"Performance of Different Fruit Crop Modules Under Rainfed Condition."

By

MISS. SHEELA VIJAY MURAGOD.
(Reg. No. D/013/345)

A Thesis Submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST.AHMEDNAGAR,
MAHARASHTRA, INDIA**

In partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (HORTICULTURE)

in

FRUIT SCIENCE

**HORTICULTURE SECTION,
COLLEGE OF AGRICULTURE, DHULE-424004
MAHARASHTRA, INDIA**

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Approved by

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CANDIDATE'S DECLARATION

I hereby declare that this thesis or part there of has not been submitted by me or other person to any other University or Institute for a Degree or Diploma

Place: Dhule **(Miss. Sheela V.M)**

Dated: / /2015

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CERTIFICATE

This is to certify that the thesis entitled, **"Performance of different fruit crop modules under rainfed condition."** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State, India, in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE** embodies the results of piece of *bona fide* research work carried out by **Miss. SHEELA VIJAY MURAGOD**, under my guidance and supervision and that no part of the thesis has been submitted to any other university for Degree or Diploma or publication in other form.

The assistance and help received during the course of this investigation and sources of reference have been duly acknowledged.

Place: Dhule (C.V. Pujari)
Date: / /2015 **Chairman and Research Guide**

Prof. (Dr.) P.N. Rasal
Associate Dean,
College of Agriculture,
Dhule-424004,
Maharashtra, (INDIA)

CERTIFICATE

This is to certify that the thesis entitled, **"PERFORMANCE OF DIFFERENT FRUIT CROP MODULES UNDER RAINFED CONDITION"**, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State, India, in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE** embodies the results of piece of *bona fide* research work carried out by **MISS. SHEELA VIJAY MURAGOD**, under the guidance and supervision of **Dr. C.V. Pujari**, Associate Professor, Horticulture Section, College of Agriculture, Dhule, Dist. Dhule, Maharashtra (India). It is sufficiently high standard to warrant its submission to the University for the Award of said degree. No part of the thesis has been submitted to any other University for degree or diploma.

Place: Dhule
Date: / /2015.

(P.N. Rasal)
Associate Dean

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Place : *Dhule*

Date: */ / 2015.* ***(Muragod S.V.)***

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LIST OF ABBREVIATIONS

%	Per cent
/	Per
^{0}C	Degree Celsius
Abst.	Abstract
BCR	Benefit cost ratio
C.D.	Critical difference
Cm	Centimeter
cv.	Cultivar
et al.	And others (et alli)
etc.	And so forth (*et Cetera*)
Eq.	Equivalent
Fig.	Figure
g	Gram
i.e.	That is
Kg.	Kilogram
M	Meter
No.	Number
Pp.	Page (s)
Rs.	Rupees
S.E. (m) ±	Standard error of mean
T	Treatment
t	Tonnes
Var.	Variety
Viz.,	Namely
Av.	Average

ABSTRACT

PERFORMANCE OF DIFFERENT FRUIT CROP MODULES UNDER RAINFED CONDITION

By
Miss. SHEELA VIJAY MURAGOD

A candidate for the degree
of
MASTER OF SCIENCE (HORTICULTURE)
in
FRUIT SCIENCE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413722
2015

Chairman and Research Guide : Dr. C. V. Pujari
Discipline : Horticulture (Fruit Science)

Present experiment entitled "Performance of different fruit crop modules under rainfed condition" was carried out at Research farm, Horticulture section, College of Agriculture, Dhule during 2014. The experiment was laid out in Randomized Block Design with eight treatments and five replications. The treatment comprised of different fruit crop combinations designated as Module-1 comprised of (Mango+ Custard apple+Aonla+Drumstick), Module-2 (Mango+Custard apple+Aonla) and Module-3 (Mango+Custard apple+Jamun) along with sole of each crop under the modules. Experimental results showed that as compared to sole crop the yield of crops under the modules was less, but in modules T_2 recorded the highest yield in mango and aonla.

Drumstick in module-1 performance was not good as compared to sole crop, the highest number of fruits per plant was observed in T_8 - sole drumstick (167.35) and in T_1 (Mango

+ Custard apple + Aonla + Drumstick) it was (92.60), average weight of the fruit the highest in T_7 - sole drumstick crop (66.75 g), and in T_1 (Mango + Custard apple + Aonla + Drumstick), it recorded (60.06 g), yield kg per plant was highest in T_8 - sole drumstick crop (11.16 kg) and in T_1 (Mango + Custard apple + Aonla + Drumstick), it was obtained about (5.53 kg). Yield per ha was the highest in T_8 - sole drumstick (7.44 t ha^{-1}) and in T_1 (Mango + Custard apple + Aonla + Drumstick) it was (0.49 t ha^{-1}).

In second module the fruit crops like mango and aonla showed good results. The highest number of fruits per plant in Mango in T_2 - (Mango + Custard apple + Aonla) was (69.25) and in T_4 - sole mango crop (80.70), in Aonla the number of fruits in T_2 - (1206.66) and in T_6 – sole aonla crop (1386.25), maximum average fruit weight in mango in T_2 - (173.35 g), in T_4 - sole crop (184.18 g), in Aonla in T_2 - (29.14 g) and in sole aonla crop T_6 - (28.41 g), yield kg per plant in Mango in T_2 - (12.00 kg) and in T_4 - sole crop (14.85 kg), in Aonla T_2 - (35.34 kg), whereas, T_6 - sole crop (39.40 kg), maximum yield per ha was observed in Mango in T_2 - (1.19 t ha^{-1}) and in T_4 sole mango crop (1.48 t ha^{-1}), in Aonla (6.37 t ha^{-1}), was obtained in T_2 (Mango + Custard apple + Aonla) and in T_6 - sole aonla crop (10.94 t ha^{-1}), also the highest equivalent yield of (5.07 t ha^{-1}) in T_2, in sole crop it was (1.48 t ha^{-1}) and highest BCR of 1: 3.21 in T_2 (Mango + Custard apple + Aonla) in sole crop it was 1: 2.74.

In case of custard apple and jamun the same trend was observed; as a sole crop they performed very well but in

modules custard apple and jamun shows good results in the treatment T_3 - (Mango + Custard apple + Jamun), with the highest number of fruits in custard apple (63.15), and in jamun (164.53) in sole crop they recorded (71.10) in custard apple and in jamun (269.10), average weight of the fruit in T_3 - (154.39 g) in custard apple and in jamun, it was (18.63 g), in T_5 - sole custard apple crop (172.24 g) and in T_7 - sole jamun crop recorded (19.4 g), yield kg per plant (9.74 kg) in module-3 in custard apple and in jamun it was (3.06 kg), in T_5 - sole custard apple crop (12.23 kg) and in T_7 - jamun sole (5.20 kg). Yield per ha (0.86 t ha^{-1}) in custard apple and in jamun (0.54 t ha^{-1}) in module-3, in custard apple sole crop (4.89 t ha^{-1}) in jamun sole crop it was (0.51 t ha^{-1}).

Inferences can be drawn from the overall results of the present study that the mixed fruit cropping improves yield and generates income also, as equivalent yield and returns are more than that of sole (mono) crop. Secondly, the treatment T_2 (Mango + Custard apple + Aonla) resulted in increased productivity and profitability of the particular Module and hence it was found to be the most feasible combination for dryland conditions owing to its higher equivalent yield and net returns; and also optimum association between these fruit crops, as compared to other modules. In another words, it can be said that mango, custard apple and aonla can be adjudged as the best companion crops for dryland conditions.

It is further felt that long term assessment of these modules is essential for more precise inferences.

1. INTRODUCTION

There is quantum jump in area and production of horticultural crops in last two decades which is evident from an increase in area from 127.70 lakh hectares in 1991-92 to 236.94 lakh hectares in 2012-13; and production from 965.62 lakh million tones in 1991-92 to 2688.47 lakh million tones in 2012-13 (Tiwari *et al.* 2014). In the year 2014, India emerged as a major producer of horticultural crops with the production of 268.82 million tones surpassing the food grain production of 264.77 million tones and is placed second after China in both fruit and vegetables production (Tiwari *et al.* 2014). Besides this, horticulture in India with its higher annual growth rate has become a significant contributor to growth of Indian agriculture and thus the economy of the country. This is because of development of new high yielding cultivars and production technologies. However, this encouraged monocropping system *i.e.* growing of single crop from the same piece of land along with the use of high inputs such as chemical fertilizers, pesticides, weedicides, plant growth regulators, etc. in order to maintain the yield levels. This means modern intensive agricultural system (often referred to as industrialized production of crops) is often based on optimizing the productivity of monocultures (Malezieux *et al.* 2009). In those systems, crop diversity is reduced to one or very few species that are generally homogenous, the planting, layout is uniform and symmetrical, and external inputs are often supplied in large quantities. Such systems

are criticized for their negative impacts, such as soil erosion and degradation, chemical contamination, loss of biodiversity and fossil fuel use (Giller *et al.* 1997, Griffon 1999 and Tilman *et al.* 2002).

The climate related aberrations have been significantly affecting crop productivity in India. Some times failure of the total crop occurs due to natural calamities viz. frequent droughts, floods, unseasonal rains, cold waves, hot waves. Such climate aberrations not only affect the stability of food production, but also livelihood security of the farmers. Thus, the problems faced by the horticulture industry in the future are more complex than those faced prior to and during green revolution era.

The demand driven paths to meet the production targets have resulted in over exploitation and degradation of natural resources. Deforestation, soil degradation, water and air pollution, and loss of biodiversity have become widespread problem affecting every ecosystem in the country. Dryland regions are more dependent on natural resources and suffer most from natural resource degradation. The situation is also further aggravated by climate change, the impact of which is being witnessed all over the world. But, country like India is more vulnerable in view of the high population depending upon agriculture and excessive pressure on natural resources. Therefore, there is an urgent need to shift thrust of research and development programmes for enhancement of total production to

engruence among productivity, sustainability, environmental soundness, profitability and equity.

Several mitigation strategies such as crop-based strategies (growing crop and their varieties that fit to changed climatic conditions), resource conservation, rainwater conservation, soil carbon sequestration, multiple cropping systems, cultural practices such as green manuring and cover cropping, etc. are suggested. Of these strategies, multiple or mixed fruit cropping systems is often considered as a practical application of ecological principles based on biodiversity, plant interactions and other natural regulation mechanisms. They are assumed to have potential advantage in productivity, stability of outputs, resilience to disruption and ecological sustainability. Multiple cropping systems use management practices where the total crop production from a single piece of land is achieved by growing several crops simultaneously and have great potential in dryland regions. According to Nelliate and Iyer (1977) the term mixed cropping is used to denote growing perennial crops in the inter spaces of plantation crops like coconut and arecanut. Mixed cropping is one of the major forms of multiple cropping than any potential system for increasing crop production, especially under subsistence farming. Thus main objective of multiple cropping is to increase the total production and income per unit area and time (Shahapurmath *et al.* 2003).

In orchard crops mostly sole cropping of unit crop is undertaken. Fruits have long gestation period and farmers have to wait for long period for returns over investment. Moreover, the yields from fruit crop are realized only once in a year in particular season and there is no insurance if the crop fails due to aberrant climatic conditions or outbreak of pest or diseases. Further, some fruit crops like mango which exhibit lower orchard efficiency as compared to many other fruit crops due to various limiting factors such as flower induction, alternate bearing, flower and fruit drop, adverse climatic conditions and occurrence of insect-pest and diseases (Baghel *et al.* 2003). Therefore, to mitigate the risk of crop failure and also to utilize resources effectively and ecofriendly, suitable crop combinations, involving perennial and hardy fruit crops, seems to be a promising proposition to get multiple outputs for ensuring production and income generation in a sustainable manner. Further, it is the most ideal strategy to provide food, nutrition, and income security to the farmers (Chundawat, 2014, Bhandari, *et al.,* 2014; Chadha, 2002,) and regular employment also (Thomas *et al.* 2011). The multiple cropping systems enable utililization of the resources very effectively and maintain environmental sustainability. The multiple or mixed fruit cropping systems are ideally suited for small holding growers as it envisage maximum production per unit area and time.

Extensive work has been done on the intercropping system with agronomic and vegetable crops in the fruit orchards during the pre-bearing stage of the fruit crop. But the evidences on multiple or mixed fruit cropping using different fruit crop species are sporadic and scanty. In view of this, the present investigation entitled "Performance of different fruit crop modules under rainfed conditions" was undertaken to assess the performance of combinations of different fruit crops and one perennial vegetable crop which henceforth are referred as fruit crop modules. Fruit crops namely Mango (*Mangifera indica* L.), Custard apple (*Annona squamosa L.*), Aonla (*Emblica officinalis L.*), Jamun (*Syzigium cumini L.*) and Drumstick (*Moringa oleifera*), a perennial vegetable which were planted making different combinations of modules. The crops were selected considering their better performance under dryland conditions and also for their non synchronous nature with different flowering and harvesting period so as to enable a steady supply of income to the grower and also employment throughout the year. Besides ideal dryland crops, these fruits are nutritious with medicinal value and widen the food basket.

The objectives of present investigation are as follows -

1. To study the performance of different fruit crop modules under *rainfed* conditions.
2. To evaluate the suitability of fruit crops in mixed cropping.

2. REVIEW OF LITERATURE

Density of population is increasing at higher rate and at the same time natural resources viz. land and water are shrinking day by day. The need for maintaining the population-food-nutrition balance should be overemphasized. Intensive agriculture systems involve monoculture associated with high input of chemical fertilizers, pesticides and growth substances. But today, the negative impacts of intensive agriculture systems on soil, water quality and on biodiversity are clearly realized. This situation warrant us shifting from monoculture cropping system to multiple or mixed fruit cropping systems with due careful mixing of fruit species (Malezieux *et al.* 2009). As evident from the literature, potential advantages of the multiple or mixed fruit cropping systems are (1) Higher overall productivity, (2) Better mitigation of risk due to aberrant climate,(3) Enhanced ecological services, and (4) Greater economic profitability (Shahapurmath *et al.* 2003; Malezieux *et al.* 2009, Arya *et al.* 2011; Hare Krishan *et al.* 2013).

Here efforts have been made to review the research work on this aspect and research findings are discussed below under the appropriate headings.

2.1 Concept

The term ***cropping system*** refers to the crops and crop sequences and the management techniques used on a particular field over a period of years. The term usually refers

to a combination of crops in time and space. This term is not a new one but it has been used more often in recent years in discussions about sustainability of our agricultural production systems**. Multiple cropping** is the intensification of cropping in time and space dimensions. Multiple cropping involves the planting of more than one crop on a single piece of land. The term mixed fruit cropping or fruit crop- based cropping system is also synonymously used. **Monocropping** or **monoculture** refers to the presence of a single crop in a field. This term is often used to refer growing the same crop year after year in the same field; this practice is better described as continuous cropping, or continuous monocropping.

In large scale farming, monocropping *i.e.* growing of only one crop and that too one variety is common. But such monocropping is highly vulnerable to aberrant climatic conditions, pests and diseases and sometimes crop failure may occur. Apart from this, monocropping reduces biodiversity. In contrast to monocropping, multiple cropping offers several advantages. Fragile agro-ecosystem especially in arid regions, where climatic catastrophe is more, monoculture of either seasonal or perennial crops is always under threat of failure. For sustainable production and ecological restoration, fruit based cropping system is considered to be the most ideal strategy for economizing productivity, generating employment opportunities, improving economic conditions of the farmers and

entrepreneurs, increasing export and nutritional security to the people (Chadha, 2002).

Multiple cropping enables to address the food and nutritional security through inclusion of suitable crops. There is insurance against the vagaries of weather, diseases and pests and provides better livelihood due to greater economic returns per unit area (Bekunda and Woomer, 1996; Trenbath, 1999; Dhakar *et al.* 2013; Hare Krishna *et al.* 2013). Multiple cropping substantially contributes to the ecosystem services through increased carbon sequestration, water infiltration and moisture retention and prevention of soil loss by runoff. Employment generation is considerably enhanced due to crop diversification and intensification (Thomas *et al.* 2011). Intercropping, a form of multiple cropping is commonly followed in fruit crop especially during the formative years of the fruit crops. But in mixed fruit cropping compatible perennial fruit crops are planted in the interspaces of orchard (Ouma and Jeruto, 2010; Chundawat, 2014).

2.2. Growth performance and yield benefits

Bajwa and Ali Niaj (1945) suggested to grow the intercrops like papaya, nursery plants, vegetables, fodder, pulses, etc., considering climate, soil, rainfall and irrigation water available at a location.

