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Studies on effect of liquid bio-fertilizer and inorganic fertilizer on growth parameters of sapota (*Manilkara achras* (Mill.) Foresberg) cv. Kallipatti

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Abstract
The experiment was laid out in factorial randomized block design with two factors *i.e.* liquid bio-fertilizer and inorganic fertilizer was carried out on field of Horticulture Research fertilizers and chemical fertilizers. These factors consist of four and three levels respectively, twelve treatment combination and three replications. Among the different treatment combination the treatment T_{10}-N_1B_3 (125%NPK + Azotobacter + PSB) application of Azotobacter and PSB with 125% dose of fertilizer reported that the highest length of shoot (13.14 cm), Girth of shoot (2.44 cm), Number of leaves per shoot (29.97), Leaf area (19.92 cm^2), Days to initiation of flowering from application of treatment (80.90), Number of flowers per shoot (9.79), Fruit set (46.34%), No. Of fruits per shoot (4.41), Final retention of fruit per shoot (17.22) and Days required for fruit maturity (250.00) of sapota were recorded highest with the application of 125% RDF+ Azotobacter (100ml) + PSB (100ml). The treatment N_1B_3 with application of 125% NPK combined with Azotobacter (100ml) and PSB (100ml) significant than other treatments.

Keywords: sapota, biofertilizers, chemical fertilizers, azotobacter, PSB

Introduction
Sapota (*Manilkara achras* (Mill.) Forseberg) is one of the important tropical fruit crop belonging to family sapotaceae. Sapota is commonly called chiku in India. It is not known when sapota first introduced in India, but sapota cultivation was taken up for the first time in Maharashtra in 1898 at village Gholwad in district Thane (Chaddha, 1993).
Sapota is a best source of digestible sugar which ranges from 12 to 18 percent. Composition of ripe sapota per 100 g of edible portion is moisture 73.7 g, carbohydrates 21.4 g, protein 0.7 g, fat 1.1 g, calcium 28.0 mg and phosphorus 27.0 mg (Shanmungavelu and Shrinivasan, 1973).
Biofertilizers are the live or latent cells of efficient strain of nitrogen fixing, phosphate solubilizing or cellulitic micro-organism used in soil or seed treatment with the objective of augment the availability and accesses nutrients to the plant. The some biofertilizer micro-organisms are either free living or symbiotic with plant and some micro-organisms are nitrogen fixing i.e Rhizobium, Azotobacter, Azospirillum and other like Phosphate solubilizing and Phosphate mobilizing i.e PSB and VAM (Phosphate solubilizing Bacteria and Vesicular Arbuscular Mycorrhizae) Azospirillum and PSB are the main bio-fertilizers for horticultural crops. Bio-fertilizers helps in saving 50-70% of the requirement of inorganic nitrogen per hectare (Jitendra Singh 2011).

Materials and Method
Experiment was conducted on fifteen years old orchard of sapota cultivar "Kalipatti" on Khirni (*Manilkara hexandra* Roxb.) rootstock spaced at 10x10 meters located at Horticulture Research Scheme, (Pomology) Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani district. The experiment was laid out in factorial randomized block design with 12 treatments and 3 replication on 15 years sapota Cv. Kalipatti. The climate is semi arid with hot dry summer, followed by humid monsoon and subsequent short cold winter. Above dose of bio fertilizers were applied 15 days before flowering in the month of May. Then after 15 days half dose of Nitrogen and full dose of Phosphate and Potassium in the form of Urea, SSP and MOP and the remaining half dose of nitrogen was applied after fruit set. Application of fertilizers was done in 1.5 meter periphery from the stem of the tree in ring method having a 15 inch depth and then covered with soil.

Treatment details

Factor	Sr. No.	Symbol	Treatment
Factor:1 Bio-fertilizer	1	B0	Control
	2	B1	Soil application of Azotobacter 100 ml / plant
	3	B2	Soil application of PSB (Phosphate Solublizing bacteria) 100 ml / plant
	4	B3	Soil application of Azotobacter and PSB. 100ml / plant each
Factor:2 Inorganic fertilizer	1	N1	125% of NPK (Whole RDF i.e. 1250:650:650 g per Plant)
	2	N2	100% of NPK (RDF)
	3	N3	75% of NPK (RDF)

