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Performance of intercrops during establishment phase of aonla (*Emblica officinalis*) orchard

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ABSTRACT

A study was conducted during 2004–06 on intercropping under arid conditions of Bikaner in newly established 'NA7' aonla (*Emblica officinals* Gaertn). Mothbean (*Vigna acontifolia* (Jacq.) Marechal) grown during rainy (*kharif*) season was a common crop in rotation with winter (*rabi*) crops, i e fenugreek (*Trigonella foenum-graceum* Linn.), chickpea (*Cicer arietinum* L.), mustard [*Brassica juncea* (L) Czernj. & Cosson] and cumin (*Cuminum cyminum* L). Growth parameters in terms of plant height, stem girth, canopy spread and canopy volume of aonla was recorded to be significantly more with intercrops compared with its sole plantation. Higher grain and straw yield were recorded in mothbean–chickpea (497, 1 250 kg/ha) and mothbean-fenugreek (465, 1 161 kg/ha) crop sequence. Amongst the winter (*rabi*) crops, grain yield of fenugreek, chickpea, mustard and cumin were higher by 28.05, 38.11, 19.96 and 36.50%, respectively, when grown in association with aonla compared to its sole crops. The highest net profit (Rs 28 260/ha) was obtained from mothbean–cumin cropping system, followed by mothbean–chickpea (Rs 25 024/ha) cropping system. Mothbean–chickpea intercropping with aonla supplemented 22.01, 5.00 and 27.90 kg/ha nitrogen, phosphorus and potassium through crop residues, followed by mothbean– fenugreek crop sequence.

Key words: Aonla, Crop residues, Economic analysis, Intercrops, Nutrient supplementation

Aonla (*Emblica officinalis* Gaertn.) is one of the important fruit crops of arid region. However, despite its adaptability in arid climate, productivity and economic returns of the crop are affected by low temperature (–2°C) and frost (CIAH 2006, Singh *et al*. 2008), which cause economic loss to the growers. In order to mitigate the risk of total crop failure, suitable crop combinations in the interspace of orchard during initial years can generate extra income, improve productivity, ameliorate and improve ecological situation (Awasthi *et al*. 2008) in a sustainable manner. Traditionally, efforts have been made by the native people, obviously to achieve sustainable production ensuring ecological stability to grow several species together, e g pearl millet, [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz], mothbean [*Vigna acontifolia* Jacq. Marechal], cluster bean (*Trigonella foenum graecum* L.) chickpea (*Cicer arietinum* L.) between the natural stands of khejri [*Prosopis cineraria* (L.) Druce] and boradi (*Ziziphus rotundifolia* Lam.) (Awasthi and Pareek 2008). No information is however, available on suitability of intercrop which can be grown in association with aonla under arid region. The present study was therefore, conducted to study the suitability and profitability aspects of inter crops in pre-bearing orchard of aonla.

MATERIALS AND METHODS

Field studies were conducted at Central Institute for Arid Horticulture, Bikaner (28° N latitude, 73° 18' longitude at an altitude of 234.84 m above mean sea level) during 2004–06 to study the performance of intercrops in pre-bearing orchard of 'NA7' aonla spaced 8 m apart. The root stocks of aonla were planted in well prepared pits during September 2003 and budded *in-situ* with cultivar 'NA7' during February 2004. Basal application of 100: 50: 50 g NPK/plant and 16 tonnes/ha farmyard manure was done in October for improving growth of the plants. During the early establishment stage, the plants were irrigated at fortnightly intervals. During first year, the young plants were thatched to protect against scorching summer and frost. The experimental field prior to experimentation was low in organic carbon (0.03%), low in available N (110 kg/ha), phosphorus (4 kg/ha) and high in potash (244 kg/ha) with alkaline reaction (*p*H 8.4). The soil texture was loamy sand with low water-holding capacity. In the interspace of aonla,

