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Efficacy of biofertilizers and the combinations with chemical fertilizers on vegetative growth and yield of okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract
A field experiment was conducted during 2017 at Horticulture Research Farm-II, BBAU, Lucknow, Studies on the " Efficacy of biofertilizers and the combinations with chemical fertilizers on vegetative growth and yield of okra [*Abelmoschus esculentus* (L.) Moench]" revealed that vegetative attribute Plant height (136.00 cm),Number of Leaves/Plant(20.91),Diameter Stem of okra(2.32cm),Number of Days Taken To First Flowering(50.33),Number of Flower/Plant(20.33),Number Of Days Taken To First Fruit Formation(50.33), Number of Branches/plant(5.33). Yield attribute Number Of Fruit/ Branch(10.76), Number Of Fruit/plant(23.90), Length Of Fruit (8.46cm),Girth Of Fruit(1.51 cm),Weight Of Fruit (9.59g), Fruit Yield/plant(144.02g), Fruit Yield/plot(2.32kg) and were maximized Fruit Yield/ha(116.38 q/ha).When we use with recommended dose of fertilizers (RDF), NPK (50%), PSB (50%), Azotobacter (50%) and Azospirillum (75%).

Keywords: Okra, vegetative growth, flowering, fruiting, yield recommended dose of fertilizers (RDF), NPK, PSB, azotobacter and azospirillum

Introduction
Okra [*Abelmoschus esculents* (L.) Moench] is commonly known as bhindi in India and lady's finger in England, Gombo in U.S.A. belonging to the family Malvaceae. It is grown in both tropical and subtropical regions of the world (Ahmed *et al*., 2006) and is natural to West Africa. India is considered as the secondary centre of diversity. In India, okra covered an area of 349.4 thousand hectares with production of 3.66 million tons. Injudicious and indiscriminate application of chemical fertilizers has created serious damages to the soil health, environment and is threatening the health of millions of people throughout the world and more importantly declining the productivity of soil. Sustainable increase in production is possible by adopting integrated fertilizer management which necessitates the use of biofertilizers. It has somatic chromosome number 2n = 130 and is an amphidiploids of *A. tuberculatus* with 2n= 58 and an unknown species with 2n=72. There are 38 species of the genus *Abelmoschus*. Okra seeds contain about 20% protein similar to amino acid composition of soybean protein and 20% oil (similar in fatty acid composition to cotton seed oil). According to Awodoyin and Olubode (2009), the immature fruits and leaves of *abelmoschusesculentus* are used in soup as a thickener because it is a rich source of vitamins and minerals. Okra is recommended for consumption by World Health Organization due to its ability to fight diseases. It is a good source of vitamin A, B, C and also rich in protein, carbohydrates, fats, minerals, iron and iodine. The green fruits (per 100 g edible portions) of okra contains 89.6 per cent of moisture, 1.9 g protein, 88 IU of vitamin A, 0.07 mg thiamine, 0.1 mg riboflavin, 13 mg vitamin C, 0.7 g minerals like 103 mg potassium, 6.9 mg sodium, 56 mg phosphorus, 66 mg calcium, 1.5 mg iron, 30 mgprovides a delicious and favorite dish in Indian vegetable meals and attributes several medicinal and nutritional properties. Biofertilizers are the formulation of living micro-organisms, which are able to fix atmospheric nitrogen in the available form for plants either by living freely in the soil or being associated symbiotically with plants.

Biofertilizers are inputs containing micro-organisms which are capable of mobilizing nutritive elements from non-usable form to usable form through biological processes. Biological nitrogen fixation is carried out by both symbiotic and free-living bacteria and blue green algae. Symbiotic nitrogen fixation provides 80% of the biologically fixed nitrogen on land. Nitrogen fixing bacteria are very selective in choosing roots of particular legumes species to infect, invade and form root nodules. Azotobactor within the plant of economics importance has been harnessed in Indian agriculture. So many workers reported that there are several free-living bacteria found the roots of plant, which convert atmosphere nitrogen to the usable ammonia cal form. Azotobactor chroococcum, a heterotrophic bacterium fixes atmospheric nitrogen symbiotically and used as an inoculants for plants.Okra has multiple uses, the extract from its stem is used for cleaning cane juice in preparation of jaggery. The dry seeds of okra contain 14-23 per cent edible oil and 21-25 per cent protein (Thamburaj and Singh, 2005). The seed cake is also used as an animal feed. In many countries, the ripe seeds of okra are used as substitute of coffee particularly in Turkey. The dry fruit shell and stem containing crude fibre is suitable for use in manufacture of paper and card board. Adding of biofertilizers along with fertilizers increased crop growth and yield of okra (Verma *et al*., 1997).

Material and Methods

The experimental material for the present study consisted of the seed of okra cv. (Kashi Pragti) was collected from Indian Institute of Vegetable Research Varanasi (U.P.). The experiment was conducted using Randomized Block Design (RBD) with three replications at Horticulture Research Farm II of Department of Horticulture, Babasaheb Bhimrao Ambedkar University, (A Central University), Vidya-Vihar, Rae Bareli Road, Lucknow- 226025 (U.P.)were taken for the investigation during Kharif season of 2017-18. Treatments T0Recommended dose of fertilizers(RDF), T_1 Azotobacter + 50% NPK, T_2 PSB + 50% NPK, T_3Azospirillum + 75% NPK, T_4 PSB + Azotobacter + 50% NPK, T_5 PSB +Azospirillum+ 50% NPK, T_6PSB + Azospirillum + Azotobacter 50%, T_7 Azotobacter + Azospirillum50%, T_8 PSB + Azospirillum 75%. Observation were recorded for vegetative attribute-Plant height (cm), Number of leaves /plant, Diameter of stem of okra (cm), Number of days taken to first flowering, Number of flower / plant, Number of branches / plant.Yield attribute-Number of days taken to first fruit formation, Number of fruit / branch, Number of fruit / plant, Length of fruit (cm), Girth of fruit (cm), Weight of fruit (g), Fruit yield / plant (g), Fruit yield/ plot (Kg), Fruit yield/ha (Q/ha). The data so obtained were analysed statically.

