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RESEARCH PAPER

Resource recycling and their management under integrated farming system for North- East Karnataka

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Abstract : A field experiment was conducted at Main Agricultural Research Station (MARS), Raichur during 2012-14 to study resource recycling and management from different IFS models in NE Karnataka. Different combination of crops, animals, fishes and birds were examined in form of seven integrated farming systems (IFS) models. Among different IFS models crop + cow + goat + poultry birds + fish (F_7) emerged as the best integrated farming system in terms of resource recycling, resource management and nutrient budgeting. The waste material/by products of crops and animals were recycled and used as inputs for other components of integrated farming system. The F_7 system (19,122 and 20,623 kg ha^{-1} during 2012-13 and 2013-14, respectively) added highest amount of organic residues in both the years which is closely followed by F_5 system (18,368 and 19,614 kg ha^{-1} during 2012-13 and 2013-14, respectively). Quantity of N, P and K added and nutrient budgeting varied between IFS models.

Key Words : Integrated farming system, IFS models, Nutrient recycling, Nutrient budgeting, Natural resource management

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INTRODUCTION

In Karnataka crop productivity trends have been below the Indian average for most of the crops and far below their potential yield, even after Karnataka's fertile land and water resources. About 84.97 per cent of the farmers are small and marginal in India having only 44.31 per cent of the total operational holdings. The average size of the holding is 0.83 ha (Singh *et al*., 2010). With the average size of land holdings shrinking as a result of increasing fragmentation, many marginal farms are becoming economically non-viable and oriented towards subsistence. Due to failure of monsoon, the farmers are forced to judicious mix up of agricultural enterprises like dairy, poultry, poultry birds, fishery, sericulture, apiculture etc., suited to their agro-climatic and socio-economic condition and largely dependent on the farm size. To overcome the problems of small resource poor farmers, diverse and risk prone environments has led to the development of a more holistic, resource based, client oriented and interacting approach, popularly known as integrated farming system. Integrated farming system is a reliable way of obtaining high productivity with

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substantial nutrient economy in combination with maximum compatibility and replenishment of organic matter by way of effective recycling of organic residues/ wastes etc. obtained through integration of various land-based enterprises (Gill *et al*., 2010 and Kumar *et al*., 2012).

There is a huge population of cattle in India and Karnataka in particular. As a tradition every households possess 1–2 cows/buffaloes or 3–4 goats. The waste material (dung) of these animals are generally used as fuel by making dungcakes and a very few quantity goes for FYM or compost production. If these materials are recycled within the farm a sizeable amount of money spent on chemical fertilizers can be saved. Likewise, the plant debris, *viz.*, leaves, roots, stem, weeds of vegetables and other crops could be converted into vermicompost and recycled to the crops in a system mode. These farmers can go for a suitable crop along with horticulture, animals, fisheries and other components that would purchasing of costly inputs (fertilizers/ manures) from market apart from improving soil fertility over a period of time. Integrating different components with crop will increase the profitability through recycling of wastes of one component into another. Therefore, the present investigation on resource recycling from different IFS models was envisaged to identify a suitable combination of components for higher natural resource management (NRM) and sustainability.

MATERIAL AND METHODS

Two years field study was carried out at Main Agricultural Research Station (MARS), Raichur during 2012-14. Seven treatments (farming systems) involving field crops, vegetables, poultry, cattle, goat, horticulture crops, fishery, forage crops and rabbit rearing were taken for evaluation in different combinations to recycle the residues and by products of one component over the others. Each system was allocated an area of 1 ha. The experiment was laid out on moderately drained deep black soil with assured irrigation source. The soil of the experiment site was deep black with pH 8.1. The N, P and K content of the soil was 243, 34, and 292 kg/ha, respectively. Farming system modules were formulated

Table A : Details of the experimental treatments

	Treatments	Livestock components	Crops on bunds
F_1	Cotton alone	Nil	Nil
F_2	Maize - Bengal gram	Nil	Nil
F_3	Cotton + Cowpea (F) 1:1 Maize + Cowpea (F) 1:1 - Bengal gram	Goat (2)	Drum stick, curry leaf and Stylo
F_4	Cotton + Cowpea (F) 1:1 Maize + Cowpea (F) 1:1 - Bengal gram	Goat (2) + Poultry birds	Drum stick, curry leaf and Guinea grass (Samruddhi)
F_5	Cotton + Cowpea (F) 1:1 Maize + Cowpea (F) 1:1 - Bengal gram Pillipesara (*Phaseolus trilobus*)	Goat (2) + Cow (1)	Agati and hybrid napier grass (CO-4)
F_6	Cotton + Chilli (1:1) Pillipesara (*Phaseolus trilobus*)	Goat (2) + Rabbit (4)	Agati and Hybrid napier grass (DHN-6)
F_7	Cotton + Onion 1:2 Maize + Cowpea (F) 1:1 - Bengal gram	Goat (2) + Cow (1) + Poultry birds + Fishery	Fish pond bund- Banana Plot bund- Agati, Drum stick and Curry leaf

