

STABILIZATION OF AGRICULTURAL PRODUCTION THROUGH AGRI-HORTI SYSTEM UNDER RAINFED CONDITIONS

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ABSTRACT

A field experiment was conducted at the Centre for Agro-Forestry, Forage Crops and Green Belts, S. D. Agricultural University, Sardarkrushinagar under arid region of North Gujarat to know the suitability of aonla based agri-horti system for the resource poor farmers. Total nine treatment combinations comprising four cropping systems viz., Pearl Millet-Clusterbean, Pearl Millet-Cowpea, Sorghum-Clusterbean, Sorghum-Cowpea and five sole crop treatments including aonla tree were tested under randomized block design with four replications from kharif 2002 to kharif 2007. At the age of six years, aonla based agri-horti system produced higher average fruit yields than the sole aonla trees. Aonla with Pearl Millet-Cowpea rotation recorded the highest aonla fruit yield (7208 kg ha^{-1}) than aonla sole (6858 kg ha^{-1}) than rest of the treatments. The mean data of grain and straw yield was considerably low in intercrop as compared to sole crop. Treatment T_2 (Aonla + Pearl Millet -cowpea rotation) gave significantly higher gross return (Rs. 40666 ha^{-1}), but it was found at par with treatments T_4 (Rs. 35882 ha^{-1}), T_5 (Rs. 34614 ha^{-1}), and T_3 (Rs. 34513 ha^{-1}). The gross income of Rs. 40666 ha^{-1} and net returns of Rs 31436 ha^{-1} were obtained with aonla + Pearl Millet-Cowpea rotation of agri-horti system, which was comparatively higher than that other agri-horti system and sole crop treatments. The B: C ratio obtained with aonla + Pearl Millet-Cowpea rotation was 1: 3.40, which was also higher than rest of the treatments.

INTRODUCTION

Resource degradation leading to an unsustainable production system has demanded our attention for sustainable practices to assure continuous production. In this, Aonla (*Embllica officinalis* Gaertn.) based agri-horticultural system has immense potential to utilize and conserve rainfed area for betterment of poor farmers. Aonla being a deep rooted deciduous tree species has a wide range of adaptability and hardiness to grow in any type of soil and climatic conditions. It is considered a highly tolerant and potential fruit species suitable for growing under wastelands. Aonla provides higher economic returns with little investments in establishment and its management. Cultivation of agricultural crops like cereals and pulses in conjunction with Aonla based Agri-Horti system will be boon for food security and provides an opportunity for maximum land use especially under arid region to distribute the risk of adverse climatic conditions. The tree canopy of aonla with sparse

foliage allows filtered light and permits intercropping even after tree are fully grown (Das *et al.*, 2011). Intercropping not only generate an extra income, but also helps to check soil erosion through ground coverage and improves the soil physico-chemical condition (Ghosh and Pal, 2010). Traditionally, intercropping in the interspaces of the fruit orchard is practiced due to economic consideration, but only a few experiments results are available for aonla based agri-horticultural systems (Kumar and Chaubey, 2008; Awasthi *et al.*, 2009). Keeping this in view, an experiment was planned out to know the suitability and sustainability aspects of intercrop under rainfed condition in arid region of north Gujarat with aonla based agri-horti systems.