Result and Discussion

Plant height (cm) the data obtained 80 DAS at the time of maturity of plants, the maximum plant height (136.00 cm) was recorded under the treatment T_7 (*Azotobacter* + *Azospirillum* 50%). The minimum plant height (103.33 cm) was recorded under T_0 (RDF). Nurzzaman *et al*. (2003) was also observed that at the maturity stage of okra (75 DAS) significantly increase plant height (106.9 cm) combination with *Azotobacter* + *Azospirillum*+cowdung as well as it gave also better response in other growth characters. Number of leaves/Plant the data obtained at 80 DAS, the maximum plant leaves (20.91) was recorded under the treatment T4 (PSB + Azotobacter + 50% NPK). However the minimum plant leaves (18.58) was recorded under T1 (*Azotobacter* + 50% NPK). similar nodules were obtained by Bhagavantagoudra and Rokhade (2001). Diameter of stem (cm) The data obtained at 80 DAS, the maximum diameter of stem (2.32cm) was recorded under the treatment T_6 (PSB + *Azospirillum* + *Azotobacter* 50%).The minimum plant diameter (2.12cm) was recorded under T_0 (RDF). Parvatham *et al. (1989) who* reported that inoculation of *Azospirillum* was more effective in Bhindi cv. Pusa Sawani, which increased the plant height, plant girth, number of leaves, root length and root volume significantly. Number of days taken to first flowering T_4 (PSB + *Azotobacter* + 50% NPK)showed earliest flowering formation of okra (33.00) days.The late flowering (45.66) was recorded with T_0 (RDF). Singh (1979) who studied the effect of application and levels of N (0, 75 and 150 kg/ha) and phosphorous and potash (0, 60 and 120 kg/ha) on Pusa Sawani variety in summer season at Varanasi, U.P. Number of flower / plant the maximum number of flower / plant (20.33) was accorded under the treatment T_4 (PSB + *Azotobacter* + 50% NPK) at final maturity stage. While minimum 13.00 in under control T_0 (RDF). This is unforunity the result of Kamal nathan *et al.(*1970) who also observed at same result, while minimum 13.00 in under control (RDF).Number of branches / plant T_4 (PSB + *Azotobacter* + 50%) NPK produced maximum number of branches (5.33). Lowest branches were (1.41) noted with T_0 (RDF). This corroborated the result of Kumar V., Saikia J. and Barik N., (2017) who studied on "Influence of organic, inorganic and biofertilizers on growth, yield, quality and economics of okra". Number of days taken to the maximum days taken to first fruit formation (50.33) was recorded with T_2 (PSB + 50% NPK).The minimum days taken to 1st fruit formation was recorded in T_1 (*Azotobacter* + 50% NPK) at 80 days. As compared to other treatment T_1.similar finding reported by Jeevajohti *et al.* (1993) also found*Azotobacter* inoculated have lead to better root development, better transport of water, uptake and deposition of nutrients. Number of fruit / branchthe maximum number of fruits/branch (10.76) in T_4 (PSB + *Azospirillum* + 50% NPK). andlowest no. of fruit / branch was noted with control T_0 (3.25). Simillar result also found by Bhushan A. Bhat K.L. and Sharma J.P., (2013) study revealed that the effect of *Azotobacter* and inorganic fertilizers on growth, fruit and seed yield of okra cv. Hisar Unnat. T_4(PSB + *Azotobacter* + 50% NPK) produced the highest no. of fruit / plant (23.90). Lowest number of fruit / plant was (10.53) noted under the control T_0 (RDF). Simillarly the result also reported by Mal *et al.* (2014*)* assessed the effect of diazotrophs (biofertilizers - *Azotobactor*, *Azospirillum*, Phosphate Solubilizing Bacteria) and chemical fertilizers that the maximum number of fruits plant-1 was recorded with FYM@10 t ha-1 + 75 (%) NPK + vermicompost. Length of fruit (cm) the highest fruit length of fruit (8.467cm) was recorded under T_1 (*Azotobacter* + 50% NPK) the lowest length of fruit was noted with T_0 (RDF) (5.71cm). Balasubramani (1988) reported that application of *Azospirillum* to seed + soil with 30 kg N ha-1 recorded the highest fruit length, fruit girth, fruit weight and number of fruits per plant in Bhendi cv. Pusa sawani. Girth of fruit (cm) T_4 (PSB + *Azotobacter* + 50% NPK) produced the maximum girth of fruit (1.51 cm). The lowest girth of fruit was recorded with T_0 (RDF) 1.02cm. Kumar V., Saikia J. and Barik N., (2017) studied on "Influence of organic, inorganic and biofertilizers on growth, yield, quality and economics of okra". The results indicated that application of RDF recorded the highest branches plant (1.80), Leaves plant (14.66), Leaf area index (1.36), and Chlorophyll content of leaf (0.210

mg/g), Fruit length (14.62 cm), Fruit girth (4.64 cm).Weight of fruit (g) T_4(PSB + *Azotobacter* + 50% NPK) produced the maximum weight of fruit (9.59g) and lowest weight of fruit was noted with T_0 (6.75g). Similarly result were also reported by Bhushan A. Bhat K.L. and Sharma J.P., (2013) who reported that the effect of *Azotobacter* and inorganic fertilizers on growth, fruit and seed yield of okra cv. Hisar unnat. Among all the treatments, (*Azotobacter* + ½ N + P + K) recorded maximum green fruit yield (18300kg/ha) as well as pod weight (13.9g).Fruit yield / plant (g) the maximum yield of fruit/plant (144.02g) was recorded in T_4 (PSB + Azotobacter + 50% NPK) and lowest fruit yield / plant was noted with T_0 (RDF) (55.25 g). Kumar V., Saikia J. and Barik N., (2017) study on "Influence of organic, inorganic and biofertilizers on growth, yield, quality and economics of okra". The results indicated that application of RDF recorded the Fruit yield plant (190.96 g) with the B:C ratio of 3.89. Fruit yield/ plot (Kg) the maximum Fruit yield/ plot (2.32 Kg) was recorded in T_4 (PSB + *Azotobacter* + 50% NPK) and lowest fruit yield / plot (0.89 Kg) was noted with T_0 (RDF). Similarly finding was reported byGamal (1996) PSB inoculation gave the higher tuber yield, while minimum (1.64 Kg) in the control. Fruit yield/ha (Q) T_4 (PSB + *Azotobacter* + 50% NPK) produced the highest yield of okra (116.38 q/ha) at 80 days after sowing.The lowest yield of fruit was (67.12q/ha) recorded with T_0 (RDF). Similarly finding was also reported by Bambal *et al*. (1968) reported that application of *Azotobacter*+ *Azospirillum*+100% significantly increased yield, while (60.85 q/ha) in the control.