Research results of Allen (1955) suggested that the crops viz. Liberian and robusta coffee, cacao, manila hemp, banana, pineapple, derris, gambier, tea, oil palm, kapok, fruit

trees (rambutan, lime, grapefruit, durian and mangosteen), sisal, *Fureraea gigantea,* patchouli, legume leys (*Centrosoma pubescens*), balsa and *Gmelina arborea*, are suitable for inter-planting with hedge row planted rubber. Hayes (1960) reported that many growers preferred quick growing fruits like guava, phalsa, papaya and banana as interplantation. Singh, (1968) reported that progressive orchardists in Uttar Pradesh generally grow phalsa (*Grewia asiatica* L.), papaya (*Carica papaya* L.), guava (*Psidium guajava* L.) and citrus species in the interspaces to supplement their income during early year of mango planting.

The experiments carried out by Chandrasekera (1977) at the Rubber Research Institute, Sri Lanka indicated the suitability of cocoa, coffee, banana, pineapple, passion fruit for intercropping with rubber. These crops require only circle weeding as it was done with rubber while the rest of the land could remain in ground cover. For intercropping, the rubber is best planted at spacing of 8 ft x 30ft (2.4 x 9 m) which gave a theoretical stand of 180 planting points to the acre. It had also recommended to plant the single row of cacao, coffee, passion fruit or bananas in between each pair of rubber rows.

Cuevas (1981) found coconut + pineapple + papaya + coffee + jackfruit as one of the promising crop combination in a multi-storey cropping system. The cropping sequence involved planting pineapple under coconut first, at a spacing of 30 x 100 cm, followed by two rows of papaya spaced at 3 x 3 m within the inter-rows and jackfruit between the

coconuts. Then within the rows of papaya, coffee is planted at the centre of each coconut block of four palms. The early-maturing papaya is harvested at the end of the first year, continuing until the end of the third year. Pineapple is harvested in the second year and allowed to ratoon thereafter. By the time papaya and pineapple are abandoned, coffee and jackfruit are expected to provide continuous return flows.

Margate and Magat (1983) studied the effect of different cropping patterns under coconut on coconut yield and profitability and reported that the planting of black pepper + papaya/ cacao + pineapple under coconut markedly improved nut and copra production per palm. In addition, the same cropping pattern gave the highest additional intercrop products in all cropping years. A net profit of 8,234.00 pounds per ha per cropping was realized during the full productive stage of the intercrop as against 2,494.00 pounds from the monoculture.

Bhuva *et al.* (1988) investigated the effect of different intercrops (two long duration, *i.e.* banana and tapioca) and two short duration, *i.e.* tomato followed by cluster bean and brinjal followed by cowpea) on yield and its economics in newly planted orchards of mango cv. Rajapuri for three years. The treatments were T_1 (Mango + banana), T_2 (Mango + tapioca), T_3 (Mango + tomato followed by cluster bean), T_4 (Mango + brinjal followed by cowpea) and T_6 Control (Mango alone). Amongst these four treatments, T_3 (Mango + tomato followed by cluster bean) appeared economical in view of

NCBR of 1:1.22 which gave net income of Rs. 8,944/- ha^{-1}. They further reported that growth and yield of mango was not affected by treatments.

Rajput *et al.* (1988) studied the potential of intercropping in young mango orchard cv. Dasheri with intercrops like vegetables, pulses and wheat which were grown in particular rotation. The intercrops did not have significant effect on the growth and yield of Dasheri mango. All the intercrops grown in the company of mango plants produced normal yield. In case of vegetables, the highest monetary return (Rs. 4,120/- ha^{-1}) was obtained from cowpea + potato + mango and the lowest from the control (Rs.192/- ha^{-1}).

Rajput *et al.* (1989) carried out an experiment on mango based cereal-pulse cropping system to assess the viability of cereal-pulse as an intercrops on 7-year old mango orchard cv. Dasheri and realized maximum net income from cow-pea rotation followed by green gram and wheat. They also concluded that the interspace in mango can be successfully exploited to increase income from orchards in the initial years without deleterious effect on yield potential of mango.

Maheswarappa *et al.* (2001) studied the impact of integrated mixed farming system in coconut garden on coconut yield and economics on 18 years old coconut plantation with different components. They observed an increase in the nutritional status of coconut and nut yield over the years with mixed farming. Also realized a net return

between Rs. 49,700/- and Rs. 1,26,900/- and the benefit: cost ratio of 1.36.

Baghel *et al.* (2003) studied the productivity and profitability of mango based intercropping system under rainfed agro-climatic conditions of Madhya Pradesh and reported that cowpea (*Kharif*) followed by bengal gram (*Rabi*) gave maximum productivity per hectare followed by pigeon pea + tomato as an companion intercrops. However, they realized maximum monetary returns in Pigeon pea + Tomato grown in 2:2 paired rows as companion intercrops.

Girish *et al.* (2003) studied the performance of arecanut based mixed cropping systems with pepper, banana and cardamom with different combinations and reported more growth and yield of main crop of arecanut in mixed cropping due to increased number of leaves (fronds) and increased yield per palm compared to sole crop. There was increased yield (chali kg/palm) of arecanut in T_6 (A+C+P) and T_8 (A+C+B+P) cropping models (3.12 kg and 3.05 kg), respectively, when compared to mono cropping of arecanut (2.95kg). Yield performance of cardamom as a component crop was satisfactory in all the cropping systems except in T_8 due to increased plant density that eventually resulted in crop competition. There was no significant difference in the yield performance of banana among all the different arecanut based mixed cropping models. This indicated that, other associated crops (pepper and cardamom) have a little or no negative influence on the performance of banana. Yield of pepper was found to be better under T_3 (A+P) and T_6 (A+C+P)

yielding (25.47 q ha^{-1}) and (22.22 q $ha^{-1)}$, respectively indicating the positive effect of cardamom on pepper. All the mixed cropping systems under study were found economically better with an elevated net profit per hectare ranging from Rs. 3,52,858/- in A+C+P to Rs. 1,69,539/- in A+P, respectively and have recorded 141.30 % and 119.69 % more profits over and above the profit from sole crop.

Nath *et al.* (2003) observed maximum canopy spread of mango in the combination mango + Guava + *Stylosanthes* during the initial years under mango based cropping system. In sole mango plots, paddy and *Stylosanthes* helped in improving canopy spread of mango plants during 2004. Tree volume is a derived value from plant height and canopy spread. Tree volume showed increasing trend during the study period due to the vegetative phase of the mango plants. Among the treatments, cowpea with guava and *Stylosanthes* without guava recorded the maximum tree volume of mango plants (22.8 m^3) during 2004.

Jahir *et al.* (2004) conducted experiment on the existing multistoried coconut orchard, to investigate the performance of lemon and guava grown under coconut based multistoried agroforestry system during the period of January to August 2004. The result revealed that, the highest plant growth and best yield contributing characters of lemon was found in coconut + lemon based agroforestry system. The highest plant height, number of leaves, flowers, fruits, harvested fruits, single fruit weight, total yield and TSS were obtained when lemon grown under coconut + lemon based agroforestry

system. But for the guava plant, the highest plant height, number of leaves, flowers, fruits, harvested fruits, single fruit weight and total yield were obtained when guava grown under open condition. They also observed decrease in total soluble solids (TSS) content of both lemon and guava in different treatments in full sunny place.

Marimuthu (2005) in a field experiment on 25 - year old coconut noted increase in yield year after year by intercropping. Based on the coconut yield, net income and B: C ratio, he reported that coconut + banana + sirukizhangu (*Coleus parviflorus*) + bhendi as the most promising combination.

Jain and Raut (2006) studied the efficacy of different intercrops (paddy, black gram, pigeon pea, ginger, pomegranate) in mango orchard and their effect on growth characters of mango and observed that the plant height and canopy area of the mango was maximum with paddy followed by black gram intercrops. The minimum plant height and canopy area was observed in ginger + mango followed by ginger + mango + pomegranate. Girth was maximum in pigeon pea + mango + pomegranate which was on par with black gram + mango + pigeon pea and black gram + mango + pomegranate.

Ranpise *et al.* (2006) studied the performance of different intercrops namely cowpea, seasmum, gram and mustard in aonla and ber; and found that cowpea was beneficial intercrop both in aonla and ber which realized additional income too.

Ratha and Swain (2006) conducted an investigation on intercropping in a six year-old mango orchard planted at 9 m x 9m spacing to identify suitable *Kharif* season intercrops for higher economic returns with the intercrops ginger, french bean, cowpea, tomato and paddy. The results of the two years of investigation indicated that, the average maximum number of fruits per plant in mango was recorded with the intercrop french bean (80) followed by cowpea (75), which was significantly higher over the sole crops of mango (47). They also concluded that mango + ginger combination proved to be the best in terms of monetary benefits (Rs. 64,940/- ha^{-1}) followed by mango + cowpea (Rs. 30,210/- ha^{-1}) as against Rs. 8,270/- from sole mango crop under similar situation.

Mutanal *et al.* (2007) studied the mixed cropping of tree species with Tamarind *(Tamarindus indica*) cv. Prathisthan planted at 12 m x 12 m spacing on the degraded and stony shallow black clayey soils and reported that at the end of 20^{th} year of experimentation, tamarind growth (ht and dbh) was higher with *C. equisetifolia* (10.46 m and 20.85 cm, respectively) and *E. tereticornis* (10.63 m and 19.32 cm, respectively) as compared other tree species. They also observed that, the contribution of income from *E. tereticornis* and *C. equisetifolia* were 85 and 77 % and was the lowest in *D. sissoo* (39.3 %). The average net returns were the highest in tamarind + *E. tereticornis* (Rs. 6179 ha^{-1} yr^{-1}) followed by tamarind + *C. equisetifolia* (Rs. 2938 ha^{-1} yr^{-1}) and was lowest in sole tamarind (Rs. 232 ha^{-1} yr^{-1}). Benefit cost ratio and internal rate of return were higher in tamarind + *E.*

tereticornis (1.79:1 and 18 % respectively) as compared to other tree combinations and sole tamarind (0.39:1 and 12 % respectively).

Nath *et al.* (2007) studied mango and aonla based cropping systems during the years 1998 - 2004 to test the suitability of guava as filler crop in multi-storied cropping model. Mango cultivar Langra and aonla cultivar Kanchan were planted as main crop at a spacing of 10 m apart. Guava was planted as filler crop at 5 m apart between and within the rows after establishment of the main crop. Various intercrop combinations including leguminous vegetables/ crops suitable for the region (Cowpea, French bean, black gram and ground nut), suitable grass species (*Stylosanthes hamata,* deenanath grass) and local staple food (upland paddy, finger millet) in different combinations were taken in the available inter space in each model. In the case of mango based cropping system, the mango plants attained the maximum height in the case of Mango+Guava+Cowpea after 6 years of planting. The guava plants attained the maximum tree height (2.7 m) with *Stylosanthes* as intercrop after 4 years. The maximum yield of guava was obtained in the case of French bean as intercrop. Different crop combinations have shown significant effect on the soil characteristics. In the case of aonla based cropping system, the maximum plant height of aonla was noticed in groundnut intercropping, whereas guava plant attained the maximum height with groundnut and black gram. The maximum yield of guava was obtained with paddy as an intercrop in the 4th year.

Bellow *et al.* (2008) investigated the potential for adoption of fruit-tree-based agroforestry by resource-limited farmers using ethnographic investigation and linear programming simulations of farm activities at the household level. Two communities with differing demographics, infrastructure, and access to regional markets were selected based on the presence of extensive fruit-tree-based agroforestry. The influences of family size, land holdings, and tree and crop yields on the optimal adoption levels of fruit trees were evaluated through a comparative study of the varying social and physical infrastructure present in the two communities. Fruit-tree-based agroforestry was potentially more attractive to relatively prosperous families or those with larger land holdings. Improvements in fruit-tree productivity and interspecies competition were of greater importance where family land holdings were smaller. The inability of families to produce sufficient food to meet annual needs, poor fruit quality, and lack of market infrastructure were identified as constraints that limit adoption. The complementarity of production with the dominant maize (*Zea mays*) crop, home consumption of fruit, and the potential to generate additional cash on limited land holdings were identified as factors promoting adoption of fruit-tree-based agroforestry.

Abouziena *et al.* (2010) studied the efficacy of intercropping mango, Balady mandarin and Egyptian clover (*Trifolium alexandrinum* L) crops in date palm on soil

chemical properties and quality and quantity of date fruits, in comparison with date palm sole. They noted the highest fruit yield/palm by growing mango or mandarin in date palm, whereas there was significant reduction in fruit diameter when intercropping with Egyptian clover in date palm. Intercropping mango gave the highest net profit ($8,213 ha^{-1} yr^{-1}), followed by the same area intercropped with mandarin ($3,992 ha^{-1} yr^{-1}). They concluded that growing mango, mandarin or Egyptian clover with date palm could be used for the higher net return per unit area and also to combat desertification in sandy soil in arid lands regions.

Arya *et al.* (2010) compared the fruit based multi-species cropping systems versus sole cropping system under arid regions of Rajathan by deploying 4 multi-species cropping models and sole of each crop involving 11 treatments. The ground storey crops, namely cluster bean and moth bean were raised during rainy (*kharif*) season, while mustard and brinjal were raised during winter (*rabi*) season. Significant differences were recorded in yield levels of perennial as well as ground storey components in multispecies cropping models as compared to sole cropping. The growth and yield in perennial component were more under the multi-species cropping systems, *i.e.* aonla (*Emblica officinalis*) + ber (*Ziziphus mauritiana*.) + karonda (*Carissa carandas*) + cluster bean (*Trigonella foenum graecum*) + brinjal (*Solanum melongena*) and aonla + ber + karonda + clusterbean + fallow. Minimum yield was recorded in sole perennial crops. Plant height, number of branches/plant,

pods/silique/fruits/plant and yield was found to be superior in multi-species cropping systems of aonla + ber + karonda + cluster bean + brinjal and aonla + ber + karonda + mothbean [*Vigna acontifolia* Jacq. Marechal] + indian mustard (*Brassica juncea* (L) Czernj & Cosson] as compared to sole cropping, except mustard where a reverse trend was observed.

Banerjee and Dhara (2011) initiated a field study to standardize the agri-horti-silvicultural model for rainfed uplands. The experiment involved silvicultural species (*Acacia auriculiformis*), fruit crops [sweet orange (*Citrus sinensis*) and guava (*Psidium guajava*) and arable crops [cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogaea*), blackgram (*Vigna mungo*) and bottle gourd (*Lagenaria siceraria*). Arable crops were grown successfully under two silvihorticultural systems (*A. auriculiformis* + sweet orange and *A. auriculiformis* + guava) during *kharif* seasons of 2006 and 2007. Experimental results revealed that tree height, bole height, diameter at breast height (dbh) and volume yield of *A. auriculiformis* were increased with the increasing age of the tree. All the four arable crops gave maximum net return under *A. auriculiformis* + sweet orange-based agroforestry system as compared to *A. auriculiformis* + guava-based agroforestry system. So far as different agroforestry systems are concerned, *A. auriculiformis* + sweet orange + bottle gourd model gave maximum total outturn (Rs. 71,028 ha^{-1} $year^{-1}$) closely followed by *A. auriculiformis* + guava + bottle gourd model (Rs. 69,286 ha^{-1} $year^{-1}$). This particular agri-horti-silvicultural system will be multifarious utility to the farmers

of dry regions of West Bengal because it not only provides fuel wood, timber, fruits and crop produce but also helps to enrich the soil health.

Das *et al.* (2011) conducted an intercropping trial on 6-year-old aonla (*Emblica officinalis*) cv. NA-7 grow under rainfed calciorthent soil, to identify the suitable and profitable intercrops. The intercrops grown were turmeric, ginger and arbi. They observed increase in the production of fruits due to intercrops and it was maximum in aonla in association with turmeric (13.30 t ha^{-1}) followed by arbi (11.71 t ha^{-1}). Economic analysis of the systems in terms of benefits: cost ratio revealed that 'aonla + turmeric' gave a higher value (6.29) followed by 'aonla + ginger' (3.44) and 'aonla + arbi' (3.20). They further concluded that, the interspaces of the aonla orchard in calcareous belt of eastern India could be better utilized for growing various intercrops to generate substantial additional income without adverse effect on the soil fertility and productivity of the main crop.

