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Effect on system productivity through inter crop diversification in agri-horti system in arid ecosystem of western Rajasthan

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Abstract

An experiment was conducted on the "study of system productivity through intercrop diversification in agri-horti system in arid ecosystem of western Rajasthan" at research farm of ICAR-CAZRI, Regional Research Station, Bikaner on the existing plantation of 10 year old plantation of citrus (*Citrus aurentifolia*), bael (*Aegle marmelose*) and *gonda* (*Cordia myxa*) planted with drip irrigation system under agri-horti system. The experiment was conducted under factorial Randomized Block design with three replications. The experimental results revealed that the intercropping of legumes (rainfed) has no competition in agri-horti system, showing positive effect on growth and yield of fruit trees. Growth parameters of all the trees were found to be non-significant in intercropping of *Lasiurus sindicus* and aloe-vera over no intercropping. Intercropping of mothbean with bael gave highest plant height of bael which was 15.9, 13.05, 4.90 and 10.70 per cent higher over intercropping of clusterbean, aloe-vera, *L. scindicus* and sole, respectively. Yield of intercrops were highest with citrus and lowest with bael during both the years. Highest water use efficiency (0.98 kg/mm) was in intercropping of mothbean with citrus whereas in perennial crops, *L. sindicus* showed highest WUE of 19.4 kg/mm in intercropping with citrus. The CEY was highest in all the crops in intercropping with citrus over rest of the trees under agri-horti system.

Key words: Agri-horti system, arid ecosystem, clusterbean equivalent yield , water use efficiency

Introduction

Intercropping is a technique of crop intensification in both space and time where in the competition between crops may occur during a part or whole of crop growth period. Beets (1982) thought that crop insurance was a major principle of intercropping in that if environmental factors change, some of the intercrop does well when others do poorly. In some related studies, the results indicated that competition for nutrients does not exist in intercropping systems (Jose *et al*., 2000; Thevathasan *et al*., 2004). Therefore, it is very important to explore the competitive mechanism in intercropping systems, in order to provide optimum management strategies and technologies for managing intercropping system with high-yield, high-efficiency and stabilization. Within tree-based intercropping systems, a number of factors can influence tree shading of adjoining agricultural crops. Intercropping of different field crops in cassava indicated that all intercropping systems had LER greater than 1 which varied between 1.35 (cassava + upland rice) and 1.6 (cassava + peanut) which showed the profitability of intercropping (Islami *et al*., 2011). Mahant (2011) inferred that intercropping in banana was more productive and profitable than their sole cultivation without loss in yield.

India is facing a big challenge in balancing its dual objectives of food security and crop diversification to increase farm income. The India's low crop productivity, limited irrigation facilities and underdeveloped infrastructural support like cold storages, markets, roads, and transportation, which have increased the woes of Indian horticulturists. As India begins to market its agricultural produce across political boundaries, it can add new dimensions to its commercial viability in agriculture. Within the horticulture sector also, besides spices, fruits and vegetables are the major crops where the area under cultivation has increased. This gain in area under horticulture and mainly under fruits and vegetables is a collective impact of diversification of the production pattern of producers and increased demand of the consumers due to shift in their consumption pattern (Mittal, 2009).

Tree-based intercropping one of the excellent farming system and can contribute much to our understanding of sustainable agriculture practices. Our current research goals are to address and quantify the numerous biophysical interactions that occur at the tree-crop interface in order to enhance our understanding of the ecology of tree-based intercropping. Investigations over the last decade have documented several complementary biophysical interactions. Nitrogen (N) transfer from fall-shed leaves to adjacent crops with enhanced soil nitrification as the proposed mechanism was estimated to be 5 kg N ha^{-1}. Soil organic carbon (C) adjacent to tree rows has increased by over 1%, largely as a result of tree litter fall inputs and fine root turnover (Thevathasan *et al.*, 2008).

It is estimated that intercropping has reduced nitrate loading to adjacent waterways by 50%, a hypothesized function of deep percolate interception by tree roots. Earthworm distribution and abundance was also found to be higher closer to the tree rows when compared to earthworm numbers in the crop alleys. We speculate that these are indicative of major changes in the flow of energy within the trophic structure identified with intercropping systems (Thevathasan *et al.*, 2008). Tree-based intercropping is considered an excellent farming system and can contribute much to our understanding of sustainable agriculture practices. Therefore, experiments was conducted with the objective of assessment of intercrop productivity and their effect on trees growth, production and quantify the numerous biophysical interactions that occur at the tree-crop interface in order to enhance our understanding of the ecology of tree-based intercropping (a form of agroforestry) in arid zone of western Rajasthan.