Table 1: Efficacy of biofertilizers and the combinations with chemical fertilizers on vegetative growth and yield of okra [*Abelmoschus esculentus* (L.) Moench]

		Plant Height (cm)	**Number of leaves/ plant**	**Diameter of stem (cm)**	**Number of days taken to first Flowering**	**Number of flower/ plant**	**Number of branch/ plant**	**First fruit formation of okra**	**Number of fruit /branch**	**Number of fruit/ plant**	**Fruit length**	**Girthof okra fruit**	**Weight of fruit (g)**	**Fruit yield/ plant of Okra (g)**	**Fruit yield per plot**	**Fruit yield/ha (Q/ha)**
Treatment	Treatments combination	80 DAS	80 DAS	80 DAS	No. of days	80 DAS	80 DAS Branch/plant	No. of days	Fruit/branch	80 DAS	Length of fruit (cm)	Girth(CM)	Weight of fruit(g)	Fruit yield/ plant of Okra (g)	Fruit/plot (kg)	Fruit yield/ha (Q/ha)
T_0	Recommended dose of fertilizers (RDF)	103.333	19.917	2.124	45.667	13.000	1.417	49.667	3.250	10.543	5.717	1.02	6.75	55.25	0.890	67.12
T_1	*Azotobacter* + 50% NPK	115.333	18.583	2.303	38.889	16.667	2.450	43.333	4.600	14.963	8.467	1.16	7.84	72.29	1.157	76.09
T_2	PSB + 50% NPK	125.667	19.250	2.197	34.333	16.667	2.367	50.333	5.917	19.870	6.857	1.30	8.25	66.30	1.213	97.12
T_3	*Azospirillum* + 75% NPK	132.667	20.083	2.202	34.000	19.333	4.333	43.667	7.933	23.550	7.493	1.37	8.57	74.53	1.153	108.88
T_4	PSB + *Azotobacter* + 50% NPK	124.000	20.917	2.317	33.000	20.333	5.333	43.667	10.767	23.903	7.493	1.51	9.59	144.02	2.323	116.38
T_5	PSB + *Azospirillum* + 50% NPK	124.667	19.167	2.241	35.333	16.667	5.000	47.667	10.133	16.867	6.997	1.48	9.29	112.86	1.810	113.75
T_6	PSB + *Azospirillum* + *Azotobacter* 50%	124.000	20.583	2.320	37.444	13.333	2.083	49.000	7.667	16.570	7.733	1.33	8.28	122.48	1.963	105.02
T_7	*Azotobacter* + *Azospirillum* 50%	136.000	20.167	2.320	34.222	15.000	2.833	47.667	6.333	23.770	8.380	1.25	8.17	94.31	1.513	97.77
T_8	PSB + *Azospirillum*	126.667	20.417	2.302	38.000	15.000	2.583	48.333	5.667	16.170	8.017	1.21	8.07	90.25	1.447	85.66
	C.D.	6.943	1.311	0.104	5.010	4.135	2.133	4.515	3.512	3.345	1.250	0.140	0.345	17.362	0.122	9.906
	S.E.(m)	2.296	0.434	0.035	1.657	1.368	0.705	1.493	1.162	1.106	0.413	0.046	0.114	5.742	0.040	3.276

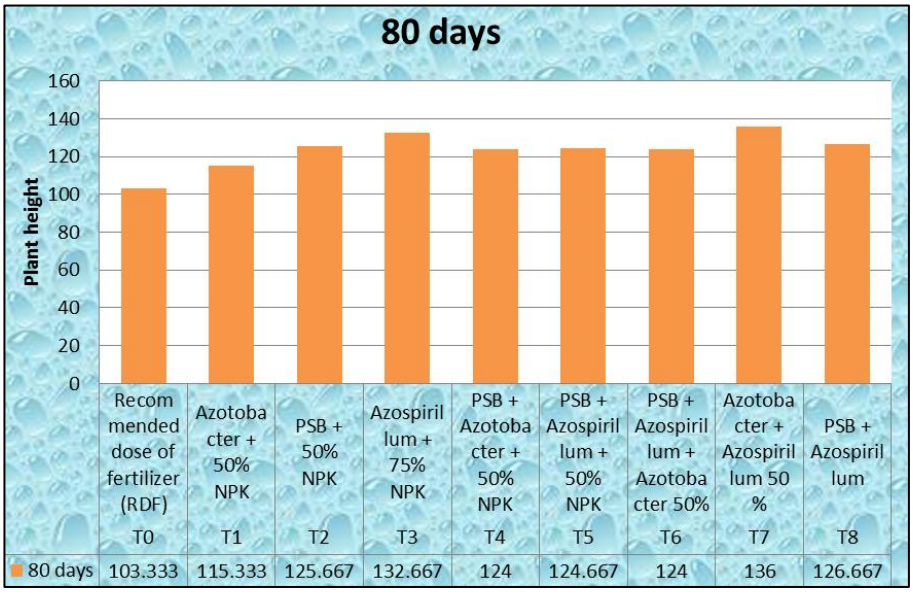

Fig 1: Plant height (cm)