Treatment combinations

Sr. No.	Treatment No.	Treatment Combination	Treatment Details
1	T_1	$N_1 B_0$	(125%RDF)1250:650:650 g NPK / Plant.
2	T_2	$N_2 B_0$	(100% RDF)1000:500:500 g NPK / plant.
3	T_3	$N_3 B_0$	(75% RDF)750:375:375 g NPK / plant.
4	T_4	$N_1 B_1$	(125% RDF)+Azotobacter 1250:650:650g NPK + 100 ml Azotobacter /Plant.
5	T_5	$N_2 B_1$	(100% RDF)+Azotobacter 1000:500:500 g NPK + 100 ml Azotobacter / Plant.
6	T_6	$N_3 B_1$	(75% RDF)+Azotobacter 750:375:375 g NPK +100 ml Azotobacter / Plant
7	T_7	$N_1 B_2$	(125%RDF)+PSB 1250:650:650 g NPK + 100 ml PSB / plant.
8	T_8	$N_2 B_2$	(100% RDF)+PSB 1000:500:500 g NPK + 100 ml PSB / Plant.
9	T_9	$N_3 B_2$	(75% RDF)+PSB 750:375:375 g NPK +100 ml PSB / Plant.
10	T_{10}	$N_1 B_3$	(125% RDF)+Azotobacter+PSB 1250:650:650gNPK+100ml Azotobacter+100ml PSB /Plant
11	T_{11}	$N_2 B_3$	(100% RDF)+ Azotobacter + PSB 1000:500:500NPK + 100ml Azotobacter+100ml PSB / Plant.
12	T_{12}	$N_3 B_3$	(75% RDF)+ Azotobacter + PSB 750:375:375NPK+100ml Azotobacter+100mlPSB / Plant.

Results and Discussion

Length of shoot and Girth of shoot

The interaction effect of bio-fertilizer and inorganic fertilizers also significantly influenced the length of shoot and girth of shoot. The results are presented in Table 1. The treatment combination N_1B_3 (125% NPK + Azotobacter +PSB) recorded maximum length of shoot (13.14 cm), followed by N_1B_1, N_1B_2,N_2B_1 and N_3B_1 recorded. The treatment combination N_1B_3 recorded highest girth of shoot (2.44 cm) followed by N_2B_3 (2.13cm). The minimum girth of shoot (1.33cm) was recorded with the application of 75 per cent NPK.

Beneficial microbes present in rhizosphere leading to mobilization of solute to root zone and lead to enhance to plant growth Sharma *et al*. (2009). The increase in shoot length by the application of 100% mineral NP and inoculated with Azotobacter or AM in Washington Navel Orange Trees reported by Shaimaa *et al.*

Table 1: Effect of liquid Bio-fertilizers and Inorganic fertilizers on length of shoots (cm) and girth of shoots (cm).

Treatment No.	Factor/Treatment	Length of shoot (cm)	Girth of shoot (cm)
1	B0-control	11.49	1.57
2	B1-Azotobacter	12.12	1.70
3	B2-PSB	12.19	1.83
4	B3-Azotobacter +PSB	12.38	1.93
SE+		0.18	0.05
CD at 5%		0.51	0.16
1	N1-125% NPK	12.49	1.96
2	N2-100% NPK	12.11	1.72
3	N3-75% NPK	11.54	1.60
SE+		0.15	0.05
CD at 5%		0.45	0.14
Interaction effect			
T1	N1B0- 125% NPK	11.76	1.65
T2	N2B0- 100% NPK	11.37	1.57
T3	N3B0- 75% NPK	11.22	1.33
T4	N1B1- 125% NPK+ Azotobacter	12.12	1.74
T5	N2B1- 100% NPK+ Azotobacter	11.84	1.73
T6	N3B1- 75% NPK+ Azotobacter	11.37	1.41
T7	N1B2- 125% NPK+PSB	12.53	1.88
T8	N2B2- 100% NPK+PSB	12.29	1.83
T9	N3B2- 75% NPK +PSB	11.27	1.47
T10	N1B3- 125%NPK +Azotobacter +PSB	13.14	2.44
T11	N2B3- 100%+NPK+ Azotobacter +PSB	12.83	2.13
T12	N3B3- 75%NPK + Azotobacter+PSB	12.73	1.92
SE+		0.14	0.09
CD at 5%		0.41	0.27

Number of leaves per shoot and Leaf area (cm^2)

The treatment combination N_1B_3 recorded maximum leaves per shoot (29.97) followed by N_1B_2 and N_1B_1. The treatment combination N_2B_3 and N_3B_3 were at par with treatment N_1B_3. The minimum number of leaves per shoot (23.90) were recorded in treatment combination of 75 per cent NPK with no bio-fertilizer application (N_3B_0).

The interaction effect of bio-fertilizer and chemical fertilizers had significantly affected the leaf area and data are presented in Table 2. The maximum leaf area (19.52 cm^2) was recorded in plant with fertilizer applied 125% NPK (N_1B_0) followed by 125% NPK + Azotobacter and PSB (N_1B_3). The minimum leaf area (17.31cm^2) was observed in plant with lowest fertilizer dose (N_3B_0). The maximum number of leaves per shoot of plant also noticed by Attia, *et al.* (2009) [1] in Banana, Kavino *et al*. (2010) [4].

