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T Chaitanya
AICRP on Agroforestry, Professor Jayashankar Telangana Agricultural University, Hyderabad, Telangana, India

YS Parameshwari
AICRP on Agroforestry, Professor Jayashankar Telangana Agricultural University, Hyderabad, Telangana, India

A Krishna
AICRP on Agroforestry, Professor Jayashankar Telangana Agricultural University, Hyderabad, Telangana, India

MA Aarif Khan
AICRP on Agroforestry, Professor Jayashankar Telangana Agricultural University, Hyderabad, Telangana, India

Corresponding Author:
T Chaitanya
AICRP on Agroforestry, Professor Jayashankar Telangana Agricultural University, Hyderabad, Telangana, India

Assessment of sweet corn-redgram cropping system under mango based agri-horti system

T Chaitanya, YS Parameshwari, A Krishna and MA Aarif Khan

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Abstract
A study was carried out with sweet corn-red gram sequence under mango based Agri-horti system with curry leaf as filler crop in light textured marginal lands for better land utilization and getting regular income. A field experiment was carried out in six year old mango orchard with curry leaf as filler crop by intercropping sweetcorn in *kharif* season and red gram in *rabi* season for two years 2020-21 and 2021-22 in red sandy loam soil with different nutrient management options viz., T_1 - Farmer practice (FYM @ 12 t ha^{-1}), T_2 -125% RDN, T_3 -100% RDF, T_4 -75% RDN + 25% N through FYM, T_5 -75% RDN + 25% N through poultry manure, T_6 -75% RDN + *Azotobacter* + PSB/*Rhizobium* @ 5 kg ha^{-1} each, T_7 -100% RDF (Sole crop without trees). The total system yield was significantly higher with 125% RDF (Sweet corn equivalent yield: 12449 kg ha^{-1} and curry leaf yield: 8360 kg ha^{-1}) and it was on par with 75% RDN + 25% N through PM (Sweet corn equivalent yield: 11912 kg ha^{-1} and curry leaf yield: 8280 kg ha^{-1}), 100% RDF (11583 kg ha^{-1} and curry leaf yield: 8115 kg ha^{-1}) and 75% RDN + 25% N through FYM (11574 kg ha^{-1} and curry leaf yield: 8140 kg ha^{-1}). Even though yield, gross and net returns were higher in 125% RDF, percent decline of gross returns was less i.e., 3.8% to 6.5% in integrated application of 75% N through inorganic fertilizer and 25% N through organic manure treatments over 125% RDF, replacement of 25% inorganic manure with organic manure is the best treatment in sustainability point of view. Even we can reduce the cost of cultivation, if the organic manure is available with the farmer.

Keywords: Mango, filler crop, intercropping, yield and economics

Introduction
Mango (*Mangifera indica* L.) is an indigenous fruit of India and also known as national fruit of the country because of its wide edaphic and climatic adaptability, high nutritive value, attractive appearance and popularity among growers. Moreover, the foliage of mango is sparse, which permits required light for the under-story intercrops and makes more compatible for inter cultivation. It is a multipurpose fruit tree suitable for agroforestry, which yields fruits, timber and fuels etc. (Musvoto and Campbell, 1995) [1]. The fruits are also considered, protective food as it contains anti-oxidants, essential vitamins, minerals and enzymes, which are required for better functioning and maintaining resistance power against many diseases of human beings (Chattopadhyay, 2001) [2]. It also has long gestation period, which allows intercropping at pre-bearing stage in order to utilize interspaces and generate additional income. Intercultural operations in annual crops positively influence the vegetative growth of fruit plants at initial stage (Saroj *et al.*, 2003) [3].

The area under mango in Telangana during the year 2022-23 was 1.31 lakh ha (3.24 lakh acres). Major Mango growing districts in Telangana are Nagarkurnool (13.86 thousand ha), Jagityal (13.78 thousand ha), Khammam (13.71 thousand ha), Rangareddy (8.93 thousand ha), Mancherial (7.32 thousand ha), Mahabubabad (6.65 thousand ha), Siddipet (6.03 thousand ha) and Sangareddy (5.93 thousand ha) (PJTSAU, *Yasangi*-pre-harvest-mango, 2023) [4]. Most of the research works on mango based agri-horticultural system have been done on arable land with assured input supply (Saroj *et al.*, 2004) [5]. Mango based alley cropping is popular and widely followed in many parts of the world (Rahman *et al.*, 2008) [6]. Since mango takes several years to grow to its full size, intercropping to utilize the interspaces is desirable. Quiet often the alleys are wide enough (10 or 12 m) to accommodate a variety of agricultural crops.

