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Mango based agri-horti system on degraded lands in Doon Valley

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ABSTRACT : A field experiment was conducted for seven years (1995-2001) to study the performance of mango cv. Mallika based Agri-Horti systems on degraded gravelly riverbed lands in Doon Valley. Okra-toria cropping system gave maximum gross income of Rs. 26015 ha^{-1} $year^{-1}$ and superseded by 298.5, 142.9, 73.1, 66.9, 26.6 and 24.3 per cent more over without intercrop, clusterbean-toria, pigeonpea, sesame-toria, blackgram-toria and cowpea-toria cropping systems, respectively. Okra-toria cropping system proved more beneficial with highest net profit of Rs.7423 ha^{-1} $year^{-1}$ and maximum benefit:cost ratio of 1.40 followed by cowpea-toria (Rs. 4285 ha^{-1} $year^{-1}$ with B:C ratio of 1.26), blackgram-toria (Rs. 4086 ha^{-1} $year^{-1}$ with B:C ratio of 1.25), pigeonpea (Rs. 1803 ha^{-1} $year^{-1}$ with B:C ratio of 1.14), sesame-toria (Rs. 1222 ha^{-1} $year^{-1}$ with B:C ratio of 1.09), and without intercrop (Rs. -764 ha^{-1} $year^{-1}$ with B:C ratio of 0.90).Pigeonpea supplemented highest amount of nitrogen, phosphorus, potassium, calcium and magnesium through their residue followed by cowpea, okra, blackgram, sesame and toria. The plant growth characters, fruit yield and quality parameters of mango not influenced were adversely due to presence of any intercrop.

Key words: Agri-Horti system; Degraded land; Economics; Mango; Nutrients supplementation

Mango (*Mangifera indica* L.) is indigenous to India and known as "King of fruit" due to its wide edaphic and climatic adaptability, high nutritive value, excellent flavour, attractive appearance and popularity among masses. In India, it is grown over an area of 1.14 million ha and producing 9.22 million tonnes of fruits, which accounts for 35.4 per cent of total fruit area and 28.0 per cent of total fruit production (Yadav1997). Almost all part of the plant are used for one or more purposes like; wood as timber, dried branches and twigs as fuel and fruit is consumed as raw and ripe both (Rocheleau *et al.* 1988). The tree has long gestation period, hence at pre-bearing stage the practice of intercropping in order to utilize interspaces and generation of some income is very common (Chundawat 1993) but without much scientific consideration. There are some findings, where mango based Agri-Horti system was found promizing (Rajput *et al.* 1989; Kanwar et al. 1993; Gill *et al.* 1995; Musvoto and Campbell 1995 and Singh *et al.* 1996). Intercultural operations in annual crops influenced positively on vegetative growth of mango plants at initial stage (Saroj *et al.* 1999). On contrary, there are several combinations where detrimental responses have also been noticed (Ram and Rajan 1985 and Taeotia, 1989). Several workers have been reported inverse relationships between and yield of intercrops canopy cover, and yield of intercrops and distances from tree basin (Bhuva *et al.* 1989; Saxena *et al.* 1990 and Ralhan *et al.* 1992).

In India, about 175 million ha of the geographical area is subjected to various processes of land degradation (Das 1985) out of which 2.75 million ha degraded land is subjected to diversion of major river courses causing excessive deposition of gravels, boulders and other course fractions (Anon. 1985). In Doon Valley, about one-third of the geographical area is under degraded bouldery riverbed lands which are virtually barren or inhabited by wild bushes particularly *Lantana camara.* There is little scope for cultivation of food grain in these lands. However, there is a need to rehabilitate such lands through suitable Agri-Horti system to meet the requirements of resource-poor farmers for fruit and food grains and to prevent their extension. The Agri-Horti system helps in conservation of vegetation, soil and nutrients and provides fruits and food grains on a sustainable basis. Almost all the works on mango based Agri-Horti system have been done on good land so far with assured input supply, but meager information is available either on resource conservation or on utilization of degraded lands. Therefore, present investigation was initiated to assess the performance and screening of suitable intercrops for mango orchard on degraded land in Doon Valley.

