Indian Journal of Agricultural Sciences **80** (5): 423–6, May 2010

Comparison of fruit-based multi-species cropping system versus sole cropping system under arid region of Rajasthan*

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Received: 13 July 2009; Accepted: 11 January 2010

Key words: Cropping system, Ground storey, Over storey, Sole cropping, Under storey

The arid region, which covers nearly 12% of the geographical area of India, is characterized by fragile ecosystem. Production system in this region is confronted by several bio-physical constraints, such as low and erratic rainfall, extreme temperature variations as high as 40°C during summer and 0°C during winter. Under such situation, multi-species cropping system integrating suitable under and ground storey crops with the hardy fruit trees has been found remunerative providing fruit, food, fuel and fodder ($4F_s$) to the farmer (Chadha 2002).

It has been recognized that hardy perennial fruit trees, such as *aonla* (*Emblica officinalis* Gaertn), *ber* (*Ziziphus mauritiana* Lamk), bael (*Aegle marmelos* Correa) etc. can be better options for crop diversification in arid region. However, there is lack of information on fruit-based multi-species cropping system except few traditional cropping systems such as growing of pearl millet [*Pennisetum glaucum* (L) R. Br. emend. Stunz], mothbean [*Vigna acontifolia* Jacq. Marechal] clusterbean (*Trigonella foenum graecum* L.) between natural stands of *khejri* [*Prosopis cineraria* (L) Druce] and *boradi* (*Ziziphus rotundifolia* Lam.) which results in sub-normal production from the farmland. Hence, the present investigation was undertaken to evaluate suitable fruit-based multi-species cropping system having different morphological characters in the form of over storey, under storey and ground storey crops.

Based on part of M Sc thesis submitted by first author to Rajasthan Agricultural University, Bikaner, Rajasthan during 2007.

*Short note

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A field experiment was conducted during 2006–07 at Central Institute for Arid Horticulture, Bikaner (28° 01' N latitude, 73°18' longitude at an altitude of 234.84 m above mean sea level) in the orchards planted during 2003. The soil was sandy loam, poor in fertility and water-holding capacity with *p*H 8.4, organic carbon 0.09%, available nitrogen 110 kg/ha, available P 4 kg/ha and available K 224 kg/ha. Deploying 4 multi-species cropping models and sole of each crop, there were 11 treatments, i e T_1, *aonla* + *ber* + *karonda* (*Carissa caramdas* Auct) + clusterbean (*kharif*) + brinjal (*rabi*); T_2, *aonla* + *ber* + *karonda* + cluster bean (*kharif*) + fallow; T_3, *aonla* + *ber* + *karonda* + mothbean (*kharif*) + mustard (*rabi*); T_4, *aonla* + *ber* + *karonda* + mothbean (*kharif*) + fallow; T_5, *aonla* sole; T_6, *ber* sole; T_7, *karonda* sole; T_8, clusterbean sole; T_9, mothbean sole; T_{10}, brinjal sole and T_{11}, mustard sole. The over storey components had the stands maintained at the spacing of 8 m × 8 m and the ground storey crops were grown over 32 m^2 area in left over spaces of over storey component. All the treatments were replicated 4 times. The ground storey crops, i e clusterbean and mothbean were raised during rainy (*kharif*) season, while mustard and brinjal were raised during winter (*rabi*) season. The details regarding number of plants and their arrangements are furnished under Table 1. Basal application of 100:50:50 g NPK/ plant and 16 tonnes/ha farmyard manure was done in October for improving the growth of perennial crops. In ground storey crops, Nitrogen and phosphorus were applied @20:40 kg/ha for mothbean and clusterbean, 60:40 kg/ha for mustard. Recommended irrigations were given as per the requirement of the crop. The crops were harvested at their respective maturity stages. To compare the growth of perennial component crops in mixed multispecies cropping model, the initial growth data (Table 2) were compared with the data obtained after harvesting of the ground storey component crops. The test of significance for growth and yield among various treatment combinations were adjudged using randomized block design

Table 1 Arrangement of over and ground storey components in different cropping systems