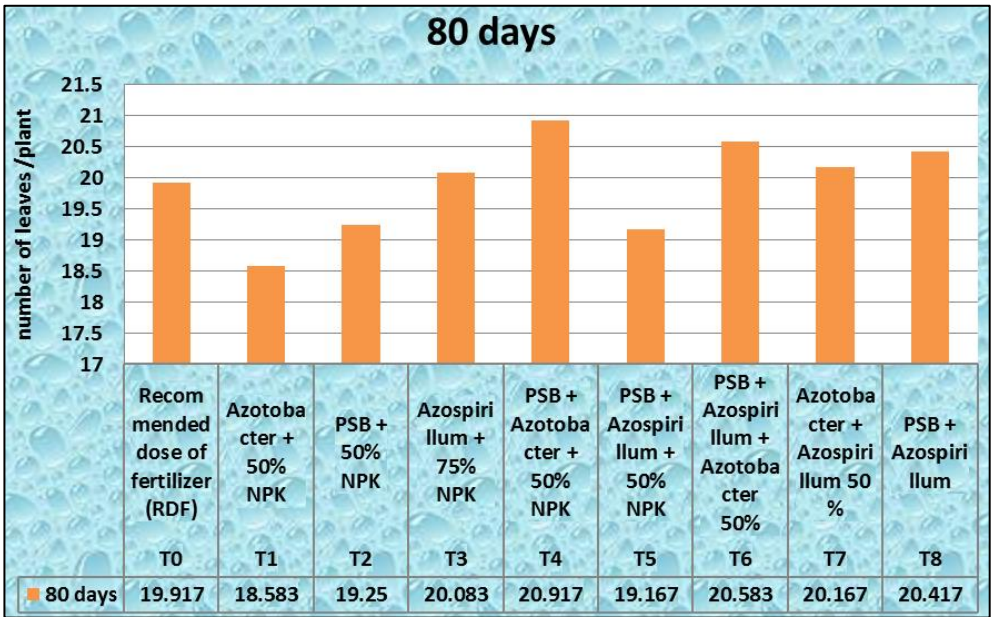

Fig 2: Number of leaves/plant

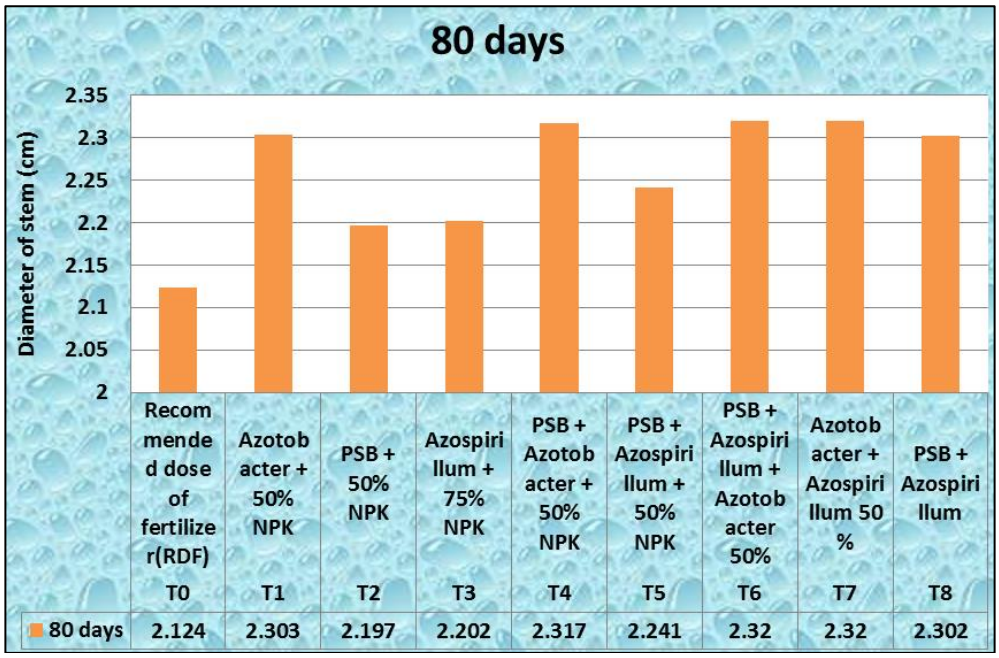

Fig 3: Diameter of stem of okra (cm)