KEY WORDS: Aonla, clusterbean, cowpea, intercrop, Pearl Millet, sorghum

MATERIALS AND METHODS

A field experiment was conducted at the Centre for Agro-Forestry, Forage Crops and Green Belts, S. D. Agricultural University, Sardarkrushinagar under arid region of North Gujarat. The experimental soil is loamy sand having pH 7.2-7.6 with a low organic carbon and available phosphorus and high in available potash. The average rainfall was 550 mm during the experimentations year. Total nine treatment combinations comprising four cropping systems viz., Pearl Millet-Clusterbean, Pearl Millet-Cowpea, Sorghum-Clusterbean, Sorghum-Cowpea and five sole crop treatments including aonla tree were planned under randomized block design with four replications. The aonla seedlings were transplanted during *kharif* 1998 and grafted with var. Gujarat-during *kharif* 1999. The first crop (i.e. Pearl Millet and Sorghum) of the rotation was sown during *kharif* 1998 and second crop (i.e. Clusterbean and Cowpea) was sown during *kharif* 1999. Thus, one rotation was completed with two season of *kharif* 1998 and 1999. The same rotation of the crop was followed in alternate year in the standing newly established Aonla orchard. The seed yield of field crops of first and second rotation (i.e. *kharif* 1998 and *Kharif* 1999; and *kharif* 2000 and *kharif* 2001) were not considered due to no fruiting in the aonla. The observations on seed yield were recorded from third rotation (*kharif* 2002 and *kharif* 2003) to fifth rotation (*kharif* 2006 and *kharif* 2007) of fruiting in Aonla from the net plot of each crop except sorghum (the dry fodder yield of and were converted into hectare basis by multiplying with multiple factors. The biochemical observations are also recorded in aonla at the end of harvest in each season. The economics is also worked out.

RESULTS AND DISCUSSION

The results of the present investigation are analyzed and presented in Table 1 to Table 5:

Field crop yield and fruit yield

The mean grain yield of field crops and fruit yield of Aonla (kg ha^{-1}) is presented in Table 1 showed that the aonla tree markedly influenced the yield of field crops than the yield of sole crops alone. The fruit yield of aonla increased in aonla + field crop systems with due course of time as compared to fruit yield of aonla sole crop except *kharif* 2004-05. At the age of six years, aonla based agri-horti system produced higher average fruit yields than the sole aonla trees. In mean data, agri-horti system of aonla with Pearl Millet-Cowpea rotation recorded the highest aonla fruit yield (7208

kg ha⁻¹) than aonla sole (6858 kg ha⁻¹) than rest of the treatments. The seed yield (Table 1) as well as straw/fodder yield (Table 2) of field crops gave additional income to the systems.

The magnitude of the crop yield losses in agri-horticultural system increased with the age of the trees (Table 1 & 2). In the present investigation, the seed as well as straw yield of intercrop was higher in fourth rotation (*kharif* 2004 and *kharif* 2005) and it was very less in fifth rotation (*kharif* 2006 and *kharif* 2007). The mean data of grain and straw yield was considerably low in intercrop as compared to sole crop. Increased competition with age was due to the increased size of the trees and their ability to mop up greater resources at the expense of crops (Prasad *et al.*, 2010). The low in under plantation is due to the fact that in shade under plantation the crop had correspondingly lower photosynthesis rate (Chaturvedi and Jha, 1998).

Gross income

The data of gross income presented in Table 3 showed significant difference among treatments in all the years except 2003-04 and 2004-05. At initial stage, it was observed that the sole crop treatments gave remarkably higher gross income as compared to aonla + field crops treatments, as the significantly highest gross returns of Rs. 16534 ha⁻¹ was received under treatment T₆ (Pearl Millet - Clusterbean rotation) which was at par with treatment T₇ (Rs. 16058 ha⁻¹) (Pearl Millet - Cowpea rotation) in 2002-03. There was non significant effect of different treatments on gross return during 2003-04 and 2004-05, however the maximum gross income Rs. 20630 ha⁻¹ and Rs. 26481 ha⁻¹ was recorded under treatment T₉ (Sorghum-Cowpea rotation) and T₆ (Pearl Millet – Clusterbean rotation) during 2003-04 and 2004-05, respectively. As the age of the trees increased the gross income of all the agri-horti systems treatments registered significantly higher gross income than all the sole crop treatments. The treatment T₂ (Aonla + Pearl Millet- Cowpea rotation) gave significantly higher gross income (Rs. 45966 ha⁻¹) which was at par with treatment T₄ (Rs. 45840 ha⁻¹) (Aonla + Sorghum-Cowpea rotation) during 2005-06. During the year 2006-07, treatment T₃ (Aonla+ Sorghum- Clusterbean rotation) gave significantly higher gross income (Rs. 92016 ha⁻¹) which was statistically at par with treatment T₂ (Rs. 89892 ha⁻¹) (Aonla + Pearl Millet-Cowpea rotation). Significantly higher gross returns (Rs 78515 ha⁻¹) were obtained from the treatment T₂ (Aonla with Pearl Millet- cowpea rotation) during 2007-08, which was at par with treatment T₅ (Rs. 76021 ha⁻¹).

