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Effect of integrated nutrient management on growth parameters of sapota cv. Kalipatti under south-eastern conditions of Rajasthan

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Abstract
For getting better growth of sapota plantation, the present investigation was conducted during 2012-14 to study the effect of integrated nutrient management on eight years old sapota orchard planted at 8m x 8m apart in silty clay loam of South-Eastern Rajasthan. Results revealed that the treatments with combined application of inorganic fertilizers (NPK), organic manures (FYM and vermicompost) and biofertilizers (*Azotobacter*, *Azospirillum* and *PSB*) sources of nutrients had significantly increased the different growth parameters of sapota over control (NPK *i.e.* 1000:500:500g/ plant) denoted as T_1. Among different treatments, application of 2/3rd of T_1 +10 kg vermicompost +250g *Azospirillum* +250g *Azotobacter*/plant (T_{15}) had significantly increased the shoot length (32.92 cm), shoot diameter (2.66 cm), number of leaves per shoot (29.00), girth of primary branches (4.02 cm) after 120 days of treatment application. The plant spread E-W (3.45 m) and plant spread N-S (3.43 m) at fruit harvest was also higher in this treatment (T_{15}) on pooled basis. From the present investigation it is concluded that the 19 % higher shoot length could be increased with application of 2/3 quantity of recommended dose of fertilizers *i.e.* 1000:500:500 g NPK + 10 kg vermicompost +250g *Azospirillum* +250g *Azoto-bacter*/plant (T_{15}) in Sapota cv. Kalipatti over the control.

Keywords: *Acharas zapota*, integrated nutrient management, shoot length, plant spread, Number of leaves

1. Introduction
Sapota (*Achras zapota* L. *Syn. Manilkara achras* (Mill) Forsberg) is one of the prominent fruits and belongs to family "Sapotaceae". It is also known as sapodilla or *chiku* in India. Sapota is a native of Mexico and Central America, and now widely cultivated throughout tropics for its delicious fruits (Bose and Mitra, 1990) [4]. Sapota is an evergreen tree usually growing up to 10 m height. Being a hardy crop, it can be grown on wide range of soil and climatic conditions (Dutton, 1976) [7]. Sapota fruit when fully ripe is delicious and eaten as dessert fruit. The pulp is sweet and melting. The fruit skin can also be eaten since it is richer than the pulp in nutritive value. The sapota fruits are a good source of sugar which ranges between 12 and 14 per cent. A 100 g of edible portion of fruit contains moisture (73.7 g), carbohydrates (21.49 g), protein (0.7 g), fat (1.1 g), calcium (28 mg), phosphorus (27 mg), iron (2 mg) and ascorbic acid (6 mg) as reported by Bose and Mitra (1990) [4]. Sapota fruits are used for making jams, jellies, osmodehydrated slices and squash (Reddy, 1959) [14]. Products like sweet chutney, dried sapota pieces, sapota milk shake, nectar, blended sapota drinks, pickle, preserve and candy can also be prepared with good sensory quality (Sawant, 1989) [15]. The bark of the tree is rich in white gummy latex which is used for preparation of chicle used in chewing gum (Ravindran *et al.* 2007) [13].
India is the largest producer of sapota followed by Mexico, Guatemala and Venezuela. The area under sapota in India is estimated to be 1.64 lakh hectares, with an annual production of 14.95 lakh metric tonnes (Anon., 2014) [2]. The major states are producing sapota in India on commercial scale are Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Tamil Nadu, Kerala, Punjab, West Bengal and Haryana. Information on area and production of sapota in Rajasthan is not readily available as the fruit has recently been introduced in the state and major plantations have not been developed on significant scale. It is also not known when it was first introduced into India (Singh *et al*., 1963) [16], but sapota cultivation was taken up for the first time in Maharashtra in 1898 in a village named Gholwad (Cheema *et al*., 1954) [5].

In Indian fruit orchards, poor soil health and nutrition are major causes of low orchard efficiency resulting in slow growth. However, the proper nutrition of Sapota orchards is very.

2. Materials and Methods

Experimental site and location

A field experiment was conducted on sapota cv Kalipatti at Research Farm, ICAR- Indian Institute of Soil and Water Conservation (Formerly, CSWCRTI), Research Centre, Kota (Rajasthan) in two consecutive years, i.e. 2012-13 and 2013-14. The Experimental Block is located at 25º 11' N latitude and 75 º 51' E longitudes at an elevation of 256.9 meters above mean sea level. The soil of the experimental site is silty clay loam having soil pH of about 7.6 with electrical conductivity of 0.42 dSm^{-1} and 0.45 per cent organic carbon. The available N, P and K were 273.26, 12.43 and 595.54 kg ha^{-1} respectively. Infact, in arid and semiarid areas, low precipitation, extremes of temperature, high wind velocity, poor soil fertility etc. are the major constraints of farming. The sapota, though, it is a hardy plant to various biotic and abiotic stresses but needs proper management with respect to nutrition and moisture management for obtaining economic return.