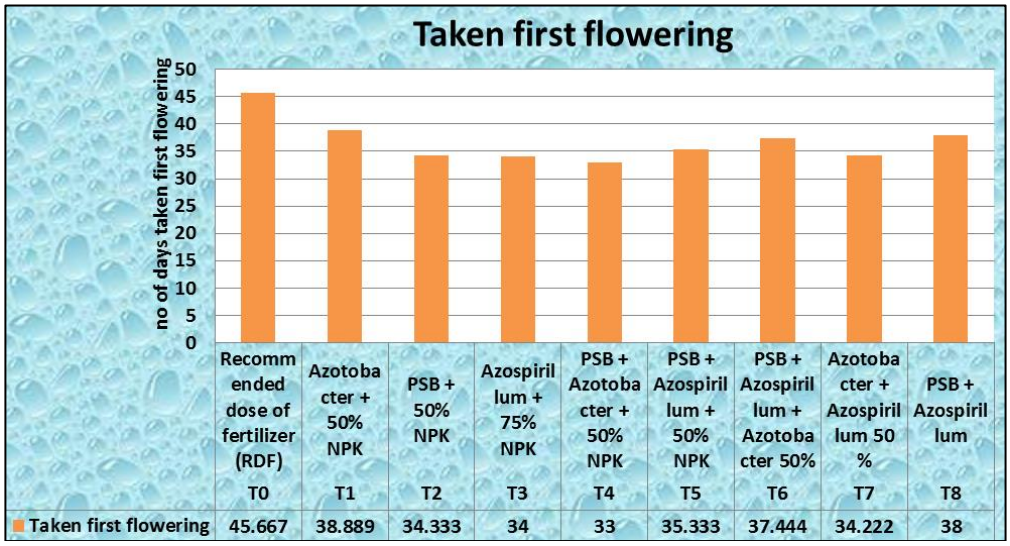

Fig 4: Number of days taken to first flowering

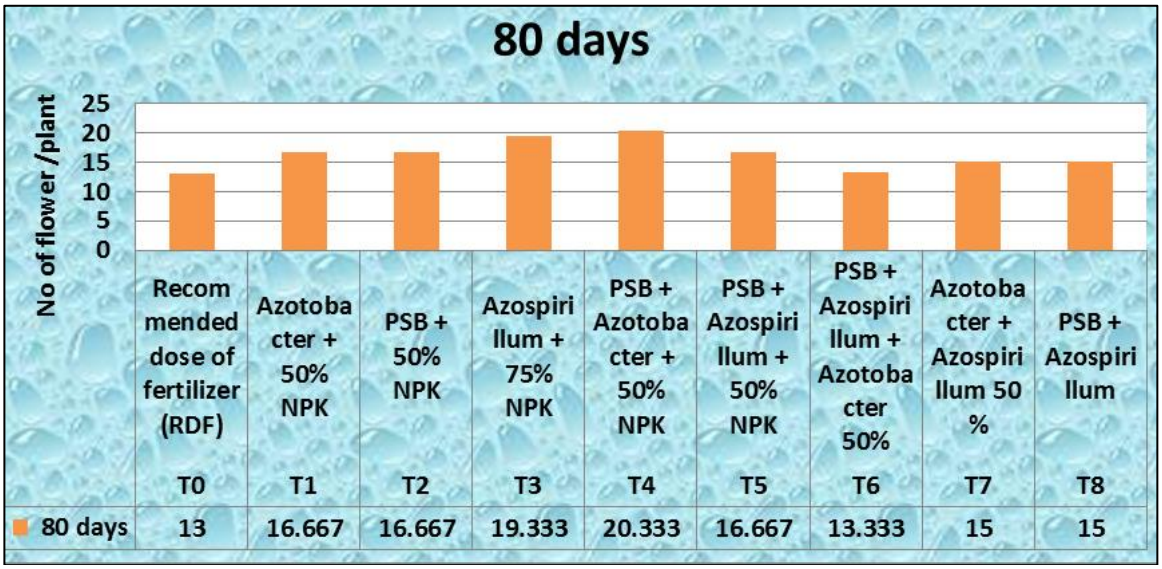

Fig 5: Number of flower/plant

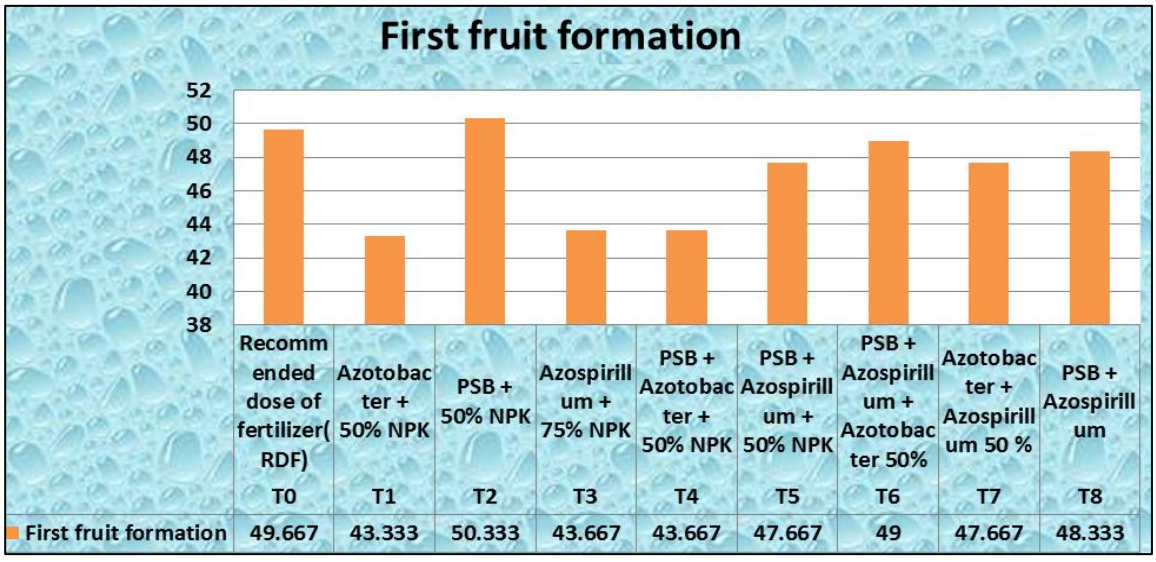