Ghosh and Bandopadhaya (2011) evaluated six coconut based cropping models *i.e.* Model I:Coconut + Black pepper + guava, Model II: Coconut + Black pepper + Lime, Model III : Coconut + Black pepper + Lemon, Model IV : Coconut + Black pepper + Pineapple, Model V : Coconut + Black pepper + Banana and Model VI : Coconut + Black pepper in a 26 years old coconut plantation and economic assessment of models revealed that out of 6 models, Model - IV (consists of coconut, black pepper, pineapple) was more remunerative

showing the highest net return of Rs. 45,600 ha^{-1} followed by Model – V (Rs 36,050/-) ha^{-1}. Multiple cropping in coconut plantation under recommended package of practice of both main crop and intercrop had no adverse effect on production of coconut. They further reported that fruit based cropping system with coconut, comprising of coconut, black pepper, pineapple was found best under West Bengal condition.

Swain and Padhi (2011) conducted an experiment with nine treatments namely mango, ginger, turmeric, tomato, cowpea, French bean, ragi, niger, upland paddy and control (without intercrop) along with filler crop guava to find out the most profitable crop combination under the rainfed upland situation of Odisha and reported the maximum fruit yield of mango and guava with mango+ guava + cowpea intercropping closely followed by mango+guava+soyabean. They concluded that cowpea and French bean could be adjudged as most potent intercrops in mango orchards because of their contribution not only to the performance of the main crop but also the sustainability of the systems.

Vikram *et.al* (2012) conducted research on Performance of mango ginger in cashew plantation (As Intercrop) compared to sole cropping. Growth of mango ginger cv. Shiralkoppa Local as intercrop in cashew plantation was significantly higher for plant height, pseudostem diameter, number of leaves per tiller and dry weight of rhizome more in intercrop. Significantly higher fresh weight (185g/ clump),

clump size (193.54 cm^2) and harvest index (83.05 %) were recorded under sole cropping compared to intercropping (120.27 g/clump, 139.10 cm^2 and 73.38 %, respectively) under cashew plantation. Due to shade loving nature of mango ginger plants growth was significantly higher under cashew intercropping and yield was recorded higher under open situation

Hare Krishan *et al.* (2013) studied the cropping system in which aonla (*Emblica officinalis*) was taken as a base crop along with the perennial crops, ber (*Ziziphus mauritiana*), bael (*Aegle marmelos*), khejri (*Prosopis cineraria*), drumstick (*Moringa oleifera*), karonda (*Carissa carandus*); and fodder crop, sewan grass (*Lasiurus sindicus*), as a component crop. In orchard cluster bean and seed spices were grown in interspaces in *kharif* and *rabi*, respectively, to generate extra income, improve productivity, and to ameliorate ecological niche in a sustainable manner. Systems comprised cropping models – aonla – ber - cluster bean - fennel, aonla – bael - cluster bean - coriander, aonla – khejri - cluster bean - ajowain, aonla – drumstick – clusterbean - dill and aonla – khejri - sewan grass. No negative allelopathic effects of the over storey crops (aonla, ber, khejri, karonda and drumstick) on the growth and production potential of the ground storey crops (*kharif* and *rabi* annuals) were observed. Besides, the yield of intercrops was found higher under multiple cropping systems than under the sole crop; probably, due to the

synergistic interaction among the ground-storey and over-storey crops.

Rathore *et al.* (2013) studied the performance of mango based agri-horticultural models under rainfed situation of western Himalaya for 15-years. The total 15 years of experimentation period (1995–2010) was divided into two phases. In the first phase (1995–2005), five mango based agri-horticultural models (AHM) viz. Mango+cowpea–toria, mango + cluster bean/okra–toria, mango+sesame–toria, mango + black gram–toria and mango + pigeon pea in addition to sole mango plantation (no intercrop) and in second phase (2005–2010), two mango based AHM (mango+colocasia and mango + turmeric) in addition to sole mango (no intercrop) were studied. Results revealed that the fruit based AHM were effective in improving fruit yields of the mango. The mean maximum fruit yield of mango (7.02 t ha^{-1}) was harvested with cowpea+toria crop rotation followed by black gram+toria (6.59 t ha^{-1}) and minimum fruit yield (5.76 t ha^{-1}) realized with sole mango tree during first phase (1995–2005). Likewise, mean maximum fruit yield (13.71 t ha^{-1}) from mango tree was obtained in the turmeric block followed by (13.00 t ha^{-1}) in colocasia block and minimum fruit yield with sole mango tree (11.86 t ha^{-1}).

Moshiur Rahman *et al.* (2014) studied the productivity and profitability of different fruit crops grown in multi-story fruit garden which involved coconut + litchi + sweet orange +

pineapple fruit crops. They reported higher equivalent yield of each fruit crop than its sole crop. In addition, the land equivalent ratio for multi-strata fruit garden was 2.6 They also obtained maximum gross margin of Tk.12,47,083.19 ha^{-1} $year^{-1}$ and the highest BCR of 6.79 from multi-stored fruit garden. They concluded that, economic benefits of multi-layered fruit garden were higher than that of sole cropping of the respective crop.

Field experiment was conducted by Thivruvarssan *et al.* (2014) with an objective to develop a multispecies cropping system model in coconut suitable for East Coast Region of Tamil Nadu. Experiment was comprised of eight different cropping models which were tested in 25 years old East Coast Tall (ECT) coconut garden. Among them, the model IV (Coconut + black pepper + banana + E.F. Yam) recorded the highest B:C ratio (2.16) and net income (Rs. 57,577 ha-1) followed by the model II (Coconut + Banana + Black pepper) where the corresponding values were 20.8 and Rs. 45,557 ha^{-1}. The model III (Coconut + Banana + Black pepper + Bhendi) recorded the highest soil available NPK when compared to other models. The soil nutrient content and soil microbial load of intercrops the model IV (Coconut + Black pepper + Banana + E.F. Yam) recorded the maximum soil microbial population. Based on the feasibility, marketability and economic viability, they concluded that the model IV is considered as the most suitable intercropping system in coconut for East Coast Region of Tamil Nadu.

2.3 Soil health benefit

Maheswarappa *et al.* (2001) studied the impact of integrated mixed farming system in 18-years old coconut *(Cocos nucifera)* garden on coconut yield and economics of coconut plantation with different components. They observed an increase in the nutritional status of coconut and nut yield over the years with mixed farming. With respect to leaf nutrient content (N, P, K, Ca and Mg) of coconut in both cvs. 'West Coast Tall' and 'Laccadive Ordinary', the leaf nutrient contents of the index leaf was higher as compared to initial status. They attributed this beneficial effect to the mixed farming system which improved the soil physical, chemical and biological environment favouring the higher uptake from the soil nutrients pool.

Mutanal *et al.* (2007) studied the mixed cropping of tree species with Tamarind *(Tamarindus indica*) cv. Prathisthan and observed higher benefit cost ratio and internal rate of returns in tamarind with tree species. They further suggested that the results can be applied to the slopy and degraded soils.

Abouziena *et al.* (2010) studied the efficacy of intercropping mango, Balady mandarin and Egyptian clover (*Trifolium alexandrinum* L) crops with date palm on soil chemical properties and quality and quantity of date fruits, in comparison with date palm sole. They reported that rhizosphere of palm (pure stand) had a high concentration of

N compared to palms intercropped with mango or mandarin. Intercropped mandarin with palms caused a depletion of N from soil by 14.3%, relative to sole date palm. High levels of Zn and Mn in soil were recorded in rhizosphere of clover and palms intercropped with mandarin. The effect of intercropping on occurrence and enumeration of micro-organisms in the rhizospere of trees was also studied. The results reported improvement in the occurrence microorganisms in the rhizosphere of date palm. They further observed increase in the total fungal count to 118.32 cfu x 10^3 g^{-1} and 52.00 x 10^3 g^{-1} in date palm root intercropped with mango and clover, respectively.

While studying yield, soil health and economics of aonla based agri-horticultural systems in eastern India on six- year old aonla orchard, Das *et al.* (2011) confirmed that aonla-based agri-horticultural systems were effective in bringing about improvement in the soil properties as reflected by the significant increase in organic carbon (32.4-56.8 %), available nitrogen (26.2 - 37.8 %) and phosphorus (22.2 - 30.8 %). However, no significant differences were observed in available potassium among the different plots of the treatments.

Hare Krishan *et al.* (2013) studied the cropping system in which aonla (*Emblica officinalis*) was taken as a base crop along with the perennial crops, ber (*Ziziphus mauritiana*), bael (*Aegle marmelos*), khejri (*Prosopis cineraria*), drumstick (*Moringa oleifera*), karonda (*Carissa carandus*); and fodder

crop, sewan grass (*Lasiurus sindicus*), as a component crop. In orchard clusterbean and seed spices were grown in interspaces in *kharif* and *rabi*, respectively, to generate extra income, improve productivity, and to ameliorate ecological niche in a sustainable manner. Systems comprised cropping models – Aonla - ber - cluster bean - fennel, Aonla – bael - cluster bean- coriander, Aonla – khejri - cluster bean - ajowain, Aonla - drumstick- clusterbean - dill and *aonla*- khejri - sewan grass. Results indicated that inclusion of the perennial fruit-crops improved soil fertility through litter fall. Further, improved physical and chemical properties of the soil under the canopy of the perennial crops resulted in increased porosity and water-holding capacity of the soil, while there was decrease in soil bulk density as compared to open sites. Their also revealed considerably higher content of available N, P and K in the soil under trees growing in diversified pattern of cropping than that under the sole cropping as well as in the bare field. Similarly, there was improvement in microbial population in soils under fruit-trees. They concluded that crop combinations such as Aonla – ber – cluster bean-fennel, Aonla - bael - cluster bean - coriander, Aonla – khejri - cluster bean - ajowain were sustainable and remunerative under the arid ecosystem.

Rathore *et al.* (2013) studied the performance of mango based agri-horticltural models under rainfed situation of western Himalaya. The total 15 years of experimentation period (1995–2010) was divided into two phases. In the first

phase (1995–2005), five mango based agri-horticultural models (AHM) viz. Mango + cowpea - toria, mango + cluster bean/okra – toria, mango + sesame - toria, mango + black gram - toria and mango + pigeon pea, in addition to sole mango plantation (no intercrop) and in second phase (2005–2010), two mango based AHM (mango + colocasia and mango + turmeric) in addition to sole mango (no intercrop). Higher soil moisture content as compared to sole mango plantation in all the treatments was recorded. Moisture retention under different AHM was in the order of cowpea (13.32 cm) > black gram (13.29 cm) > pigeon pea (13.27 cm) > okra (12.42 cm) > sesame (12.17 cm) > sole mango (11.62 cm) during first phase, whereas moisture retention was observed in the order of turmeric (14.20 cm) > colocasia (14.01 cm) > sole mango (12.60 cm) during second phase. In the first phase, the mango + cowpea-toria system improved organic carbon, total nitrogen, phosphorus, potash and reduced pH by 49.0, 56.3, 48.6, 58.5 and 11.6 %, respectively as compared to initial values, whereas mango + turmeric system increased organic carbon, nitrogen, phosphorus, potash and reduction in pH by 51.0, 45.0, 29.7, 29.0 and 3.4 %, respectively over initial values within soil depths of 0-30 cm during second phase. They recommended mango based AHM with selective intercrops up to 15 years of age of mango plantation for multiple outputs and good economic viability without impairing site fertility.

Thivruvarssan *et al.* (2014) conducted the field experiment comprised of eight different cropping systems models which were tested in 25 years old East Coast Tall (ECT) coconut garden with an objective to develop a multispecies cropping system model in coconut suitable for East Coast Region of Tamil Nadu. Among them, the model III (Coconut + Banana + Black pepper + Bhendi) recorded the highest soil available NPK when compared to other models, whereas, maximum load of soil microbial population and soil nutrient content was higher in the model IV (Coconut + Black pepper + Banana + Elephant Foot Yam). Based on the feasibility, marketability, soil health and economic viability, they concluded that the model IV is considered as the most suitable intercropping system in coconut for East Coast Region of Tamil Nadu.

3. MATERIAL AND METHODS

Field experiment entitled, “Performance of Different Fruit Crop Modules under Rainfed Conditions” was carried out at Research Farm of Horticulture Section, College of Agriculture, Dhule.

Details of experimental procedure adopted, materials used and techniques followed during the course of present investigation have been described in this chapter as under.

Location

The College of Agriculture, Dhule is situated at an elevation of 258 m above mean sea level. Research Farm of Horticulture Section, College of Agriculture, Dhule lies between 20.4^0 North latitude and 74^0 East longitudes.

Climate

Agro climatically, Dhule comes under scarcity zone and the average annual rainfall of the place is 597 mm. Dhule region receives rains mainly from south - west monsoon during June to September. The maximum and minimum temperature was 42^oC and 23^oC, respectively and the relative humidity was 97.7 - 17.0 per cent during the period of research work.

3.1 Materials

The present experiment was carried out on the already established modules comprising of combinations of different fruit crops, namely mango, custard apple, aonla, jamun and one perennial vegetable crop - drumstick. Different

combinations of these crops are referred to as modules. The details of fruit modules, fruit crop planted and their year of planting are detailed below-

Fruit Crop	Cultivar	Year of planting	Plot number
1. Module-I			
Mango (M)	Kesar	2003	74
Custard apple (C)	Balanagar	2004	
Aonla (A)	NA 7	2005	
Drumstick (D)	PKM-1	2007	
2. Module-II			
Mango (M)	Kesar	2003	83
Custard apple (C)	Balanagar	2005	
Aonla (A)	NA 7	2005	
3. Module-III			
Mango (M)	Kesar	2003	79
Custard apple (C)	Balanagar	2005	
Jamun (J)	Gokak Local	2005	

1. Layout of planting of Module-I

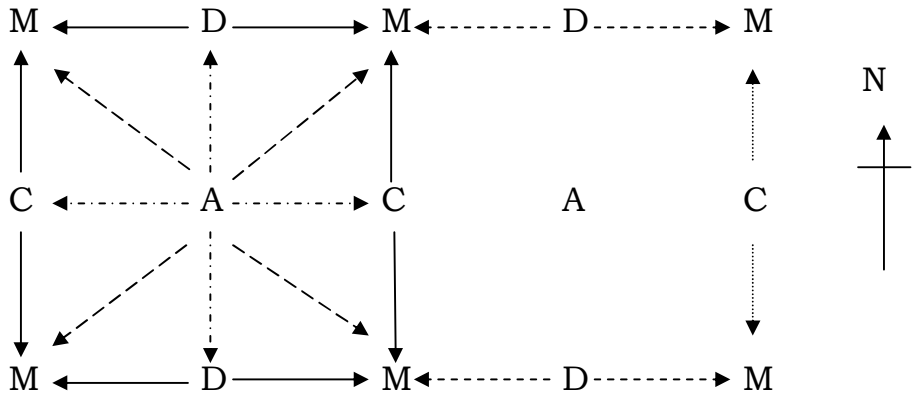

Fig. 1 Module-1

2. Layout of planting of Module-II

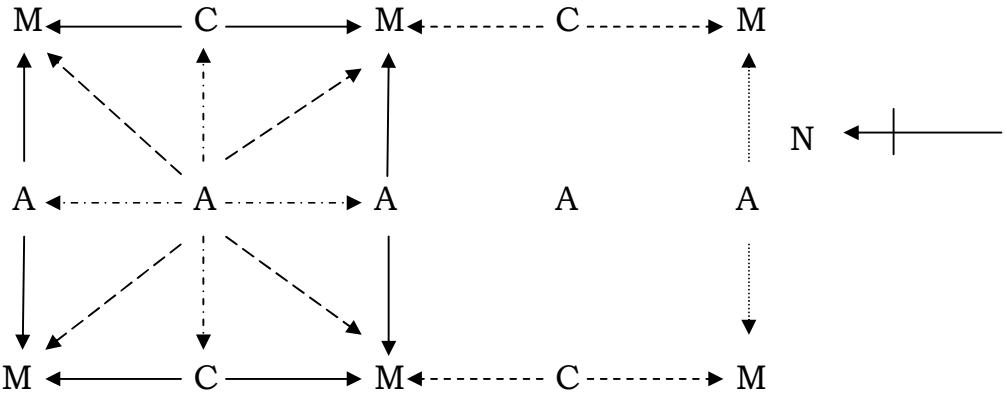

Fig. 2 Module-2

3. Layout of planting of Module-III

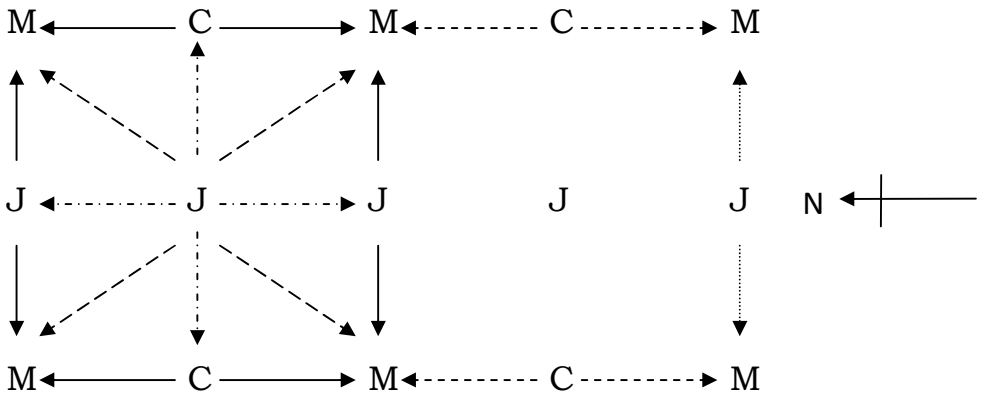

Fig. 3 Module-3

In this study, mango is the base crop in all the modules which is planted at regular spacing of 10 m x 10 m and all other crops are planted in the interspaces in the mango as shown in the Fig.1, 2 and 3. Among these crops, custard apple is common in all the three modules, aonla is planted in two modules *i.e.* Module-1 and Module-2; whereas, drumstick and jamun are planted only in the Module-1 and Module-3, respectively.