However, one has to be careful in choosing the compatible crop combinations. For instance, legumes like sun hemp, cowpea and vegetables are suggested. However, wheat, oat, sorghum and pearl millet prove harmful to mango due to their common time of grain formation with flower bud initiation and the competition for moisture and nutrients. Among different intercrops (groundnut, green gram and cowpea) tried in four–year–old mango orchard at Hyderabad, CRIDA, groundnut was tested as successful intercrop (CRIDA, 1995) [7]. The leguminous intercrops can be taken in mango orchard with minimum reduction in yields of crops. In young mango plantations in Karnataka, ragi and groundnut intercropping is very common. It has been reported that the farm families of Uttar Pradesh, India adopted the cultivation of wheat, lentil, chicory, oat (green fodder) and potato in association with mango (Singh *et al.*, 2008) [8]. The growth habit, spatial and temporal advantages permit integration of mango with many other crops, qualifying its suitability as an agroforestry species. (Kunhamu and Santhoshkumar, 2012) [9]. Since mango is one of the principal fruit crops in Telangana, an economic cropping system was examined using a sweet corn-redgram intercropping system with curry leaf as a filler crop in mango. This was carried out at an early stage of orchard establishment in order to provide the farmer with steady and supplementary income.

Materials and Methods

A field experiment was conducted at the research farm of AICRP on Agroforestry, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. Field experiment of agri - horti system with mango (variety baneshan) in 8 m x 8 m spacing (156 trees ha^{-1}) with curry leaf as filler crop in between the mango plants (2m spacing i.e., 3 curry leaf trees in between two mango tress) and intercropped with sweet corn (sugar – 75 hybrid) in *kharif* and red gram (Hanuma) in *rabi* were grown for two years in six-year-old mango orchard during 2020-21 and 2021-22. Sweet corn and red gram were taken in a Randomized Block Design (RBD), consisting of seven treatments i.e., T_1 - FYM 12 t ha^{-1}, T_2 - 125% RDF (Sweet corn - 225 N : 75 P_2O_5 : 62.5 K_2O, Red gram - 50 N : 62.5 P_2O_5 : 0 K_2O), T_3 - 100% RDF (Sweet corn - 180 N : 60 P_2O_5 : 50 K_2O, Red gram - 40 N : 50 P_2O_5 : 0 K_2O), T_4 - 75% RDN + 25% N FYM, T_5 - 75% RDN + 25% N PM, T_6 - 75% RDN + *Azotobacter*/*Rhizobium* + PSB @ 5 kg ha^{-1} (T_6 treatment, *Azotobacter* was applied to soil during *kharif* season for sweet corn and *Rhizobium* was used during *rabi* season for red gram seed treatment) and T_7 - Sole crop without tree replicated three times. All the agronomic practices were followed as per the recommendations of Professor Jayashankar Telangana State Agricultural University. Common management practices were followed for mango and curry leaf as per the recommendations by the Professor Jayashankar Telangana State Agricultural University.

Results and Discussion

Yield and economics during the year 2020-21

In 1st year of mango based agri - horti system intercropped with sweet corn (Sugar – 75 hybrid) in *kharif* and red gram (Hanuma) in *rabi* along with curry leaf as filler crop during 2020-21. Significantly higher sweet corn green cob yield of 8367 kg ha^{-1} with higher fresh curry leaf yield of 4840 kg ha^{-1} in *kharif* and redgram grain yield of 922 kg ha^{-1} with curry leaf yield of 4140 kg ha^{-1} were recorded with application of 125% RDF which was on par with all treatments except 75% RDN + *Azotobacter* + PSB @ 5 kg ha^{-1} and FYM @ 10 t ha^{-1}. Higher gross and net returns with sweet corn green cobs and curry leaf were recorded with application of 125% RDF (Rs. 125505 ha^{-1} and Rs. 85666 ha^{-1}, respectively) with a B:C ratio of 2.2 in *kharif*. Further, in *rabi* red gram higher gross and net returns were recorded in same treatment *i.e.,* 125% RDF (Rs. 66800 $ha^{-1}$and Rs. 43400 ha^{-1}, respectively) with B:C ratio of 1.85 (Table. 1)

