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Growth and yield of ginger (*Zingiber officinale* L) under Sapota- Jatropha based agroforestry systems in south Gujarat

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Abstract
The field experiments were conducted under support irrigated conditions during 2013-14 and 2014-15 at the Agronomy Farm (Block-E), ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari (Gujarat). The nine year old plantation of Sapota (*Manilkara acharas* (Mill.) Fosberg) with seven year old plantation of Jatropha (*Jatropha curcas* L.) was used for the present intercropping study. The ginger crop with two varieties *viz*. *Zingiber officinale* L var. Navsari local and *Zingiber officinale* L. var. Udaipur local was selected for the study. The experiments were laid out in randomized block design with eight treatments and three replications. The observations on growth and yield were recorded during the course of investigation under study for both the years. At the harvesting stage, maximum fresh rhizome yield and total number of fingers per plant, Plant height, length of rhizome, width of rhizome and survival percent of ginger was registered under Sapota + Jatropha or Jatropha based agro-forestry systems as compared to their sole cropping.

Keywords: Agroforestry, Intercropping, Ginger, Growth and Yield

Introduction

Agroforestry systems combine annual and perennial crops, allowing farmers to reap benefits while long term, income-generating crops are establishing. Besides alleviating the risk against total crop failure, generate extra income; improve productivity per unit area, time and inputs as a result of more efficient utilization of resources like sunlight, soil, water and labour.

Agroforestry systems play major role in the protecting environment and forests (Gaur *et al*, 1993; Quli, 2001) [6, 11]. There is immense potential in agroforestry systems to enhance productivity and sustainability of agricultural lands or the land resources, which have never been put into service due to so many factors, can be better used by adopting different agroforestry practices like inclusion of ginger and turmeric cultivation in it for high remuneration and useful combination (age and spacing of tree species) if properly managed (with recommended agronomic and/or silvicultural practices for particular region) could increase the production potential sufficiently. Hence, such systems need to be made popular among farmers for sustainable livelihood.

The estimated total tree green cover in the agroforestry system of the country is 111,554 sq km which is 3.39 % of country's geographical area. Physigraphic zone-wise tree green cover is maximum in West Coast (13,523 sq km, i.e. 11.15% of geographical area) followed by East Deccan (12,450 sq km). The states having maximum agroforestry area is Maharashtra (11,806 sq km) followed by Gujarat (11,591 sq km) and Rajasthan (8,373 sq km). As percentage to geographical area, the maximum percentage of tree green cover was observed in Lakshadweep (50.0%) followed by dadra and Nagar haveli (11.36%) and Kerala (9.79%) (Anonymous, 2013) [2].

The basic idea of intercropping is not only that two or more crop species grown together can exploit the resources better than either of them grown separately, but also to cover the inherent risks in agriculture and more so, under dry land condition which is buffered to some extent and is called as "biological insurance" (Ayyar, 1963) [3].

The choice of intercrop is important as the economic returns depend on particular tree species (the performance of the intercrop is affected by root system, canopy, allelopathic effect of litter etc. of the tree crop). The choice of crops is also determined by the technical factors like agro-climatic and edaphic conditions. Agroforestry systems with judicious mixing of crop, tree and grasses meet most of basic requirements of mankind and his livestock. When two or more crops with different rooting systems, a different pattern of water and nutrient demands and a

different above ground habits, are planted together, water, nutrients and sunlight are used more efficiently. Therefore the combined yields of crops grown as intercrops can be higher than the yield of the same crop grown as pure stand.

So, there is an urgent need for evolving ways and means to encourage the Indian masses to conserve the forests and/or reduce the pressure on forests for various demands by growing more trees in non-forest areas and adopting agroforestry practices on parts of agricultural lands and wastelands at national level (Khosla, 1995) [7]. Vegetable crops are high output crops as compared to other field crops. They can be cultivated in plains and hills at different altitudes. Growing of vegetables in agroforestry systems not only cater house hold requirements of farmers and gives additional income but also provides employment for labour round the year (Bandyopadhyay, 1997) [4].

