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Mango-toria based agri-horti model for degraded foothills of north-western Himalayan region

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ABSTRACT : The mango based agri-horti model was studied under gravely riverbed land in foothills of north-western Himalayan region from 1995 to 1997. The perennial overstorey component `mango' was managed by drip irrigation system while annual groundstorey component `toria' was raised under rainfed conditions. At initial stage, overall growth of mango plants was not much influenced when toria was grown as an intercrop in comparison to sole plantation of mango. About 3.68 q ha^{-1} (average of 1996 and 1997) grain yield of toria was obtained under gravely rainfed conditions. The yield of toria was highly influenced by distribution of rains during growing period. There was no significant effect of direction on the yield of toria but negative response was recorded at close proximity with tree canopy due to shade effect. There were significant differences in dry matter and grain yield of toria under varying topsoil depths, which increased with increasing depth of topsoil. The net income of about Rs.3000/- ha^{-1} $annum^{-1}$ can be obtained by growing toria as intercrop with mango orchard under gravely rainfed conditions. The model needs long term testing for interaction effect among components and on site productivity.

Key words : Agri-horti system; Degraded lands; Directions; Economics; Mango; Toria

Growing of various intercrops at pre-bearing stage of mango is an age old practice, though the selection of intercrops depend upon edapho climatic conditions and farmer's need/ tradition as well as resource availability (Saroj and Dadhwal 1997). In foothills of north-western Himalayan region, mango is most liking fruit crop in Doon valley and mango+wheat during *Rabi* season is most popular agroforestry practice on good land (Saroj and Arora 1994) but further extension of area under mango particularly on good land is least possible due to increasing population pressure in the locality. On the other hand, a large area in Doon valley (35% of total geographical area), characterized as gravely riverbed land, is either lying vacant or underutilized particularly during *Rabi* season due to high gravel content (68.66% by weight), poor water holding capacity, shallow workable soil depth (< 1'), poor fertility status and lack of site specific technologies. Therefore, an attempt was made to establish a mango orchard on degraded gravely land and a short duration toria (*Brassica campestris* var. Toria) was integrated as an inter crop with mango.

MATERIALS AND METHODS

The experiment was conducted during 1995 to 1997 at Central Soil and Water Conservation Research and training Institute, Research Farm Selakui, Dehradun located in foothills of Doon valley. The area is located at 680 m asl along the bank of *Bainkhala torrent* (seasonal river), having gentle slope from north-west to south-east approaching *Tons* river. After clearing the area from bushes and some perennial vegetation, the pits of $1 m^3$ were dug out at a spacing of 8 X 8 m during summer. The experimental site was highly gravely in nature, hence the gravels (>5 cm in diameter) were shorted out and remaining materials (smaller gravels and good soil) mixed with 20 kg FYM were filled in the pits before onset of rain. The mango cultivar `Mallika' was planted during July, 1995. The drip system has been installed to provide irrigation to mango plants during stress months (April- June). The plants were fertilized with recommended dose of fertilizers every years and intercultural operations were done as and when required. During first year no crop was grown considering the year of plant establishment. In the year 1996 and 1997 toria was grown in the inter spaces of mango by leaving tree basin under rainfed basis.

The experiment was laid out in RBD, having three replications. The data were collected on various growth parameters of mango. The toria samples (from 2 m^2 area) were taken both distance and direction wise. The yield and yield attributing characters of toria were recorded from 24 samples collected randomly. The initial soil fertility status (<2mm fractions) of the experimental site was determined before starting the experiment. The rainfall data of 1996 and 1997 during crop period were also recorded and depicted in Fig.1.

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Fertility status of experimental site

Before experimentation, fertility status of experimental site was assessed by analyzing 54 soil samples taken randomly at three depths (0-30, 30-60 and 60-100 cm). It was observed that among mechanical fractions, coarse sand alone was more than 50 per cent (51.73 %) followed by fine sand (26.73 %) while silt (10.40 %) and clay (11.13 %) fractions were very low. The soil reaction was almost neutral (7.2 pH). Organic carbon content was 0.49 per cent. Major nutrients i.e. N, P, K, Ca and Mg were analyzed by standard method and the mean values were 0.06 per cent, 11.13 ppm, 52.92 ppm, 0.19 per cent and 0.14 per cent, respectively. It was also observed that the content of various nutrients decreased further with increasing depth of soil.