The research work was initiated in January, 2014 and was carried for a period of one year *i.e.* during January to December 2014. All the fruit crops in the different modules were at economical bearing stage. All the fruit crops in the different modules received uniform cultural practices and nutrients as per recommendations according to the respective fruit crop.

3.2 Experimental design and layout

The experiment was laid out in Randomized Block Design (RBD) with eight treatments which were replicated five times and each treatment comprised of a unit of 1 (one) plant. The treatments were assigned randomly in each replication. Treatment details are depicted in the Table 1.

Table 1. Treatment Details

Treat	Treatment details
T_1	Module-1 (Mango + Custard apple + Aonla + Drumstick)
T_2	Module-2 (Mango + Custard apple + Aonla)
T_3	Module-3 (Mango + Custard apple + Jamun)
T_4	Mango sole crop
T_5	Custard apple sole crop
T_6	Aonla sole crop
T_7	Jamun Sole crop
T_8	Drumstick sole crop

3.3. Treatment implementation

The observational plants, treatment and replication wise, in each module were marked by painting numbers on the trunk with oil paint for facilitating easy recording of different observations.

3.4. Methods adopted

Details of observations and method adopted for recording the observations are presented here.

3.4.1. Growth observation

A long and straight bamboo stick of 7 meter length was calibrated with meter scale with oil paint for easy recording of growth observations. The growth observations on observational plants were taken after complete harvesting of respective crop.

1. Plant height (m)

Plant height was measured by using calibrated bamboo as mentioned earlier and expressed in meter (m).

2. Stem girth (m)

For recording stem girth a tailor tape was used and girth was expressed in centimeter (cm).

3. East - West plant spread (m)

East-West plant spread was measured by using calibrated bamboo as mentioned earlier and was expressed in meter (m).

4. North – South plant spread (m)

North - South plant spread was measured by using calibrated bamboo as mentioned earlier and was expressed in meter (m).

5. Days to harvesting (days)

The period from flower emergence to the date of final harvest was computed and was taken as number of days to fruit harvesting.

6. Average weight of fruit (g)

Twenty fruits were randomly selected from each treatment and the weight of fruits was recorded on the

electronic weighing balance. The average weight of fruit was worked out by dividing total weight of fruits by number of fruits and weight was expressed in grams (g).

7. Number of fruits plant^{-1}

The fruits were harvested periodically as and when fruits matured in all fruit crops *i.e.* Mango, custard apple, aonla, drumstick and jamun. At each harvesting in each crop, number of fruits at each picking was recorded and then summed up to get total number of fruits per plant.

8. Yield (kg pt^{-1})

The yield of mango, custard apple, aonla, jamun, and drumstick recorded from each experimental plant both in the module and as a sole. The yield per plant was expressed in terms of kilogram (Kg).

9. Yield (t ha^{-1})

The yield of constituent crop recorded as mentioned in the point no. VIII was multiplied by number of plants in hectare according to that module and was expressed in tons per hectare (t ha^{-1}).

10. Equivalent yield (t ha^{-1})

To assess the performance of the modules under study and to identify most suitable module for dryland conditions, the mango equivalent yield was worked out for different crops based on prevailing market prices as suggested by Thiruvvarssan, *et al.* (2014).

$$\text{Equivalent yield} = \frac{\text{Yield of intercrop x Market price}}{\text{Prevailing price of base (main) crop}}$$

In the present study mango is the base (main) crop as it is planted on the regular spacing and other crops are planted in the interspaces of the mango.

11. Economics

Based on the yield of each component fruit crop in the module and cost of cultivation, economics were worked out in accordance with the prevailing market prices for all the modules for the year under study (January to December, 2014).

3.4. Statistical Analysis

In the present study, mango is the base crop and therefore it appears in all the modules (Fig.1, 2 and 3). Besides mango, custard apple is also common in all three modules. However, aonla appears in two modules *i.e.* Module-1 and 2; whereas, drumstick and jamun appears in only in one module *i.e.* the Module-1 and Module-3, respectively. However, data generated on mango and custard apple were subjected to statistical analysis as per the method given by Panse and Sukhatme (1995).

4. EXPERIMENTAL RESULTS

Field experiment entitled, "Performance of different fruit crop modules under rainfed conditions" was carried out during January to December 2014 at Research Farm, Horticulture section, College of Agriculture, Dhule. In this study, mango is the base crop which is planted at regular spacing in all the modules and other crops are planted in the interspaces of the mango. Among these crops, custard apple is common in all three modules, aonla in two modules *i.e.* Module-1 and Module-2, whereas jamun and drumstick is planted only in the Module-3 and module-1, respectively. The results of this investigation are presented as under appropriate headings.

4.1. Growth Characters

1. Plant height (m)

The data regarding plant height of different crops in the module and as a sole crop have been presented in Table 2 and figure 4.

All the component fruit crops in the modules significantly affected the plant height of mango. Maximum plant height was observed in the treatment T_3 - (Mango + Custard apple + Jamun) 5.51m. This treatment was on par with the treatment T_4 *i.e.* sole mango crop (5.48 m). Reduction in the height of mango was observed in the treatments T_2 - (Mango + Custard apple + Aonla) and T_1 - (Mango + Custard apple + Aonla + Drumstick) which was 4.84 m and 4.80 m, respectively.

Incase of custard apple, maximum plant height (3.96 m) was recorded in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick) which was on par with the treatment T_5 *i.e.* sole custard apple crop (3.56 m). The minimum height (3.21, 3.39 m) was recorded in the treatments T_2 - (Mango + Custard apple + Aonla) and T_3 - (Mango + Custard apple + Jamun), respectively, which were on par with each other.

As regards to aonla, same trend was observed. The maximum plant height (5.72 m) was recorded in the treatment T_6 *i.e.* sole aonla crop and minimum in T_1 - (Mango + Custard apple + Aonla + Drumstick) 5.40 m which was closely followed by T_2 - (Mango+ Custard apple + Aonla) 5.42 m. In case of jamun, maximum plant height (6.60m) was recorded in the treatment T_3 - (Mango + Custard apple + Jamun); whereas, minimum in the T_7 - sole jamun crop (6.52 m). The same trend was observed in the drumstick. Maximum plant height (6.93 m) recorded in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick), whereas, minimum in the T_8 - sole drumstick crop (5.84 m).

2. East-West plant spread (m)

As revealed from the data presented in Table 3 and figure 5, the east-west plant spread was not influenced by different fruit combinations. However in mango, numerically highest east-west plant spread (4.99 m) was recorded in the treatment T_2 - (Mango + Custard apple + Aonla) which was higher than the sole mango (4.82 m). The lowest values were registered in the treatments T_1 - (Mango + Custard apple +

Aonla + Drumstick) and T_3 - (Mango + Custard apple +Jamun) which were 4.63 m and 4.24 m, respectively.

Significant differences were observed with respect to east-west plant spread in custard apple. The highest east-west plant spread (3.51 m) was recorded in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick), which was on par with T_5 *i.e.* sole custard apple crop recorded (3.17 m). The lowest east-west plant spread (2.76 m) was recorded in the treatment T_3 - (Mango + Custard apple + Jamun). The treatments T_2 - (Mango + Custard apple + Aonla) with 2.88 m, T_3 - (Mango + Custard apple + Jamun) with 2.76 m were on par which each other.

In aonla, maximum (5.04 m) east-west plant spread was recorded in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick) and the lowest (4.58 m) in the treatment T_2 - (Mango + Custard apple + Aonla). In case of jamun no difference was observed in the east west plant spread in both T_3 - (Mango + Custard apple + Jamun) and in T_7 - sole Jamun both recorded (5.08 m). As regards drumstick, maximum (5.49 m) east-west plant spread was recorded in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick) and the lowest in treatment T_8 *i.e.* sole drumstick crop (5.33 m).

Table 2. Plant height of different fruit crops under modules (different crop combinations) and in sole crops.

Treatments	Plant Height (m)				
	Mango	**Custard apple**	**Aonla**	**Jamun**	**Drumstick**
T_1- Module -1 (Mango + Custard apple + Aonla + Drumstick)	4.80 (-12.41%)	3.96 (+11.23%)	5.40 (-5.6%)	--	6.93 (+18.66%)
T_2 - Module -2 (Mango+ Custard apple + Aonla)	4.84 (-11.68%)	3.39 (-4.78%)	5.42 (- 5.25%)	--	--
T_3 - Module -3 (Mango + Custard apple + Jamun)	5.51 (+0.54%)	3.21 (- 9.84 %)	--	6.60 (+1.22%)	--
T_4 - Sole Mango	5.48	--	--	--	--
T_5 - Sole Custard	--	3.56	--	--	--
T_6 - Sole Aonla	--	--	5.72	--	--
T_7 - Sole Jamun	--	--	--	6.52	--
T_8 - Sole Drumstick	--	--	--	--	5.84
S.E. ±	0.18	0.13	--	--	--
CD at 5 %	0.55	0.41	--	--	--

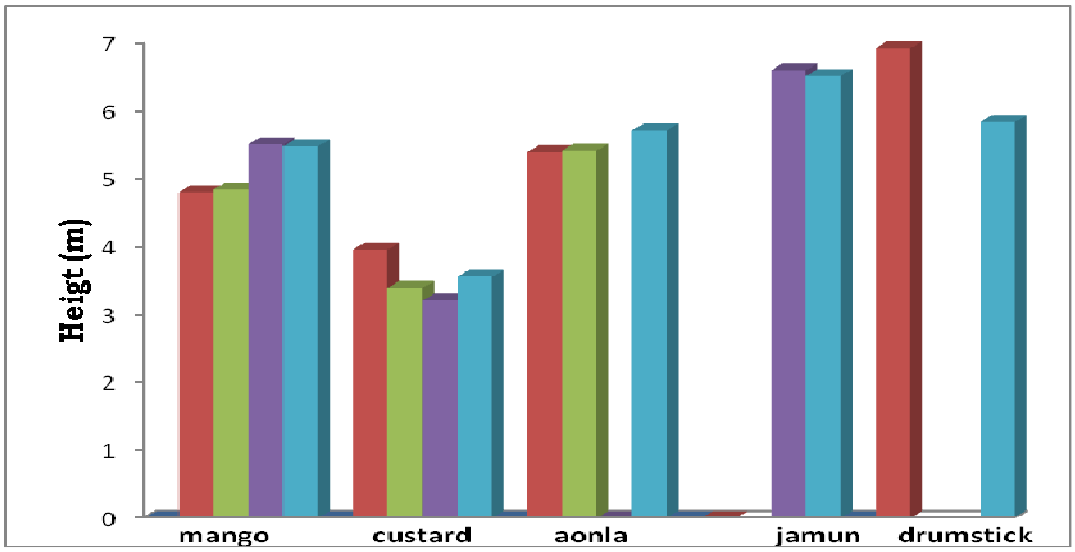

Fig.4. Height of the different fruit crops under the modules

Table 3. East-West plant spread of different fruit crops under modules (different crop combinations) and in sole crops.

Treatments	East- West plant spread (m)				
	Mango	**Custard apple**	**Aonla**	**Jamun**	**Drumstick**
T_1 - Module -1 (Mango+ Custard apple + Aonla + Drumstick)	4.63 (-3.85%)	3.51 (+10.72 %)	5.04 (+3.49%)	--	5.49 (+3 %)
T_2 - Module -2 (Mango+ Custard apple + Aonla)	4.99 (+3.52%)	2.88 (-9.85%)	4.58 (-5.95%)	--	--
T_3 - Module -3 (Mango + Custard apple + Jamun)	4.24 (-12.04%)	2.76 (-12.94 %)	--	5.08 (0%)	--
T_4 - Sole Mango	4.82	--	--	--	--
T_5 - Sole Custard	--	3.17	--	--	--
T_6 - Sole Aonla	--	--	4.87	--	--
T_7 - Sole Jamun	--	--	--	5.08	--
T_8 - Sole Drumstick	--	--	--	--	5.33
S.E. ±	0.29	0.12	--	--	--
CD at 5 %	NS	0.38	--	--	--

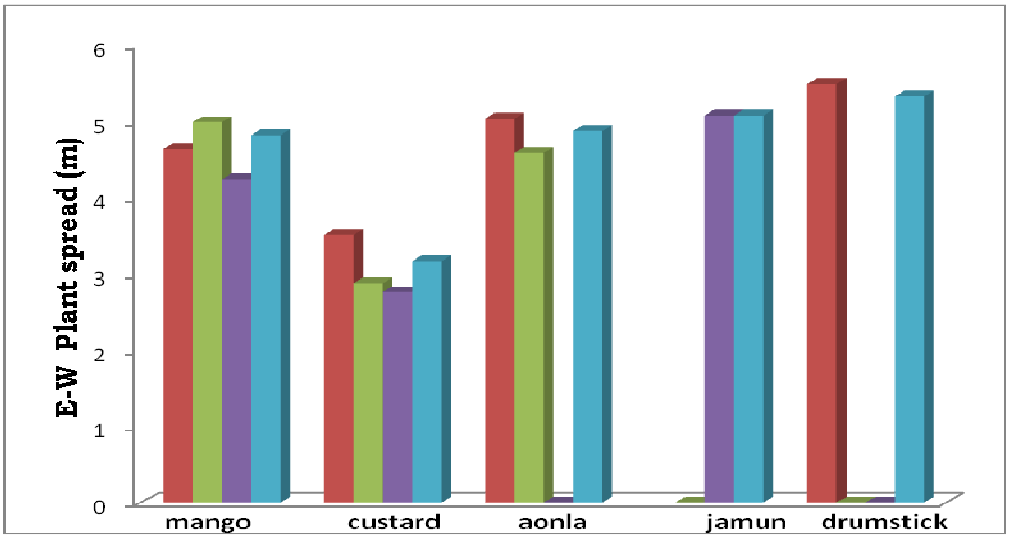

Fig. 5. East - West plant spread of different fruit crops under the modules

3. North- South plant spread (m)

Data depicted in Table 4 and figure 6, showed that, no significant differences with respect to north - south plant spread, except in custard apple. In mango numerically, higher (5.21 m) and lowest (4.18 m) north - south plant spread was recorded in the treatment T_2 - (Mango + Custard apple + Aonla) and it was lower in T_3 - (Mango + Custard apple + Jamun) 4.18 m, respectively. In custard apple, the highest north - south plant spread (3.19 m) was observed in the treatment T_5 *i.e.* sole custard apple crop whereas, it was minimum (2.58 m) in the treatment T_3 - (Mango + Custard apple + Jamun). The treatments T_1 - (Mango + Custard apple + Aonla + Drumstick) (3.03 m) and T_2 - (Mango + Custard apple + Aonla) with (2.88 m) and T_5 - sole Custard apple crop (3.19 m) were on par with each other.

As regards aonla, the highest (4.91 m) and the lowest (4.40 m) north - south plant spread was recorded in the treatments T_6 - sole aonla crop and T_2 - (Mango + Custard apple + Aonla), respectively. In jamun, the highest (4.90 m) and the lowest (4.82 m) north-south plant spread was recorded in the treatments T_7 - sole jamun crop and T_3 - (Mango + Custard apple + Jamun), respectively. In drumstick, the highest (5.43 m) and the lowest (5.15 m) north-south plant spread was recorded in the treatments T_1 - (Mango + Custard apple + Aonla + Drumstick) and T_8 *i.e.* sole drumstick crop, respectively.