Ginger and Turmeric are most suitable vegetables (Spice crops) for intercropping in agro-forestry systems in Prehumid –Subhumid and Semihumid-Semiarid regions from lowlands (500 mt.) to medium elevation (500-1000 mt.) (Nair, 1993) [8]. India is the largest producer of ginger and turmeric in the world. Ginger is an indigenous plant where as Turmeric is native to tropical south East Asia. Ginger (*Zingiber officinale* L.) is an important commercial crop grown for its aromatic rhizomes, which are used both as a spice and a medicine. Ginger (*Zingiber officinale* L.) is an indigenous plant and important spice worldwide. In India, It is grown in an area of 1, 25, 347 ha with a production of 9, 24, 417 tonnes of ginger. Karnataka, Orissa and west Bengal account for more area under ginger though it is grown in almost all states of the country. India is the largest producer (70 % of world production) and exporter to more than 50 countries. India, China, Taiwan, Sierra and Nigeria are the major exporter of dry ginger. The ginger growing area in Gujarat is 4, 389 ha with the production of 70, 646 tonnes. In processed ginger, very recently the manufacture of ginger paste has just began on a commercial scale. In the ayurvedic system of medicine, ginger is used as a carminative and stimulant. Ginger oil is used in medicated ointments.

Material and Methods

The field experiments were conducted under support irrigation conditions during *kharif* season 2013-14 and 2014-15 at Navsari Agricultural University, Navsari, Gujarat to study the growth and yield of Ginger (*Zingiber officinale* L.) under different Sapota and Jatropha based agro-forestry systems in south Gujarat. Geographically, Navsari is situated at 20^0 95'N latitude, 75^0 90'E longitude and at an altitude of 10 metres above the mean sea level. The college farm is located 3 km away in west from Navsari city and 12 km away in the East from the historical place Dandi on Arabian Sea shore. The climate of the area is characterized by three well defined seasons *viz*., monsoon, winter and summer. The monsoon commences from the middle of June and ends by the second fortnight of September. Pre-monsoon rains in the last week of May or in the first week of June are not uncommon. Most of the precipitation is received from South West monsoon, concentrated during the month of June, July and August. The winter season starts from November with mild cold and lasts up to February. December and January are the coldest months of the season and the minimum temperature registered during these months of the experimental period were 13.4^0C and 9.6^0C, respectively. Summer season commence during the middle of February and ends during middle of June. The temperature reached a maximum of 34.9 ^{0}C in the month of May. April and May are the hottest months of summer season. The climate of this area is humid and the mean relative humidity remained above 68.27 per cent throughout the year. The nine year old plantation of Sapota (*Manilkara acharas* (Mill) Fosberg.) at 10.0 x 10.0 m spacing grown with seven year old plantation of Jatropha (*Jatropha curcus* L.) at 2.5 x 2.5m spacing were used for intercropping study. Ginger crop with two varieties *viz*., **(***Zingiber officinale* L var. Navsari local and Udaipur local**)** were selected for the present study. The experiment as laid out in Randomized Block Design (RBD) with three replications and eight treatments for attributes of Ginger growth and yield.

Result and discussion

The observations regarding growth and yield status of Ginger (Table No. 1 & 2 and Figure No. 1, 2 & 3) showed that at the harvesting stage, ginger recorded significant variability in various morphological observations under different agroforestry systems among both the varieties when compared to the sole cropping for first and second year. It showed the same trend many times or different trend as per the results of first year or sometimes distinctly different from both the years. The data with respect to the total number of fingers/rhizome of both the varieties of ginger (Navsari local & Udaipur local) as a sole crop and in combination with other agroforestry systems were found non- significant during both the years (2014 and 2015) but found significant in pooled analysis.

