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# Integrated nutrient supply system of linked components in lowland integrated farming system

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## ABSTRACT

Integrated farming system comprising enterprises like cropping, fishery, poultry, pigeon and goat rearing were undertaken at Coimbatore during 1998–2000, to sustain the productivity, profitability, employment generation and nutrient recycling for lowland farms of Tamil Nadu. Among the enterprises, cropping with fish and goat integration recorded higher rice (*Oryza sativa* L.) grain equivalent (39,610 kg/ha) than other systems. Similarly, the best returns (Rs 126,564) were obtained with integration of goat + fish + cropping applied with recycled fish pond silt fed with goat droppings and the same combination resulted in the highest return of Rs 493/ha/rupee invested. Crop + fish + pigeon stood next, fetching Rs 443/ha/rupee invested. Crop applied with recycled fish pond silt fed with poultry manure resulted in higher rice-grain-equivalent yield (29,166 kg/ha) and net return (Rs 104,231). The highest level of employment (575 man-days/ha/year) was achieved in crop + fish + goat integration. Additional nutrients gained by recycling were the highest with poultry manure (65.7, 28.4 and 25.0 kg N, $P_2O_5$ and $K_2O$ respectively) than with goat or pigeon manure. To enhance the productivity, economic returns and employment generation for family labour, integration of crop with fish + goat or pigeon or poultry could be adopted than cultivating the crop alone under lowland situation. Better residue recycling could be achieved through integration of crop with fish + poultry than other systems.

***Key words :*** Integrated farming system, Cropping, Poultry, Fishery, Pigeon, Goat rearing, Productivity, Profitability

Indian economy is predominantly rural and agriculture oriented where the marginal and small farmers constitute 76.2% of farming community. Due to failure of monsoon, the farmers are forced to undertake judicious mix of agricultural enterprises like dairy, poultry, pigeon, fishery, sericulture etc., suited to the given agro-climatic conditions and socio-economic status of the farmers, instead of cropping alone. Integrated Farming Systems (IFS) approach is not only a reliable way of obtaining fairly high productivity with substantial fertilizer economy but also deriving maximum compatability and replenishment of organic matter by way of effective recycling of organic residues/ wastes obtained through integration of various land-based enterprises. The recycling process could reduce the cost of production per unit of grain, meat, milk, egg, edible mushroom, biogas etc., and thereby enhances net return. An effort was made for a holistic integration of different agricultural enterprises such as linking poultry, pigeon and goat rearing with cropping, with the objectives of increased income and recycling of farm wastes and by-products.

## MATERIALS AND METHODS

A field experiment with integrated farming system (IFS) was conducted at Coimbatore during 1998–2000 involving cropping, poultry, pigeon, goat and fishery enterprises in all possible combinations, to recycle the residue and by-products of one component over the other. In 1 ha farm, an area of 0.75 ha was assigned for crop activity, 0.10 ha for growing fodder grass to feed goat unit (20+1), 0.03 ha allotted to goat shed and the remaining 0.12 ha allotted to 3 fish ponds. In another 1 ha, conventional cropping system as practised by farmers was taken up. Twenty numbers of Bapkok layer birds, 40 productive pairs of pigeon sheltered over 2 fish ponds and goat unit (Tellicherry breed of 20 females and males) maintained in 0.03 ha goat shed were linked to supplement the feed requirement of polyculture fingerlings (400 numbers) reared in each pond to assess the feasibility of rearing fish by using different manures as feed.

In cropping, conventional cropping systems comprising (*i*) rice (*Oryza sativa* L.)–rice–blackgram (*Phaseolus mungo* L.), (*ii*) maize (*Zea mays* L.)–rice–blackgram, (*iii*) maize–rice–sunnhemp (*Crotalaria juncea* L.) and (*iv*) rice–rice–sunnhemp each in 0.25 ha as practised by the farmers were followed. Under IFS, (*i*) sugarcane (planted)–sugarcane (ratoon)–banana (*Musa* sp.) (3 years),