F: Fodder crop

Animal components

1.	Goat (Jamanpari and Shirohi)	:	5 male (Stall fed system)
2.	Cow (HF)	:	1 each for F_5 and F_7
3.	Poultry birds (Giriraj Broiler)	:	25 Giriraj poultry birds each for F_4 (Brooder system) and F_7 (Battery system on fish pond)
4.	Rabbit (New Zealand White)	:	3 female + 1 male
5.	Fish (Common carp)	:	225 for F_7

Verities and hybrids used: *Bt* Cotton (Jaadoo), Maize (Hiro-555), Chilli (G-4), Onion (Nasik Red), Fodder cowpea [Swad (DFC-1)], Pillipesara (Local), Bengal gram (A1), Drum stick (Dhanraj), Curry leaf (Suvasini), Banana (G-9), Stylo (Local), Guinea grass (Samruddhi), Hybrid napier grass (CO-4 and DHN-6) and Agati (Local)

based on the primary data of existing farming systems of raichur district. The treatments consisted of six various farming system models of IFS compared with conventional system of cotton alone (Table A). Livestock components chosen by looking to the integration potentiality of the system. Poultry *var*., Giriraj was reared in cage constructed on the fish pit (F_7) or reared separately (F_4) as brooder system. The poultry birds were fed with starter feed upto 20 days and later farm wastes (broken grains) were used as the source of feed. The droppings were allowed to drop directly into the fish pit in models (F_7) where the cage was constructed on the fish pit, while when poultry was reared separately (F_4) the droppings were collected once in 15 to 30 days and added to respective treatments. Common carp fish (*Cyprinus carpio* var. communis) was reared in farm pond (F_7). After the harvest of fish, the fish pit silt was recycled to respective plots. Goat and dairy animals reared in stall fed system and dung/ refuge was collected and composted separately. The compost was recycled in the respective treatments. In F_7 system on regular basis certain, quantity of dung/ droppings added to the fish pond to supplement the dietary needs of fishes. Rabbits were reared in cages (F_6 system), droppings recycled in the respective treatments. Since, the study includes diversified enterprises like fish, poultry, goat, rabbit, milch animals and various crops, the yield was converted into cotton kapas equivalent yield. Vermi-pits and FYM pits were also linked with IFS models. To sustain the productivity of soil, inorganic fertilizers combined with organic wastes obtained from various components of IFS recycled poultry, goat droppings, rabbit droppings and cowdung as FYM, composted residues (veg. residues + cereal residues) and vermicompost were applied to the crops. A suitable and viable IFS model could be identified for their existence based on resource utilization, management and improvement in soil fertility attained over a period of time.

RESULTS AND DISCUSSION

Integration of different components in a system and recycling of by products/ farm wastes has been practiced in this study. Samples of raw animal and bird droppings, recycled products like FYM, goat manure, vermicompost and silted silt in the ponds were collected and analysed for their N, P and K contents. The total amount of organic residues/ manures and quantity of nutrients added through poultry, goatry, cattle as droppings and plant wastes in form of vermicompost have been presented in Table 1. The nutrient content of raw droppings and plant wastes increased manifolds after recycling into compost and vermicompost.

Organic residue and NPK addition :

The total organic residue added by the crops + goat + poultry birds + HF cow + fishery farming system (F_7) was higher in the second year (20,623 kg ha^{-1}) than the

Table 1 : Total organic residues/ manures (kg ha^{-1}) and NPK addition (kg ha^{-1}) through various farming systems

Treatments		Residue addition (kg ha^{-1})							Nutrient addition (kg ha^{-1})		
		Crop	Goat	Poultry birds	Cow	Rabbit	Fish pond silt	Total	N	P	K
First year (2012-13)	F_1	1375	-	-	-	-	-	1375	9.9	3.3	15.4
	F_2	2805	-	-	-	-	-	2805	20.5	5.9	30.3
	F_3	4180	2350	-	-	-	-	6530	74.9	40.8	67.2
	F_4	4532	2360	265	-	-	-	7157	85.6	46.9	78.0
	F_5	4675	2390	-	11303	-	-	18368	237.5	86.4	123.8
	F_6	3053	2530	-	-	850	-	6433	94.9	58.7	71.3
	F_7	3355	2550	290	12027	-	900	19122	251.5	94.3	130.8
Second year (2013-14)	F_1	2475	-	-	-	-	-	2475	17.6	5.5	26.4
	F_2	3850	-	-	-	-	-	3850	28.2	8.1	41.6
	F_3	5060	2470	-	-	-	-	7530	83.6	44.3	77.9
	F_4	5720	2480	270	-	-	-	8470	96.7	51.0	92.1
	F_5	5896	2510	-	11208	-	-	19614	247.4	90.3	137.7
	F_6	3925	2660	-	-	890	-	7475	104.8	61.7	82.6
	F_7	4576	2680	299	12088	-	980	20623	262.1	99.3	144.7