It is evident from the results that in first year of study, the maximum length of rhizome (cm) of ginger was found in the treatment G_6 (7.11 cm), which was found significantly at par with the treatments G_2 (6.75 cm) & G_5 (6.74 cm). However, all other treatments remained at par with each other. Same trend was observed in second year of study as well as in pooled analysis. It is evident from the results that in first year of study, the maximum width of rhizome (cm) of ginger was found in the treatment G_6 (4.80 cm), which was found significantly at par with the treatments G_2 (4.61 cm) & G_5 (4.02 cm). However, all other treatments remained at par with each other. Same trend of results was visible in the second year data and in pooled analysis.

These results indicate that both the varieties of ginger performed better either intercropped with sole Jatropha or with Sapota + Jatropha agro-forestry systems in comparison to the sole cropping and cropping under sole Sapota. However, ginger var. Udaipur local performed better than ginger var. Navsari local in all the agroforestry systems for width of rhizome (cm) in both years.

An appraisal of data presented in Table 2.0 for the plant height indicates that in the year 2014, maximum plant height of ginger was found in the treatment G_2 (40.67 cm), which remained at par with the treatments G_6 (40.27 cm) & G_1 (39.23 cm). However, minimum plant height was recorded in the treatment G_3 (27.78 cm), which was found at par with the treatments G_4 (31.54 cm) &G_7 (31.99 cm). In the next year (2015) as indicated by the results, all the treatments were found significantly superior and at par with each other over the treatments G_3 (34.33 cm) & G_4 (35.91 cm) for plant height of ginger crop. Both G_3 & G_4 were also found statistically at par with each other.

These results reveal that plant height of ginger crop was significantly increased in those treatments where ginger was intercropped either with sole Jatropha or with Sapota + Jatropha agroforestry system rather than intercropping with sole Sapota or sole cropping of ginger. However, ginger var.

Udaipur local performed better with regard to plant height in all agroforestry systems and as sole crop. Same pattern of results were found in pooled analysis. This might be due to tree-crop association providing better micro-site conditions than pure crop. Secondly it might be due to less light intensity (partial shade loving nature of ginger plants) under intercropping as compared to open condition. These results are in conformity with the findings of Parihar *et al*. (2015) [9] in turmeric under agri-silvi-horti system, Chaudhary *et al*. (1998) [5] in ginger under mango orchard, Alam, *et al. (*2014) [1] under different regimes of shade in turmeric., Prajapati *et al*. (2007) [10] in ginger, Vanlalhluna and Sahoo (2010) in ginger, turmeric, maize, Saroj *et al.* (2003) [12] in groundnut, wheat, cluster bean, mustard, and Singh *et al.* (1997) [13] in turmeric.

The survival percentage of ginger for both varieties was recorded significantly maximum when grown under sole Jatropha or under Sapota + Jatropha system than sole cropping or with sole Sapota. It is clear from the data specified in Table-2.0 that during the first year, the treatments G_6 (73.21 %), G_5 (70.47 %), G_2 (69.88 %), G_1 (68.98 %) and G_4 (68.23 %) were found significantly superior over the treatments G_7 (59.24 %), G_8 (61.47 %) & G_3 (62.82 %) and remained statistically at par with each other. The minimum survival percentage of ginger crop was recorded in treatment G_7 (59.24 %), which was found at par with the treatments G_8 (61.47 %) & G_3 (62.82 %). This may be due to their capability to grow better with the partial shade conditions and establishing root system, ability to retain more soil moisture and provided better microclimate. It may also be due to the possibility of their compatibility, interaction and greater biological efficiency of crop grown in association. These results are in conformity with the findings of Vanlalhluna and Sahoo (2009) [15] in ginger and turmeric under intercropping.