Table 4. North - South plant spread of different fruit crops under modules (different crop combinations) and in sole crops.

Treatments	North - South plant spread (m)				
	Mango	**Custard apple**	**Aonla**	**Jamun**	**Drumstick**
T_1 - Module -1 (Mango+ Custard apple + Aonla + Drumstick)	4.72 (-4.07%)	3.03 (-5.01%)	4.80 (-2.24%)	--	5.43 (+ 5.43 %)
T_2 - Module -2 (Mango+ Custard apple + Aonla)	5.21 (+5.89%)	2.88 (-9.71%)	4.40 (-10.38%)	--	--
T_3 - Module -3 (Mango + Custard apple + Jamun)	4.18 (-15.05 %)	2.58 (-19.12%)	--	4.82 (-1.63%)	--
T_4 - Sole Mango	4.92	--	--	--	--
T_5 - Sole Custard	--	3.19	--	--	--
T_6 - Sole Aonla	--	--	4.91	--	--
T_7 - Sole Jamun	--	--	--	4.90	--
T_8 - Sole Drumstick	--	--	--	--	5.15
S.E. ±	0.28	0.10	--	--	--
CD at 5 %	NS	0.33	--	--	--

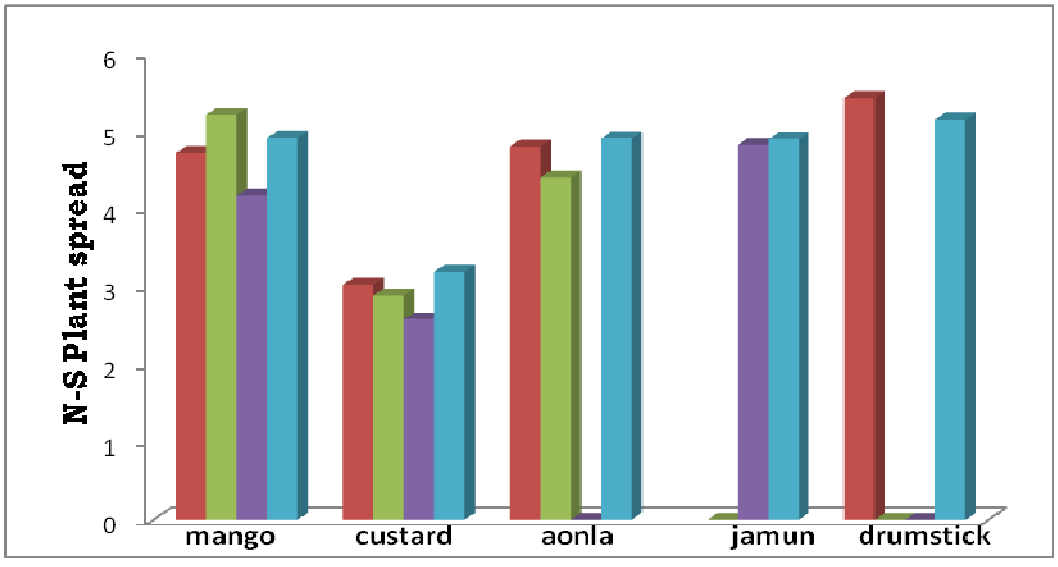

Fig.6. North- South plant spread of different fruit crops under the modules

4. Stem girth (cm)

It is very clear from the Table 5 and figure 7, that, modules did not influence the stem girth; however, numerically higher stem girth of (57.12 cm) was recorded in the treatment T_2 - (Mango + Custard apple + Aonla) than the sole mango crop T_4 - (56.49 cm). In custard apple the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick) recorded the highest stem girth (33.50 cm), which was higher than T_5 - sole custard apple crop (28.62 cm).

In aonla, the highest (60.37 cm) and the lowest (51.50 cm) stem girth was observed in T_6 - sole aonla and T_1 - (Mango + Custard apple + Aonla + Drumstick), respectively. In jamun, the highest (69.49 cm) and the lowest (66.87 cm) stem girth was observed in T_3 - (Mango + Custard apple + Jamun) and T_7 - sole jamun crop, respectively. In drumstick, the highest (81.75 cm) and the lowest (63.74 cm) stem girth was observed in T_1 - (Mango + Custard apple + Aonla + Drumstick) and T_8 - sole drumstick crop, respectively.

Table 5. Stem girth of different fruit crops under modules (different crop combinations) and in sole crops.

Treatments	Stem girth (cm)				
	Mango	Custard apple	Aonla	Jamun	Drumstick
T_1 - Module -1 (Mango+ Custard apple + Aonla + Drumstick)	50.97 (- 9.78%)	33.50 (+17.05%)	51.50 (-14.7 %)	--	81.75 (+ 28.25 %)
T_2 - Module -2 (Mango+ Custard apple + Aonla)	57.12 (+1.15 %)	30.75 (+ 7.44%)	59.66 (-1.18%)	--	--
T_3 - Module -3 (Mango + Custard apple + Jamun)	50.37 (-10.84%)	28.00 (- 2.16%)	--	69.49 (+3.91%)	--
T_4 - Sole Mango	56.49	--	--	--	--
T_5 - Sole Custard	--	28.62	--	--	--
T_6 - Sole Aonla	--	--	60.37	--	--
T_7 - Sole Jamun	--	--	--	66.87	--
T_8 - Sole Drumstick	--	--	--	--	63.74
S.E. ±	1.92	1.70	--	--	--
CD at 5 %	NS	NS	--	--	--

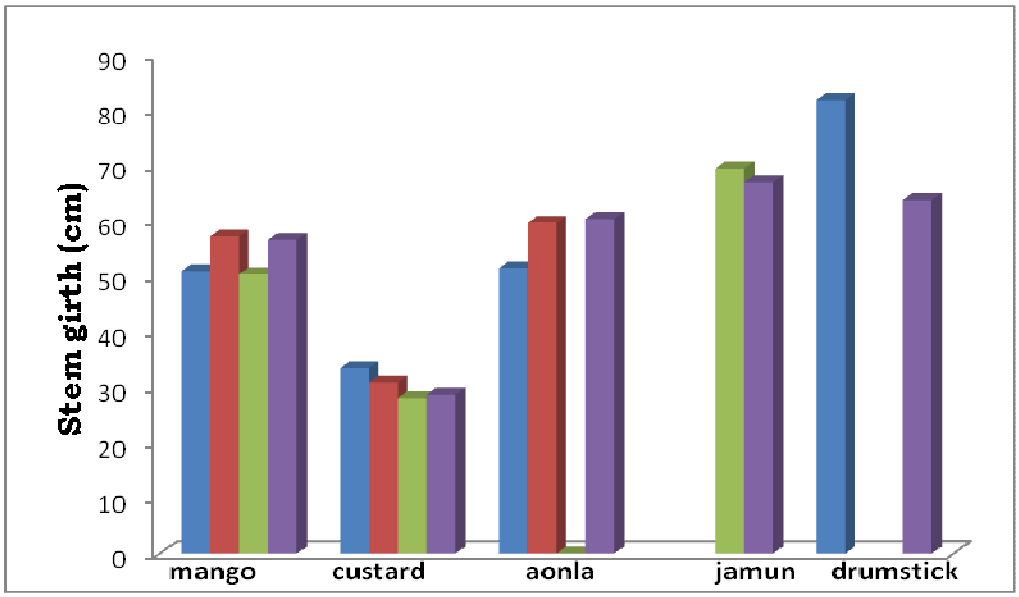

Fig. 7. Stem girth of different fruit crops under the modules

5. Days to harvest

As evident from the Table 6 and figure 8, influence of the modules on the days to harvest fruits was observed. In general, delayed maturity was observed in all crops in modules, except aonla.

In mango, least number of days for fruit maturity from flowering to harvest was observed in the T_2 - (Mango + Custard apple + Aonla) 151.70 days and it was on par with T_4 - sole mango crop (151.95 days). In custard apple, the lowest days (91.50 days) for fruit maturity were observed in T_1 - (Mango + Custard apple + Aonla + Drumstick) as compared to T_5 - sole custard apple crop (92.00 days). Both of these treatments T_1 and T_5 were on par with each other. The highest days for fruit maturity (96.40 days) were required in T_3 - (Mango + Custard apple + Jamun) which was on par with T_2.

In aonla, least number of days for fruit maturity from flowering to harvest was observed in the T_2 - (Mango + Custard apple + Aonla) 225.59 days as compared to T_6 - sole aonla crop (244.95 days) About 84.46 days for maturity were required in jamun in the T_3 - (Mango + Custard apple + Jamun) against (78.55 days) in T_7 - sole crop of jamun. In drumstick, 76.50 days was recorded in the T_1 - (Mango + Custard apple + Aonla + Drumstick); whereas, (71.90 days) for maturity was required in T_8 - sole drumstick crop.

Table 6. Days to harvest from flowering of different fruit crops under modules (different crop combinations) and in sole crops.

Treatments	Duration from flowering to harvest (days)				
	Mango	**Custard apple**	**Aonla**	**Jamun**	**Drumstick**
T_1 - Module -1 (Mango+ Custard apple + Aonla + Drumstick)	155.75 (+2.50%)	91.50 (- 0.55 %)	232.60 (-5.05 %)	--	76.50 (+6.39%)
T_2 - Module -2 (Mango+ Custard apple + Aonla)	151.70 (-0.17%)	95.20 (+3.47 %)	225.59 (- 7.91%)	--	--
T_3 - Module -3 (Mango + Custard apple + Jamun)	157.00 (+3.32%)	96.40 (+ 4.78%)	--	84.46 (+7.52%)	--
T_4 - Sole Mango	151.95	--	--	--	--
T_5 - Sole Custard	--	92.00	--	--	--
T_6 - Sole Aonla	--	--	244.95	--	--
T_7 - Sole Jamun	--	--	--	78.55	--
T_8 - Sole Drumstick	--	--	--	--	71.90
S.E. ±	0.31	0.46	--	--	--
CD at 5 %	0.95	1.44	--	--	--

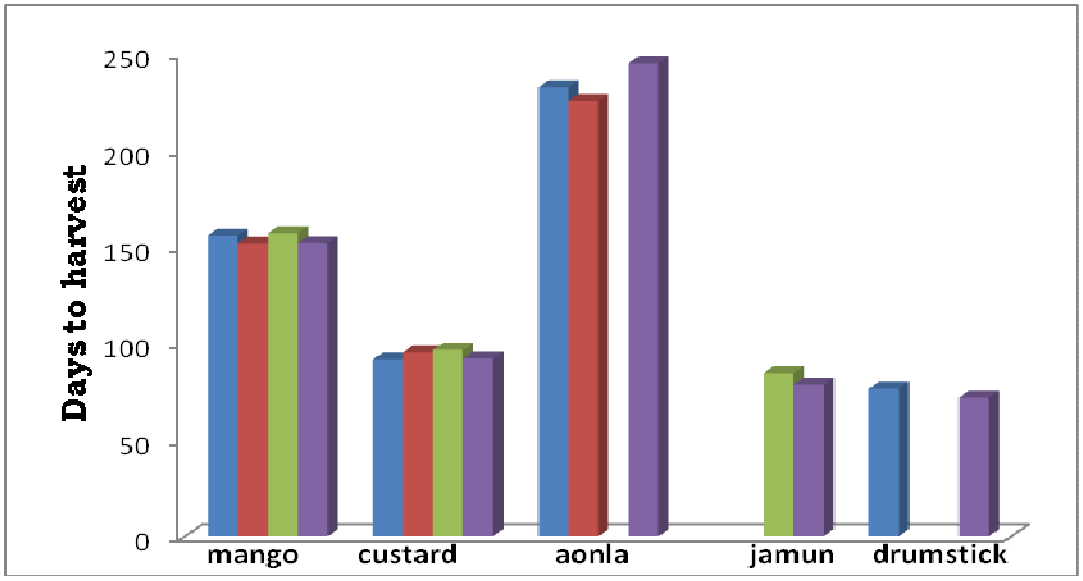

Fig. 8. Days from flowering to harvest of different fruit crops under the modules

4.2 Yield and yield parameters

1. Number of fruits per plant

All the component fruit crops in the modules had significant effect on number of fruits per plant which was revealed from the data presented in the Table 7 and figure 9.

In base crop mango, significantly the highest number of fruits per plant (80.70) was recorded in T_4 - sole crop of mango (T_4). Among the modules, the maximum number of fruits per plant (69.25) was registered in the treatment T_2 - (Mango + Custard apple + Aonla). All treatments significantly differ in their effect.

With respect to custard apple, significantly the highest fruits per plant were observed in T_5 - Sole custard crop (71.10) and among the modules; significantly the highest number of fruits per plant (63.15) was noted in the treatment T_3 - (Mango + Custard apple + Jamun). The treatment T_2 - (Mango + Custard apple + Aonla) with (57.70) where as T_1 - (Mango + Custard apple + Aonla + Drumstick) recorded (54.20) in respect of fruits per plant were on par with each other. In aonla, maximum fruits per plant were observed in T_6 - sole aonla (1386.25); whereas, minimum (1104) fruits were observed in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick). In jamun maximum fruits (269.10) per plant were observed in T_7 - (sole jamun crop), while minimum fruits (164.53) per plant were observed in T_3 - (Mango + Custard apple + Jamun). In drumstick maximum (167.35) and minimum (92.60) number of fruits per plant were observed in the treatment T_8 - sole drumstick and T_1 - (Mango+ Custard apple + Aonla + Drumstick), respectively.

Table 7. Number of fruits per plant in different fruit crops under modules (different crop combinations) and in sole crops.

Treatments	Number of fruits per plant				
	Mango	Custard apple	Aonla	Jamun	Drumstick
T_1 - Module -1 (Mango+ Custard apple + Aonla + Drumstick)	57.10 (- 29.25 %)	54.20 (-23.76%)	1104.00 (-20.36 %)	--	92.60 (-44.66 %)
T_2 - Module -2 (Mango + Custard apple + Aonla)	69.25 (-14.88%)	57.70 (-18.84%)	1206.66 (-12.95%)	--	--
T_3 - Module -3 (Mango + Custard apple + Jamun)	51.85 (-35.74%)	63.15 (-11.18%)	--	164.53 (-38.59%)	--
T_4 - Sole Mango	80.70	--	--	--	--
T_5 - Sole Custard	--	71.10	--	--	--
T_6 - Sole Aonla	--	--	1386.25	--	--
T_7 - Sole Jamun	--	--	--	269.10	--
T_8 - Sole Drumstick	--	--	--	--	167.35
S.E. ±	0.84	1.25	--	--	--
CD at 5 %	2.60	3.85	--	--	--

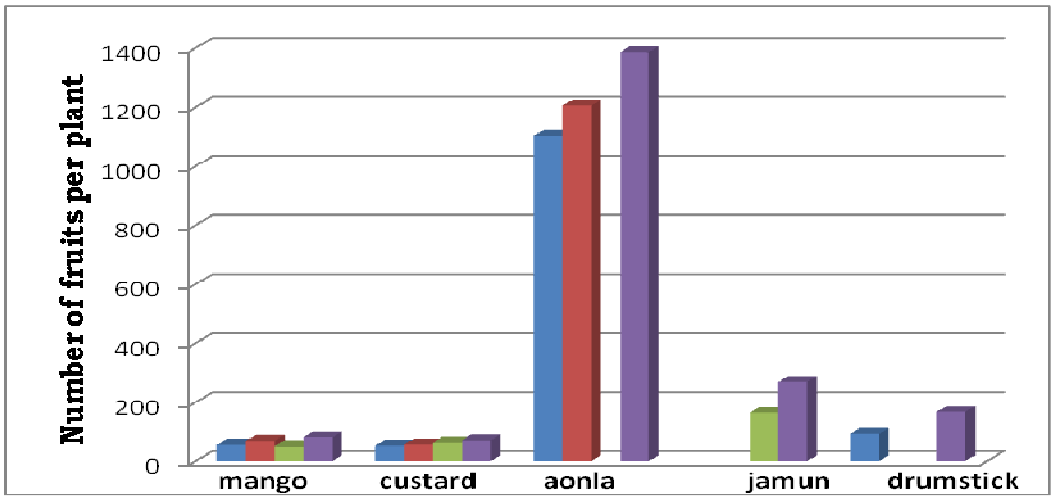

Fig. 9. Number of fruits per plant in different fruit crops under the modules

2. Average fruit weight (g)

The data with regard to average fruit weight per plant been depicted in Table 8 and figure 10. It was explicit from the data that all the component fruit crops in the modules had significant effect on fruit weight.