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field crops were sown in a plot size of 7 m×7 m in a randomized block design with four replications. Aonla and intercrops were also raised as sole crops for comparison adopting the same spacing, i e 8 m×8 m for aonla and 7 m×7 m for the field crops. During rainy (*kharif*) season (July–September), mothbean was taken as a common rainfed intercrop, while in winter (*rabi*) season (November–March) 'RMT 1' fenugreek 'RSG 44' chickpea 'Bio 902' mustard [*Indian*] and 'RZ 19' cumin (*Cuminum cyminum* L.) were grown following mothbean rotation. The recommended spacing were adopted for different crops, like fenugreek and cumin (25 cm×10 cm), mothbean, mustard (30 cm×10 cm) and chickpea (30 cm). Nitrogen and phosphorus were applied @ 20: 40 kg/ha for mothbean and chickpea, 15: 10 kg/ha for fenugreek, 60: 40 kg/ha for mustard and 30: 20: 20 kg/ha (N, P, K) for cumin. Recommended irrigations were applied to *rabi* crops as per the requirement of the crops. Observations on growth parameters of aonla and grain and straw yield of intercrops were recorded during 2004–06. Canopy volume was calculated after measuring tree height (H) and width in parallel (D_1) and perpendicular (Dr) by the formulae $V= (\pi/6)\times H\times D_{1\times}Dr$ (Zekri 2000).

Crop residues obtained from mothbean, fenugreek, chickpea, mustard and cumin were recycled in the same plot in all the treatment combinations. Mothbean, fenugreek, chickpea, mustard and cumin crop residues contain 1.55, 0.12 and 1.30; 0.75, 0.16 and 1.20; 0.67, 0.23 and 1.12; 0.40, 0.06 and 1.21; and 0.80, 0.32 and 1.33% N, P and K, respectively. The soil samples were collected after the harvest of the crop, processed and analyzed for physico-chemical properties by following standard procedures (Jackson 1973). The contents of N, P and K in crop residues were determined by following suitable procedure as described by Jackson (1973) and the contribution of N, P and K was computed by multiplying straw nutrient concentration with straw yield. The economics was calculated by considering the actual expenditure incurred on various operations, prevalent labour charges and current price of inputs and value of produce in the market. The net returns were computed taking into account the rates of grain as Rs 12, 13.50, 15, 18, 50/kg for mothbean, fenugreek, chickpea, mustard and cumin during 2004, Rs 17.50, 15.50, 18.50, 16.50, 57.00/kg during 2005 and Rs 25, 16, 21.50, 17, 90/kg during 2006 respectively. The benefit : cost ratio was calculated dividing net returns by the cost of cultivation of individual treatment. The data were subjected to analysis of variance using INDOSTAT packages.

RESULTS AND DISCUSSION

Growth performance

Intercrops grown in association with aonla did not offer any competition on annual growth and development of aonla which may be due to different rooting behaviour of the aonla and inter crops. Plant height of aonla increased significantly with age in all the intercrop combinations, however the increase was more pronounced (>100%) when grown in association with mothbean–chickpea and mothbean–fenugreek crop rotations as compared to its sole plantation (Table 1). Similar trends were recorded with respect to stem girth, canopy spread and canopy volume. Better growth of aonla plants in association with intercrops may be attributed to the better response of inputs applied to the intercrops than in sole plantation (control) where the interspaces were left uncultivated and did not receive any additional input in terms of fertilizer, supplemental irrigation, additional biomass, etc. Profused vegetative growth of aonla plants in mothbean–chickpea and mothbean– fenugreek intercropping was due to the leguminous nature of the intercrops, which have better N-fixing ability and must have contributed in better uptake of N. Since desertic soils are very low in N even a minimal amount of additional source of N helps in better growth and development of plants. Similar effects of intercropping with leguminous crops (greengram, blackgram, cowpea) on