The maximum rhizome yield (fresh) was observed in the treatment G_2 (61.23 q /ha), which was found statistically at par with the treatments G_6 (58.79 q /ha), G1 (56.68 q /ha), & G_5 (50.91q /ha). The minimum rhizome yield of ginger (fresh) was recorded in treatment G_3 (32.47q/ha), which was found statistically on the same bar with the treatments G_7 (35.78 q /ha), G4 (42.20 q /ha), & G_8 (42.69q /ha) during the first year. Similar pattern of results were found in the second year of study as well as in pooled analysis. These results clearly indicate that those treatments performed better, where ginger was intercropped either under Sapota + Jatropha or sole Jatropha agroforestry systems. Probably with regard to rhizome yield (fresh) (q/ha), ginger var. Udaipur local performed better than var. Navsari local in both the years as well as in pooled analysis among different agroforestry systems. This might be due to less light intensity (shade loving nature of ginger plants) under intercropping as compared to open condition. These results are in conformity with the findings of Prajapati *et al.* (2007) [10] in ginger, Vanlalhluna and Sahoo (2010) [15] in ginger, turmeric, maize, Singh *et al.* (1997) [13] in turmeric and Saroj *et al.* (2003) [12] in groundnut, wheat, cluster bean and mustard.

On the basis of present investigation, it may be concluded that, growing of ginger crop with Sapota + Jatropha or Jatropha only resulted in significant increase in the growth as well as the Yield as compared to growing ginger as a sole crop or under sole Sapota based agroforestry systems. Significantly maximum plant height, length of rhizome, width of rhizome and survival percent was observed under intercropping with Jatropha as compared to sole crops. Significantly maximum fresh rhizome yield and total number of fingers per plant of ginger was registered under Sapota + Jatropha agro-forestry systems.

Table 1: Growth parameters of Ginger under Sapota-Jatropha based Agro-forestry systems.

Treatments	Total number of fingers per rhizome			Length of rhizome (cm)			Width of rhizome (cm)		
	Yr I	Yr II	Pooled	Yr I	Yr II	Pooled	Yr I	Yr II	Pooled
G_1 (Sapota + Jatropha + Ginger var. Navsari local)	4.22	4.05	4.13	6.22	6.86	6.54	3.77	4.08	3.92
G_2 (Sapota + Jatropha + Ginger var.Udaipur local)	4.77	4.65	4.71	6.75	7.36	7.05	4.61	4.68	4.65
G_3 (Sapota + Ginger var. Navsari local)	4.12	4.04	4.08	5.46	5.63	5.55	3.12	3.46	3.29
G_4 (Sapota + Ginger var.Udaipur local)	4.40	4.18	4.29	5.87	6.06	5.96	3.40	3.58	3.49
G_5 (Jatropha + Ginger var. Navsari local)	4.33	4.12	4.22	6.74	7.20	6.97	4.02	4.20	4.11
G_6 (Jatropha + Ginger var.Udaipur local)	4.55	4.65	4.60	7.11	7.36	7.24	4.80	5.16	4.98
G_7 (Ginger var. Navsari local sole)	3.77	3.77	3.77	5.91	6.16	6.03	3.67	3.67	3.67
G_8 (Ginger var.Udaipur local sole)	3.93	3.83	3.88	6.18	6.52	6.35	3.73	3.90	3.82
S. Em ±	0.284	0.241	0.168	0.284	0.337	0.202	0.294	0.274	0.182
CD at 5 %	NS	NS	0.48	0.86	1.02	0.58	0.89	0.83	0.52
CV %	11.55	10.03	10.83	7.84	8.81	8.36	13.07	11.61	12.31

Table 2: Growth and Yield parameters of Ginger under Sapota-Jatropha based Agro-forestry systems