The climate during both the years was normal. Total rainfall of 257 mm and 279.9 mm was received which was almost equal to the normal rainfall of the region followed by highest rainfall of 153 mm 128.9 mm was received in month of August during 2012 and 2013, respectively. The highest maximum temperature of 40.3°C and 43°C was recorded in month of May with a minimum mean temperature 4.0 & 4.3°C in January during 2012 and 2013, respectively. The highest evaporation of 12.6 mm/day was recorded in month of May 2012. Highest evaporation was recorded in month of May during both the years. The soil of the experimental site contains 83-87% sand, 8-9% clay and 5-7 % clay content. The bulk density of soil varies from 1.52 to1.55 g cm^{-3} and alkaline in chemical reaction having pH 7.8 to 8.1. The moisture content at field capacity and permanent wilting point varied from 15.4- 16.8% and 7.7-8.6%, respectively. The soil was low in organic carbon (0.09%) and available N (135 kg ha^{-1}), medium in available P (38.31 kg ha^{-1}) and high in available potassium (356- 375 kg ha^{-1}).

Materials and Methods

The present investigation was conducted for two consecutive years 2012 and 2013 at Research farm of Central Arid Zone Research Institute, Regional Research Station Bikaner which falls in Zone-I (1c) defined as partially irrigated hyper arid zone of western Rajasthan. The intercropping of arable crops like mothbean and clusterbean, sewan grass (*Lasiurus scindicus*) as rainfed and aloe-vera (drip irrigation) were taken under agri-horti system in between the sows of fruit trees (10 year old) of lime (*Citrus aurentifolia*), bael (*Aegle marmelose*) and *gonda* (*Cordia myxa*) which were grown under drip irrigation system. The irrigation of fruit trees were done as per the requirement and recommendation of fruit trees. The *sewan* grass (*Lasiurus scindicus)* and aloe-vera were planted during 2009 as perennial component in agri-horti system. All the treatments were laid under randomized block design with three replications. The growth data of trees were taken each year in month of November whereas the arable crops growth and yield data were taken as per their schedule. No irrigation was given to any intercrop except aloe-vera which was grown with drip irrigation system.

Results and Discussion

Growth of trees

All the fruit trees under drip irrigation system showed significantly higher plant height, stem girth and tree canopy with the intercropping of mothbean. Regarding the plant height of fruit trees which was highest with mothbean intercropping and 5.5% higher over sole citrus (without intercrop) but found at par with intercropping of rest of the crops. The data showed that citrus plant height was unaffected significantly by intercropping. Mothbean intercropping with bael gave highest plant height of bael which was 15.9, 13.05, 4.9 and 10.7 per cent higher over intercropping of clusterbean, aloe-vera, *L. scindicus* and sole, respectively. The plant height of *gonda* was not significantly affected by any intercrop (Table 1). The variation in different growth parameters of trees were found to be non-significant in intercropping of *L. sindicus* and aloe-vera over no intercropping because of being the perennial nature of these crops.

The collar diameter of all the trees were not affected significantly and found to be at par with intercropping of annual (mothbean and clusterbean) or perennial crops (*L. sindicus* and aloe-vera). The canopy was highest with intercropping of mothbean but in case of citrus the canopy was non-significant with all the intercrops. The canopy cover of bael and *gonda* was significantly affected and 38.5, and 47.3 per cent higher in mothbean intercropping over their sole plantations (Table 1). This shows that the intercropping have a positive effect on tree growth. This may be due to more inter culture and other operation going on with intercropping system providing more favorable conditions than the sole plantations. In different studies it was found that the leguminous plants, soybean and peanut could fix nitrogen from the air *via* a symbiotic relationship with rhizobium bacteria and increase the mineral soil nitrogen content (Cheng 1994; Wani *et al.*, 1995).

Fruit yield

The highest fruit yield of all the trees were highest with intercropping of mothbean during both the years. Highest citrus fruit yield (1197.9 kg/ha) was recorded with mothbean intercropping which was 55.13 per cent higher over sole planting. The yield was 38 and 54 per cent higher with perennial intercrops of *L. sindicus* and aloevera, respectively. The lower yield with the system was due to perennial nature of intercrop giving completion for year round for moisture and nutrient (Fig.1). Many researchers have supported that as one of the main reasons leading to the reduction of crop yield, the competition for soil nutrients does exist in the interface of trees and crops and has a negative impact (Newman and

Bennett, 1979; Yun *et al.*, 2012).