RESULTS AND DISCUSSION

Growth of mango plant

Based on new flushes, various growth parameters of mango plants were recorded twice in a year i.e. April and September and data presented in Table 1. It is apparent from the data that there was no much variation in growth of mango plants either grown with intercrop or as sole plantation. The growth differences between sole plantation of mango and mango with intercrop were also computed and expressed as percentage increase/ decrease at the end of final observation, though the differences were very meager except for stock : scion ratio. There was more than 24.1 per cent increase in stock : scion ratio of sole plantation over interplantation of mango. At the end of September, 1997 the plant height, crown spread, stock : scion, crown volume with interplanted mango were 1.50m, 1.36m, 1.12, 0.93m^3 and with sole plantation 1.47m, 1.27m, 1.39, 0.83m^3, respectively. Good response of toria with perennial component suggested the scope of integrating different intercrops in mango orcharding. Bhua *et al.* (1989) from Gujarat and Rajput *et al.* (1989) from Uttar Pradesh have also observed the good response of intercrops in terms of yield and economics without any adverse effect to the mango crop. However, Kanwar *et al.* (1993) suggested that though mango tolerates intercrops quite well but there was 18 per cent yield reduction due to intercropping.

Yield and yield attributes of toria

The yield and yield attributing characters of toria grown under rainfed gravely land with mango are given in table 2. It is obvious from the data that the grain yield of toria was better during 1997 (4.21 q ha^{-1}) as compared to 1996 (3.15 q ha^{-1}). The improvement in yield during 1997 was not only due to high rainfall but also its good distribution during the crop season. Toria as a short duration crop was raised under rainfed conditions, which was sown in October and harvested in the end of December. During 1997, there was 25.6, 28.2 and 102.2 mm rainfall, respectively in all the months of growing period i.e. October to December while in 1996 only 53.7 mm rainfall during early stage of crop growth (October) was received. This leads to poor response of grain yield. During 1997, proper distribution of rainfall ensured availability of moisture regularly throughout the growing period of toria. The effect of rainfall distribution during growing season on grain yield is depicted by Fig. 1. The yield attributing characters like, plant height, number of branches $plant^{-1}$, number of siliquae $plant^{-1}$, stover yield, and test weight also varied accordingly and showed promising response during 1997 than that of 1996 (Table 2).

Effect of distance and direction on the yield of toria

In general, tree decreases the crop growth in their vicinity and the affect on growth and yield is more pronounced with increase in canopy cover of the trees (Saroj and Dadhwal, 1994). In present investigation, toria harvesting has been done by considering four lateral distances (0-1, 1-2, 2-3m and in between tree rows) from tree basin and direction wise (North, South, East and West) too. Data presented in table 3 indicated that there was no significant effect of direction on the yield of toria. Though, the influence of north and west directions were numerically better

Table 1. *Growth parameters of `Mallika' mango grown with and without intercrop on gravely land*

Parameters	With crop (Mnago + Toria)					Without crop (Sole mango)					Difference*
	1995	1996		1997		1995	1996		1997		1997
	Initial	April	September	April	September	Initial	April	September	April	September	September
Plant height (m)	0.60	0.63	1.11	1.21	1.50	0.53	0.57	1.16	1.23	1.47	-2.00
Crown spread (m)	0.39	0.45	0.60	0.91	1.36	0.35	0.42	0.65	0.79	1.27	-6.62
Stock diameter (cm)	1.55	1.62	3.30	3.78	5.81	1.46	1.47	3.11	3.76	5.65	-2.75
Scion diameter (cm)	1.01	1.02	2.46	2.76	5.19	0.95	0.96	2.32	2.73	4.07	-2.86
Scion : Stock	0.63	0.64	0.75	0.73	0.70	0.65	0.65	0.75	0.73	0.73	+4.29
Crown volume (m^3)	-	-	-	0.85	0.93	-	-	-	0.78	0.83	-10.75