(*ii*) banana–turmeric (*Cucurma longa* L.)–rice–banana (3 years), (*iii*) maize–rice–sesame (*Sesamum indicum* L.)–sunnhemp (annual) each in 0.25 ha and (iv) napier bajra hybrid grass ('Co 3') + *Desmanthus* (perennial) in 0.10 ha form the cropping systems. The soil was moderately drained, sandy clay loam classified as Typic Haphlustalf and medium in avialable N (298 kg/ha) and $P_2O_5$ (15.2 kg/ha) and high in available $K_2O$ (580 kg/ha). To sustain the productivity of soil through inorganic fertilizers combined with organic wastes obtained from the components of IFS, a field experiment was carried out in split–plot design with 3 replications. Recycled poultry, pigeon and goat manures and composted crop residue (banana waste and sugarcane trash) as vermicompost each @ 6.25 tonnes/ha were assigned to the main plots and 3 fertilizer levels (100%, 80% and 60% of the recommended fertilizer schedule) were tested in subplots for the first 3 sequences of cropping. Sugarcane (planted) and sugarcane (ratoon) under sequence, I. Banana, turmeric and rice under sequence II and crops grown under sequence III for 2 years were harvested and the economics of crop cultivation was worked out. Observations were also made on productivity in terms of rice–grain equivalent, economics and employment for crop under coventional cropping system as well as for IFS. The crops in each cropping system were raised by adopting the recommended practices for each crop in sole stand.

In fish, at the end of 1 year, the grown-up fishes were harvested twice at 15-day interval. After harvesting, the average fish weights were computed and expressed as fish productivity. Water in the pond was drained and the settled silt in the pond (4.5 tonnes silt) was removed and applied as organic source to the first crop of the sequences. In poultry, observations were taken on the number of eggs laid everyday. In pigeon, meant for meat purpose were disposed when they attained maximum weight on 30 to 35 days after hatching and were accounted. In goat rearing, the growth rate/live weight of the goats and kids was recorded at regular intervals to account for its productivity.

Observations were made on productivity in terms of rice–grain–equivalent yield of different cropping system, productivity and economics of individual components and farming systems as a whole, employment generation and nutrient recycling of different components in farming systems

## RESULTS AND DISCUSSION

### *Productivity*

Integrated farming system provides an opportunity to increase the yield and economics/unit area and unit time by virtue of intensification of crop and allied enterprises. The productivity of the components (fish + pigeon + poultry + goat) integrated in each system was converted as rice-grain-equivalent for comparison. Research results on integrated farming system for 2 years revealed that integration of crop with fish, poultry, pigeon and goat resulted in higher productivity than cropping alone under lowland. The highest yield of different sequences was obtained with the recycled fish pond silt fed with poultry dropping (40,120; 39,993 and 17,109 kg for II, III and I sequences respectively).

Among the cropping sequences under the IFS compared, the sequence with banana–turmeric–rice–banana recorded higher mean yields of 39,187, 39,669 and 39,652 kg when applied with recycled fish pond silt fed with pigeon, goat droppings and vermicompost. However, the sequence I, with sugarcane (planted)–sugarcane (ratoon)–banana registered higher productivity of 40,120 kg with recycled fish pond silt fed with poultry dropping, followed by banana–turmeric–rice–banana (39,993 kg) (Table 1). 'Co 3' grass and *Desmanthus* mixture resulted in 29 tonnes of green fodder from 0.10 ha area, was utilized as feed for the goat unit. Crop + fish + poulty integration recorded the maximum rice–grain–equivalent yield of 39,610 kg/ha (Table 3 and 4). Cropping applied with enriched pond silt having higher plant nutrients and integration of high-value components like fish and goat might have contributed for better productivity. Similar results of higher productivity was obtained by Jayanthi (1996) by integrating cropping + fish + pigeon or poultry and mushroom enterprises in lowland farming.

While considering the individual animal component, productivity of 5,936 kg and 11,700 kg for I and II year, respectively, were obtained with 20 + 1 goat unit. The goat unit could also provide 11.0 tonnes manure apart from supplementing the feed requirement of fish reared in pond. While assessing the feasibility of rearing fish by using poultry, pigeon and goat dropping as feed, the fish fed with poultry droppings resulted in higher yield (810 kg and 840 kg/0.04 ha ponded water for I and II year, respectively) than the other two sources of fish feed. A higher level of fish productivity through recycling of poultry manure was reported by Jhingran and Ghosh (1988) and Banerjee *et al.* (1989) owing to better plankton development as well as direct feed to fishes.