Yield of intercrops

In different agri-horti system the highest total dry matter yield and grain yield of annual crops (mothbean and clusterbean) and intercropping of *L. sindicus* (perennial) were recorded in intercropping with citrus. In mothbean and aloe-vera the effect on yield was found to be non-significant (Table 2). *Lasiurus sindicus* grown as intercrop (rainfed) gave highest total dry matter (TDM) yield of 64.20 q/ha in intercropping with citrus which was 73.0, 50.9 per cent higher over intercropping with bael and gonda, respectively (Table 2). Aloe vera gave highest green pad yield of 611q/ha which was at par in intercropping with bael and gonda. This showed that bael has heavy competition and affecting adversely on growth of *L. sindicus* but no adverse effect on growth of aloe vera. Aiyer (1949) also showed that the increase in yield was the better utilizing of resources because the crops with varying root depth, tap different layers of soil for plant nutrients and moisture. The periodical return and distribution of labour requirements throughout the year is of great help to the resource poor cultivators.

Water Use Efficiency (WUE)

Among the intercropping of annual crops mothbean showed the highest water use efficiency (0.98 kg/mm) in intercropping with citrus which was 43.8, 21.48 and 39.7 per cent higher over intercropping with bael, *gonda* and sole, respectively (Table 3). In perennial intercops, *L. sindicus* showed highest WUE of 19.4 kg/mm in intercropping with citrus which was 55.67, 12.86 and 23.7 per cent higher over bael, *gonda* and sole cropping, respectively.

Water use efficiency of agri-horti system was highest with mothbean intercropping which was at par with clusterbean but significantly higher over rest of the intercrops. The system WUE by intercropping of perennials also were highest in intercropping with citrus over rest of trees which showed that citrus has very less competition with intercrops than bael and *gonda* (Table 3).

Clusterbean equivalent yield (kg/ha) of agri-horti system

Clusterbean equivalent yield in all the intercrops was highest in intercropping with citrus. In citrus+ mothbean agri-horti system highest CEY was 265.5 which was 44.16, 21.88 and 40.33 per cent higher over bael + mothbean, *gonda* + mothbean and sole, respectively (Table 4). Citrus + *L. sindicus* intercropping gave 31.2 per cent higher CEY over citrus + aloe-vera system. All the intercropping system gave higher CEY in agri-horti system than their sole cropping.

Table 1. Growth of trees affected by different intercrops agri-horti system (Mean of 2012 and 2013)

Fruit trees	Tree height (cm)					Tree Collar diameter (cm)					Tree canopy (m^2)				
	Moth bean	Cluster bean	Aloe-vera	*L. sindicus*	Sole	Moth bean	Cluster bean	Aloe-vera	*L. sindicus*	Sole	Moth bean	Cluster bean	Aloe-vera	*L. sindicus*	Sole
Citrus	348.35	315	331.65	322	330.8	18.16	14.86	14.32	14.07	13.52	17.9	16.3	13.10	15.65	13.3
Bael	521.7	438.35	453.65	495	456.65	17.61	14.62	15.68	15.77	15.69	20.5	13.15	18.85	15.5	12.6
Gonda	385.85	385.3	346.65	353.3	320.35	18.20	14.92	14.12	16.58	14.82	19.3	15.95	11.75	13.35	10.9
Mean	418.63	379.55	377.32	390.10	369.27	17.66	14.80	14.71	15.47	14.68	19.23	15.13	14.57	14.83	12.27
CD 5%	T=34.89	C=59.03		TXC=64.05		T=4.87	C=6.29		TXC=10.9		T=3.11	C=5.345		TXC=5.62	