Component	Crops	Cultivar	No. of plants	Spacing	Remarks
*Over storey components**					
I storey	*Aonla*	'NA 7'	04	8 m × 8 m	Top storey component
II storey	*Ber*	'Seb'	01	8 m × 8 m	Planted as filler between 4 *aonla* plants
III storey	*Karonda*	'Red' (Local)	04	3 m × 3 m	Planted in intra-row spacing of *aonla*
*Ground storey component***					
	Clusterbean (*kharif*)	'RGC 936'	266	60 cm × 20 cm	Sown in inter-spaces of *aonla-ber* and *karonda* plants
	Brinjal (*rabi*)	Local	88	60 cm × 60 cm	Sown in inter-spaces of *aonla-ber* and *karonda* plants
	Mothbean (*Vigna acontifolia*) (*kharif*)	'RMO 40'	1066	30 cm × 10 cm	Sown in inter spaces of *aonla-ber* and *karonda* plants
	Mustard (*Brassica juncea*) (*rabi*)	'Bio 902'	1066	30 cm × 10 cm	Sown in inter-paces of *aonla-ber* and *karonda* plants

• Top storey components were distributed over 64 m^2 area and **ground storey components covering 32 m^2 was utilized for sowing

Table 2 Growth parameters (at initiation and termination) and yield of perennial components perennial components under different cropping system

Treatment	Plant height (cm)			Stem girth (cm)			Plant spread (cm)			Fruit yield (tonnes/ha)		
	Aonla	*Ber*	*Karonda*	*Aonla*	*Ber*	*Karonda*	*Aonla*	*Ber*	*Karonda*	*Aonla*	*Ber*	*Karonda*
T_1, *aonla+ber+karonda+* clusterbean + brinjal	67.67 (96.45)	184.55 (269.10)	80.72 (105.10)	7.88 (8.57)	30.20 (40.37)	19.82 (25.20)	13.62 ((28.0)	203.30 (224.20)	84.29 (106.47)	0.80	8.50	4.37
T_2, *aonla + ber + karonda +* clusterbean + fallow	67.05 (101.40)	182.26 (267.75)	78.92 (99.80)	7.75 (8.17)	29.40 (36.70)	20.50 (26.40)	13.72 (23.20)	202.82 (223.50)	92.27 (110.30)	0.78	8.46	4.40
T_3, *aonla + ber + karonda+* mothbean + mustard	56.02 88.20)	(175.62 262.75)	(62.82 (90.77)	7.48 (8.07)	31.62 (39.47)	19.42 (24.30)	12.42 (25.87)	180.15 (220.70)	85.55 (102.30)	0.80	8.65	4.35
T_4, *aonla + ber + karonda +* mothbean + fallow	64.19 (77.13)	181.65 (265.00)	72.07 (82.42)	7.45 (8.20)	28.62 (35.45)	17.25 (26.52)	11.57 (23.12)	190.22 (216.80)	76.92 (90.67)	0.77	8.46	4.39
T_5, *aonla* (sole)	41.85 (69.62)			6.66 (7.02)			10.90 (20.02)			0.25		
T_6, *ber* (sole)		141.20 (209.90)			25.42 (31.70)			178.50 (198.20)			5.63	
T_7, *karonda* (sole)			63.50 (92.30)			19.15 (21.97)			81.02 (91.95)			1.96
SEm±	1.37 (1.91)	2.08 (2.93)	0.98	0.07 (0.10)	0.63 (0.86)	0.61 (0.85)	0.49 (1.03)	1.98 (1.75)	1.27 (1.37)	0.02	0.13	0.09
CD (*P*=0.05)	4.25 (5.90)	6.42 (9.04)	3.02	0.23 (0.33)	1.94 (2.66)	1.88 (2.63)	1.52 (3.19)	6.11 (5.39)	3.94 (4.23)	0.08	0.40	0.28

Figures in parentheses are values recorded at termination of experiment

and critical variation per cent for perennial and ground storey crops, respectively.

All the perennial components grown in multi-species cropping models had significant effect on plant growth parameters as compared to its sole plantation. Maximum plant height of *ber* and *karonda* (at termination) were recorded in T_1. In *aonla*, it was recorded to be maximum in T_2. Stem girth of *aonla* and *ber* were maximum under T_1. In *karonda*, the maximum girth of stem was recorded under T_4. The plant spread (N-S, E-W) of *aonla* and *ber* were observed higher in T_1 as compared to their sole stands in which the values were 20.02 cm (T_5) and 198.20 cm (T_6), respectively. In *karonda*, the maximum plant spread was observed in T_2 and minimum under T_4 (Table 2).