Nutrient application

Experimental plantation was established with spacing of 8m X 8 m during the year 2007. All operations of orchard were followed as suggested by Singh *et al*. (2005) [17] and uniform management practices were applied for all treatments, except integrated nutrient management (INM) treatments, so as to assess its performance. The manure and fertilizer treatments were applied with two split doses. Whole manure, phosphorous, potassium and half dose of nitrogen were applied in middle of June and remaining half nitrogen was applied in end of the September during both the year of experimentation. Fertilizers were applied in a ring which covers an area of 90 cm away periphery of the plant trunk and covering the periphery of the plants. Soil should be dug to depth of 25-30 cm and the fertilizer should be properly mixed in the soil. The first light irrigation was given immediately after application of treatment and thereafter one or two light irrigation were given before the onset of rains.

Treatments and design

The experimental design of study was Randomized Block Design (RBD) with four replications, considering four plants as treatment unit. The INM treatments comprised of inorganic fertilizers (NPK), organic manures (vermi-compost and farm yard manure) and biofertilizers (*Azotobacter, Azospirillum* and PSB). The total treatment combinations were seventeen are below. The observations on shoot length, shoot diameter, number of leaves and girth of primary branches were recorded after 120 days of treatment application while plant spread (E-W and N-S) was noted at fruit harvest. The analysis was done as per standard procedure (AOAC, 1994) [1]. The data on various parameters were statistically analyzed to test the significance of the treatments.

Treatments	Details about the treatments
T_1	Recommended dose of NPK i.e.1000:500:500 g/plant denotes as Control
T_2	½ of T_1 + 50 kg FYM + 250 g *PSB* / Plant
T_3	½ of T_1 + 50 kg FYM + 250g *Azospirillum* + 250g *Azotobacter* / Plant
T_4	½ of T_1 + 50 kg FYM +250g *PSB* + 250g *Azosprillum* / Plant
T_5	½ of T_1 + 50 kg FYM +250g *Azosprillum* / Plant
T_6	½ of T_1 + 10 kg Vermicompost + 250 g *PSB* / Plant
T_7	½ of T_1 + 10 kg Vermicompost+250 g *Azospirillum*+250g *Azotobacter*/Plant
T_8	½ of T_1 + 10 kg Vermicompost + 250 g *PSB* + 250 g *Azospirillum*/ Plant
T_9	½ of T_1 + 10 kg Vermicompost +250 g *Azospirillum* / Plant
T_{10}	2/3 of T_1 + 50 kg FYM + 250 g *PSB* / Plant
T_{11}	2/3 of T_1 + 50 kg FYM +250g *Azosprillum* + 250g *Azotobacter* / Plant
T_{12}	2/3 of T_1 + 50 kg FYM + 250g *PSB* + 250 g *Azospirillum* / Plant
T_{13}	2/3 of T_1 + 50 kg FYM + 250g *Azosprillum* / Plant
T_{14}	2/3 of T_1 + 10 kg Vermicompost + 250g *PSB* / Plant
T_{15}	2/3 of T_1 + 10 kgVermicompost+250g *Azospirillum*+250g *Azotobacter*/Plant
T_{16}	2/3 of T_1 + 10 kg Vermicompost + 250g *PSB* + 250g *Azosprillum* / Plant
T_{17}	2/3 of T_1 + 10 kg Vermicompost +250g *Azospirillum* / Plant

3. Results and Discussion

The results obtained during course of this investigation are interpreted and discussed in detail with the renown of work done in this direction. The growth parameters (Table- 1 to 3) such as shoot length, shoot diameter, number of leaves, girth of primary branches and plant spread (E-W and N-S) were significantly influenced by different treatments of integrated nutrient management during study period and in pooled analysis.

The results clearly indicated that the soil application of 2/3 of T_1 +10 kg Vermicompost +250g *Azospirillum* +250g *Azotobacter* /plant (T_{15}) were recorded maximum shoot length, shoot diameter, number of leaves, girth of primary branches, plant spread followed by application of 2/3 of T_1 +50 kg FYM +250g *Azospirillum* +250g *Azotobacter* /plant (T_{11}) as compare to other treatments and minimum increment in shoot length, shoot diameter, number of leaves, girth of primary branches and plant spread at 1/2 of T_1 +50 kg FYM +250 g PSB/plant (T_2) during study period *i.e.* 2012-13 and 2013-14 and in pooled analysis.