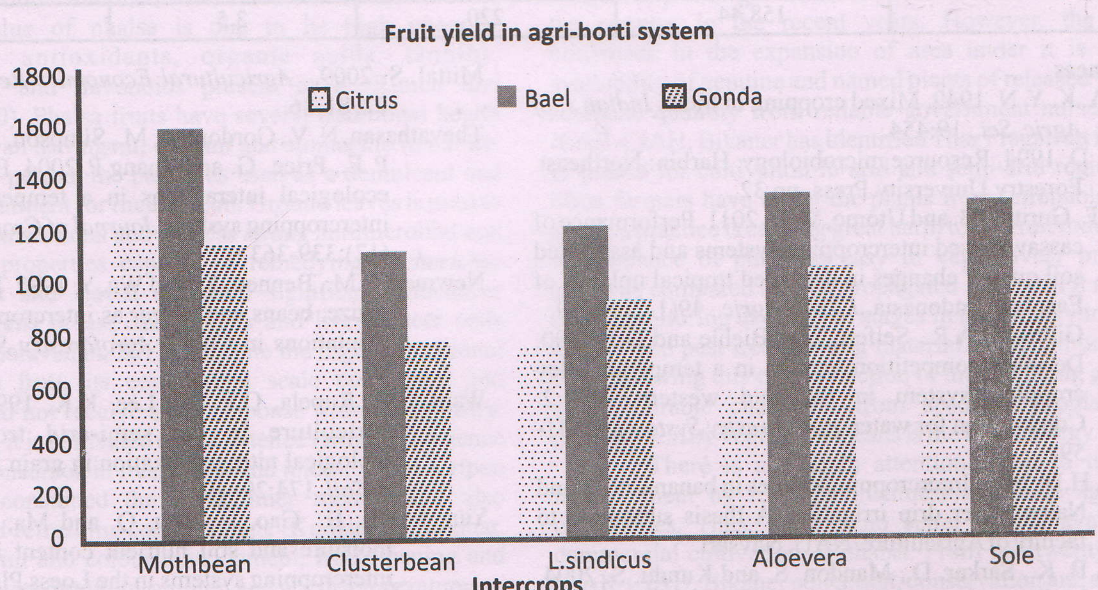

Fig. 1. Fruit yield under agri-horti system in drip irrigation

Table 2. Growth and yield of intercrops under agri-horti system (mean of 2012 and 2013)

Fruit trees	Dry matter production (kg/ha)		Seed yield		Dry matter yield (q/ha)	Green Pad yield (q/ha)
	Moth bean	Clusterbean	Mothbean	Clusterbean	*L. sindicus*	Aloe-vera
Citrus	660.85	3014.15	240.4	1001.6	64.2	584
Bael	506.25	1865.85	192.5	732.85	17.3	611
Gonda	506.25	2032.9	211.25	841.9	31.5	404
sole	629	3018.95	247.5	1035	31.02	394
Mean	575.59	2482.9	222.91	902.84	36	498
CD 5%	419.3	526	NS	198.3	1.19	NS

Table 2. Growth and yield of intercrops under agri-horti system (mean of 2012 and 2013)

Trees/ Intercrops	Inter Crop WUE (kg/mm)				Agri-horti System WUE (kg/mm)			
	Moth bean	Cluster bean	Aloe- vera	*L. sindicus*	Moth bean	Cluster bean	Aloe vera	*L. sindicus*
Citrus	0.989	0.682	4.498	19.423	2.511	2.257	5.929	19.5
Bael	0.557	0.461	4.814	8.635	0.557	0.461	4.814	8.635
Gonda	0.778	0.509	3.919	16.994	0.778	0.509	3.919	16.994
Sole	0.595	0.485	3.2	14.8	0.595	0.485	3.5	14.8

Table 3. Water use efficiency (WUE) of intercrops and agri-horti system

Trees/ Intercrops	Inter Crop WUE (kg/mm)				Agri-horti System WUE (kg/mm)			
	Moth bean	Cluster bean	Aloe- vera	*L. sindicus*	Moth bean	Cluster bean	Aloe vera	*L. sindicus*
Citrus	0.989	0.682	4.498	19.423	2.511	2.257	5.929	19.5
Bael	0.557	0.461	4.814	8.635	0.557	0.461	4.814	8.635
Gonda	0.778	0.509	3.919	16.994	0.778	0.509	3.919	16.994
Sole	0.595	0.485	3.2	14.8	0.595	0.485	3.5	14.8

Table 4. Clusterbean equivalent yield of agri-horti system

Trees/ Intercrops	Clusterbean equivalent yield (kg/ha) agri-hotri system 2012-13			
	Mothbean	Clusterbean	Aloe-vera	*L. sindicus*
Citrus	265.59	179.95	516.41	749.67
Bael	148.22	120	550.02	299.6
Gonda	207	132.5	447.8	589.6
Sole	158.44	220	3.5	14.8

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