Fruit yields of *aonla*, *ber* and *karonda* were significantly higher in all the multi-species cropping models. As compared to its sole crop, fruit yield in *aonla* increased by 220.84% in T_3 to 208% in T_4. Similar yield trend was observed in case of *ber* where it was higher by 53.64% in T_3. Fruit yield in *karonda* increased by 124.48% in T_2 to 121.93% in T_3. In rest of the multi-species cropping models, a general increase of 50% was recorded. Better growth and fruit yield of

Table 3 Growth and yield parameters of ground storey components under different cropping systems

Treatment	Growth parameters								Yield parameters (pods/silique/fruits/plant)				Yield (tonnes/ha)			
	Plant height (cm)				Number of Branches per plant											
	Cluster-bean	Moth-bean	Mustard	Brinjal	Cluster-bean	Moth-bean	Mustard	Brinjal	Cluster-bean	Moth-bean	Mustard	Brinjal	Cluster-bean	Moth-bean	Mustard	Brinjal
T_1, *aonla* + *ber* + *karonda* + Clusterbean + brinjal	94.5			67.6	6.45			13.40	39.51			7.18	0.82			8.17
T_2, *aonla* + *ber* + *karonda* + Clusterbean + fallow	93.02				6.00				36.72				0.72			
T_3, *aonla* + *ber* + *karonda* + mothbean + mustard		26.83	144.9			5.52	6.31			16.30	450.2			0.39	1.40	
T_4, *aonla* + *ber* + *karonda* + mothbean + fallow		25.35				5.45				16.87				0.42		
T_8, clusterbean (Sole)	87.06				5.15				35.47				0.66			
T_9, mothbean (Sole)		22.96				4.65				14.55				0.35		
T_{10}, brinjal (Sole)				64.3				12.82				6.56				6.4
T_{11}, mustard (Sole)			146.5				6.85				467.5				1.50	
CV (%)	3.80	12.89	2.48	3.69	7.70	7.09	3.31	1.01	13.10	6.97	4.17	12.1	0.96	1.07	0.94	1.11

perennial crops under multi-species cropping may be attributed to better intercultural operations and additional inputs applied to the intercrops than in sole plantation (control). Addition of leaf biomass to the soil and their further decomposition in the soil as a mulch via conserving moisture, must have favoured better source-sink relationship, resulting in increased fruit yield under multi-storey cropping system. Positive influence of ground storey crops on growth and yield of perennial crops have been reported by Awasthi *et al*. (2009) in *aonla*, Awasthi and Saroj (2004) in mango and Saroj *et al.* (2003) in *ber*.

Data pertaining to growth and yield parameters of cluster bean, mothbean, mustard and brinjal grown during their respective season are presented in Table 4. Maximum plant height of clusterbean and brinjal (T_1) and mothbean (T_3) was recorded in mixed multi species cropping system. Plant height of mustard was however, recorded to be more in sole crop (T_{11}) as compared to the plant height of mustard in multi-species cropping system T_3 The number of branches/plant of different ground storey crops did not differ much between multi-species crop combinations and their sole cropping (Table 3).

The yield parameters, viz number of pods/silique/fruits/plant and yield/ha of ground storey crops were significantly higher in multi-species crop combinations, except mustard which produced 450.2 silique/plant in T_3 as against 467.5 silique/plant in sole cropping (T_{11}). The average increase in grain yield of clusterbean in multi-species cropping model over the sole cropping was of the order of 24.24 and 9.09% in T_1 and T_2 (Table 3). In mothbean, it increased by 11.42 and 20.0% in T_3 and T_4, respectively over sole cropping. However, in case of mustard when grown as sole crop higher yield (1.50 tonnes/ha) was obtained as compared to multi-species cropping model (1.40 tonnes/ha). Brinjal grown as ground storey crop during *rabi* season in multi-species cropping system, gave 27.65% (T_1) more yield than its sole crop. Higher yield of ground storey crops in association with perennial crops may be due to less competition between trees and crops for nutrient and moisture due to deep root system. It may also be ascribed to microclimate moderation (Pateria *et al*. 2005). Similar results of better growth and yield of ground storey crops have been reported by Kaushik and Kumar (2003) in *khejri*-based cropping system. Reduced plant height and yield of mustard as compared to its sole crops may be due to better canopy growth of *ber* which must have restricted adequate penetration of solar radiation resulting in reduced biosynthesis of photosynthates required for growth. Allelochemicals released by *ber* and *aonla* leaves may also be attributed behind reduced plant height and yield in mustard. Saroj e*t al.* (2002) and Awasthi *et al.* (2005) reported the effect of allelochemicals on mustard crop treated with aqueous leaf extracts of *ber* and *aonla*, respectively.

SUMMARY

Significant differences were recorded in yield levels of

perennial as well as ground storey components in multi-species 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* Gaertn) + *ber* (*Ziziphus mauritiana* Lam.) + *karonda* (*Carissa carandas* Auct) + clusterbean (*Trigonella foenum graecum* L.) + brinjal (*Solanum melongena* L) 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* + clusterbean + 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.

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