MATERIALS AND METHODS

A field experiment was conducted at the Research Farm of Central Soil and Water Conservation Research and Training Institute, Selakui (30° 21′ N latitude, 70° 52′ E longitude and at an altitude of 517 m above m.s.l.) about 16 km North-West of Dehradun. The experimental site was located on old bouldery riverbed of Asan river, a tributary of river Yamuna. Sieve analysis of pit material was done at the time of soil working which indicates that only 31% of the material was found <2 mm in size, whereas 69% were gravels and boulders by weight basis

in $1m^{-3}$ profile pit. From mechanical composition point of view, 45.13, 29.73, 13.74 and 11.40 per cent were coarse sand, fine sand, silt and clay, respectively. The soil of experimental field was almost neutral in reaction (pH 7.2) with low organic carbon (0.525%), poor in total N (0.06%), available P_2O_5 (24.49 kg ha^{-1}) and available K_2O (116.42 kg ha^{-1}), rich in Ca (0.195%) and Mg (0.14%). The climate is humid subtropical with average annual rainfall of 1636 mm. The mean maximum and minimum temperatures ranged between 19.0-37.6°C and 3.6-24.0°C, respectively during experimental period. In general, May-June was the hottest months (45°C) while December-January were coldest months (2°C) of the year.

The experiment was laid-out in randomized block design with three replications during 1995-2001 under newly mango cv. Mallika plantation planted during July, 1995 at 8 m x 8 m spacing. Four plants were kept as a unit of plot and plot size per treatment was 16 m x 16 m. There were five inter-cropping systems i.e. Cowpea-Toria, Clusterbean-Toria, Sesame-Toria, Blackgram-Toria and Pigeonpea in addition to control (no intercrop). The intercrops were introduced from *Kharif* season, 1997 with cowpea, clusterbean, sesame, blackgram and pigeonpea. Toria was grown uniformly in all the plots except control and pigeonpea during *Rabi* season. All the intercrops were grown as rainfed and without any fertilizer application. Clusterbean failed continuously for three years (1997-1999) due to wilting and rotting, hence, it was replaced by okra. Recommended doses of manure and fertilizers were applied in tree basins and plants were irrigated by drip system. Plant protection measures and interculture operations were done as and when required for both the components.

Observations were recorded on plant growth characters (plant height, canopy spread, canopy height, stock and scion diameter and scion:stock ratio), fruit yield and quality parameters (size, weight, pulp and stone weight, pulp: stone ratio, TSS, acidity and total sugar) of mango. In case of crops, dry matter of straw / stover and grain / pod yield were recorded and nutrients supplemented by crop residue were analyzed by standard methods. The grains and pods were sold while crop residues were incorporated in the same plots from where they were harvested. The gross income, net income and benefit: cost ratio was also computed by considering the cost of all inputs and gross output by selling the produce at farm itself on prevailing local market rate.

RESULTS AND DISCUSSION

Yield of intercrops

On the basis of mean value, cowpea and okra produced 18.57 and 25.36 q ha^{-1} green pods for vegetable and 25.83 and 19.16 q ha^{-1} stover, respectively (Table 1). However, yield of 2.10, 5.03 and 2.95 q ha^{-1} grain and 12.18, 17.28 and 81.66 q ha^{-1} stover was obtained from sesame, blackgram and pigeonpea, respectively during *kharif* season. Similarly, toria grown in sequence with cowpea, okra, sesame and blackgram produced 3.48, 3.17, 3.27 and 3.49 q ha^{-1} grain and 11.42, 10.19, 10.87 and 11.72 q ha^{-1} stover yield, respectively during *Rabi* season. In 1998, pigeonpea crop was failed due to uncongenial weather conditions i.e. unexpected heavy rain (227.1

Table 1. *Effect of mango plants on grain/pod and straw/stover yield of intercrops*