Significantly the highest fruit weight (184.18 g) was recorded in the treatment T_4 - sole crop of mango. Among the modules, the maximum fruit weight (173.35 g) was observed in T_2 - (Mango + Custard apple + Aonla). It was followed by the treatments T_1 - (Mango + Custard apple + Aonla + Drumstick) with (165.40 g) and T_3 - (Mango + Custard apple + Jamun) with (161.31 g) and these treatments were on par with each other. In custard apple the same kind of trend was observed. Significantly the highest fruit weight (172.24 g) was observed in T_5 - sole custard apple crop, where as in Modules, significantly the highest fruit weight (162.15 g) was observed in the treatment T_2 - (Mango + Custard apple + Aonla). The treatments T_3 - (Mango + Custard apple + Jamun) (154.39 g) and T_1 - (Mango + Custard apple + Aonla + Drumstick) (157.28 g) were on par with each other. In aonla, the highest fruit weight (29.54 g) was observed in T_2 - (Mango + Custard apple + Aonla) and the lowest (26.03 g) in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick). In jamun, the highest (19.41g) and the lowest (18.63 g) fruit weight was observed in the treatments T_7 - sole jamun crop and T_3 - (Mango + Custard apple + Jamun), respectively. In drumstick, the highest (66.75 g) and the lowest (60.06 g) fruit weight were observed in the treatments T_8 - sole drumstick and in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick), respectively.

Table 8. Average weight of fruit in different fruit crops under modules (different crop combinations), and in sole crops.

Treatments	Average Weight of Fruit (g)				
	Mango	**Custard apple**	**Aonla**	**Jamun**	**Drumstick**
T_1 - Module -1 (Mango + Custard apple + Aonla+ Drumstick)	165.40 (-10.19%)	157.28 (-8.6%)	26.03 (-8.37%)	--	60.06 (-10.02%)
T_2 - Module -2 (Mango + Custard apple + Aonla)	173.35 (-5.88 %)	162.15 (-5.8%)	29.54 (+3.97%)	--	--
T_3 - Module -3 (Mango + Custard apple + Jamun)	161.31 (-12.41%)	154.39 (-10.36 %)	--	18.63 (-4.01%)	--
T_4 - Sole Mango	184.18	--	--	--	--
T_5 - Sole Custard	-	172.24	--	--	--
T_6 - Sole Aonla	--	--	28.41	--	--
T_7 - Sole Jamun	--	--	--	19.41	--
T_8 - Sole Drumstick	--	--	--	--	66.75
S.E. ±	1.41	0.97	--	--	--
CD at 5 %	4.36	3.01	--	--	--

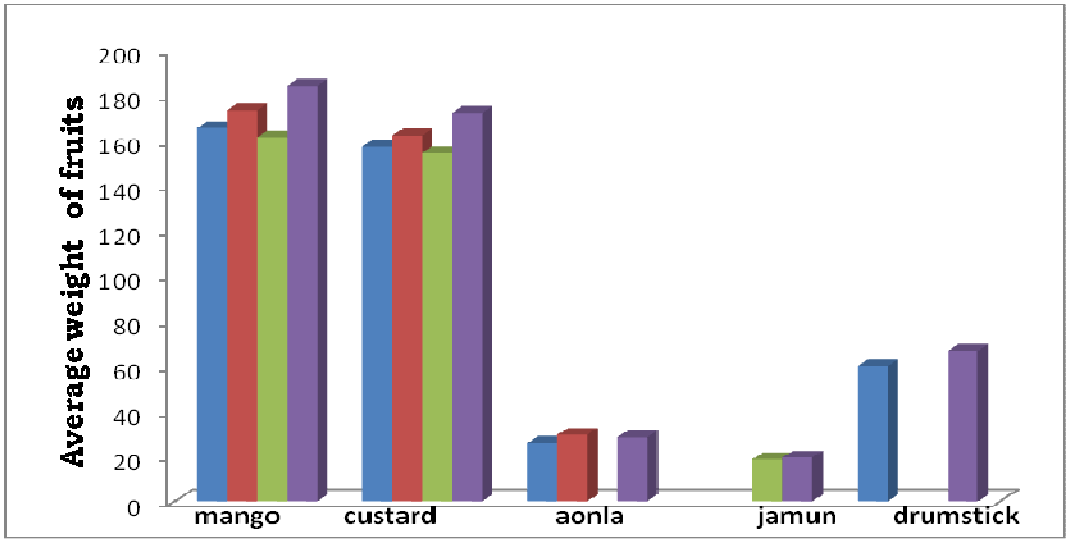

Fig. 10. Average fruit weight in different fruit crops under the modules

3. Yield (kg plant^{-1})

As noticed from the Table 9 and figure 11, the yield per plant was significantly influenced due to the constituent fruit crops in the modules

Significantly the highest yield per plant (14.85 kg) was recorded in Sole crop of mango T_4. Among the modules, the maximum yield per plant (12.00 kg) was registered in the treatment T_2 - (Mango + Custard apple + Aonla), followed by the treatments T_1 - (Mango + Custard apple + Aonla + Drumstick) 9.44 kg and T_3 - (Mango + Custard apple + Jamun) 8.36 kg.

In custard apple significantly the highest fruit yield per plant (12.23 kg) was observed in T_5 - sole custard apple crop. Among the modules, higher fruit yield per plant (9.74 kg) was observed in T_3 - (Mango + Custard apple + Jamun). Minimum yield per plant (8.49 kg) was observed in the T_1 - (Mango +

In aonla maximum fruit yield (39.40 kg) per plant was observed in T_6 - sole aonla crop and minimum fruit yield per plant (28.70 kg) was observed in T_1 - (Mango + Custard apple + Aonla + Drumstick). In jamun, maximum fruit yield per plant (5.20 kg) was observed in T_7 - (Sole jamun crop); minimum fruit yield (3.06 kg) per plant was observed in T_3 - (Mango + Custard apple + Jamun). In drumstick, maximum fruit yield per plant (11.16 kg) was observed in T_8 - (Sole drumstick crop) and minimum fruit yield (5.53 kg) per plant was observed in T_1 - (Mango + Custard apple + Aonla + Drumstick).

Table 9. Yield (Kg plant^{-1}) of fruit in different fruit crops under modules (different crop combinations), and in sole crops.

Treatments	Yield (Kg plant^{-1})				
	Mango	Custard apple	Aonla	Jamun	Drumstick
T_1 - Module -1 (Mango+ Custard apple + Aonla + Drumstick)	9.44 (-36.4%)	8.49 (-30.58%)	28.70 (-27.15%)	--	5.53 (-50.44%)
T_2 - Module -2 (Mango+ Custard apple + Aonla)	12.00 (-19.19%)	9.35 (-23.54%)	35.44 (-10.05%)	--	--
T_3 - Module -3 (Mango+ Custard apple + Jamun)	8.36 (- 43.70%)	9.74 (-20.35%)	--	3.06 (-41.15%)	--
T_4 - Sole Mango	14.85	--	--	--	--
T_5 - Sole Custard	--	12.23	--	--	--
T_6 - Sole Aonla	--	--	39.40	--	--
T_7 - Sole Jamun	--	--	--	5.20	--
T_8 - Sole Drumstick	---	--	--	--	11.16
S.E. ±	0.20	0.22	--	--	--
CD at 5 %	0.61	0.70	--	--	--

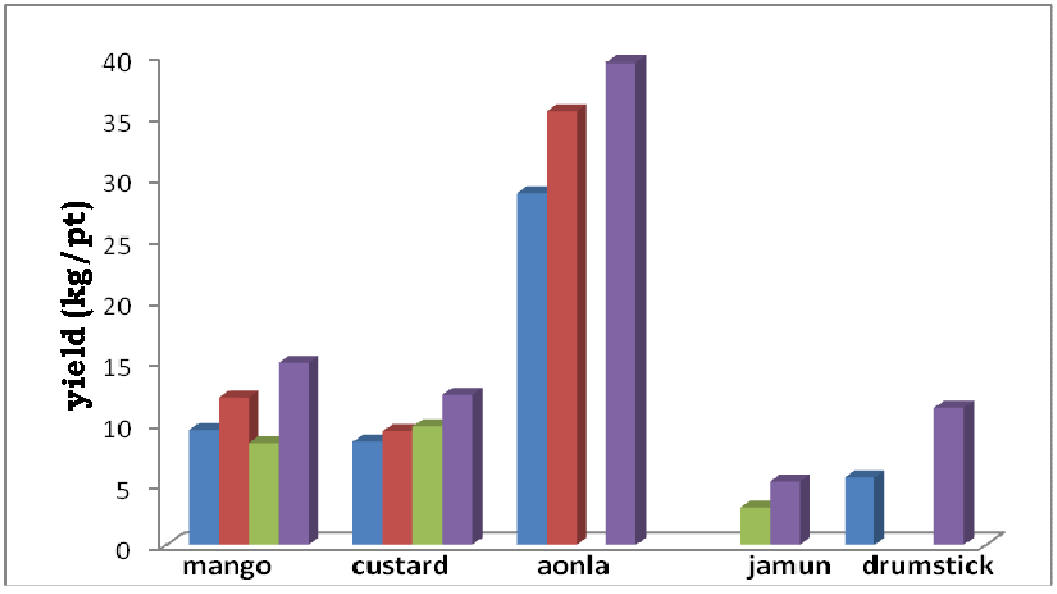

Fig. 11. Yield plant^{-1} in different fruit crops under the modules

4. Yield (tons ha^{-1})

This yield parameter was also significantly influenced by the constituent fruit crops in the modules as revealed from the Table 10 and figure 12.

Mango fruit crop exhibited the same trend as in number of fruits and average fruit weight. Here, in this character also, T_4 sole crop of mango recorded the highest yield per hectare (1.48 t ha^{-1}). Among the modules, the maximum yield per hectare (1.19 t ha^{-1}) was registered in the treatment T_2 - (Mango + Custard apple + Aonla).

In custard apple, significantly higher yield (4.89 t ha^{-1}) was observed in T_5 - sole custard apple crop. Among the modules, the treatment T_3 - (Mango + Custard apple + Jamun) recorded the highest yield (0.86 t ha^{-1}). All the three modules, T_1 - (Mango + Custard apple + Aonla + Drumstick), T_2 - (Mango + Custard apple + Aonla), and T_3 - (Mango + Custard apple + Jamun) were on par with each other, with a yield of 0.75, 0.83 and 0.86 t ha^{-1}, respectively.

In aonla, maximum fruit yield (10.94 t ha^{-1}) was observed in T_6 - sole aonla crop, while minimum yield (2.32 t ha^{-1}) was observed in T_1 - (Mango + Custard apple + Aonla + Drumstick). In jamun, the highest yield (0.54 t ha^{-1}) was observed in T_3 - (Mango + Custard apple + Jamun) and minimum yield (0.51 t ha^{-1}) in T_7 - (Sole jamun crop). In drumstick, maximum fruit yield (7.44 t ha^{-1}) was observed in T_8 - sole drumstick, and the lowest yield (0.49 t ha^{-1}) was observed in T_1 - (Mango + Custard apple + Aonla + Drumstick).

Table 10. Yield (t ha^{-1}) of fruit indifferent fruit crops under modules (different crop combinations), and in sole crops.

Treatments	Yield (t ha^{-1})				
	Mango	**Custard apple**	**Aonla**	**Jamun**	**Drumstick**
T_1 - Module -1 (Mango+ Custard apple + Aonla + Drumstick)	0.93 (-37.16%)	0.75 (-84.66%)	2.32 (-78.79%)	--	0.49 (-93.41%)
T_2 - Module -2 (Mango+ Custard apple + Aonla)	1.19 (-19.59%)	0.83 (-83.02%)	6.37 (-41.77%))	--	--
T_3 - Module -3 (Mango+ Custard apple + Jamun)	0.83 (-43.91%)	0.86 (-82.41%)	--	0.54 (+5.88%)	--
T_4 - Sole Mango	1.48	--	--	---	--
T_5 - Sole Custard apple	--	4.89	--	--	--
T_6 - Sole Aonla	--	--	10.94	--	--
T_7 - Sole Jamun	--	--	--	0.51	--
T_8 – Sole Drumstick	--	--	--	--	7.44
S.E. ±	0.02	0.04	--	--	--
CD at 5 %	0.06	0.13	--	--	--

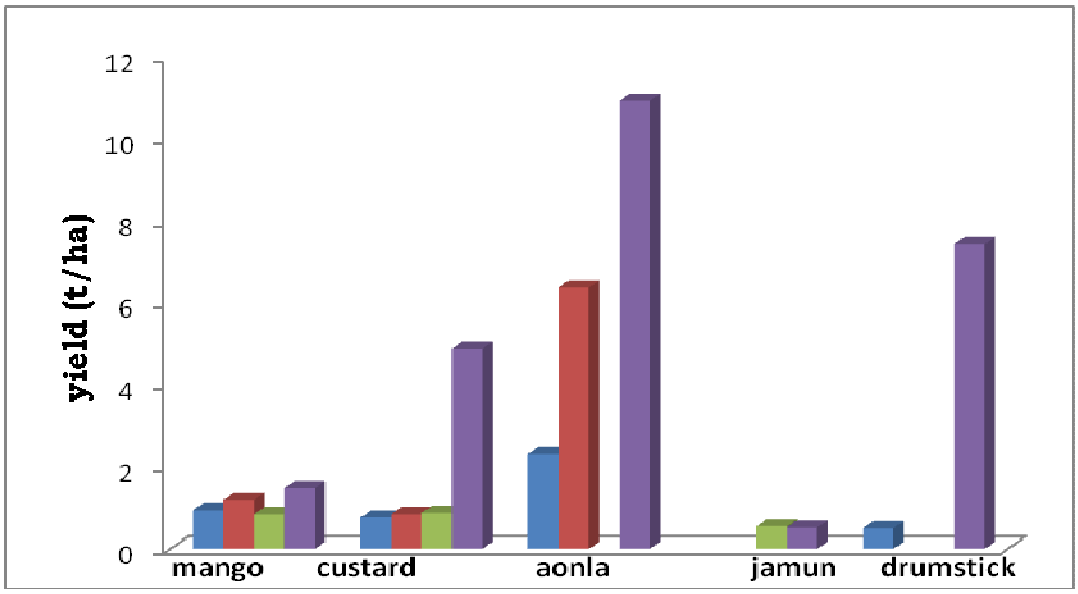

Fig. 12. Yield ha^{-1} in different fruit crops under the modules

4.3 Equivalent yield (t ha^{-1})

To assess the performance of the modules under study and to identify most suitable module for dryland conditions, the mango equivalent yield was worked out and has been presented in the Table 11 and figure 13. It was very explicit from the table that, the treatment T_2 - (Mango + Custard apple + Aonla) registered significantly the highest equivalent yield (5.07 t ha^{-1}) which was significantly higher than the other modules. The next best module was T_1 - (Mango + Custard apple + Aonla + Drumstick) (3.04 t ha^{-1}) equivalent yield

4.4. Economics of modules (mango based fruit cropping system)

Based on the yield of each component fruit crop in the module and cost of cultivation, economics were worked out in accordance with the prevailing market prices during the year under study for all the modules and presented in the Table 11 and figure 13. Among all these modules, T_2 - (Mango + Custard apple + Aonla) recorded the maximum net returns of Rs. 1,04,784.00 per ha with B:C ratio of 1:3.21 followed by T_1 - (Mango + Custard apple + Aonla + Drumstick) which recorded net return of Rs. 50,130.00 with B:C ratio of 1:2.22.

Table 11. Equivalent yield (t ha^{-1}) and Cost: Benefit ratio.