Yield and economics during the year 2021-22

During 2021-22 with same cropping system in 2nd year, significantly higher green cob yield of 10330 kg ha^{-1} in *kharif* and redgram grain yield of 939 kg ha^{-1} in *rabi* were recorded with application of 125% RDF which was on par with all treatments except 75% RDN + *Azotobacter* + PSB @ 5 kg ha^{-1} and FYM @ 10 t ha^{-1}. Higher fresh Curry leaf yield of 4800 kg ha^{-1} in *kharif* and 3700 kg ha^{-1} in *rabi* were obtained with 75% RDN + 25% N through FYM and 75% RDN + 25% N through PM. In *kharif* maximum net returns with Sweet corn green cobs and curry leaf were recorded with application of 125% RDF (Rs. 1,25,505 ha^{-1}) with B:C ratio of 2.2 in *rabi* season, higher net returns were recorded with same treatment 125% RDF (Rs. 24428 ha^{-1}) with B:C ratio of 1.09. Thus, sweet corn followed by redgram cropping system with curry leaf as filler crop in mango based agri-horti system with the application of 125% RDF was superior over all other treatment in terms of yield and economics (Table. 2). Similar findings were also given by Avinash *et al.* (2013) [10] and Singh *et al.* (2015) [11].

Pooled data results

The two years pooled data results furnished in Table 3 indicated that the green cob yield of *kharif* sweet corn and seed yield of *rabi* red gram were significantly higher in 125% RDF (Sweet corn: 9349 K_2O kg ha^{-1}, Red gram: 930 kg ha^{-1}). It was statistically at par with all other treatments except FYM 10 t ha^{-1} and 75% RDN + *Azotobacter* + PSB/*Rhizobium*@ 5 kg ha^{-1}. The total system (Mango based agri - horti system) yield was significantly higher with 125% RDF (Sweet corn equivalent yield: 12449 kg ha^{-1} and curry leaf yield: 8690 kg ha^{-1}). However, it was on par with 75% RDN + 25% N through PM (Sweet corn equivalent yield: 11912 kg ha^{-1} and curry leaf yield: 8625 kg ha^{-1}), 100% RDF (11583 kg ha^{-1} and curry leaf yield: 8435 kg ha^{-1}) and 75% RDN + 25% N through FYM (11574 kg ha^{-1} and curry leaf yield: 8595 kg ha^{-1}). Further, 125% RDF increased yield by 3.3 percent over sole crop with 100% RDF, while integrated nutrient management treatments reduced yield by less than 4% over sole crop. Intercropping in mango with a 25% higher nitrogen dose boosted production over sole cropping because crop performance is good in the early stages of mango orchard with reduced shade and the leaf litter acts as a mulch for moisture and nutrient conservation, further improving soil organic carbon. Among the integrated nutrient management approaches in a mango-based agri-horti system, the application of 125% RDF resulted in significantly higher system gross and net returns (Rs.2,06,097 ha^{-1} and Rs. 1,41,977 ha^{-1}, respectively). Furthermore, when 75% N was applied through inorganic fertiliser and 25% N through poultry manure, the decrease in gross returns and net returns over 125% RDF was 3.8% and 8.7%, respectively. When 75% N was applied through inorganic fertiliser and 25% N through farm yard manure, the decrease was 6.5% and 12%, respectively. Since the integrated application of 75% N through inorganic fertiliser and 25% N through organic manure treatments over 125% RDF resulted in a percent decline of gross returns of 3.8% to 6.5%, which is less. So, replacing 25% of the inorganic manure with organic manure is the optimal treatment from a sustainability perspective. If the

farmer has access to organic manure, he can also lower the cost of cultivation. Aparna (2017) [12] evaluated the performance of certain mango based intercropping systems and found that intercropping was effective in sustaining income and employment generation especially during the pre-production phase and "off" year especially for small and marginal farmers in mango. The higher returns from agroforestry systems in comparison to sole cropping has been reported by Dalvi *et al.* (2019) [13] for rainfed groundnut as intercrop under mango based horti-agricultural system in juvenile phase of mango plantation. Intercropping in mango orchards can help farmers for year-round production, employment, reduced cost of cultivation and increase monetary returns besides providing nutritional security.