### *Profitability or economics*

While considering the individual animal component, higher net return of Rs 22,380/year and Rs 46,988/year for I and II year, respectively, were obtained with 20+1 goat unit. The highest net return of Rs 126,564 (mean of 2 years) was obtained from a total area of 1.00 ha with an expenditure of Rs 51,483 by integrating goat + fish + cropping applied with recycled fish pond silt fed with goat dropping. Similarly, the per day return was higher in crop-

**Table 1.** Productivity [rice grain equivalent yield (kg/ha)] of different cropping sequences under integrated farming system (1998–2000)

| Cropping sequence | Poultry | | | Pigeon | | | Goat | | | Vermicompost | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean |
| I. Sugarcane (planted)–sugarcane (ratoon)–banana* | 48,200 | 32,040 | 40,120 | 48,188 | 27,388 | 37,788 | 48,095 | 28,513 | 38,304 | 48,596 | 26,157 | 37,376 |
| II, Banana–turmeric–rice–banana* | 50,560 | 29,426 | 39,993 | 51,422 | 26,952 | 39,187 | 51,062 | 28,276 | 39,669 | 52,647 | 26,658 | 39,652 |
| III, Maize–rice–sesame–sunnhemp | 16,552 | 17,665 | 17,109 | 16,162 | 16,374 | 16,268 | 15,617 | 17,045 | 16,331 | 16,984 | 16,282 | 16,633 |
| IV, 'CO 3' napier bajra + *Desmanthus*** | | | | | | | | | | | | |

*3rd and 4th crop (banana) in the I and II sequences, respectively, were not taken into account as they are the standing crop for the III year
**About 29 tonnes of grass + legume mixture obtained from 0.10 ha area was used as feed for goat unit

**Table 2.** Rice grain equivalent yield (RGEY) and economics of the conventional cropping systems (1998–2000)

| Cropping sequence | RGEY (kg/ha) | | | Gross return (Rs) | | | Net return (Rs) | | | Benefit : cost ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean |
| I, Rice–rice–blackram* | 11,363 | 15,075 | 13,219 | 56,818 | 75,375 | 66,096 | 38,378 | 41,020 | 39,699 | 3.06 | 2.09 | 2.57 |
| II, Maize–rice–blackgram* | 11,576 | 15,542 | 13,559 | 57,880 | 77,710 | 67,795 | 39,870 | 42,360 | 41,115 | 3.19 | 2.18 | 2.68 |
| III, Maize–rice–green-manure | 9,677 | 14,525 | 12,101 | 48,387 | 72,626 | 60,506 | 33,127 | 42,276 | 37,701 | 3.14 | 2.48 | 2.81 |
| IV, Rice–rice–green-manure | 9,161 | 13,700 | 11,430 | 45,804 | 68,501 | 57,152 | 30,114 | 40,246 | 35,180 | 2.98 | 2.34 | 2.66 |