Cropping system	Yield of *Kharif* crops (q ha^{-1})						Yield of Toria (q ha^{-1})					
	1997	1998	1999	2000	2001	Mean	1997	1998	1999	2000	2001	Mean
						Grain/Pod yield						
Cowpea -Toria	18.45	20.52	15.99	21.94	15.94	18.57	4.15	2.42	4.11	3.40	3.30	3.48
Sesame -Toria	2.10	2.35	2.63	1.88	1.58	2.11	4.30	2.58	3.59	3.04	2.85	3.27
Blackgram -Toria	5.20	6.36	4.96	4.86	3.77	5.03	4.10	2.68	4.00	3.40	3.25	3.49
Cluster bean -Toria	NIL	NIL	NIL	-	-	-	4.32	2.42	3.95	-	-	3.56
Okra -Toria	-	-	-	29.85	20.87	25.36	-	-	-	3.23	3.11	3.17
Pigeonpea	3.56	NIL	5.12	3.14	2.91	2.95	-	-	-	-	-	-
						Straw/Stover yield						
Cowpea -Toria	26.50	28.92	26.37	26.34	21.01	25.83	13.50	10.15	12.46	10.34	10.67	11.42
Sesame -Toria	15.53	11.75	12.35	11.65	9.63	12.18	13.55	10.10	11.42	9.79	9.47	10.87
Blackgram -Toria	17.50	18.25	18.22	17.90	14.51	17.28	13.26	10.35	12.39	11.45	11.13	11.72
Cluster bean -Toria	NIL	NIL	NIL	-	-	-	13.62	10.25	11.90	-	-	11.92
Okra -Toria	-	-	-	21.98	16.34	19.16	-	-	-	10.28	10.09	10.19
Pigeonpea	86.85	83.02	81.31	81.65	75.48	81.66	-	-	-	-	-	-

* *Cluster bean failed continuously for 3 years, therefore, replaced by okra.*

** *In case of cowpea and okra, pod yield was recorded.*

mm) and prevailing foggy atmosphere during 3rd week of October and subsequently infestation of Alternaria blight, resulted no grain formation.

Nutrients supplementation by crop residue

Pigeonpea and cowpea played a vital role in supplimenting the nutrients through their residue incorporatiou in soil than other intercrops (Table 2). Pigeonpea supplemented 21.39 kg ha^{-1} nitrogen, 8.42 kg ha^{-1} phosphorus, 45.12 kg ha^{-1} potassium, 56.19 kg ha^{-1} calcium and 40.70 kg ha^{-1} magnesium through their residue which was closely followed by cowpea having 18.64, 7.45, 41.37, 37.26 and 24.18 kg ha^{-1} nitrogen, phosphorus, potassium, calcium and magnesium, respectively. The minimum nutrient supplementation by crop residue was recorded with toria followed by sesame. These results are in conformity with the findings of Rocheleau *et al.* (1988).

Growth, yield and fruit quality of mango

Growth characteristics of mango viz., plant height, canopy spread, canopy height, stock and scion diameter and scion:stock ratio did not affect considerably (Fig. 1). Likewise, the annual growth increment of mango plants was not influenced significantly due to various intercrops (Table 3). The average fruit yield of mango recorded during initial three years of bearing under different intercrops was also found non-significant. However, the fruit quality of mango in terms of size, weight, pulp and stone weight, pulp: stone ratio, total soluble solid, acidity and total sugar were not influenced adversely by any intercrop (Table 4). Bhuva *et al.* (1989) also found similar results with mango based agri-horti system under south Gujarat conditions.