The maximum shoot length of 31.46, 34.38 and 32.92 cm and shoot diameter of 2.64, 2.69 and 2.66 cm was recorded on 120 days after treatment application during both the years and pooled analysis basis, respectively under the T_{15} treatment while minimum value was observed under treatment T_2 (500: 250: 250g NPK +50 kg FYM +250 g PSB/plant) in shoot length and shoot diameter (Table 1). These findings are in accordance with the findings of Madhavi *et al*. (2008) [11] in mango and Mir *et al*. (2013) [12] in pomegranate.

Table 1: Effect of integrated nutrient management on shoot length and shoot diameter in Sapota cv. Kalipatti

Treatments	Shoot length (cm)			Shoot diameter (cm)		
	2013	2014	Pooled	2013	2014	Pooled
T_1	26.16	29.34	27.75	2.00	2.02	2.01
T_2	19.85	22.47	21.16	1.75	1.77	1.76
T_3	23.53	25.92	24.72	2.22	2.27	2.24
T_4	23.02	26.12	24.57	1.80	1.85	1.82
T_5	22.12	25.36	23.74	2.16	2.19	2.18
T_6	20.37	24.13	22.25	2.22	2.25	2.23
T_7	24.35	27.42	25.88	2.09	2.12	2.11
T_8	23.13	26.18	24.65	1.94	1.97	1.95
T_9	22.17	25.16	23.66	2.17	2.20	2.18
T_{10}	24.28	27.32	25.80	2.27	2.29	2.28
T_{11}	26.72	29.85	28.28	2.56	2.59	2.57
T_{12}	26.50	29.72	28.11	2.50	2.53	2.51
T_{13}	25.64	28.32	26.98	2.27	2.30	2.29
T_{14}	25.23	28.29	26.76	2.18	2.22	2.20
T_{15}	31.46	34.38	32.92	2.64	2.69	2.66
T_{16}	26.38	29.52	27.95	2.37	2.40	2.38
T_{17}	25.75	28.76	27.25	2.31	2.39	2.35
S.Em (±)	1.214	1.244	0.869	0.111	0.115	0.080
CD(p=0.05)	3.452	3.539	2.440	0.317	0.328	0.225

The maximum numbers of leaves per shoot at 120 days after application of treatments were observed during both the years as well as in pooled analysis and which was 28.25, 29.75 and 29.00 (leaves/shoot), respectively in treatment T_{15}. The minimum number of leaves per shoot of 14.00 (leaves/shoot), was recorded at 500:250:250 g NPK + 50 kg FYM + 250 g *PSB* / Plant (T_2) treatment under pooled analysis (Table-2). The increase in number of leaves per shoot in T_{15} treatment was 27.47 per cent higher than recommended dose of NPK treatment 1000:500:500 g per plant, respectively (T_1).

The pooled data indicates that the maximum girth of primary branches (4.02 cm) was observed in treatment T_{15} as compared to recommended dose of NPK treatment (T_1) and minimum (2.82 cm) was observed in treatment (T_2) *i.e.* 500:250:250 g NPK + 50 kg FYM + 250 g *PSB* / plant. These results are in agreement with the findings of Hiwale *et al.* (2010) [10] and Baviskar *et al.* (2011) [3] in Sapota.

Table 2: Effect of integrated nutrient management on number of leaves and girth of primary branches in sapota cv. Kalipatti

Treatments	Number of leaves per shoot			Girth of primary branches (cm)		
	2013	2014	2013	2014	2013	2014
T_1	22.00	23.50	22.00	23.50	22.00	23.50
T_2	13.25	14.75	13.25	14.75	13.25	14.75
T_3	18.75	20.25	18.75	20.25	18.75	20.25
T_4	15.50	17.00	15.50	17.00	15.50	17.00
T_5	14.25	15.75	14.25	15.75	14.25	15.75
T_6	13.75	15.25	13.75	15.25	13.75	15.25
T_7	17.25	18.75	17.25	18.75	17.25	18.75
T_8	17.75	19.50	17.75	19.50	17.75	19.50
T_9	15.00	16.25	15.00	16.25	15.00	16.25
T_{10}	20.00	21.50	20.00	21.50	20.00	21.50
T_{11}	24.75	25.75	24.75	25.75	24.75	25.75
T_{12}	23.50	25.25	23.50	25.25	23.50	25.25
T_{13}	20.50	22.00	20.50	22.00	20.50	22.00
T_{14}	19.25	20.50	19.25	20.50	19.25	20.50
T_{15}	28.25	29.75	28.25	29.75	28.25	29.75
T_{16}	22.25	23.50	22.25	23.50	22.25	23.50
T_{17}	21.75	23.25	21.75	23.25	21.75	23.25
Sem (±)	1.07	1.12	1.07	1.12	1.07	1.12
CD(p=0.05)	3.03	3.18	3.03	3.18	3.03	3.18