Table 1 Effect of different intercrops on growth of aonla

Crop sequence	Growth parameters															
	Plant height (m)				Stem girth (cm)				Canopy spread (m)				Canopy volume (m^3)			
	2004	2005	2006	Mean	2004	2005	2006	Mean	2004	2005	2006	Mean	2004	2005	2006	Mean
Mothbean–fenugreek	1.14	3.00	4.00	2.82	0.08	0.19	0.22	0.16	0.90	1.04	1.27	1.07	0.48	1.70	3.37	1.85
Mothbean–chickpea	1.23	3.25	4.25	2.80	0.08	0.21	0.25	0.18	0.87	1.14	1.40	1.13	0.48	2.20	4.30	2.32
Mothbean–mustard	1.06	2.80	3.48	2.44	0.06	0.16	0.20	0.14	0.73	0.87	1.10	0.90	0.29	1.14	2.18	1.19
Mothbean–cumin	1.24	2.60	3.37	2.40	0.07	0.14	0.20	0.13	0.78	0.80	1.22	0.93	0.37	0.90	2.62	1.29
Control	0.82	1.20	2.00	1.34	0.05	0.09	0.15	0.29	0.48	0.62	0.85	0.65	0.22	0.30	0.75	0.42
SEm ±	0.03	0.12	0.15		0.007	0.01	0.01		0.03	0.05	0.02		0.03	0.12	0.13	
CD (*P*=0.05)	0.12	0.39	0.49		0.023	0.03	0.03		0.10	0.16	0.07		0.11	0.39	0.42	

Table 2 Grain and straw yield (kg/ha) of different crops grown sole and in association with aonla trees

Crop sequence	Grain yield								Straw yield							
	Kharif (mothbean)				Rabi				*Kharif* (mothbean)				*Rabi*			
	2004	2005	2006	Mean	2004	2005	2006	Mean	2004	2005	2006	Mean	2004	2005	2006	Mean
With aonla																
Mothbean–fenugreek	415	450	531	465	875	935	1 150	986	977	1 125	1 383	1 161	2 224	2 335	3 135	2 564
Mothbean–chickpea	425	477	591	497	1 320	1 500	1 660	1 493	1 000	1 143	1 607	1 250	3 231	3 695	4 370	3 765
Mothbean–mustard	415	445	470	443	1 020	1 301	1 375	1 232	1 048	1 121	1 212	1 127	3 284	4 097	4 056	3 812
Mothbean–cumin	410	447	497	451	700	775	300	602	1 030	1 240	1 362	1 210	816	989	450	751
Sole cropping																
Mothbean–fenugreek	370	400	450	406	787	843	760	770	1 061	1 020	1 335	1 138	2 007	2 024	2 090	2 040
Mothbean–chickpea	375	425	460	420	1 100	1 200	943	1 081	1 085	1 084	1 299	1 156	2 869	3 329	2 540	2 912
Mothbean–mustard	370	407	445	407	912	1 000	1 170	1 027	1 027	1 067	1 232	1 108	3 054	3 415	3 861	3 443
Mothbean–cumin	380	400	445	408	526	700	075	441	1 077	1 039	1 312	1 142	710	880	112	567
SEm ±	6.8	14.1	10.1		16.7	11.7	16.1		48.1	45.9	46.6		96.7	119.3	37.8	
CD (*P*=0.05)	18.5	41.5	29.7		49.2	34.6	49.2		141.7	135.2	137.1		284.5	350.9	111.4	

Table 3 Nutrient supplementation (kg/ha) through crop residue (mean of three years)