**Percentage increase/decrease at the end of final observation*

Table 2. *Yield and yield attributing characters of toria grown in interspaces of mango on gravely land.*

Parameters	1996	1997	Mean
Plant height (cm)	85.65	89.57	87.61
No. of branches plant^{-1}	3.22	3.28	3.25
No. of siliquae plant^{-1}	65.26	70.45	67.86
Test weight (g)	2.90	3.06	2.98
Stover yield (q ha^{-1})	12.13	13.47	12.80
Grain yield (q ha^{-1})	3.15	4.21	3.68

on grain yield probably due to mild sun shine hours in these directions during winter have favourable effect on moisture conservation under degraded land and thus better yield response. However, the effect of distance from tree basin gave significant variation and grain yield of toria increased with increasing distance from tree basin. The maximum grain yield (4.43 q ha^{-1}) was obtained in between tree rows while minimum (3.87 q ha^{-1}) at close proximity with tree basin (0-1 m) due to shading effect of mango plants. The yield differences between 2-3m and in between tree rows were nonsignificant indicating low effect beyond two meter of lateral distance. The interactive effect between distance and direction were also found nonsignificant.

Effect of top soil depth on yield of toria

There was heterogenity in top soil depth of experimental site as it is gravely riverbed land formed by layered deposition of eroded materials from the adjoining hills. Therefore, crop was also responded to these variations and soil moisture was the key factor in controlling performance of the rainfed toria crop. Data presented in table 4 indicated that there were significant differences in dry matter and grain yield of toria under varying topsoil depths except between 15-30 cm and 30-45 cm. The grain yield of toria increased with increasing depth of topsoil. The maximum grain yield (5.16 q ha^{-1}) was recorded at 60-100 cm top soil depth while minimum (3.12 q ha^{-1}) under < 15cm top soil and the differences were highly significant. The similar trend was recorded with dry matter yield of toria though the differences between 45-60cm and 60-100cm were non-significant. Infect, top soil is considered most productive part of the slum, therefore, utilization of top soil without

Table 3. *Effect of distance and direction on the grain yield of toria (q ha^{-1}) grown with mango plantation - 1997*

Direction	Distance from tree basin (m)				Mean
	0-1	1-2	2-3	Between tree rows	
North	3.95	4.15	4.45	4.43	4.25
South	3.80	4.10	4.40	4.41	4.18
East	3.82	4.00	4.39	4.39	4.14
West	3.92	4.20	4.41	4.47	4.25
Mean	3.87	4.11	4.41	4.43	
		SEm±	*CD (p=0.05)*		
	Distance (D1)	*0.0369*	*0.07536*		
	Direction (D2)	*0.0054*	*NS*		
	Interaction (D1 X D2)	*0.0054*	*NS*		

Table 4. *Drymatter and grain yield of toria as influenced by topsoil depth - 1997*

Soil depth (cm)	Drymatter yield (q ha^{-1})	Grain yield (q ha^{-1})
< 15	11.26	3.12
15-30	13.76	3.84
30-45	14.90	4.15
45-60	18.07	5.02
60-100	18.58	5.16
SEm ±	0.392	0.239
CD (p=0.05)	0.904	0.551

any detrimental effect is need of the hour. In the alluvial region Khybri *et al.*(1980) reported that removal of 1 cm top soil induced reduction of maize yield to the extent of 76 kg ha^{-1}.

Economics of toria

Ultimate viability of any system is expressed in terms of economic return. In present study, for raising toria neither irrigation nor fertilizer was applied; only seeds were sown (5 kg ha^{-1}) as input in the system. Therefore, in calculation of economics, the cost of seed and cost of various operations like ploughing, harvesting, threshing were taken into account. The grain yield was auctioned at the prevailing market rate (Rs.900 q^{-1}). The net return of Rs. 3000/- ha^{-1} was obtained from toria grown as intercrop with mango orchard.

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