Fig 6: Number of days taken to first fruit formation

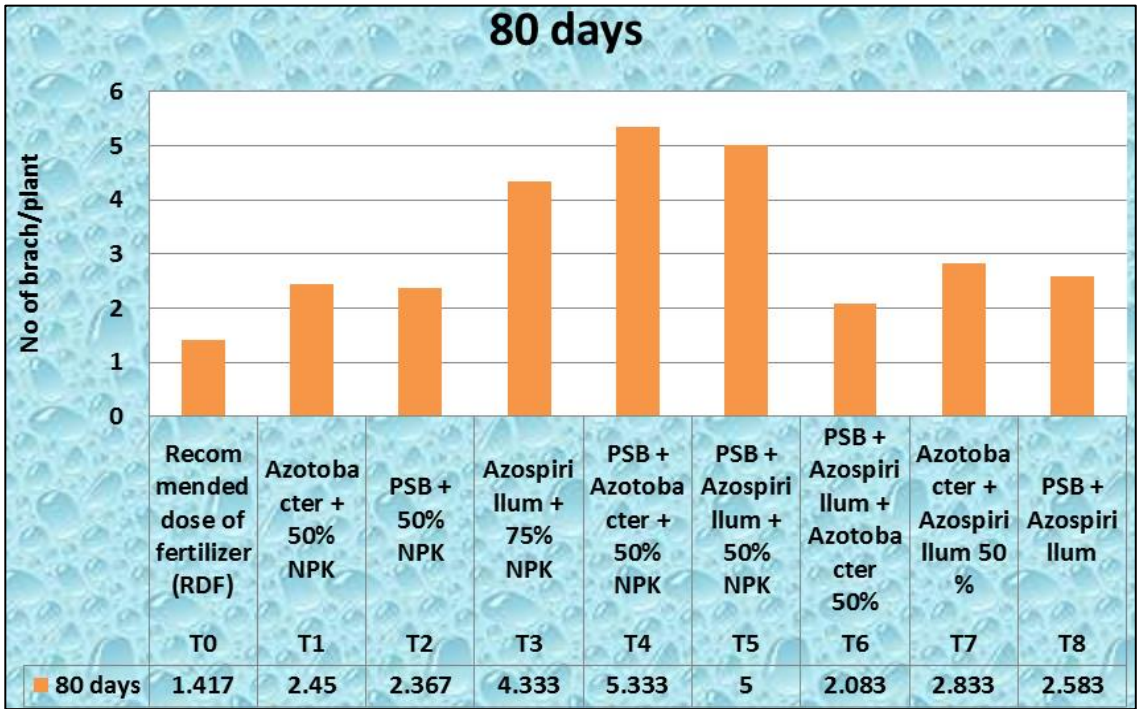

Fig 7: Number of branches/plant

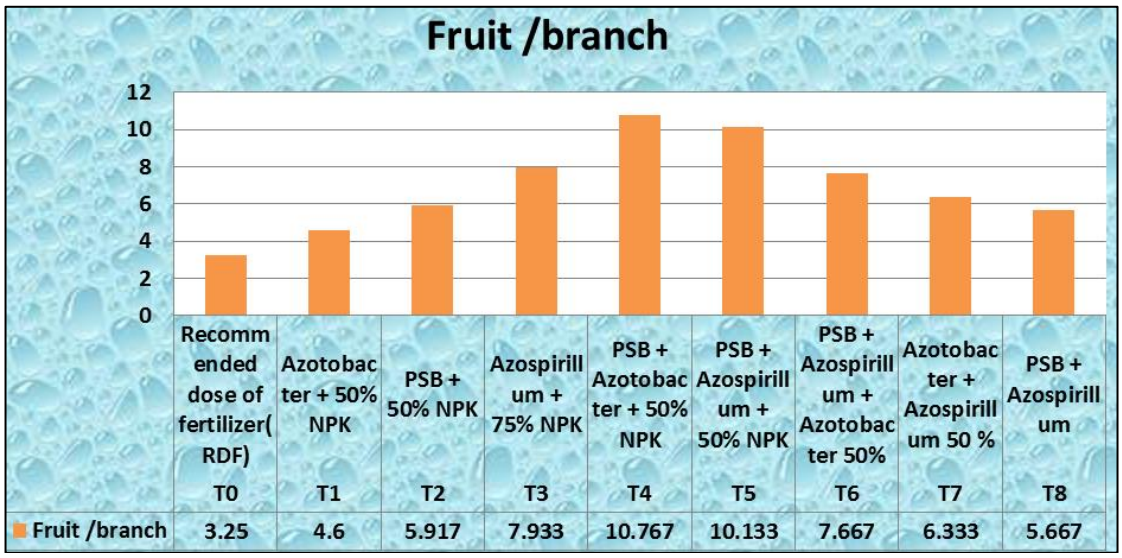

Fig 8: Number of fruit/branch

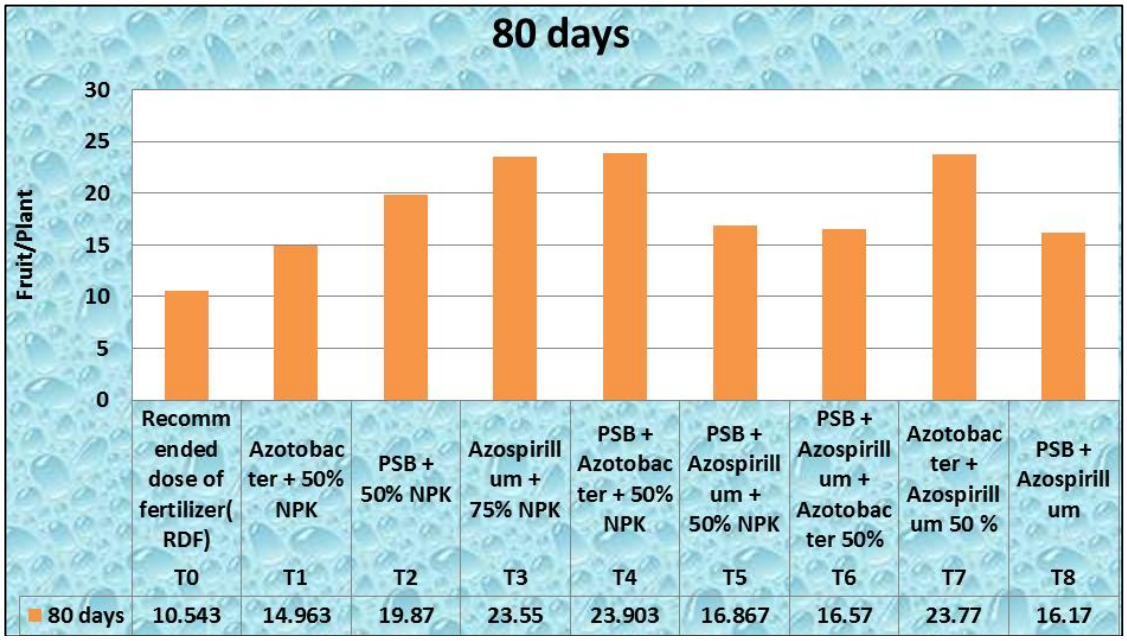