The results of pooled analysis of six years data exhibited the significant differences among the agri-horti system treatments and sole crops. Higher gross returns were received from the adoption of various agri-horti systems. Treatment T₂ (Aonla +Pearl Millet -cowpea rotation) gave significantly higher gross return (Rs. 40666 ha⁻¹), but it was found at par with treatments T₄ (Rs. 35882 ha⁻¹), T₅ (Rs. 34614 ha⁻¹), and T₃ (Rs. 34513 ha⁻¹). The increased returns from tree crop combination have also been reported by earlier workers in aonla based agri-horticultural system (Awasthi *et al.*, 2009 and Das *et al.*, 2011)

Economics

The gross income of Rs 40666 ha⁻¹ and net returns of Rs 31436 ha⁻¹ (Table 4) were obtained with aonla + Pearl Millet- Cowpea rotation of agri-horti system, which was comparatively higher than that other agri-horti system and sole crop treatments. The B: C ratio obtained with aonla + Pearl

Millet-cowpea rotation was 1: 3.40, which was also higher than rest of the treatments (Table 4). The similar results were reported by Awasthi *et al.*, 2009 and Das *et al.*, 2011.

Biometric observations

The mean data of biochemical observations recorded in aonla at the end of harvest are presented in Table 5. The data revealed that fruit weight, fruit width and fruit volume was slightly lowered down in aonla under intercropping, and this might be due to the competition for fertilizers and other inputs with field crops. The other biochemical parameters remained almost same.

CONCLUSION

The aonla based agri-horticultural system i.e. aonla + Bajara-Cowpea rotation recorded significantly higher gross and net return than that of other agri-horticultural system and sole crop treatments.

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Table 1: Effect of various treatments on grain yield and fruit yield of Aonla (kg ha⁻¹)

Treat. No.	Treatments Details	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Mean
T₁	Aonla +	66	1882	381	5519	13125	10625	5260
	(Pearl Millet-	206	-	335	-	218	-	253
	Clusterbean rotation)	-	144	-	137	-	65	115
T₂	Aonla +	20	2609	371	8254	16651	15343	7208
	(Pearl Millet-	218	-	301	-	240	-	253
	Cowpea rotation)	-	209	-	305	-	92	202
T₃	Aonla +	98	2210	1391	5707	17773	11250	6405
	(Sorghum –	-	-	-	-	-	-	-
	Clusterbean rotation)	-	151	-	139	-	78	123
T₄	Aonla +	39	1970	898	8180	14687	13672	6235
	(Sorghum –	-	-	-	-	-	-	-
	Cowpea rotation)	-	265	-	296	-	61	207
T₅	Aonla sole	102	1140	1660	6438	16601	15204	6858
T₆	Pearl Millet –	405	-	2088	-	1366	-	1286
	Clusterbean rotation	-	260	-	473	-	231.48	321
T₇	Pearl Millet –	489	-	1948	-	1480	-	1306
	Cowpea rotation	-	1058		572	-	257	629
T₈	Sorghum –	-		-		-		
	Clusterbean rotation	-	810	-	472	-	353	545
T₉	Sorghum –	-		-		-		
	Cowpea rotation	-	1111	-	571	-	323	668

Table 2: Effect of various treatments on straw yield (kg ha⁻¹)

Treat. No.	Treatments Details	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Mean
T₁	Aonla +	--	-	-	-	-	-	-
	(Pearl Millet-	2119	-	2529	-	3115	-	2588
	Clusterbean rotation)	-	1161	-	234	-	93	496
T₂	Aonla +	-	-	-	-	-	-	-
	(Pearl Millet-	2080	-	2486	-	3008	-	2525
	Cowpea rotation)	-	1443	-	429	-	230	701
T₃	Aonla +	-	-	-	-	-	-	-
	(Sorghum –	967	-	1506	-	2100	-	1524
	Clusterbean rotation)	-	1221	-	233	-	125	526
T₄	Aonla +	-	-	-	-	-	-	-
	(Sorghum –	918	-	1436	-	1856	-	1403
	Cowpea rotation)	-	1428	-	472	-	203	701
T₅	Aonla sole	-	-	-	-	-	-	-
T₆	Pearl Millet –	14019	-	13955	-	12235	-	13403
	Clusterbean rotation	-	1630	-	937	-	1025	1197
T₇	Pearl Millet –	13117	-	12622	-	10022	-	11920
	Cowpea rotation	-	6272	-	1051	-	864	2729
T₈	Sorghum –	7606	-	8920	-	12456	-	9661
	Clusterbean rotation	-	1699	-	1267	-	1010	1325
T₉	Sorghum –	7716	-	8157	-	11684	-	9186
	Cowpea rotation	-	6347	-	786	-	1850	2994