Not statistically analysed

first year (19,122 kg ha^{-1}) and it was followed by crops + goat + dairy farming system (F_5) with a residue addition of 18,368 and 19,614 kg ha^{-1} for the first and second year, respectively. The cotton alone (F_1), added least amount of residues (1,375 and 2,475 kg ha^{-1} for the first and second year, respectively). The F_7 system added higher NPK nutrients in both the years over other farming system models. The NPK nutrient added by F_7 system was 251.5, 262.1, 94.3, 99.3, 130.8 and 144.7 kg ha^{-1} in the first and second year, respectively. The next best

Table 2 : Available nitrogen balance (kg ha^{-1}) in soil of various farming systems

Treatments	Initial soil N status	N added through		Total quantity of N added	Total quantity of N removed by crops	Expected N	Actual N	Net gain or loss
		Inorganics	Organics					
First year (2012-13)								
F_1	243.00	150.00	0.00	150.00	106.43	286.57	240.33	-2.67
F_2	243.00	175.00	0.00	175.00	116.90	301.10	263.67	20.67
F_3	243.00	175.00	44.40	219.40	123.60	338.80	276.00	33.00
F_4	243.00	175.00	52.50	227.50	130.56	339.94	277.33	34.33
F_5	243.00	175.00	203.40	378.40	137.37	484.03	286.67	43.67
F_6	243.00	150.00	72.60	222.60	135.03	330.57	274.33	31.33
F_7	243.00	175.00	227.00	402.00	138.22	506.78	287.67	44.67
Second year (2013-14)								
F_1	240.33	150.00	17.60	167.60	109.79	298.15	263.67	23.33
F_2	263.67	175.00	28.20	203.20	120.67	346.19	283.00	19.33
F_3	276.00	175.00	83.60	258.60	129.63	404.97	294.67	18.67
F_4	277.33	175.00	96.70	271.70	134.55	414.48	305.67	28.33
F_5	286.67	175.00	247.40	422.40	141.88	567.18	313.33	26.67
F_6	274.33	150.00	104.80	254.80	136.72	392.41	293.00	18.67
F_7	287.67	175.00	262.10	437.10	142.28	582.48	315.67	28.00

Not statistically analysed N: Nitrogen

Table 3 : Available phosphorus balance (kg ha^{-1}) in soil of various farming systems

Treatments	Initial soil P_2O_5 status	P_2O_5 added through		Total quantity of P_2O_5 added	Total quantity of P_2O_5 removed by crops	Expected P_2O_5	Actual P_2O_5	Net gain or loss
		Inorganics	Organics					
First year (2012-13)								
F_1	34	75	0	75.00	23.68	85.32	36.93	2.93
F_2	34	125	0	125.00	25.23	133.77	36.97	2.97
F_3	34	125	32.0	157.00	31.56	159.44	37.30	3.30
F_4	34	125	37.3	162.30	32.89	163.41	37.47	3.47
F_5	34	125	76.6	201.60	35.21	200.39	38.60	4.60
F_6	34	75	52.3	127.30	35.17	126.13	37.23	3.23
F_7	34	125	87.3	212.30	35.67	210.63	39.03	5.03
Second year (2013-14)								
F_1	36.93	75	5.5	80.50	24.56	92.87	37.97	1.03
F_2	36.97	125	8.1	133.10	25.95	144.12	38.47	1.50
F_3	37.30	125	44.3	169.30	32.45	174.15	38.67	1.37
F_4	37.47	125	51.0	176.00	33.35	180.12	39.03	1.57
F_5	38.60	125	90.3	215.30	36.38	217.52	40.03	1.43
F_6	37.23	75	61.7	136.70	35.97	137.97	38.53	1.30
F_7	39.03	125	99.3	224.30	37.42	225.92	41.03	2.00

Not statistically analysed P_2O_5: Phosphorus

system with higher NPK nutrient addition was F_5 with 237.5, 247.4, 86.4, 90.3, 123.8 and 137.7 kg ha^{-1} in the first and second year, respectively. The contribution of organic residues added by the crop components was more than the residues/ manures added by the goat, rabbit, poultry birds and fishery through their voids and litter wastes whereas, cow component was highest with residues/ manures addition over crop components (Table 1). Similar results were earlier reported by Prein (2002); Halwart *et al*. (2006); Rufino *et al*. (2007) and Tittonell *et al.* (2007). There was no much variation on NPK addition between F_7 and F_5 farming systems since there was no much variation in the total organic residues/ manures addition. The higher organic residues/ manures addition in F_7 and F_5 systems ultimately favored for higher NPK addition. This result is in accordance with the findings of Das and Singh (1992); Tilman *et al.* (2002); Sanchez *et al*. (2004); Bationo *et al*. (2004) and Makinde *et al*. (2007). As discussed earlier the conventional cotton cropping alone system (F_1) added the least quantity of NPK addition through the residues.