Fig 9: Number of fruit/plant

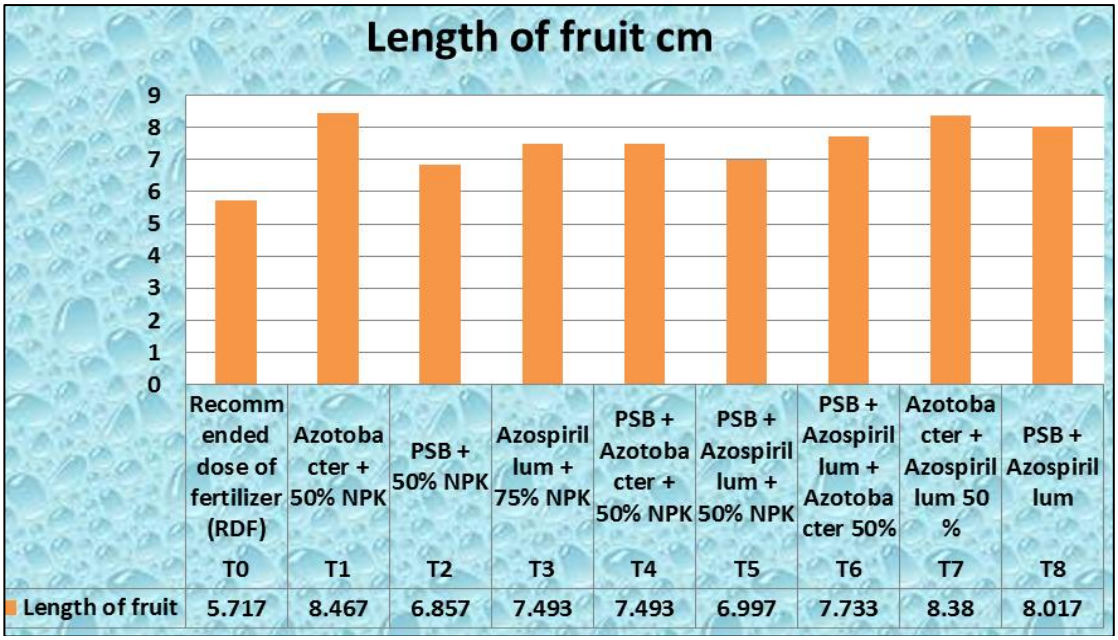

Fig 10: Length of fruit (cm)

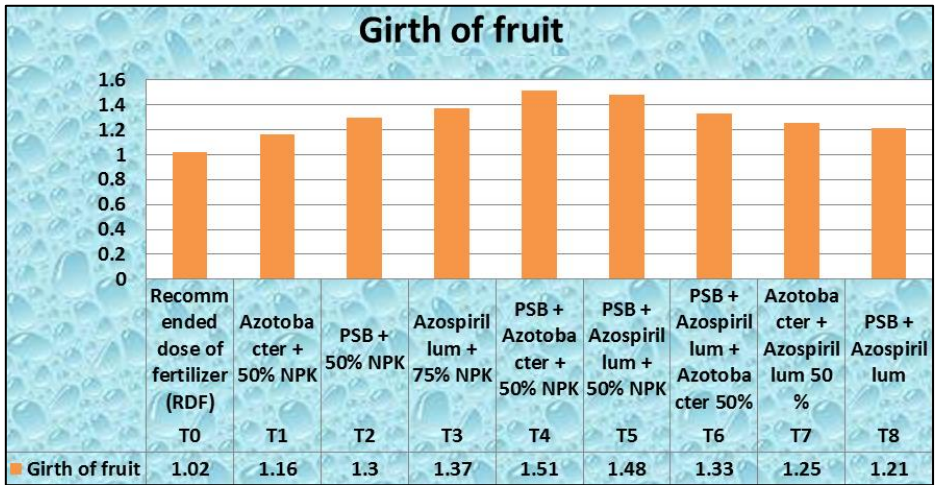

Fig 11: Girth of fruit (cm)

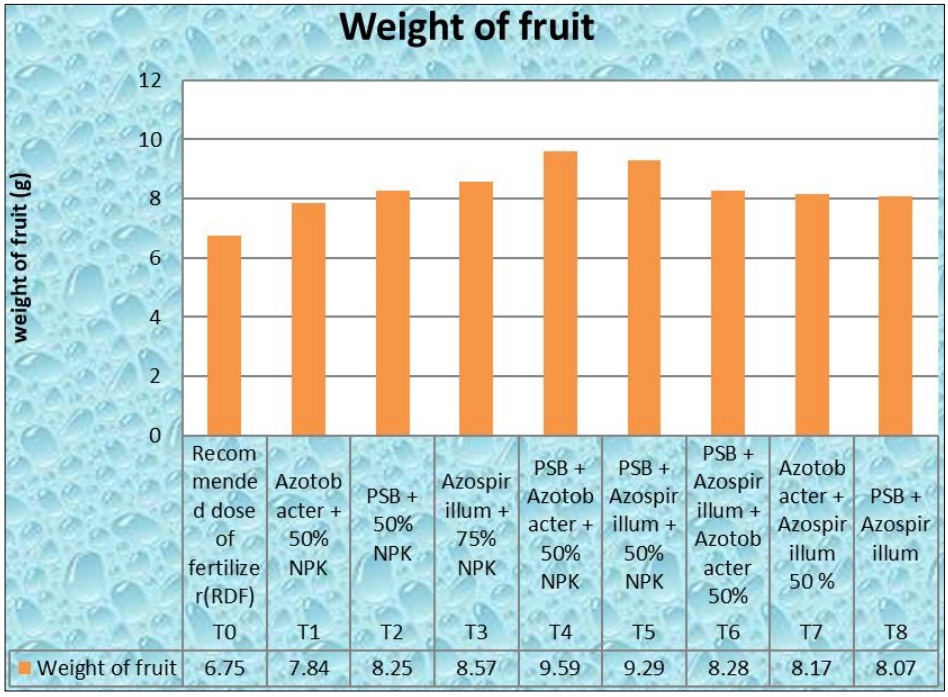

Fig 12: Weight of fruit (g)

