *Azospirillum*	186.42	6.95	218.33
T_9 - 90:60:80 kg NPK ha^{-1}	204.73	8.49	240.55
T_{10} - 90:60:80 kg NPK ha^{-1} + *Azospirillum*	206.55	8.67	242.76
S. Ed	1.84	0.16	2.23
CD (p=0.05)	5.53	0.50	6.71

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