*In the II year, instead of blackgram, greengram was raised

**Table 3.** Productivity and economics (Rs) of individual components in integrated farming system (1998–2000)

| Component | GREY (kg) | | | Production cost (Rs) | | | Cross return (Rs) | | | Net return (Rs) | | | Benefit : cost ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean |
| Cropping alone–1.00 ha | 9,765 | 14,680 | 12,222 | 16,905 | 32,939 | 24,922 | 48,826 | 73,399 | 61,112 | 31,921 | 40,460 | 36,190 | 2.89 | 2.23 | 2.56 |
| Crop with poultry 0.90 ha manure | 34,593 | 23,739 | 29,166 | 49,027 | 34,176 | 41,602 | 172,968 | 11,8697 | 145,832 | 123,941 | 8,452 | 104,231 | 3.53 | 3.47 | 3.50 |
| Crop with pigeon manure 0.90 ha | 34,731 | 21,214 | 27,972 | 49,027 | 33,827 | 41,427 | 173,658 | 10,6071 | 139,864 | 124,631 | 72,244 | 98,437 | 3.54 | 3.13 | 3.33 |
| Crop with goat manure 0.90 ha | 34,432 | 22,150 | 28,291 | 49,027 | 33,827 | 41,427 | 172,161 | 11,0751 | 141,456 | 123,134 | 76,924 | 100,029 | 3.51 | 3.27 | 3.39 |
| Crop with vermicompost 1.00 ha | 35,468 | 20,729 | 28,098 | 49,526 | 35,073 | 42,300 | 177,340 | 103,645 | 140,492 | 127,814 | 68,572 | 98,193 | 3.58 | 3.00 | 3.29 |
| Poultry | | 1,260 (5,400) | 630 (2,700) | 7,000 | 4,452 | 5,726 | | 6,300 | 3,150 | (-3,650) | 5,198 | 779 | | | |
| Pigeon | 2,160 (308) | 3,024 (432) | 2,592 (370) | 5,815 | 3,350 | 4,583 | 10,800 | 15,120 | 12,960 | 8,335 | 15,120 | 11,727 | | | |
| Goat | 5,936 (470) | 11,700 (950) | 8,818 (710) | 10,650 | 14,862 | 12,756 | 29,680 | 58,500 | 44,090 | 22,380 | 46,988 | 34,684 | | | |
| Fish (0.1ha pond) Poultry dropping | 2,025 (289) | 2,100 (350) | 2,062 (320) | 4,000 | 4,000 | 4,000 | 10,125 | 10,500 | 10,312 | 9,475 | 9,850 | 9,662 | | | |
| Pigeon dropping | 1,780 (254) | 1,800 (257) | 1,790 (256) | 4,000 | 4,000 | 4,000 | 8,900 | 9,000 | 8,950 | 8,250 | 8,350 | 8,300 | | | |
| Goat dropping | 1,945 (278) | 2,020 (289) | 1,982 (284) | 4,000 | 4,000 | 4,000 | 9,725 | 10,100 | 9,912 | 9,075 | 9450 | 9,262 | | | |

Figures in parentheses indicate the actual production of components in the system

**Table 4.** Productivity [rice grain equivalent yield (kg/ha)] and economic analysis of different integrated farming system (1998–2000)

| Farming system | REGEY (kg/ha) | | | Cost of production (Rs/ha) | | | Gross return (Rs/ha) | | | Net return (Rs/ha) | | | Per day return (Rs/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean |
| Cropping alone | 9,765 | 14,680 | 12,222 | 16,905 | 32,939 | 24,922 | 48,826 | 73,399 | 61,112 | 31,921 | 40,460 | 36,190 | 134 | 201 | 167 |
| Crop + fish + poultry | 36,618 | 27,099 | 31,858 | 53,327 | 35,927 | 44,627 | 183,090 | 135,494 | 159,292 | 129,763 | 99,568 | 114,665 | 501 | 371 | 436 |
| Crop + fish + pigeon | 38,671 | 26,038 | 32,354 | 52,142 | 34,477 | 43,310 | 193,355 | 130,190 | 161,772 | 141,213 | 95,713 | 118,462 | 530 | 357 | 443 |
| Crop + fish + goat | 43,349 | 35,870 | 39,610 | 56,977 | 45,989 | 51,483 | 216,745 | 139,350 | 178,047 | 159,768 | 93,361 | 12,564 | 594 | 391 | 493 |

ping + fish + goat activity (Rs 493/ha) than in cropping + fish + poultry or pigeon integration (Table 4). Lesser cost of production with better productivity of each component integrated in the system increased the returns. Behera and Mahapatra (1998), also reported increase in net income through integrated farming system. Higher net return of Rs 3.74/ rupee invested on cost or production was obtained by integration of pigeon + fish + cropping applied with recycled fish pond still fed with pigeon droppings. The system as a whole provided opportunity to make use of produce or waste material, of one component as input on another at the least or no cost at farm level. Thus there is a possibility for reduction of production cost of enterprises from one to another and finally the return/rupee invested is very much enhanced. Economic viability of pigeon component as a result of lower production cost was also reported by Jayanthi (1996) in lowland integrated farming systems.

### *Employment generation*

The employment generation increased to 575 man-days/ha /year by integrating fish + goat with cropping compared with cropping alone (369 man-days/year/ha). An employment of 61 man-days from pigeon or poultry enterprise, 34 man-days from fish and 122 man-days from goat unit could be generated (Table 5). Combining cropping with other allied enterprises would increase labour requirement and thus provide scope to employ family labour round the year without much lean and peak demand for labour. Similar increase in employment generation was reported with integrated fish + poultry with cropping in *deltaic* region by Chinnuswami (1994) and rice + poultry + fish + mushroom by Rangasamy *et al.* (1995) for wetlands of Western Zone of Tamil Nadu.