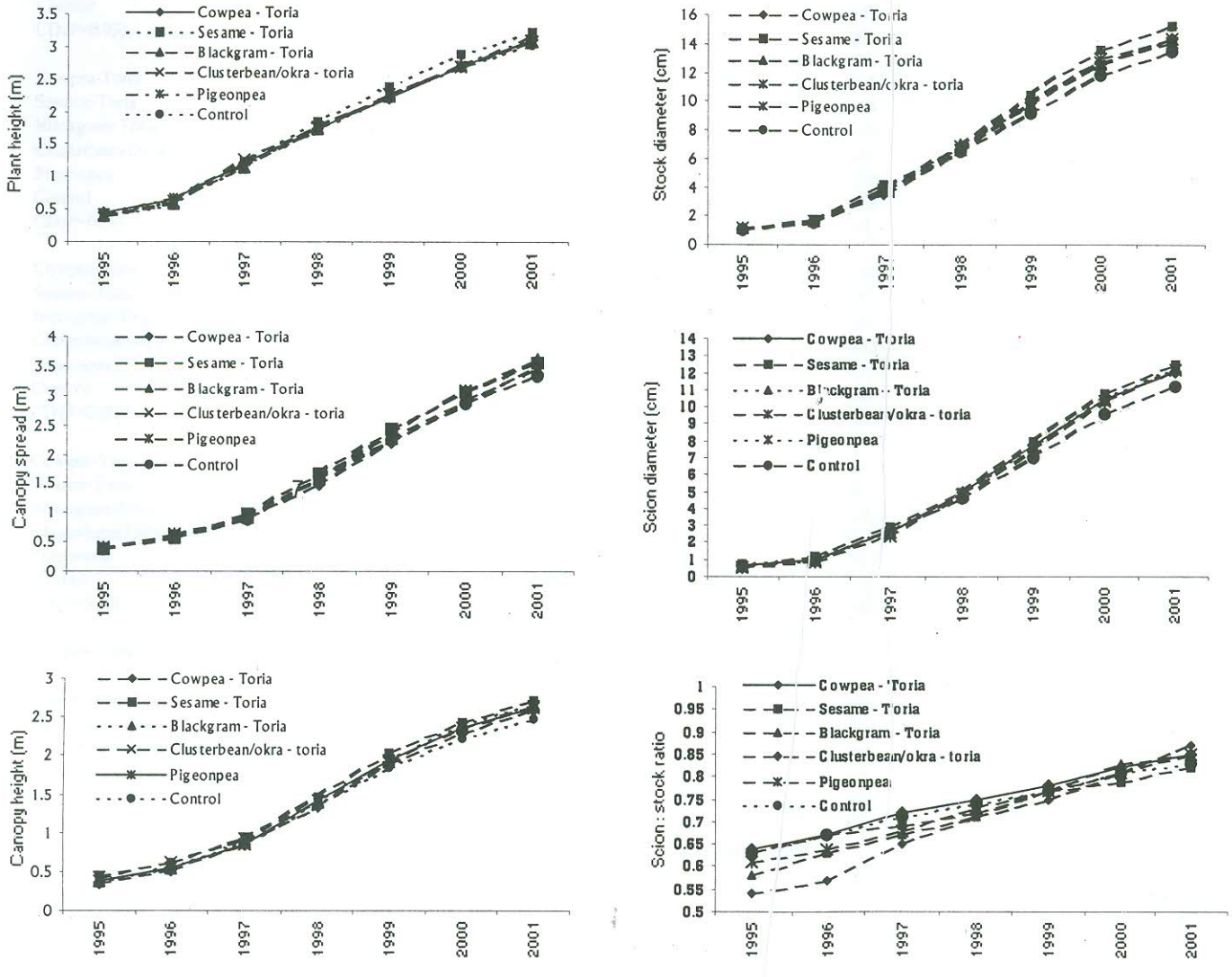

Fig. 1 : *Effect of different cropping systems on plant growth characters of mango.*

Table 2. *Nutrients recycled by crop residue (mean of five years)*

Crop residue incorporated	Dry weight of residue (q ha^{-1})	Nutrients supplemented by crop residue (kg ha^{-1} year^{-1}) N	P	K	Ca++	Mg++
Cowpea	25.83	18.64	7.45	41.37	37.26	24.18
Sesame	12.18	8.15	3.16	22.04	26.80	17.57
Blackgram	17.28	13.24	5.63	29.78	35.64	25.49
Okra	19.16	13.80	5.96	34.93	38.50	26.31
Pigeonpea	26.95	21.39	8.42	45.12	56.19	40.70
Toria	11.22	6.87	3.95	18.30	21.47	15.69