Treatments details	Eq. yield (t ha^{-1})	Cost of cultivation (Rs)	Gross Monetary returns (Rs)	Net monetary returns (Rs)	Cost: Benefit ratio
T_1-Module 1 (Mango + Custard apple + Aonla + Drumstick)	3.04	41,070	91,200	50,130	1:2.22
T_2- Module 2 (Mango + Custard apple + Aonla)	5.07	47,316	1,52,100	1,04784	1:3.21
T_3- Module 3 (Mango + Custard apple + Jamun)	2.09	35,606	62,700	27,094	1: 1.76
T_4- Sole Mango	1.48	23,180	44,400	28,220	1: 1.91
T_5 - Sole custard	4.89	55,000	1,22,250	91,750	1:2.22
T_6 - Sole aonla	10.94	80,800	1,64,100	1,03,300	1:2.03
T_7 - Sole jamun	0.51	10,000	15,300	5,300	1:1.53
T_8-Sole drumstick	7.44	68,000	1,48,800	83,800	1:2.18
S. E. ±	0.11				
C. D. at 5%	0.36				

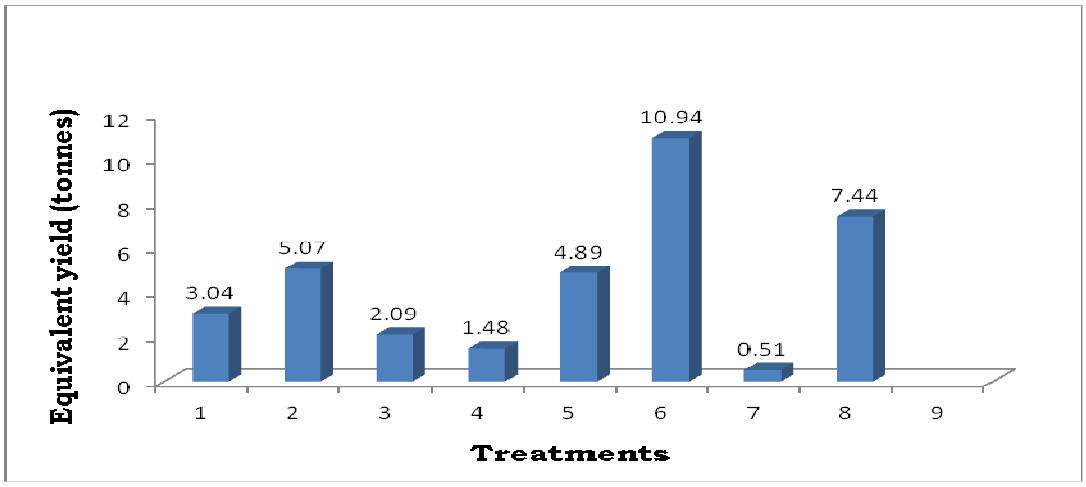

Fig. 13. Equivalent yield of different fruit crops under the modules

5. DISCUSSION

Field experiment entitled, "Performance of different fruit crop modules under rainfed conditions" was carried out during January to December 2014 at Research Farm, Horticulture section, College of Agriculture, Dhule. The data generated on different parameters such as plant height, east-west and north-south plant spread, stem girth, number of fruits per plant, average fruit weight and yield per plant and per hectare, mango equivalent yield and cost: benefit ratio has been presented in the preceding chapter. The results obtained are interpreted and discussed in this chapter.

5.1 Growth Characters

1. Plant height (m)

It was evident from the Table 2 and figure 4, that the plant height of all the constituent fruit crops in the modules was significantly affected. In general, there was decrease in plant height in all the fruits crops in modules, except jamun and drumstick as compared to sole crop. Maximum plant height (5.51m) was observed in the treatment T_3- (Mango + Custard apple + Jamun), which was on par with the treatment T_4 *i.e.* sole mango crop (5.48 m). However, there was decrement of about (11.68 %) in the height of mango in the treatments T_2 - (Mango + Custard apple + Aonla) and T_1 - (Mango + Custard apple + Aonla + Drumstick) which recorded a height of 4.84 m and 4.80 m, respectively as compared to T_4 sole mango crop. The same trend was observed in custard apple (3.96 m), Jamun (6.60 m), and

Drumstick (6.93 m) which recorded maximum plant height in the treatment T_1 (Module -1) (Mango + Custard apple + Aonla + Drumstick), T_3 (Module-3) (Mango + Custard apple + Jamun) and T_1 Module-1 (Mango + Custard apple + Aonla + Drumstick), respectively. In case of aonla, sole crop T_6 registered maximum plant height of (5.72 m) and there was decrement in height of about (11.68 %) in the T_2 - (Mango + Custard apple + Aonla) as compared to sole crop having a height of 5.42 m and in T_1 - (Mango + Custard apple + Aonla + Drumstick) which was having a height of (5.40 m) showed 12.41% decrement in height as compared to sole aonla crop. Jain and Raut (2013) were of the opinion that intercrops influence the growth of base crop. The results of present investigations are in close agreement with Moshiur Rahman *et al.* (2014) who reported higher plant height in the sole crop of coconut compared to fruit crops grown in multi-storey fruit garden.

In young orchards, Jain and Raut (2006); and Nath *et al.* (2007) reported increased height of mango due to intercrops. Rajput *et al.* (1988) observed increased height of mango in mango based cereal-pulse cropping system. Taller trees of mango was also observed by Bhuva *et al.* (1988) in the intercropping studies with banana and tapioca, a long duration crops in newly planted orchards of mango.

Intercropping in fruit orchards is generally done in the pre-bearing stage and therefore increase in plant height is always beneficial. However, in the later stage of growth *i.e.* in the post-bearing stage, more height may create difficulties in

harvesting and intercultural operations viz. spraying, weeding etc. Therefore, manageable height *i.e.* dwarfness might be useful to divert energy from vegetative growth to reproductive growth *i.e.* more flowering and fruiting and thus the yield. Moreover, reduced height is desirable in multiple cropping systems to avoid scuffle for light.

2. Plant spread (m)

It was observed from the Table 3 and 4 and figure 5 and 6 that the different fruit crop combinations had no influence on the plant spread, except in the custard apple. In mango, numerically higher east-west and north - south plant spread of 4.99 m and 5.21 m respectively was recorded in the treatment T_2 - (Mango + Custard apple + Aonla) which were (+ 3.52 %) (5.89 %) higher than the sole mango T_4 - (4.82 m) In custard apple, the highest east - west spread (3.51 m) was observed in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick) which was on par with T_5 - sole custard apple crop (3.17 m).

As regards to aonla, crop in the T_1 (Module-1) and T_2 (Module-2) exhibited 5.61% and 5.25 % decreased plant height as compared to T_6 - sole aonla crop. In jamun crop also (2.24 %) and (10.38 %) decrease in north - south Plant spread was observed in module 1 and module 2 respectively as compared to sole crop. But in drumstick, there was (5.43 %) increase in north-south plant spread of as compared to sole drumstick crop.

Reports of Rajput *et al.* (1988) and Raut and Jain (2013) in mango; Mutanal *et al.* (2007) in tamarind corroborate with the present findings.

3. Stem girth (cm)

It is very explicit from the results presented in the Table 5 and graph 7 that different treatments *i.e.* modules did not influence stem girth. In general, there was (9.78%) and (14.7 %) decrease in the stem girth of mango and aonla respectively whereas, there was (17.05 %), (3.91 %), (28.25 %) increase in the stem girth of custard apple, jamun and drumstick respectively as compared to their respective sole crop. Although the differences were non-significant in mango, numerical data showed that in the treatment T_2 - (Mango + Custard apple + Aonla) (1.15%) higher stem girth (57.12 cm) was recorded than in the sole mango crop (56.49 cm). In custard apple (33.50 cm), and drumstick (81.75 cm), about (17.75 %) and (28.25 %) increased stem girth respectively was observed in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick) as compared to their respective sole crop treatments T_5 and T_8. In jamun higher stem girth of (69.49 cm), was observed in T_3 - (Mango + Custard apple + Jamun) which was higher than T_7 - sole crop of jamun.

Jain and Raut (2006); Ratha and Swain (2006) and Nath *et al.* (2007) also observed the influence of intercrops on the growth of mango and they further reported that increase in stem girth over sole mango crop.

In a study on arecanut based cropping systems, Shahapurmath *et al.* (2003) also reported enhancement of growth of arecanut which was the base crop in their study. On the contrary, Bhuva *et al.* (1988) reported that intercrops had no significant effect on the girth of trunk of young mango.

4. Days to harvest from flowering

As perceived from the Table 6 and figure 8, in general delayed maturity was observed in all fruit crops grown in modules, except aonla. In mango, treatments significantly influenced days to harvest. In T_2 - (Mango + Custard apple + Aonla), mango required 151.70 days to harvest from flowering and was on par with T_4 - sole mango crop which required 151.95 days to harvest. In custard apple also, least days for fruit maturity was observed in the treatment T_1 - (Mango + Custard apple + Aonla + Drumstick). Least days for fruit harvesting in aonla (225.59 days), jamun (78.55 days) and drumstick (71.90 days) were observed in the treatments T_1 - (Mango + Custard apple + Aonla + Drumstick), T_7 - sole aonla crop and T_8 - sole drumstick crop, respectively.

Delayed maturity might be due to more competition for food, light response among fruits crops in modules than the sole crop.

5.2. Yield performance

1. Number of fruits plant^{-1}

It was clearly observed from the Table 7 and figure 9, that all the component fruit crops in the modules had significant effect on number of fruits per plant. Further, higher number of fruits per plant was recorded in sole crop of each fruit crop as compared to fruit crops grown in the modules.

Significantly higher number of fruits per plant (80.70) was obtained from the sole crop of mango as compared to the modules. The maximum number of fruits per plant (69.25) among the modules was obtained in the treatment T_2 - (Mango + Custard apple + Aonla). It was followed by the treatments T_1 - (Mango + Custard apple + Aonla + Drumstick) and T_3 - (Mango + Custard apple + Jamun) which recorded 57.10 and 51.85 fruits per plant, respectively they were (29.25 %), (14.88 %), (35.74 %) lesser as compared to sole mango. This clearly suggested that less number of fruits per plant were obtained from modules as compared to sole crop. However, the reduction was comparatively less in the T_2. Same trend was observed in all the other fruit crops in the different modules. In custard apple, aonla, jamun and drumstick, maximum number of fruits per plant were observed in the T_3 - (63.15), T_2 - (1206.66), T_3 - (164.53) and T_1 - (92.60), respectively. The findings are in conformity with those of Moshiur Rahman *et al.* (2014) in coconut. The decrease in the number of fruits per plant as compared to sole crop might be due to increased competition for light and

space as well as food material shared by each component crop. Higher number of fruits in sole crop might be due to more availability of light which would have synthesized more photosynthates for reproductive growth and fruits to develop in sole crop as compared to multiple cropping systems.

On the contrary, increase in the number of fruits in young orchards of mango has been reported by Bhuva *et al.* (1988); Ratha and Swain (2006); and Raut and Jain (2013).

2. Average fruit weight (g)

As revealed from the Table 8 and figure 10, sole crop of each fruit crop produced heavier fruits as compared to fruit crops grown in the modules.

In mango among modules, maximum fruit weight (173.35 g) was observed in T_2, but it was -5.88 % lower than T_4 - sole crop of mango (184.18 g). It was followed by the treatments T_1 - (Mango + Custard apple + Aonla + Drumstick) and T_3 - (Mango + Custard apple + Jamun), which recorded 165.40 g and 161.31 g fruit weight, respectively. Decrement in fruit weight was less in the T_2 about (5.88 %) as compared to the T_3 (12.41 %). Same trend was reported in all the other fruit crops in the different modules, except aonla, in which fruit weight (29.14 g) was 3.97% higher in T_2 - (Mango + Custard apple + Aonla), than the T_6 - sole aonla (28.41 g) crop.

In custard apple, jamun and drumstick, maximum fruit weight was observed in the T_2 - (162.15 g), T_3 - (18.63 g), and

T_1 - (60.06 g), respectively which were (5.8%), (4.01 %), (10.02 %) lower than their respective sole crops.

The findings are in similar line with Moshiur Rahman *et al.* (2014) they reported decrease in fruit weight in base crop of coconut and also component fruit crops in multi storied fruit gardens. Higher fruit weight in sole crop might be due to availability of more space, sunlight and food as compared to fruits under multiple cropping systems due to sharing by component crops.

3. Yield (kg plant^{-1})

Influence of combinations of different fruit crops *i.e.* modules on the yield were clearly noticed from the Table 9 figure 11.

Statistically differences were significant, but it was worth to mention that maximum yield per plant was registered in sole crop of each fruit crop in all the modules. In mango, significantly the highest yield (14.85 kg plant^{-1}) was recorded in the T_4 - sole mango crop, whereas it was 12.00 kg in the treatment T_2 - (Mango + Custard apple + Aonla) it was followed by the treatments T_1 - (Mango + Custard apple + Aonla + Drumstick) and T_3 - (Mango + Custard apple + Jamun) which had recorded 9.44 and 8.36 kg yield per plant, respectively which were (36.4%), (19.19%), (43.70 %) lower than sole crop respectively. The decline in the fruit yield in module as compared to sole crop of mango was conspicuous. Similar trend was observed in all the component crops. In custard apple, the yield was 9.74 kg per plant in T_3 - (Mango + Custard apple + Jamun) which was 20.35% lesser as

compared T_5 - sole custard apple crop (12.23 kg plant^{-1}). The maximum yield in the modules in aonla (35.34 kg plant^{-1}), jamun (3.06 kg plant^{-1}) and drumstick (5.53 kg plant^{-1}), was noticed in the treatment T_2 - (Mango + Custard apple + Aonla), T_3 - (Mango + Custard apple + Jamun) and T_1 - (Mango + Custard apple + Aonla + Drumstick), respectively which were (10.05 %), (41.15 %), (50.44 %) lesser as compared to respective sole crops which recorded 39.40, 5.20 kg plant^{-1} and 11.16 kg plant^{-1} respectively.

The results are congruence with Moshiur Rahman *et al.* (2014) who reported decrease in yield in base crop of coconut and component fruit crops of Litchi and sweet orange in multi-storied fruit garden. Decline in yield might be due to decrease in number of fruits per plant and fruit weight.

4. Yield (tons ha^{-1})

This character exhibited same trend as in fruit yield per plant, except in jamun as observed from the Table 10 and figure 12.

In this character also, decline in yield (t ha^{-1}) of crops was observed as compared to their respective sole crop, except in jamun. Mango registered maximum yield (1.48 t ha^{-1}) in sole mango crop. Among the modules, the maximum yield (1.19 t ha^{-1}) was registered in the treatment T_2 - (Mango + Custard apple + Aonla). It was followed by the treatments T_1 - (Mango + Custard apple + Aonla + Drumstick) and T_3 - (Mango + Custard apple + Jamun) which had registered 0.93 and 0.83 t ha^{-1} yield, respectively which were (37.16%), (19.69 %), (43.91 %) lower than their respective

sole crops. Higher yield per ha in sole crop might be due to higher per plant yield which might be due to more number of fruits per plant and higher fruit weight. The results are congruence with Moshiur Rahman *et al.* (2014) who reported decrease in yield in base crop of coconut and component fruit crops of litchi and sweet orange in multi-storied fruit garden.

On the contrary, improvement in yield due to intercropping in young orchard was reported by Ratha and Swain (2006) in mango based cropping. Results of Baghel *et al.* (2003) also showed increased yield of mango but in the young mango orchards.

5.3. Equivalent yield (t ha^{-1})

It is evident from the Table 11, figure 13 that the treatment T_2 - (Mango + Custard apple + Aonla) registered significantly the highest mango equivalent yield (5.07 t ha^{-1}) as compared to rest of the modules.

The results are in agreement with Moshiur Rahman *et al.* (2014) who reported higher equivalent yield of coconut than the sole crop in multi- storied fruit garden.

Higher equivalent yield in all the modules might be due to contribution of the entire component crops for overall increase in the yield under multiple cropping systems. Hare Krishan *et al.* (2013) also reported that different combinations of fruit crops with annual crops were sustainable and remunerative under the arid ecosystems. Shahapurmath *et al.* (2003) while studying the arecanut

based cropping systems also reported enhancement in the yield of main crop of arecanut.

Decline in plant height as compared to respective sole crop especially in mango, custard, aonla, was observed. But energy saved which otherwise would have been used for vegetative growth, was utilized for enhancing yield which is clearly reflected in the increased equivalent yield. This also suggested that, in mixed fruit cropping the yield of component fruit crops may be low as compared to sole crop, due sharing in space and competition for light and food, but equivalent yield of base crop is more because of significant contribution of each component fruit crop. This is what expected in the mixed fruit cropping system not only for sustainability of yield, but also for economic sustainability of the farmer in dryland region.

5.4. Economics of multiple fruit cropping

Based on the yield of each component fruit crop in the module and cost of cultivation, economics was worked out in accordance with the prevailing market prices for all the modules under study. As evident from the Table 11, figure 13 the highest net returns of Rs. 1,04,784.00 with B:C ratio of 1:3.21 were realized from T_2 - (Mango + Custard apple + Aonla), followed by T_1 - (Mango + Custard apple + Aonla + Drumstick) which recorded returns of Rs.50,130.00 with B:C ratio of 1:2.22. The increased returns from three crop combinations over sole crops are also supported by the study of Margate and Magat (1983); Reddy and Sudha (1989); Bhuva *et al.* (1988); Shahapurmath *et al.* (2003); Marimuthu

(2005); Nath *et al.* (2007); Swain and Padhi (2011) and Moshiur Rahman *et al.* (2014).