Table 2: Effect of liquid Bio-fertilizers and Inorganic fertilizers on Number of leaves and Leaf area (cm^2).

Treatment No.	Factor / Treatment	Number of leaves per shoot	Leaf area (cm^2)
1	B0-control	25.09	18.45
2	B1-Azotobacter	26.45	18.52
3	B2-PSB	26.95	19.01
4	B3-Azotobacter +PSB	27.45	19.08
SE+		0.46	0.17
CD at 5%		1.34	0.51
1	N1- 125% NPK	28.09	19.07
2	N2-100% NPK	25.77	18.66
3	N3-75 NPK	25.59	18.57
SE+		0.39	0.15
CD at 5%		1.16	0.44
Interaction Effect			
T1	N1B0- 125% NPK	25.68	18.63
T2	N2B0- 100% NPK	25.67	18.54
T3	N3B0- 75% NPK	25.66	17.53
T4	N1B1- 125% NPK+ Azotobacter	25.71	18.92
T5	N2B1- 100% NPK+ Azotobacter	25.70	18.76
T6	N3B1- 75% NPK+ Azotobacter	24.35	18.17
T7	N1B2- 125% NPK+PSB	26.67	19.13
T8	N2B2- 100% NPK+PSB	25.76	19.06
T9	N3B2- 75% NPK +PSB	25.66	18.53
T10	N1B3- 125%NPK +Azotobacter +PSB	29.97	19.92
T11	N2B3- 100%+NPK+ Azotobacter +PSB	29.27	19.35
T12	N3B3- 75%NPK +Azotobacter+PSB	29.24	19.25
SE+		0.79	0.30
CD at 5%		2.31	0.88

The interaction effect of bio-fertilizer and inorganic fertilizers significantly affected the days to initiation of flowering from application of treatment and results are presented in Table 3. The interaction effect of Azotobacter and PSB with 125% dose of NPK (N_1B_3) recorded minimum days to initiation of flowering from application of treatment (80.90) and maximum number of flowers per shoot (9.79). It was followed by the treatment combination N_2B_3 i.e. 100% NPK + Azotobacter + PSB (84.23) and (9.70). The treatments N_1B_1, N_1B_2 and N_2B_2 were at par with treatment N_1B_3. The maximum days (88.83) to initiation of flowering from application of treatment was observed in trees which were supplied with lowest fertilizer dose (N_3B_0) i.e. 75 per cent NPK only. The minimum number of days required to produce flowers and maximum number of flowers per plant by the application of Azotobacter 6 kg/ha + NPK that were reported by Beer *et al.* (2017) [2] in strawberry.

Table 3: Effect of liquid Bio-fertilizers and Inorganic fertilizers on Days to initiation of flowering from application of treatment and No. of flowers per shoot.

Treatment No.	Factor / Treatment	Days to initiation of flowering from application of treatment.	No. of flowers per shoot.
1	B0-control	85.71	9.15
2	B1-Azotobacter	85.25	9.27
3	B2-PSB	84.17	9.48
4	B3-Azotobacter +PSB	83.79	9.49
SE+		0.33	0.06
CD at 5%		0.96	0.17
1	N1-125% NPK	83.18	9.55
2	N2-100% NPK	85.18	9.31
3	N3-75 NPK	85.83	9.18
SE+		0.33	0.05
CD at 5%		0.96	0.14
Interaction effect			
T1	N1B0- 125% NPK	84.84	9.17
T2	N2B0- 100% NPK	84.65	9.07

T3	N3B0- 75% NPK	88.73	8.45
T4	N1B1- 125% NPK+ Azotobacter	85.73	9.49
T5	N2B1- 100% NPK+Azotobacter	85.44	9.25
T6	N3B1- 75% NPK+ Azotobacter	86.13	9.03
T7	N1B2- 125% NPK+PSB	84.23	9.56
T8	N2B2- 100% NPK+PSB	84.20	9.30
T9	N3B2- 75% NPK +PSB	86.78	9.18
T10	N1B3- 125%NPK + Azotobacter +PSB	80.90	9.79
T11	N2B3- 100%+NPK+ Azotobacter +PSB	82.48	9.70
T12	N3B3- 75%NPK + Azotobacter+PSB	82.57	9.66
SE+		0.65	0.10
CD at 5%		1.91	0.29

Fruit set (%) and Number of fruit per shoot

The interaction effect of bio-fertilizers and chemical fertilizers and results are presented in Table 4. The fertilizer combination N_1B_3 recorded the maximum fruit set (46.34%), at par with N_2B_3 (45.54), N_3B_3 (45.00%). The fertilizer combination of N_3B_0 recorded the lowest fruit set (36.02%). The interaction effect of Azotobacter and PSB with dose of NPK (N_1B_3) *i.e.* 125% NPK + Azotobacter + PSB recorded the maximum number of fruits per shoot (4.41) it was followed by the treatment combination N_2B_3 i.e. 100%NPK + Azotobacter + PSB (4.21). The similar result also found by Singh and Singh (2009) [7] in strawberry, Gogai *et al*. (2004) [3] in banana.