The data on plant canopy spread (East-West and North-South) as affected by integrated nutrient management have been presented in Table 3. A perusal of data revealed that various integrated nutrient management treatments significantly influenced the East- West plant spread. The maximum value for East- West plant spread was recorded in (T_{15}) treatment of 750: 375 :375 g NPK + 10 kg vermicompost + 250g *Azospirillum* +250g *Azotobacter* / plant *i.e.* (3.45 m), however minimum (3.00 m) East- West plant spread in T_2 (500:250:250 g NPK + 50 kg FYM + 250 PSB / plant) in pooled analysis at harvest. Whereas maximum value for the North-South plant spread was recorded in (T_{15}) treatment of 750: 375 :375 g NPK + 10 kg vermicompost + 250g *Azospirillum* +250g *Azotobacter* / plant *i.e.* (3.43 m), however minimum (2.54 m) the North-South plant spread in T_2 (500:250:250 g NPK + 50 kg FYM + 250 *PSB* / plant) in pooled analysis. The increment in plant spread (N-S) in T_{15} treatment was 8.54 per cent higher than recommended dose of NPK treatment 1000:500:500 g per plant, respectively (T_1). Improvement in the plan growth under the influence of *Azospirillum* and *Azotobacter*, the microbial inoculants, which helps in fixation of atmospheric nitrogen through free-living

N_2 fixers in rhizosphere. It also produced a variety of growth substances like indole acetic acid, gibberellins, vitamin B and anti fungal substances. The results on similar lines were also reported by earlier researchers namely Dalal *et al.* (2004) [6] and Hebbara *et al*. (2006) [9] in Sapota.

Table 3: Effect of integrated nutrient management on plant spread (E-W and N-S) in sapota at harvest

Treatments	Plant spread E-W (m)			Plant spread N-S (m)		
	2013	2014	2013	2014	2013	2014
T_1	3.10	3.25	3.10	3.25	3.10	3.25
T_2	2.87	3.14	2.87	3.14	2.87	3.14
T_3	3.05	3.26	3.05	3.26	3.05	3.26
T_4	2.36	3.08	2.36	3.08	2.36	3.08
T_5	2.73	2.93	2.73	2.93	2.73	2.93
T_6	2.57	2.75	2.57	2.75	2.57	2.75
T_7	2.82	3.01	2.82	3.01	2.82	3.01
T_8	2.95	3.14	2.95	3.14	2.95	3.14
T_9	2.90	3.08	2.90	3.08	2.90	3.08
T_{10}	2.93	3.12	2.93	3.12	2.93	3.12
T_{11}	3.25	3.43	3.25	3.43	3.25	3.43
T_{12}	3.21	3.38	3.21	3.38	3.21	3.38
T_{13}	3.05	3.23	3.05	3.23	3.05	3.23
T_{14}	3.01	3.19	3.01	3.19	3.01	3.19
T_{15}	3.35	3.54	3.35	3.54	3.35	3.54
T_{16}	3.17	3.38	3.17	3.38	3.17	3.38
T_{17}	3.14	3.34	3.14	3.34	3.14	3.34
S.em (±)	0.159	0.163	0.159	0.163	0.159	0.163
CD (p=0.05)	0.452	0.465	0.452	0.465	0.452	0.465

Combined application of inorganic fertilizers, organic manures and biofertilizers favored for good soil fertility status which improve availability of nutrients and improve in plant height, girth of primary branches and trunk, tree canopy spread, number of leaves per shoot, number of branches per shoot, length of shoot and diameter may be attributed to the fact that the better nourishment causes beneficial effects such as accelerated rate of photosynthesis, assimilation, cell division and vegetative growth. The results of the present investigation are in close conformity to the findings of Dalal *et al*. (2004) [6] and Hebbara *et al*. (2006) [9], Hazarika and Ansari (2007) [8], Hiwale *et al*. (2010) [10], Baviskar *et al*. (2011) [3], Varu, Devashi (2012) [18] in sapota. The similar results were reported in Mango (Madhavi *et al*. 2008) [11] and in Pomegranate (Mir *et al.* 2013) [12] were in accordance with findings of present investigation.

4. Conclusion

Overall, it can be concluded that application of 2/3 quantity of recommended dose of fertilizers *i.e.* 1000:500:500 g NPK + 10 kg vermicompost +250g *Azospirillum* +250g *Azoto-bacter*/plant (T_{15}) can be recommended for increased growth parameters (shoot length, shoot diameter, number of leaves, girth of primary branches and plant spread) of Sapota cv. Kalipatti under South- Eastern conditions of Rajasthan.

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