Treatments	Height of Plants (cm)			Survival percent			Rhizome yield (Fresh) q ha^{-1}		
	Yr I	Yr II	Pooled	Yr I	Yr II	Pooled	Yr I	Yr II	Pooled
G_1 (Sapota + Jatropha + Ginger var. Navsari local)	39.23	41.67	40.45	68.98	67.83	68.41	56.68	53.72	55.20
G_2 (Sapota + Jatropha + Ginger var.Udaipur local)	40.67	42.80	41.73	69.88	68.98	69.43	61.23	59.99	60.61
G_3 (Sapota + Ginger var. Navsari local)	27.78	34.33	31.06	62.82	61.86	62.34	32.47	32.48	32.47
G_4 (Sapota + Ginger var.Udaipur local)	31.54	35.91	33.73	68.23	64.33	66.28	42.20	35.94	39.07
G_5 (Jatropha + Ginger var. Navsari local)	38.31	42.95	40.63	70.47	69.87	70.17	50.91	51.13	51.02
G_6 (Jatropha + Ginger var.Udaipur local)	40.27	44.29	42.28	73.21	74.10	73.66	58.79	59.06	58.92
G_7 (Ginger var. Navsari local sole)	31.99	39.83	35.91	59.24	58.91	59.08	35.78	32.21	34.00
G_8 (Ginger var.Udaipur local sole)	33.63	41.37	37.50	61.47	59.59	60.53	42.69	39.78	41.24
S. Em ±	1.644	1.926	1.24	2.876	3.025	1.891	4.382	3.881	2.668
CD at 5 %	4.99	5.84	3.55	8.72	9.17	5.43	13.29	11.77	7.67
CV %	8.04	8.26	8.18	7.46	7.98	7.72	15.95	14.76	15.40

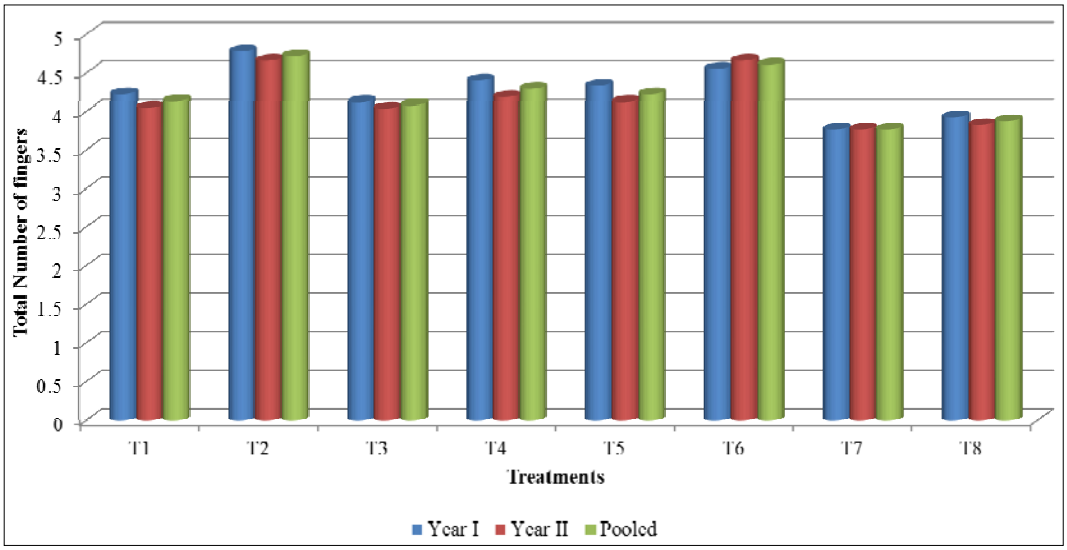

Fig 1: Total number of fingers/rhizome of Ginger under Sapota-Jatropha based Agro-forestry systems.