Crop sequence	*Kharif*			*Rabi*		
	N	P	K	N	P	K
With aonla						
Mothbean–fenugreek	17.75	1.40	15.12	19.22	4.08	30.83
Mothbean–chickpea	19.46	1.50	16.08	24.56	8.51	39.72
Mothbean–mustard	17.54	1.34	14.60	15.22	2.45	49.85
Mothbean–cumin	18.82	1.45	15.56	6.00	2.40	10.03
Sole cropping						
Mothbean–fenugreek	17.74	1.36	14.81	15.31	3.23	24.46
Mothbean–chickpea	17.92	1.39	14.95	19.50	6.70	32.61
Mothbean–mustard	17.22	1.31	14.45	13.75	2.05	41.72
Mothbean–cumin	17.72	1.37	14.85	4.56	1.81	7.52
SEm ±	0.10	0.004	0.10	0.098	0.017	0.03
CD (*P*=0.05)	0.28	0.013	0.30	0.27	0.05	0.08

vegetative growth of aonla have been reported by Kumar and Pandey (2004). The findings also support the views of Saroj *et al*. (2003) in ber (*Zizyphus mauritiana* Lam.) and Awasthi and Saroj (2004) in mango (*Mangifera indica* L.) where they reported the positive influence of intercrops on growth and vigour of trees.

Yield of intercrops

The grain and straw yields of both *kharif* (mothbean) and *rabi* (fenugreek, chickpea and mustard) increased over the years and were significantly higher when grown as intercrop with aonla than sole cropping (Table 2). Cumin seed yield, although was higher during the first two years (700, 775 kg/ha), a sharp decline in yield (300 kg/ha) was recorded during the third year due to damage caused to the crop by low temperature (–1.5°C) and frost injury. On mean basis, higher grain and straw yield of mothbean was recorded in mothbean–chickpea (497, 1 250 kg/ha) and mothbean–fenugreek (465, 1 161 kg/ha) crop sequence. Amongst the *rabi* crops, chickpea and mustard yielded more than fenugreek and cumin. As compared to its sole crops average grain yield of fenugreek, chickpea, mustard and cumin were higher by

28.05, 38.11, 19.96 and 36.50%, respectively. Straw yield data of these crops was significantly higher in mustard (3 812 kg/ha), followed by chickpea (3 765 kg/ha), it was minimum in cumin (751 kg/ha). Average increase in straw yield when grown in association with aonla was of the order 25.68, 29.29, 10.71 and 32.45% in fenugreek, chickpea, mustard and cumin, respectively, as compared to sole cropping.

Higher grain yield of intercrops grown in association with aonla as compared to its sole crops may be due to less competition between trees and crops for nutrient, moisture and light as aonla is a deep-rooted tree species and is able to draw nutrient and moisture from the deeper profiles of the soil. It may also be ascribed to microclimate moderation (Pateria *et al*. 2005). Reduction in grain yield of cumin during third year of its cropping in association with aonla and sole crop was due to the damage caused to the crop by frost and low temperature at the time of flowering. The variation in straw yield was due to diverse growing habit and specific root : shoot ratio of the component crops.

Nutrient supplementation by crop residue

Mothbean–chickpea and mothbean–fenugreek cropping sequence grown in the inter space of aonla tree played a vital role in supplementing N, P and K through the residues incorporated in soil. On an average, the amount of N, P and K supplemented through mothbean–chickpea in association with *aonla* was to the tune of 22.01, 5.00 and 27.90 kg/ha, followed by mothbean–fenugreek cropping sequence, ie 18.48,2.74 and 22.97 N, P and K kg/ha, respectively (Table 3). The minimum nutrient supplementation through crop residue was recorded with cumin. The highest nutrient supplementation by crop residue through mothbean–chickpea and mothbean–fenugreek crop rotation was due to the combined effect of its N-fixing ability and higher straw yield. These findings are in conformity with the findings of Jha and Rattan (2007) in mineralization study on leguminous crop residues of mung bean and *Sesbania*.

Incorporation of crop residues into the soil also improved the soil nutrient status. As compared to the initial soil status, available N, P and K in soil three years after experimentation in mothbean–chickpea, mothbean–fenugreek, mothbean–mustard and mothbean–cumin crop rotation increased by 4.54, 27.5 and 10.65; 2.72, 25.0 and 14.75; 0.90, 20.0 and 6.55; 0.90, 12.5 and 2.45% N, P and K, respectively. The increase in available N, P and K in soil after harvest of the crop was due to better supply of nutrients accruing directly through decomposition of crop residues and organic manure (Kumar *et al*. 2008).