Table 4: Effect of liquid Bio-fertilizers and Inorganic fertilizers on Fruit set (%) and Number of fruits per shoot.

Treatment No.	Factor / Treatment	Fruit set (%).	No. of fruits per shoot.
1	B0-control	40.60	3.58
2	B1-Azotobacter	41.01	3.69
3	B2-PSB	41.52	3.77
4	B3-Azotobacter +PSB	42.94	5.92
SE+		0.35	0.08
CD at 5%		1.04	0.22
1	N1-125% NPK	45.55	5.11
2	N2-100% NPK	40.50	4.04
3	N3-75 NPK	39.40	3.55
SE+		0.31	0.07
CD at 5%		0.90	0.19
Interaction Effect			
T1	N1B0- 125% NPK	41.36	3.51
T2	N2B0- 100% NPK	41.26	3.42
T3	N3B0- 75% NPK	36.05	3.23
T4	N1B1- 125% NPK+ Azotobacter	42.01	3.64
T5	N2B1- 100% NPK+ Azotobacter	41.91	3.54
T6	N3B1- 75% NPK+ Azotobacter	36.26	3.49
T7	N1B2- 125% NPK+PSB	42.20	3.95
T8	N2B2- 100% NPK+PSB	42.24	3.81
T9	N3B2- 75% NPK +PSB	36.05	3.49
T10	N1B3- 125%NPK + Azotobacter +PSB	46.34	4.41
T11	N2B3- 100%NPK+Azotobacter +PSB	45.54	4.21
T12	N3B3- 75%NPK + Azotobacter +PSB	45.00	4.12
SE+		0.61	0.13
CD at 5%		1.80	0.38

Final retention of fruits per shoot and Days required for fruit maturity

The interaction effect of bio-fertilizer and inorganic fertilizers significantly influenced the final retention of fruits per shoot and results are presented in Table 5. The treatment combination N_1B_3 (125% NPK + Azotobacter +PSB) recorded highest final retention of fruits per shoot (17.22) at par with N_1B_2, N_1B_1, and followed by N_2B_3, N_3B_3 recorded highest final retention of fruits per shoot. The minimum retention of fruits per shoot was recorded with 75% NPK only.

The interaction effect of Azotobacter and PSB with full dose of NPK (N_1B_3) recorded the minimum days to maturity from fruit set (250.00) it was at per with N_1B_1,N_1B_2 and followed by the treatment combination N_3B_1 i.e. 75% NPK + Azotobacter (250.48). The maximum days (252.33) required to maturity from fruit set was observed in trees which were supplied lowest fertilizer dose (N_3B_0) i.e. 75 per cent NPK only. This might be due to increase in the availability of nutrients and better solute uptake by the plant reported by Sharma *et al.* (2016).

Table 5: Effect of liquid Bio-fertilizers and Inorganic fertilizers on Final retention of fruits per shoot and Days required for fruit maturity

Treatment No.	Factor / Treatment	Final retention of fruits per shoot.	Days required for fruit maturity.
1	B0-control	13.75	251.43
2	B1-Azotobacter	13.98	250.83
3	B2-PSB	15.02	250.55
4	B3-Azotobacter +PSB	15.83	250.52
SE+		0.25	0.11
CD at 5%		0.74	0.33
1	N1-125% NPK	15.96	250.44
2	N2-100% NPK	14.52	250.67
3	N3-75 NPK	13.46	251.40
SE+		0.22	0.10
CD at 5%		0.64	0.29
Interaction Effect			
T1	N1B0- 125% NPK	12.42	251.14
T2	N2B0- 100% NPK	12.14	251.31
T3	N3B0- 75% NPK	11.88	252.02
T4	N1B1- 125% NPK+ Azotobacter	16.68	250.79
T5	N2B1- 100% NPK+Azotobacter	15.31	251.02
T6	N3B1- 75% NPK+ Azotobacter	13.11	250.48
T7	N1B2- 125% NPK+PSB	16.83	250.66
T8	N2B2- 100% NPK+PSB	15.49	251.00
T9	N3B2- 75% NPK +PSB	14.21	252.33
T10	N1B3- 125%NPK +Azotobacter +PSB	17.22	250.00
T11	N2B3- 100%+NPK+Azotobacter +PSB	15.81	250.16
T12	N3B3- 75%NPK +Azotobacter +PSB	14.63	250.30
SE+		0.44	0.20
CD at 5%		1.28	0.57

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