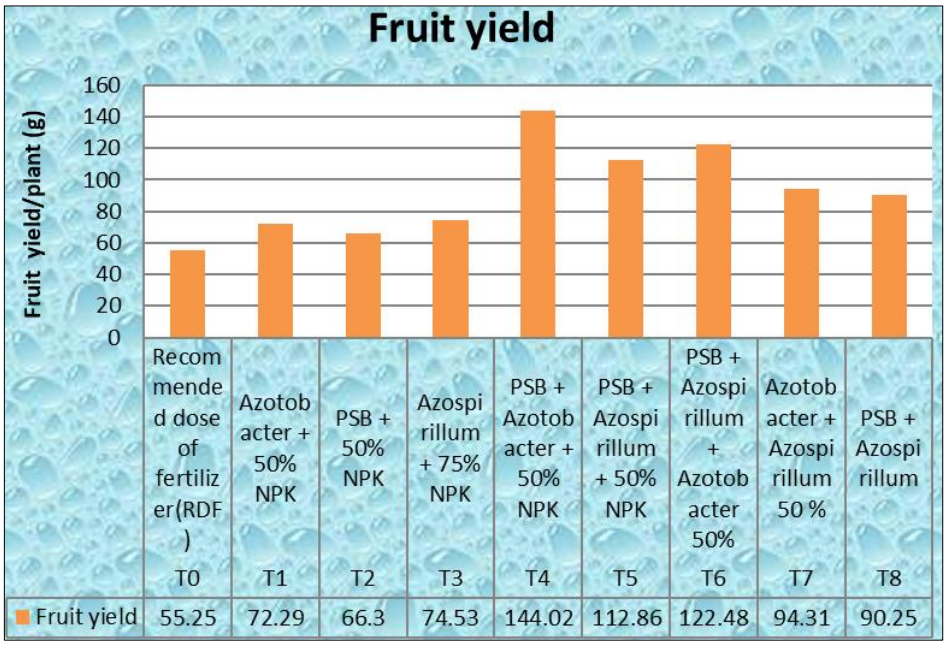

Fig 13: Fruit yield / plant (g)

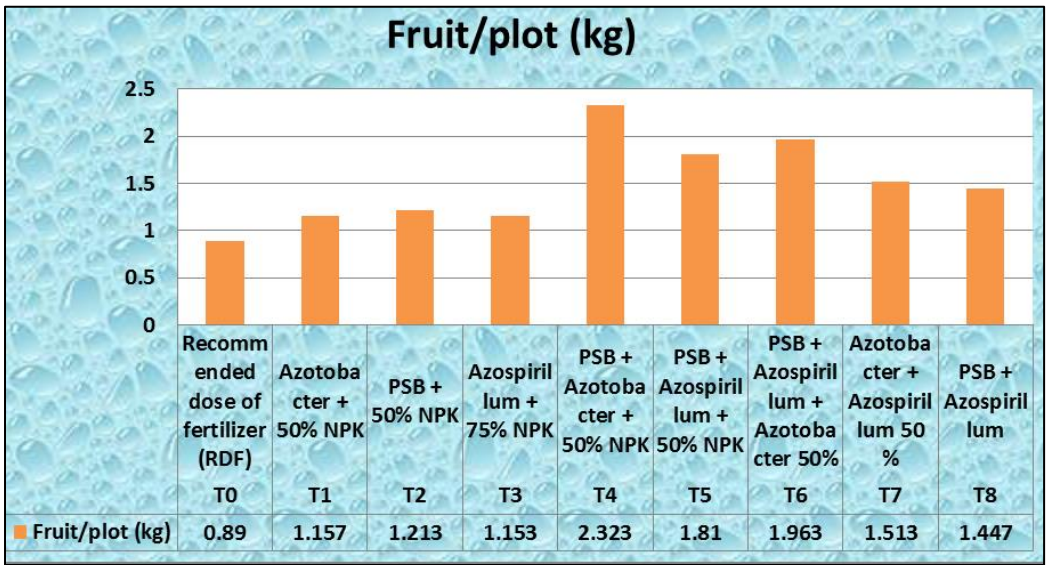

Fig 14: Fruit yield/ plot (Kg)

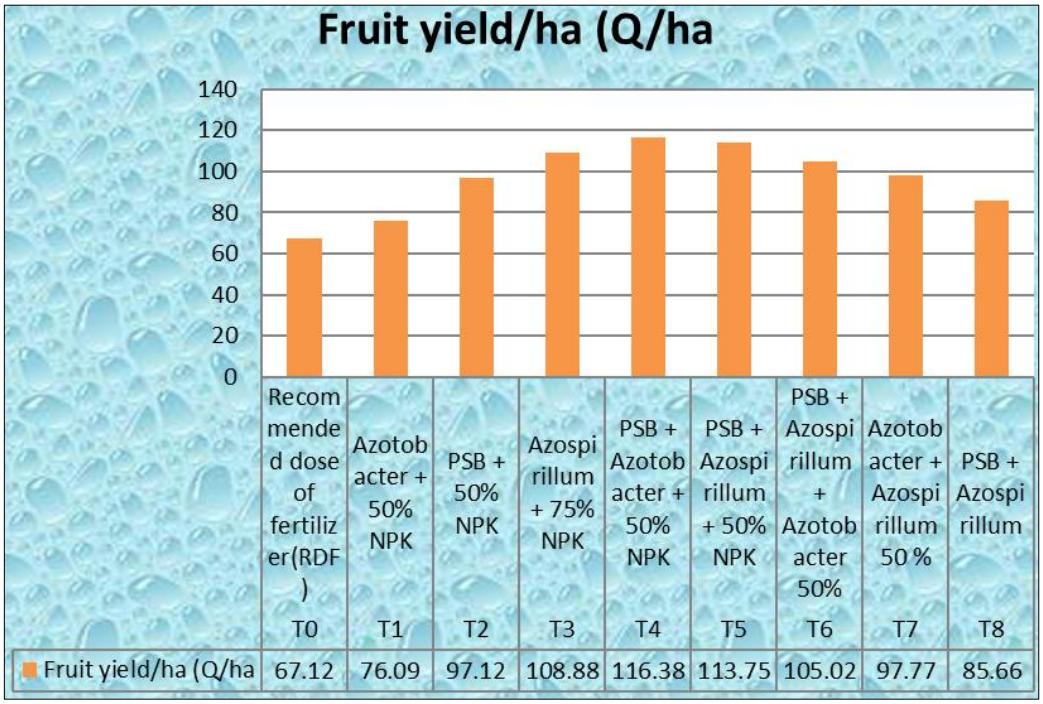

Fig 15: Fruit yield/ha (Q/ha)

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