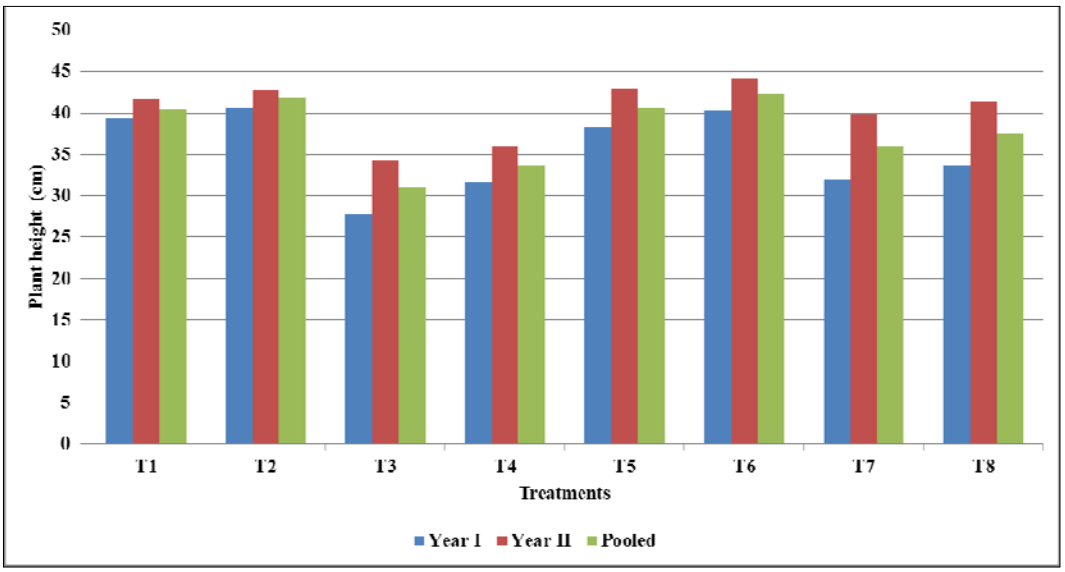

Fig 2: Plant height (cm) of Ginger under Sapota-Jatropha based Agro-forestry systems.

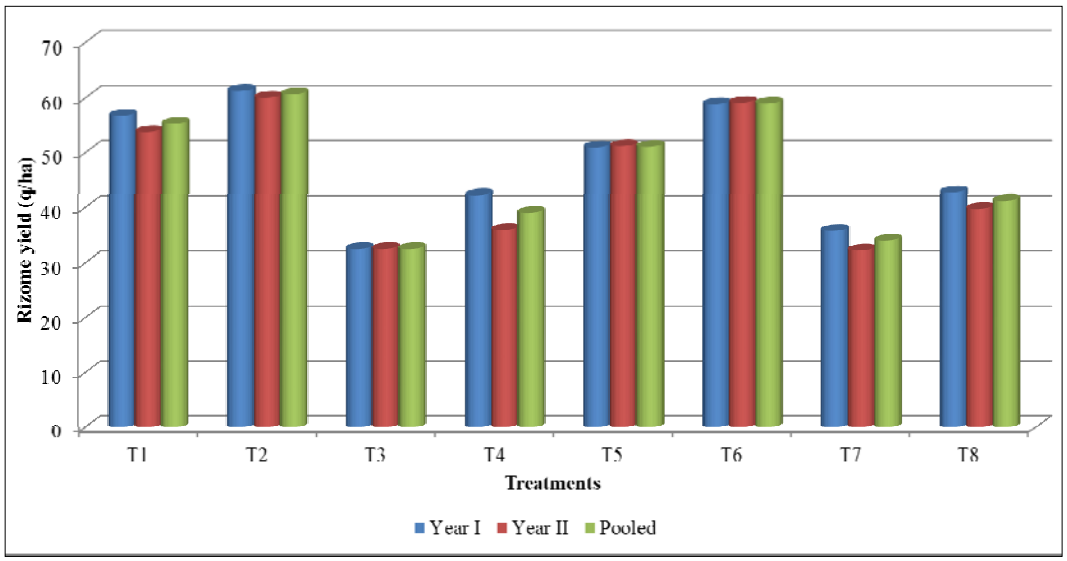

Fig 3: Rhizome yield (Fresh) (q/ha) of Ginger under Sapota-Jatropha based Agro-forestry systems

Plate-IV : Performance of Ginger (*Zingiber officinale* L.) under Sapota-Jatropha based agro-forestry systems

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