** In case of pigeon pea, woody portions were used for fuel and only branches, twigs and leaves were incorporated into the soil.*

Table 3. *Effect of intercrops on annual growth increment and scion:stock ratio of mango plant*

Cropping system	Annual growth increment 1996	1997	1998	1999	2000	2001
			Plant height (m)			
Cowpea-Toria	0.21	0.56	0.54	0.47	0.46	0.43
Sesame-Toria	0.21	0.61	0.61	0.54	0.50	0.35
Blackgram-Toria	0.19	0.57	0.59	0.48	0.49	0.37
Clusterbean/Okra-Toria	0.22	0.62	0.52	0.50	0.42	0.38
Pigeonpea	0.21	0.52	0.59	0.47	0.48	0.44
Control	0.18	0.61	0.54	0.52	0.44	0.35
CD (P=0.05)	NS	NS	NS	NS	NS	NS
			Canopy spread (m)			
Cowpea-Toria	0.20	0.34	0.57	0.71	0.68	0.61
Sesame-Toria	0.21	0.37	0.69	0.76	0.63	0.50
Blackgram-Toria	0.19	0.35	0.71	0.74	0.73	0.54
Clusterbean/Okra-Toria	0.22	0.31	0.63	0.81	0.72	0.48
Pigeonpea	0.23	0.32	0.62	0.70	0.67	0.53
Control	0.19	0.32	0.67	0.69	0.61	0.49
CD (P=0.05)	NS	NS	NS	NS	NS	NS
			Canopy height (m)			
Cowpea-Toria	0.16	0.32	0.50	0.54	0.41	0.30
Sesame-Toria	0.18	0.33	0.51	0.57	0.41	0.28
Blackgram-Toria	0.17	0.33	0.52	0.55	0.47	0.25
Clusterbean/Okra-Toria	0.19	0.31	0.49	0.50	0.46	0.28
Pigeonpea	0.17	0.31	0.56	0.51	0.44	0.26
Control	0.19	0.30	0.51	0.49	0.39	0.26
CD (P=0.05)	NS	NS	NS	NS	NS	NS
			Stock diameter (cm)			
Cowpea-Toria	0.5	2.1	2.9	3.4	2.8	1.6
Sesame-Toria	0.7	2.4	2.7	3.5	3.2	1.6
Blackgram-Toria	0.5	2.3	3.1	2.8	2.8	1.8
Clusterbean/Okra-Toria	0.5	2.1	3.1	3.0	2.9	1.4
Pigeonpea	0.6	2.0	2.8	3.2	3.1	1.4
Control	0.5	2.3	2.7	2.6	2.7	1.7
CD (P=0.05)	NS	NS	NS	NS	NS	NS
			Scion diameter (cm)			
Cowpea-Toria		0.36	1.6	2.3	2.8	2.7
1.7						
Sesame-Toria	0.39	1.8	2.1	3.0	2.8	1.7
Blackgram-Toria	0.36	1.6	2.4	2.6	2.8	1.9
Clusterbean/Okra-Toria	0.31	1.5	2.4	2.6	2.9	1.9
Pigeonpea	0.37	1.5	2.2	2.8	2.9	1.7
Control	0.37	1.7	1.9	2.4	2.6	1.6
CD (P=0.05)	NS	NS	NS	NS	NS	NS
			Scion:stock ratio			
Cowpea-Toria	0.67	0.72	0.75	0.78	0.82	0.85
Sesame-Toria	0.69	0.72	0.75	0.78	0.80	0.83
Blackgram-Toria	0.62	0.67	0.71	0.77	0.82	0.85
Clusterbean/Okra-Toria	0.60	0.65	0.70	0.76	0.81	0.86
Pigeonpea	0.65	0.70	0.74	0.78	0.82	0.86
Control	0.67	0.71	0.74	0.77	0.81	0.83
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 4. *Effect of different cropping systems on yield and fruit quality of mango*