### *Nutrient recycling*

Samples of raw animal manures and settled silt collected from different fish ponds were analysed for their NPK contents. The quantity of nutrients received through poultry, pigeon and goat droppings are furnished in Table 6. Residue recycling revealed that integration of crop with fish and poultry resulted in higher fish productivity and economics than pigeon or goat under lowlands. Poultry and pigeon units droppings generated 22.5, 17.5 and 7.4 and 12.7, 3.9 and 6.9 kg of N, $P_2O_5$ and $K_2O$ nutrients respectively. Recycling their droppings through fish pond, enhanced the nutrients contents 2-3 folds (65.7, 28.4 and 25.0 kg and 25.1, 9.6 and 18.3 kg of N, $P_2O_5$ and $K_2O$ for poultry and pigeon respectively). Similarly, goat unit manure generated 11.3, 6.9 and 5.7 kg of N, $P_2O_5$ and $K_2O$ nutrients, which were further enhanced by 3 folds through recycling. Jayanthi (1996) reported the advantages of re-

**Table 5.** Employment generation (man-days) by different integrated farming system (1998–2000)

| Farming system | Crop | | | Poultry | | | Pigeon | | | Fish | | | Goat | | | Total system employment generation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean | I year | II year | Mean |
| Cropping alone | 369 | 369 | 369 | | | | | | | | | | | | | 369 | 369 | 369 |
| Crop + fish + poultry | 415 | 424 | 420 | 61 | 61 | 61 | | | | 34 | 34 | 34 | | | | 510 | 519 | 515 |
| Crop + fish + pigeon | 415 | 424 | 420 | | | | 61 | 61 | 61 | 34 | 34 | 34 | | | | 510 | 519 | 515 |
| Crop + fish + goat | 415 | 424 | 420 | | | | | | | 34 | 34 | 34 | 122 | 122 | 122 | 571 | 580 | 575 |

**Table 6.** Nutrient value of recycled poultry or pigeon or goat manure in integrated farming system

| Nutrient | Raw poultry dropping | | Pond manure | | Additional nutrient gained by recycling (kg) |
|---|---|---|---|---|---|
| | % | kg/700 kg | % | kg/4,500 kg | |
| N | 3.22 | 22.5 | 1.96 | 88.2 | 65.7 |
| $P_2O_5$ | 2.50 | 17.5 | 1.02 | 45.9 | 28.4 |
| $K_2O$ | 1.05 | 7.4 | 0.72 | 32.4 | 25.0 |
| | Raw pigeon dropping | | Pond manure | | Additional nutrient gained by recycling (kg) |
| | % | kg/700 kg | % | kg/4,500 kg | |
| N | 1.82 | 12.7 | 0.84 | 37.8 | 25.1 |
| $P_2O_5$ | 0.56 | 3.9 | 0.30 | 13.5 | 9.6 |
| $K_2O$ | 0.98 | 6.9 | 0.56 | 25.2 | 18.3 |
| | Raw goat dropping | | Pond manure | | Additional nutrient gained by recycling (kg) |
| | % | kg/810 kg | % | kg/4,500 kg | |
| N | 1.40 | 113 | 0.70 | 31.5 | 20.2 |
| $P_2O_5$ | 0.85 | 6.9 | 0.62 | 27.9 | 21.0 |
| $K_2O$ | 0.70 | 5.7 | 0.48 | 21.6 | 15.9 |

cycling of poultry and pigeon manures which were enriched as settled pond silts in lowland IFS.

The additional nutrients gained by recycling were the highest with poultry manure (65.7, 28.4 and 25.0 kg N, $P_2O_5$ and $K_2O$ respectively) than with goat or pigeon manure. Sivaraj (1989) and Rangasamy and Jayanthi (1994) also reported the economic advantage of poultry and pigeon components, respectively, in lowland IFS with better residue or waste recycling through allied components.

To enhance the productivity, economic returns and employment generation for family labour, integration of crop with fish + goat or pigeon or poultry could be adopted than cultivating the cropping alone under wetland situation. Better residue recycling could be achieved through integration of crop with fish + poultry than other systems under lowlands.

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