All the modules of mixed cropping systems under study registered higher equivalent yield and were found to be economically better with increased net returns over and above the returns from sole crop. Baghel *et al.* (2003), and Swain and Padhi (2011) have also reported the profitability of mango based cropping systems either by annual or perennial crops.

Inferences can be drawn from the overall results of the present study that the mixed fruit cropping improves yield and generates income also, as equivalent yield and returns are more than that of sole (mono) crop. Secondly, the treatment T_2 having combinations of Mango + Custard apple + Aonla resulted in increased productivity and profitability of the particular Module and hence was found to be the most feasible combination for dryland conditions owing to its higher equivalent yield and net returns; and also optimum association between these fruit crops, as compared to other modules. In another words, it can be said that mango, custard apple and aonla can be adjudged as the best companion crops for dryland conditions.

It is further felt that long term assessment of these modules is essential for more precise inferences.

6. SUMMARY AND CONCLUSION

Field experiment entitled, "Performance of different fruit crop modules under rainfed conditions" was carried out during January to December 2014 at Research Farm, Horticulture section, College of Agriculture, Dhule. In this study, mango is the base crop which is planted at regular spacing in all the modules and other crops are planted in the interspaces of the mango. Among these crops, custard apple is common in all three modules, aonla in two modules *i.e.* Module-1 and Module-2; whereas, jamun and drumstick is only in the Module -3 and Module-1, respectively. The results of this investigation are summarized as under.

6.1 Growth Characters

1. Plant height (m)

In general, it was observed that there was decrease in plant height of the all fruit crops grown in the modules as compared to sole crop, except in jamun and drumstick. In mango fruit crop, in T_1 (12.41%) and T_2 (11.68 %) decrease in plant height as compared to sole mango crop. whereas, increased plant height (5.51 m) was observed in the treatment T_3 - (Mango + Custard apple + Jamun) and was on par with the treatment T_4 *i.e.* sole mango crop (5.48 m).

In custard apple also 9.84%, 4.78% decrease in plant height in the treatment T_3 (3.21 m) and T_2 (3.39 m) as compared to T_5 sole custard apple crop. However, maximum plant height (3.96 m) was recorded in the treatment T_1. As regards to aonla, same trend was observed and 5.61%

decrease in plant height was noticed in treatment T_1 with a height of 5.40 m and T_2 (5.42 m) as compared to sole crop (5.72 m).

In case of jamun and drumstick, increase in height in the module as compared to sole crop was noticed.

2. East-West plant spread (m)

A general, decrement in East-West plant spread as compared to sole crop was observed, except in drumstick.

In mango, although differences were non-significant, numerically the lowest east-west plant spread was recorded in the treatment T_3 (4.63 m) and T_1 (4.24 m) which were 3.85%, 12.04% lesser as compared to T_4 sole mango crop (4.82 m). On the contrary, highest east-west plant spread (4.99 m) was recorded in the treatment T_2 which was 3.52 % higher than the T_4 sole mango (4.82 m). In custard apple, though the differences were significant, there was 12.94%, 9.85% decrease in east - west plant Spread was observed in T_3 (2.76 m) and T_2 (2.88 m) as compared to T_5 sole custard apple crop (3.17 m). Significantly the highest east-west plant spread (3.51 m) was recorded in the treatment T_1 which was 10.92% higher as compared to T_5 sole custard apple crop with a height of (3.17 m) and were on par which each other.

In aonla, maximum (5.04 m) east - west plant spread was recorded in the treatment T_1 and the lowest (4.58 m) in the treatment T_2. In case of jamun no difference was observed in the east west plant spread in T_3 and T_6 sole crop. As regards to drumstick, maximum (5.49 m) east-west plant spread was

recorded in the treatment T_1- (Mango + Custard apple + Aonla + Drumstick) and the lowest in the treatment T_8 *i.e.* sole drumstick crop (5.33 m).

3. North- South plant spread (m)

This character exhibited almost same trend as that of east-west plant spread and in general decrement in north-south plant spread as compared to sole crop was observed except in jamun and drumstick.

In mango, this character was statistically non-significant. But, numerical observations showed 15.05%, 4.07% decrease in north-south plant spread in the treatments T_3 - (4.18 m) and T_1 - (4.72 m) as compared to T_4 - sole crop (4.92 m). In the treatment T_2 with a height of 5.21 m recorded 5.89% increase in north - south plant spread. In custard apple also, the differences were significant, decrease in north-south plant spread was observed in all the modules as compared to sole crop. However, among the modules, maximum north-south plant spread was observed in T_1 - (3.03 m) and was on par with T_5 *i.e.* Sole custard apple crop.

As regards to aonla, in the treatment T_1 and T_2 exhibited 2.24% and 10.38% decreased values as compared to T_6 sole aonla crop. In jamun crop also 1.63% decrease in north-south Plant spread was observed in modules as compared to T_7 - sole crop. But in drumstick, there was 5.43% increase in north-south plant spread as compared to T_8 - sole drumstick crop.

4. Stem girth (cm)

Statistically the differences were non-significant, but however in general decrease stem girth was observed in mango and aonla crops grown in the modules as compared to sole crop whereas, increased stem girth was observed in custard apple, jamun and drumstick.

In mango, though statistical differences were non-significant, but numerically, the highest stem girth was recorded in the treatment T_2 - (57.12 cm) as compared to T_4 - sole mango crop. However, 10.84%, 9.78% decrease in stem girth was noticed in the treatment T_3 - (50.37 cm) and T_1 - (50.97 cm). In custard apple, 17.05 % increased stem girth was observed in the treatments T_1 - (33.50 cm) and T_2 - (30.75 cm). T_1 (Mango + Custard apple + Aonla + Drumstick) recorded the highest stem girth (33.50 cm) and the treatment T_3 - (28.00 cm) recorded the lowest stem girth.

In aonla, the data showed that stem girth was the 14.71%, 1.18% lowest in both the treatments *i.e.* T_1 (51.50 cm) and T_2 (59.66 cm) as compared to T_6 - sole crop (60.37 cm). In jamun, the 3.91% highest stem girth (69.49 cm) was registered in T_3, as compared to T_7 -sole crop (66.87 cm). In drumstick also, 28.25% increased stem girth (81.75 cm) was observed in T_1 as compared to T_8 - sole drumstick crop (63.74 cm).

5. Days to harvest from flowering (days)

In general it was observed that more number of days were required for harvest from flowering in all fruit crops

grown in the module as compared to sole crop, except in aonla.

In mango, maturity was delayed but least number of days for harvest from flowering to noticed in the treatment T_2 - (151.70 days) and it was on par with T_4 - Sole mango crop (151.95 days). In custard apple, least days from flowering to harvest were recorded in the treatment T_1 - (91.50 days) as compared to 92.00 days in T_5 *i.e.* sole custard apple crop. Both of these treatments were on par with each other.

In aonla, least number of days for fruit maturity from flowering to harvest was observed in treatment T_2 - (225.59 days) which was 5.05 % lesser as compared to T_6 sole aonla crop with 244.95 days. About 84.46 days were required in jamun in the treatment T_3 which was 7.52% higher as against 78.55 days in T_7 sole crop of jamun. In drumstick, the highest duration of 76.50 days was required for fruit maturity in the treatment T_1 as compared to T_8 - sole drumstick crop (71.90 days).

6.2 Yield and yield parameters

1. Number of fruits plant^{-1}

It is very clear from the data depicted in Table 7 figure 9, sole crop of each fruit crop recorded maximum number of fruits as compared to fruits grown in the modules.

In mango among modules, maximum number of fruits per plant (69.25) was recorded in the T_2. In case of custard apple, among modules, maximum number of fruits per plant (63.15) was recorded in the treatment T_3.

In aonla fruit crop, maximum fruits per plant among modules were observed in the treatment T_2 - (1206.66). Jamun and drumstick have appeared only in one module only *i.e.* T_3 and T_1, respectively. Sole jamun crop T_7 produced 269.10 fruits as compared to jamun in T_3 - (164.53). In drumstick, maximum number of fruits (167.35) was recorded in T_8 - sole crop as compared to drumstick T_1 (92.60).

2. Average fruit weight (g)

From the data of the Table 8 figure 10, sole crop of each fruit crop recorded that highest weight of fruits as compared to fruits grown in the modules.

In mango among modules, maximum fruit weight (173.35 g) was observed in T_2. In case of custard apple, the highest fruit weight (162.15 g) was observed in the treatment T_2.

In aonla, the highest fruit weight (29.54 g) was observed in T_2. In jamun, the highest (19.41g) and the lowest (18.63 g) fruit weight was observed in the treatments T_7 sole jamun crop and T_3 - (Mango + Custard apple + Jamun), respectively. In drumstick, the highest (66.75 g) and the lowest (60.06 g) fruit weight was observed in the treatments T_8 Sole drumstick and in the treatment T_1, respectively.

3. Yield plant^{-1} (Kg)

As revealed from the Table 9 figure 11, highest yield (kg plant^{-1}) was registered in sole crop of each fruit crop as compared to fruit crops grown in the modules.

In mango, among the modules, the maximum yield per plant (12.00 kg plant^{-1}) was registered in the treatment T_2. In custard apple, the maximum yield (9.74 kg) was registered in the treatment T_3.

In aonla, maximum fruit yield (35.44 kg plant^{-1}) was observed in T_2. In jamun and drumstick, fruit yield of 3.06 kg plant^{-1} and 5.53 kg plant^{-1} was observed in the treatment T_3 and T_1, respectively.

4. Yield ha^{-1} (tonnes)

As revealed from the Table 10 figure 12, yield (t ha^{-1}) exhibited the same trend as that of yield (kg pt^{-1}), sole crop of each fruit crop produced more yield as compared to fruit crops grown in the modules.

In mango, among the modules, the maximum yield per hectare (1.19 t ha^{-1}) was registered in the treatment T_2. In custard apple, among the modules, the maximum yield was registered in the treatments T_2 (0.86 t ha^{-1}) and T_3 (0.83 t ha^{-1}).

In aonla, maximum fruit yield (6.37 t ha^{-1}) was observed in T_3. In jamun and drumstick, fruit yield of 0.54 t ha^{-1} and 0.49 t ha^{-1} was observed in the treatment T_3 and T_1, respectively.

6.3. Equivalent yield (t ha^{-1})

The treatment T_2 (Mango + Custard apple + Aonla) registered significantly highest equivalent yield (5.07 t ha^{-1}) which was significantly higher than the other modules.

6.4. Economics of multiple fruit cropping

Among all these modules, T_2 (Mango + Custard apple + Aonla) recorded the maximum net returns of (Rs.1,04,784.00) with B:C ratio of 1:3.21 followed by T_1 (Mango + Custard apple + Aonla + Drumstick) which recorded returns of Rs. 50,130.00 with B:C ratio of 1:2.22.

CONCLUSION

Based on the whole results obtained from the present investigation, it can be concluded that, the T_2 comprised of Mango + Custard apple + Aonla fruit crops is found most suitable and profitable which orchestrate with dryland conditions considering their commendable growth performance, the highest equivalent yield of 5.07 t ha^{-1} and maximum monetary returns of Rs. 1,04,784.00 with a BCR ratio of 1: 3.21.

The crops under T_2 (Mango + Custard apple + Aonla) are compatible with each other, and could be adjudged as the best companion fruit crops.

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Appendix

Weekly meteorological data (January to December, 2014).

Month	Met. Week No.	Temperature 0^0C		Relative Humidity (%)		Rainfall m. m.	No. of Rainy days	Sun Shine hour	Evaporation m.m.
		Max	Min	Morning	Evening				
Jan. 2014	1	28.8	13.2	81.2	32.5	000.0	00	7.0	04.5
	2	28.1	12.4	79.1	37.2	000.0	00	06.1	03.8
	3	29.4	12.9	72.8	34.5	000.0	00	05.7	04.4
	4	27.6	14.6	90.7	51.1	009.0	02	05.6	03.2
Feb. 2014	6	30.8	12.6	71.0	25.1	000.0	00	8.6	5.2
	7	27.8	10.0	76.8	27.2	000.0	00	7.3	5.0
	8	31.3	14.4	80.7	52.4	022.0	01	5.4	5.4
	9	29.4	13.0	97.7	69.7	008.2	02	5.2	4.9
March 2014	10	29.8	15.0	85.2	39.7	010.2	02	6.7	5.4
	11	35.9	17.5	64.8	27.1	000.0	00	8.2	6.3
	12	37.2	16.0	130.2	21.2	000.0	00	9.1	7.9
	13	38.2	19.7	53.0	17.0	000.0	00	9.1	8.2
April 2014	14	39.4	20.5	45.5	13.7	000.0	00	8.0	9.7
	15	39.0	18.3	48.2	14.2	000.0	00	9.3	9.7
	16	39.5	22.1	54.7	21.7	000.0	00	8.4	9.3
	17	41.9	24.6	39.3	12.7	000.0	00	9.4	11.7
	18	42.4	23.7	40.7	18.1	000.0	00	8.8	11.7
May 2014	19	40.7	24.7	45.4	19.4	000.0	00	7.6	11.1
	20	40.5	25.8	54.7	25.6	000.0	00	7.2	11.0
	21	42.5	26.0	44.41	16.9	000.0	00	9.0	13.7
	22	43.0	26.8	54.1	20.3	000.0	00	9.0	13.1

Weekly meteorological data (January to December, 2014)

Month	Met. Week No.	Temperature 0^0C		Relative Humidity (%)		Rainfall m. m.	No. of Rainy days	Sun Shine hour	Evaporation m.m
		Max	Min	Morning	Evening				
June 2014	23	42.4	27.5	51.6	25.0	000.0	00	7.7	14.1
	24	38.9	20.8	71.0	39.3	049.0	02	6.6	8.8
	25	37.6	24.7	65.9	35.7	000.8	00	6.7	8.1
	26	38.7	25.7	61.4	30.6	000.0	00	8.8	12.3
July 2014	27	37.9	23.9	64.6	38.4	000.0	00	5.6	10.3
	28	36.4	21.9	73.7	46.3	014.5	3	3.9	5.4
	29	31.8	23.9	82.9	68.1	047.6	2	1.3	3.8
	30	29.9	22.4	86.3	68.7	111.4	3	0.8	3.3
	31	32.5	24.4	32.6	60.9	011.6	1	2.4	3.2
August 2014	32	32.1	23.8	78.0	53.0	001.2	00	5.6	4.6
	33	32.6	22.8	84.6	53.1	006.8	2	5.0	4.5
	34	32.8	23.5	89.7	68.7	52.6	3	2.5	3.8
	35	30.8	22.2	89.7	73.3	68.4	3	1.0	3.0
September 2014	36	30.5	21.9	85.0	69.7	101.8	2	2.4	3.0
	37	30.8	21.0	85.4	66.4	005.6	1	4.9	3.1
	38	32.8	22.3	81.6	50.9	000.0	-	7.7	5.0
	39	34.8	21.9	77.4	42.9	000.0	-	8.2	5.8
October 2014	40	36.0	22.1	76.0	33.3	000.0	-	8.6	6.2
	41	35.5	21.8	68.4	35.9	000.0	-	7.7	6.6
	42	33.9	22.1	74.9	37.4	000.0	-	7.8	5.7
	43	32.6	19.9	73.4	31.7	000.0	-	4.8	5.4
	44	34.2	17.7	74.1	24.9	000.0	-	8.4	5.3

Weekly meteorological data (January to December, 2014).

Month	Met. Week No.	Temperature 0^0C		Relative Humidity (%)		Rainfall m. m.	No. of Rainy days	Sun Shine hour	Evaporation m.m.
		Max	Min	Morning	Evening				
November 2014	45	33.6	18.3	65.6	30.4	000.0	-	8.0	6.1
	46	31.6	21.6	88.1	55.6	135.4	3	5.7	4.4
	47	31.2	16.7	85.7	33.7	000.0	-	8.1	3.6
	48	31.1	14.1	82.1	27.9	000.0	-	7.8	3.7
December 2014	49	30.4	11.9	84.9	27.9	000.0	-	8.1	3.7
	50	29.7	14.1	88.7	41.6	39.6	1	6.0	2.8
	51	25.5	8.7	91.0	29.6	0.00	-	7.5	2.7
	52	26.9	9.2	85.1	33.0	0.00	-	7.3	2.9
Total rain fall m.m. and no. of rainy days						695.7	35		