Cropping systems	Fruit yield (q ha^{-1})				Fruit size (cm)	Fruit weight (g)	Pulp weight (g)	Stone weight (g)	Pulp: stone (ratio)	Acidity (%)	TSS (°Brix)	Total sugar (%)
	1999	2000	2001	Mean								
Cowpea-Toria	7.60	14.05	42.79	21.48	9.3	410.0	364.1	48.9	7.4	0.42	18.3	41.66
Sesame-Toria	8.05	14.49	44.07	22.20	8.6	379.6	345.9	47.6	7.3	0.41	18.0	40.00
Blackgram-Toria	8.47	15.46	42.20	22.04	9.0	406.6	363.2	49.0	7.4	0.42	18.3	41.66
Clusterbean /Okra-Toria	7.36	15.16	45.38	22.64	8.9	391.3	358.3	48.8	7.3	0.39	18.2	40.00
Pigeonpea	8.21	14.75	42.90	21.95	8.7	389.7	354.6	48.2	7.4	0.41	17.8	40.00
Control	7.25	13.42	39.94	20.20	8.8	390.0	357.1	48.0	7.4	0.40	18.5	40.00
CD (P=0.05)	NS	NS	NS	-	NS	NS	NS	NS	NS	NS	NS	NS

Economic aspect of agri-horti systems

The economic aspect of different cropping systems indicates that vegetable crops i.e., okra and cowpea in sequence with toria proved more beneficial than other pulse and oil seed crops (Table 5). Okra-toria cropping system gave maximum gross income of Rs. 26015 ha^{-1} year^{-1} which was superseded by 298.5, 142.9, 73.1, 66.9, 26.6 and 24.3 per cent more over without intercrop, clusterbean-toria, pigeonpea, sesame-toria, blackgram-toria and cowpea-toria cropping systems, respectively. Okra-toria cropping system proved more beneficial with highest net profit of Rs.7423 ha^{-1} year^{-1}) followed by cowpea-toria (Rs. 4285 ha^{-1} year^{-1}), blackgram-toria (Rs. 4086 ha^{-1} year^{-1}) pigeonpea (Rs. 1803 ha^{-1} year^{-1}), sesame-toria (Rs. 1222 ha^{-1} year^{-1}), without intercrop (Rs. 764 ha^{-1} year^{-1}) and clusterbean-toria (Rs. 1228 ha^{-1} year^{-1}) cropping systems. However, the maximum benefit:cost ratio of 1.40 was recorded with okra-toria cropping system followed by cowpea-toria (1.26), blackgram-toria (1.25), pigeonpea (1.14), sesame-toria (1.09),

Table 5. *Effect of different cropping systems on economics of mango based Agri-horti system*