Table 3: Effect of various treatments on gross return (Rs ha⁻¹)

Treat. No.	Treatments Details	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Mean
T₁	Aonla + (Pearl Millet-Clusterbean rotation)	4553	13669	6444	30021	70489	54379	29925
T₂	Aonla + (Pearl Millet-Cowpea rotation)	3743	19736	6146	45966	89892	78515	40666
T₃	Aonla + (Sorghum - Clusterbean rotation)	2433	15748	8459	31000	92016	57784	34573
T₄	Aonla + (Sorghum - Cowpea rotation)	1504	16670	5928	45480	76220	69492	35882
T₅	Aonla sole	1523	6843	8105	32187	83007	76021	34614
T₆	Pearl Millet - Clusterbean rotation	16534	7495	26481	8540	23169	5192	13913
T₇	Pearl Millet - Cowpea rotation	16058	19830	24303	9052	25078	5495	14568
T₈	Sorghum - Clusterbean rotation	7610	9459	8932	8562	18683	7350	10099
T₉	Sorghum - Cowpea rotation	7716	20630	8157	8787	17526	7663	11747
	S Em _±	572	4055	6406	2501	9598	6226	4893
	CD at 5 %	1669	NS	NS	7300	28016	18174	15797
	CV %	29.33	35.59	36.53	20.50	34.83	29.64	37.83

Selling Price (Rs ha⁻¹)

Crop	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Aonal fruit	15	15	05	05	05	-
Pearl Millet grain	06	-	06	-	05	-
Pearl Millet straw	01	-	01	-	1	-
Sorghum straw	01	-	01	-	1.50	-
Cowpea seed	-	14	-	14	-	18
Clusterbean seed	-	10	-	16	-	18
Cowpea straw	-	0.60	-	01	-	01
Clusterbean straw	-	0.80	-	01	-	01

Table 4: Economics of various treatments.

Treat. No.	Aonla Equivalent Yield (q ha ⁻¹)	Gross Income (Rs ha ⁻¹)	Cost of Cultivation (Rs ha ⁻¹)	Net Income (Rs ha ⁻¹)	Cost: Benefit Ratio
T ₁	59.91	29953	9230	20723	1:2.24
T ₂	81.33	40666	9230	31436	1:3.40
T ₃	69.15	34573	9380	25193	1:2.68
T ₄	7178	35882	9380	26502	1:2.82
T ₅	41.23	34614	5550	29064	1:5.3
T ₆	27.83	13913	3680	10233	1:2.78
T ₇	25.81	14568	3680	10888	1:2.96
T ₈	18.20	10099	3830	6269	1:1.64
T ₉	21.57	11747	3830	7917	1:2.07

Table 5: Effect of various treatments on biometric observation of Aonla (average of six years)

Treat. No.	Treatments Details	Plant height (cm)	Plant girth (cm)	Plant spread(cm)		10 fruit weight (gm)	10 fruit length (cm)	10 fruit width (cm)	10 fruit volume (mm)	TSS
				N-S	E-W					
T ₁	Aonla + (Pearl Millet-Clusterbean rotation)	316	35.56	338	372	196	28.57	33.01	184	16.4
T ₂	Aonla + (Pearl Millet-Cowpea rotation)	368	40.22	391	393	180	27.51	32.31	176	15.6
T ₃	Aonla + (Sorghum - Clusterbean rotation)	373	40.03	397	393	181	27.37	32.20	180	15.9
T ₄	Aonla + (Sorghum - Cowpea rotation)	358	40.88	415	445	201	28.27	33.48	192	14.8
T ₅	Aonla sole	337	39.17	397	394	209	29.47	34.18	198	16.5

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