Economic returns

The cost of production and returns of the inter crops in association with aonla and sole crops are given in Table 4. Economic analysis of different cropping system showed that higher returns were obtained when the intercrops were grown

Table 4 Economics (Rs/ha) of different crops grown sole and in association with aonla

Crop sequence	Cost of cultivation				Returns				Net returns				Benefit : cost ratio			
	2004	2005	2006	Mean	2004	2005	2006	Mean	2004	2005	2006	Mean	2004	2005	2006	Mean
With aonla																
Mothbean–fenugreek	10 320	11 750	13 340	11 803	16 792	22 367	31 675	23 611	6 472	10 617	18 335	11 808	0.62	0.90	1.37	0.96
Mothbean–chickpea	10 820	12 050	13 520	12 130	24 900	36 097	50 465	37 154	14 080	24 047	36 945	25 024	1.30	1.99	2.73	2.00
Mothbean–mustard	10 520	11 700	13 000	11 740	23 340	29 253	35 125	29 239	12 820	17 553	22 125	17 499	1.22	1.50	1.70	1.47
Mothbean–cumin	16 510	14 150	15 900	15 520	39 920	51 997	39 425	43 780	23 410	37 847	23 525	28 260	1.41	2.67	1.47	1.85
Sole cropping																
Mothbean–fenugreek	9 000	10 100	10 670	10 670	15 064	20 067	23 410	19 513	6 064	9967	12 740	9 590	0.67	0.98	1.19	0.94
Mothbean–chickpea	10 060	10 900	12 600	12 600	21 000	29 637	31 774	27 470	10 940	18 737	19 174	16 283	1.08	1.71	1.52	1.43
Mothbean–mustard	9 180	10 200	11 700	11 700	20 856	23 622	31 015	25 164	11 676	13 422	19 315	14 822	1.27	1.31	1.65	1.41
Mothbean–cumin	12 780	14 000	14 750	14 750	30 860	46 900	17 875	31 878	18 080	32 900	3125	18 035	1.41	2.35	0.21	1.32

in association with aonla rather than sole cropping. Mothbean grown in rotation with cumin earned maximum net returns (Rs 28 260/ha), followed by mothbean–chickpea (Rs 25 024/ ha) and mothbean– mustard (Rs 17 499/ha) with nominal returns in mothbean–fenugreek crop sequence. The higher returns in mothbean–cumin crop sequence was due to the high ruling price of cumin, however, during 2006 there was an abrupt decrease in net returns bringing down the benefit : cost ratio to 0.21 in sole cropping suggesting the risky nature of the crop. It is to be noted that even at low price, the returns from mothbean–chickpea cropping sequence in association with aonla are substantial with an over all benefit : cost ratio of 2.00. The benefit : cost ratio although was lower in mothbean–mustard cropping sequence, it was higher by 4.25% than its sole crop. Similar results have been reported by Dhandar *et al*. (2004) in ber and aonla and Kaushik and Kumar (2003) in *khejri*-based cropping system. The increased returns from tree-crop combinations have also been reported by Nath (2007) in perennial fruit-based multi-storied production system. Almost no returns obtained from mothbean–fenugreek crop sequence when grown in association with aonla may be attributed to lower prevailing market price and additional maintenance cost incurred on aonla in all the treatments.

It could be concluded that intercrops did not exert any competition neither on the growth and development of aonla nor the productivity of intercrops were affected by aonla. Mothbean–cumin and mothbean–chickpea can be profitably cultivated in the inter space of aonla up to three years. For areas which are susceptible to frost or low temperatures, mothbean–mustard is another profitable option. The study also revealed that incorporation of crop residue into the soil improved the soil nutrient status in terms of N, P and K through mothbean–chickpea and mothbean–fenugreek crop rotations.

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