Sweet corn (Hybrid: Sugar 75) in *kharif* season

Redgram (Variety: Hanuma) in *Rabi* season

Fig 1: Nutrient management in Sweet corn-Red gram sequence in marginal lands in Mango based Agri-horti system

Table 1: Economics of Sweet corn -redgram intercropping system and curryleaf as filler crop in Mango based agri-horti system by different nutrient management practices (2020-21)

Treatments	Sweet corn- *Kharif*, 2020					Red gram- *Rabi*, 2020-21				
	Fresh cob yield with husk (kg ha^{-1})	Curry leaf Yield (kg ha^{-1})	Gross Returns (Rs ha^{-1})	Net Returns (Rs ha^{-1})	B: C ratio	Grain yield (kg ha^{-1})	Curry leaf Yield (kg ha^{-1})	Gross Returns (Rs ha^{-1})	Net Returns (Rs ha^{-1})	B: C ratio
T_1 FYM 10 t ha^{-1}	6732	4220	100980	57984	1.30	854	3920	62300	32300	1.07
T_2 125% RDF	8367	4840	125505	85666	2.21	922	4140	66800	43400	1.85
T_3 100% RDF	8177	4710	122655	83416	2.10	802	4060	60400	38400	1.74
T_4 75% RDN + 25% N FYM	7952	4700	119280	76141	1.81	792	3940	59300	34300	1.37
T_5 75% RDN + 25% N PM	8038	4640	120570	75923	1.71	807	4110	60900	35900	1.44
T_6 75% RDN + *Azotobacter* + PSB (5 kg ha^{-1})	7333	4260	109995	70960	1.80	693	3960	54450	30500	1.27
T_7- Sole crop without tree	8100	--	121500	83260	2.21	885		44250	24250	1.21
SEm±	350.9	--		--		65.0		--	--	
CD @ 5%	983	--		--		182		--	--	

Rates considered: Green cobs @ Rs. 15/- kg^{-1}, Curry leaf –Rs. 5 kg^{-1}. FYM -Rs. 1 kg^{-1}, Poultry Manure -Rs. 1.5 kg^{-1}.

Table 2: Economics of Sweet corn -redgram intercropping system in Mango based agri-horti system by different nutrient management practices (2021-22)

Treatments	Sweet corn- *Kharif*, 2021					Red gram- *Rabi*, 2021-22				
	Fresh cob yield (with husk) (kg ha^{-1})	Curry leaf Yield (kg ha^{-1})	Gross Returns (Rs ha^{-1})	Net Returns (Rs ha^{-1})	B: C ratio	Grain yield (kg ha^{-1})	Curry leaf Yield (kg ha^{-1})	Gross Returns (Rs ha^{-1})	Net Returns (Rs ha^{-1})	B: C ratio
T_1 FYM 10 t ha^{-1}	7280	4500	1,25,200	80,200	1.78	793	3200	39635	10135	0.34
T_2 125% RDF	10330	4800	1,72,960	1,30,460	3.07	939	3600	46928	24428	1.09
T_3 100% RDF	9360	4700	1,57,400	1,16,100	2.81	886	3400	44323	22323	1.01
T_4 75% RDN + 25% N FYM	9640	4850	1,63,060	1,19,660	2.76	876	3700	43803	19303	0.79
T_5 75% RDN + 25% N PM	10090	4800	1,69,820	1,26,820	2.95	902	3700	45103	20603	0.84
T_6 75% RDN + *Azotobacter* + PSB (5 kg ha^{-1})	8940	4500	1,50,660	1,10,660	2.77	840	3300	41978	19478	0.87
T_7- Sole crop without tree	9980	--	1,49,700	1,09,300	2.71	918	--	45887	23387	1.04
SEm±	398	--				25.8				
CD @ 5%	1115					72.4				

Rates considered: Green cobs @ Rs. 15/- kg^{-1}, Curry leaf –Rs. 5 kg^{-1}. FYM -Rs. 1 kg^{-1}, Poultry Manure -Rs. 1.5 kg^{-1}.