Cropping system	1995	1996	1997		1998		1999		2000		2001		Mean		
	Fruit crop	Fruit crop	Intercrop	Fruit crop	Intercrop	Fruit crop	Intercrop	Fruit crop	Intercrop	Fruit crop	Intercrop	Fruit crop	Intercrop	Fruit crop	Total
							Input Cost (Rs. ha^{-1})								
Cowpea -Toria	10818	3310	7305	3987	8350	4631	9495	6512	10540	8140	11100	13646	9358	7292	16650
Sesame -Toria	10818	3310	5500	3987	6285	4631	7170	6512	7955	8140	8455	13646	7073	7292	14365
Blackgram -Toria	10818	3310	7140	3987	8185	4631	9330	6512	10300	8140	10875	13646	9166	7292	16458
Cluster bean -Toria	10818	3310	4085	3987	4590	4631	5270	6512	-	8140	-	13646	4648	7292	11940
Okra -Toria	10818	3310	-	3987	-	4631	-	6512	10950	8140	11650	13646	11300	7292	18592
Pigeonpea	10818	3310	4625	3987	5300	4631	6025	6512	6700	8140	7000	13646	5930	7292	13222
Without intercrop	10818	3310	-	3987	-	4631	-	6512	-	8140	-	13646	-	7292	7292
							Gross Income (Rs. ha^{-1})								
Cowpea -Toria	0.00	0.00	12960	0.00	13175	0.00	13064	4560	16515	10835	13513	34232	13845	7090	20935
Sesame -Toria	0.00	0.00	8805	0.00	8091	0.00	10034	4830	7892	10143	7164	35356	8397	7190	15587
Blackgram -Toria	0.00	0.00	13050	0.00	14630	0.00	13920	5082	13776	10822	11869	33760	13449	7095	20544
Cluster bean -Toria	0.00	0.00	3888	0.00	2299	0.00	3950	4416	-	10612	-	36304	3379	7333	10712
Okra -Toria	0.00	0.00	-	0.00	-	0.00	-	4416	21003	10612	16360	36304	18682	7333	26015
Pigeonpea	0.00	0.00	6890	0.00	2236	0.00	11628	4926	9353	10325	9609	34320	7943	7082	15025
Without intercrop	0.00	0.00	-	0.00	-	0.00	-	4350	-	9394	-	31952	-	6528	6528
							Net Income (Rs. ha^{-1})								
Cowpea -Toria	-10818	-3310	5655	-3987	4825	-4631	3569	-1952	5975	2695	2413	20586	4487	-202	4285
Sesame -Toria	-10818	-3310	3305	-3987	1806	-4631	2864	-1682	-63	2003	-1291	21710	1324	-102	1222
Blackgram -Toria	-10818	-3310	5910	-3987	6445	-4631	4590	-1430	3476	2682	994	20114	4283	-197	4086
Cluster bean -Toria	-10818	-3310	-197	-3987	-2291	-4631	-1320	-2096	-	2472	-	22658	-1269	41	-1228
Okra -Toria	-10818	-3310	-	-3987	-	-4631	-	-2096	10053	2472	4710	22658	7382	41	7423
Pigeonpea	-10818	-3310	2265	-3987	-3064	-4631	5603	-1586	2653	2185	2609	20674	2013	-210	1803
Without intercrop	-10818	-3310	-	-3987	-	-4631	-	-2162	-	1254	-	18306	-	-764	-764
							Benefit:Cost Ratio								
Cowpea -Toria	0.00	0.00	1.77	0.00	1.58	0.00	1.38	0.70	1.57	1.33	1.22	2.51	1.48	0.97	1.26
Sesame -Toria	0.00	0.00	1.60	0.00	1.29	0.00	1.40	0.74	0.99	1.25	0.85	2.59	1.19	0.99	1.09
Blackgram -Toria	0.00	0.00	1.83	0.00	1.79	0.00	1.49	0.78	1.34	1.33	1.09	2.47	1.47	0.97	1.25
Cluster bean -Toria	0.00	0.00	0.95	0.00	0.50	0.00	0.75	0.68	-	1.30	-	2.66	0.73	1.01	0.90
Okra -Toria	0.00	0.00	-	0.00	-	0.00	-	0.68	1.92	1.30	1.40	2.66	1.65	1.01	1.40
Pigeonpea	0.00	0.00	1.49	0.00	0.42	0.00	1.93	0.76	1.40	1.27	1.37	2.52	1.34	0.97	1.14
Without intercrop	0.00	0.00	-	0.00	-	0.00	-	0.67	-	1.15	-	2.34	-	0.90	0.90

without intercrop and clusterbean-toria (0.90) cropping systems. Bhuva et al. (1989) and Singh *et al.* (1996) obtained the similar beneficial economic return with mango based agri-horti systems.

It is inferred from the present study that for economic utilization of degraded bouldery riverbed lands in Doon valley through agri-horti land use system, okra-toria or cowpea-toria cropping system may be adopted in the interspaces between mango fruit trees at pre-bearing stage for better economic return without adversely affecting the tree growth, fruit yield and quality. The residue of intercrops i.e. straw/ stover should be incorporated in soil for the improvement of soil structure and fertility.

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