Nutrient budgeting :

Nutrient budgeting of NPK states that, there was net gain in nitrogen and phosphorus status in all the farming system models (Table 2, 3 and 4). Among the various IFS models, F_7 system showed maximum expected nitrogen (506.78 and 582.48 kg ha^{-1} during first and second year, respectively) closely followed by F_5 (484.03 and 567.18 kg ha^{-1} during first and second year, respectively) whereas, F_1 registered least values with 286.57 and 298.18 kg ha^{-1} during first and second year, respectively. The actual nitrogen balance based on soil status at the end of study period and it was highest in F_7 (287.67 and 315.67 kg ha^{-1} during first and second year, respectively) followed by F_5 (286.67 and 313.33 kg ha^{-1} during first and second year, respectively) whereas, least recorded with F_1 (240.33 and 263.67 kg ha^{-1}). Similar trend was observed in case of phosphorus and potassium with respect to expected and actual figures. IFS model with crops + goat + poultry birds + HF cow + fishery (F_7) system registered highest expected P and K (210.63, 310.09, 225.92 and 364.98 kg ha^{-1} P and K during first and second year, respectively) which is closely followed by F_5 system (200.39, 293.14, 217.52 and 343.56 kg ha^{-1} P and K during first and second year, respectively). Actual P and K were higher in F_7 system (39.03, 307.48, 41.03 and 360.61 kg ha^{-1} P and K during first and second year, respectively). Second best system with higher actual P and K observed was F_5 model (38.60, 292.96, 40.03 and 339.50 kg ha^{-1} P and K during first and second year, respectively). It might be due to application of organic manures obtained out of livestock components and crop residues incorporated during the study period.

Table 4 : Available potassium balance (kg ha^{-1}) in soil of various farming systems

Treatments	Initial soil K_2O status	K_2O added through		Total quantity of K_2O added	Total quantity of K_2O removed by crops	Expected K_2O	Actual K_2O	Net gain or loss
		Inorganics	Organics					
First year (2012-13)								
F_1	292	75	0	75.00	134.12	232.88	232.07	-59.93
F_2	292	40	0	40.00	138.47	193.53	192.71	-99.29
F_3	292	75	22.10	97.10	140.14	248.96	237.65	-54.35
F_4	292	75	29.00	104.00	140.82	255.18	243.59	-48.41
F_5	292	75	73.30	148.30	147.16	293.14	292.96	0.96
F_6	292	75	38.30	113.30	145.83	259.47	236.75	-55.25
F_7	292	75	94.60	169.60	151.51	310.09	307.48	15.48
Second year (2013-14)								
F_1	232.07	75	26.4	101.40	140.63	192.83	192.78	-39.28
F_2	192.71	40	41.6	81.60	145.81	128.49	128.15	-64.56
F_3	237.65	75	77.90	152.90	153.63	236.92	227.69	-9.96
F_4	243.59	75	92.10	167.10	154.15	256.55	246.55	2.96
F_5	292.96	75	137.70	212.70	162.10	343.56	339.50	46.53
F_6	236.75	75	82.60	157.60	160.80	233.55	226.10	-10.65
F_7	307.48	75	144.70	219.70	162.26	364.92	360.61	53.12

Not statistically analysed K_2O: Potassium

Data delineate the net gain in available soil nitrogen and phosphorus which was observed in all the farming system models. These findings are in conformity with the findings of Ikpe and Powell (2002) and Halwart *et al*. (2006).

Conclusion :

Results on integration of different components with crop in a system depending upon their suitability and preferences were found encouraging. Hence, it can be concluded that to enhance the productivity of soil, economic returns and maintaining soil health of farm and farm families crop + fish + poultry birds + goat + cow combinations can be adopted successfully in NE Karnataka instead of cultivating cotton crop alone on same piece of land under irrigated condition. Recycling of organic residues in form of animal and plant wastes could be beneficial in improving the soil health and productivity over a longer period of time with lesser environmental hazards. Livelihood of small and marginal farmers could be upgraded by adopting IFS technologies on a larger scale.

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