Table 3: Grain yield of sweet corn, red gram, Sweet corn equivalent yield (system productivity) and curry leaf yield in Mango based Agri- horti system with curry leaf as filler crop (2020-21 and 2021-22)

Treatments	Sweet corn fresh cob yield (kg ha^{-1})			Red gram grain yield (kg ha^{-1})			Sweet corn equivalent yield (MEY) (kg ha^{-1})			Curry leaf yield (kg ha^{-1})		
	2020-21	2021-22	Pooled data	2020-21	2021-22	Pooled data	2020-21	2021-22	Pooled data	2020-21	2021-22	Pooled data
T_1: FYM 10 t ha^{-1}	6732	7280	7006	854	793	823	9580	9922	9751	8140	7700	7920
T_2: 125% RDF	8367	10330	9349	922	939	930	11440	13459	12449	8980	8400	8690
T_3: 100% RDF	8177	9360	8769	802	886	844	10851	12315	11583	8770	8100	8435
T_4: 75% RDN + 25% N FYM	7952	9640	8795	792	876	834	10591	12558	11574	8640	8550	8595
T_5: 75% RDN + 25% N PM	8038	10090	9063	807	902	855	10728	13095	11912	8750	8500	8625
T_6: 75% RDN + *Azotobacter*/ *Rhizobium* + PSB	7333	8940	8137	693	840	766	9642	11743	10692	8220	7800	8010
T_7: Sole crop without tree	8100	9980	9042	885	918	902	11051	13043	12047			
SEm±	350.9	398.0	256.4	65.0	25.8	35.7	381.0	449.0	303.0			
CD (p = 0.05)	983	1115	718	182	72	100	NS	1257	849			

Market price: Green cobs: Rs. 15 kg^{-1}, Curry leaf: Rs. 5 kg^{-1}, Red gram: Rs. 50 kg^{-1}

Note: In T6 treatment, *Azotobacter* was applied to soil during *kharif* season in sweet corn and *Rhizobium* was used during *rabi* season for red gram seed treatment

Table 4: Economics of sweet corn-redgram sequence in Mango based Agri-horti system with curry leaf as filler crop (2020-21 and 2021-22)

Treatments	System gross returns (Rs ha^{-1})			System cost of cultivation (Rs ha^{-1})			System net returns (Rs ha^{-1})			System B: C ratio		
	2020-21	2021-22	Pooled data	2020-21	2021-22	Pooled data	2020-21	2021-22	Pooled data	2020-21	2021-22	Pooled data
T_1: FYM 10 t ha^{-1}	163280	164835	164058	73000	74500	73750	90284	90335	90310	1.2	1.2	1.2
T_2: 125% RDF	192305	219888	206097	63234	65000	64117	129066	154888	141977	2.0	2.4	2.2
T_3: 100% RDF	183055	201723	192389	61240	63300	62270	121816	138423	130120	2.0	2.2	2.1
T_4: 75% RDN + 25% N FYM	178580	206863	192722	68140	67900	68020	110441	138963	124702	1.6	2.1	1.8
T_5: 75% RDN + 25% N PM	181470	214923	198197	69640	67500	68570	111823	147423	129623	1.6	2.2	1.9
T_6: 75% RDN + *Azotobacter* + PSB	164445	192638	178542	62990	62500	62745	101160	130138	115649	1.5	2.1	1.8
T_7: Sole crop without tree	165750	195587	180669	58540	62900	60720	107510	132687	120099	1.8	2.1	2.0

Market price: Green cobs: Rs. 15 kg^{-1}, Curry leaf: Rs. 5 kg^{-1}, Red gram: Rs. 50 kg^{-1}

Conclusion

Intercropping of sweet corn in *kharif* and red gram in *rabi* season in mango-based agri-horti system with curry leaf as filler crop is a profitable and sustainable agroforestry system with the application 75% nitrogen through inorganic fertilizer and 25% nitrogen through organic manure. Furthermore, intercropping in mango orchards with integrated nutrient management and filler crops can assist farmers to achieve year-round income, employment, lower cultivation costs, and higher monetary returns, in addition to better land utilisation.

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