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Multiple Water Use in Gardenland Integrated Farming System for Enhancing Productivity

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A B S T R A C T

A model of integrated input management to suit small farmers under garden-land conditions was studied at Agricultural Research Station, Bhavanisagar during 2015 and 2016 in an area of 1 ha. The objective of the study was to achieve better utilization of available resources to maximize returns by integrating cropping, dairy, poultry and vermin-compost, to recycle farm and livestock wastes effectively to assure stability in production and returns. The results over the two year period revealed that by integrating allied enterprises with crop activity, income and productivity can be enhanced. Integrated Farming System recorded lower water consumed (14249 m^3) compared to conventional farming system (22925 m^3). The higher gross income of Rs.5,62,044/- physical water productivity (8.26 kg m^{-3}) and economic water productivity (39.44 Rs.m^{-3}) recorded under Integrated Farming System compared to conventional farming system.

Introduction

Agricultural sector in India has been and is likely to remain the largest consumer of water. The share of water allocated to irrigation is likely to decrease by 10 to 15 % in the coming decades (CWC 2018). Hence, more focus should be on sustainable management of water resources for optimal agricultural production. It is essential to increase the efficiency of each component of irrigation system and crop production, preventing wasteful and ecologically injurious use of water. In view of these considerations, it is largely emphasized for enhancing water productivity through multiple uses. In general, multiple use of water is not a new concept. There are examples of several water resource projects simultaneously planned for electricity generation, irrigation, and meeting rural, urban and industrial uses and also naval and transport purposes (Bakker *et al.,* 1999). At the farm level, water can be judiciously applied for multiple uses such as drinking, irrigation, livestock, fisheries etc. to optimize water productivity. Integrated farming system (IFS) based on multiple uses of water, comprising of crop, fishery, duckery, poultry, piggery, agro-forestry etc. are in practice not only in India but also in other Asian countries. Such a system results in more judicious use of water resulting in higher water productivity and also improving livelihood of resource poor farmers (Sharda and Juyal, 2007; Gill *et al.,* 2005). The field experiments were conducted at Agricultural Research Station, Bhavanisagar under ICAR - All India Co-ordinated Project (AICRP) on Irrigation Water Management project resulted evaluation of Integrated farming system compared to conventional method of farming in gardenland situation.

Materials and Methods

The IFS for gardenland situation experiments were conducted in Northern block of Agricultural Research Station, Bhavanisagar during 2015 and 2016 under ICAR – AICRP on Irrigation Water Management. The objective of the study was to work out the water requirements for cropping components and livestock components in Integrated Farming System under wetland situation, to assess the multiple use of water by way of estimating water use and water productivity in different components of farming system under wetland situations in western zone of Tamil Nadu. For conventional method Rice - Groundnut – Maize were followed in one hectare area. In gardenland Integrated Farming Systems, the experiment details is presented in Table 1. Since it is a farming system experiment it does not involve any specific design and non replicated. Vaccination was done for the poultry birds regularly for Ranikhet disease. Vaccine for Foot and Mouth disease were given for the milch cows once in 6 months.

In integrated farming system, irrigation based on IW/CPE ratio (Table 2) and conventional methods surface irrigation once in 7-10 days were adopted. The major soil type of the study area was sandy loam in nature and the soil fertility status was medium in available nitrogen, phosphorus and potash. Two methods of cultivation viz., Integrated farming system and conventional method were compared.

The total water use was calculated by adding irrigation water applied and effective rainfall. Yield was recorded and total water used, water use efficiency (WUE) and economics were worked out and presented. The rainfall during 2015 and 2016 were 862 mm, 236 mm and pan evaporation were 1644 and 1693 mm respectively.

Results and Discussion

Water productivity in integrated farming system

Output in terms of biological yield per unit of water is termed as water productivity. It varies with scale as well as the purpose for which it is being quantified. The definition of water productivity varies with the background of the researcher or stakeholders involved (Bastiaanssen *et al.,* 2003). Water productivity at field level is the amount of crop output in physical terms *i.e.* crop yield divided by amount of water consumed (*i.e.* the crop evapo-transpiration) or monetary terms *i.e.* crop yield multiplied by its price divided by amount of water used. It accounts for all or one of the inputs of the production system giving rise to two productivity indicators: (i) total productivity *i.e.* the ratio of total tangible outputs divided by total tangible inputs; and (ii) partial or single factor productivity *i.e.* the ratio of total tangible output to input of one factor within a system (Molden, 1997). Like land productivity, water productivity is also a partial factor productivity that measures how the systems convert water into goods and services (Molden *et al.*, 2003). Its generic equation is:

$$Water\ productivity = \frac{Product\ output}{Water\ input}$$

In gardenland situation, each one hectare area was allocated for Conventional Farming System (CFS) and Integrated Farming System (IFS). From the Table 3, it concluded that the total water consumed in one hectare IFS was lower (14249 m^3) compared to conventional farming system (22925 m^3). The higher physical water productivity in one hectare IFS (8.26 kg m^3) compared to conventional farming system (1.62 kg m^3).

At the farm level, water can be judiciously applied for multiple uses such as drinking, irrigation, livestock, fisheries etc. to optimize water productivity. Integrated farming system (IFS) based on multiple uses of water, comprising of crop, fishery, duckery, poultry, piggery, agro-forestry etc. are in practice not only in India but also in other Asian countries. Such a system results in more judicious use of water resulting in higher water productivity and also improving livelihood of resource poor farmers (Sharda and Juyal, 2007; Gill *et al.*, 2005). An integrated farming system (IFS) in Punjab under shallow water table conditions, the water productivity increased by 56–86 % under IFS in comparison with only rice-wheat system (Gill *et al.*, 2005).

Table.1 Integrated farming system components (1 ha) – gardenland

Components	Area	
Sugarcane	2000 m^2	
Banana	2000 m^2	
Turmeric	2000 m^2	
Maize – Fodder sorghum	2000 m^2	
CO 4 grass	1800 m^2	
Dairy unit	2 cows	200 m^2
Poultry shed	50 desi birds	
Vermicompost	2 units	
Total area	**10,000 m^2 (1 ha)**	

Table.2 Experimental details of integrated farming system

Crop	Date of planting/ sowing		Variety	Irrigation based on IW/CPE ratio
	First year	Second year		
Sugarcane	06.04.2015	06.05.2016	CO 86032	**0.75**
Banana	26.02.2015	20.02.2016	Kathali	**1.0**
Turmeric	17.06.2015	14.06.2016	BSR 2	**0.9**
Maize	13.02.2015	05.06.2016	CO 6	**0.8**
Cumbu Napier	**30.02.2015**	**18.03.2016**	**CO(CN)4**	**once in ten days**

Table.3 Water productivity of gardenland IFS and CFS (Average of two year)

Enterprises	Area (ha)	Water usage (m^3)	Unit Yield (kg)	Physical WP(kgm^{-3})
Integrated Farming System (IFS)				
Sugarcane	0.2	2866	22250	7.77
Banana	0.2	3174	3325	1.05
Turmeric	0.2	2047	5338	2.61
Maize	0.2	1076	1258	1.18
Fodder sorghum		2039	5450	2.67
Cumbu napier grass	0.18	2942	2942	18.44
Dairy	2 Nos.	99.12	5017 lit	50.61
Poultry	50 Nos.	1.49	148	99.02
Vermicompost	2 units	4.48	1805	403.30
Total (1 ha)		**14249**	**117784**	**8.26**
Conventional Farming System (CFS)				
Rice	1	11655	5225	0.45
Groundnut	1	5275	1343	0.25
Maize	1	5995	5488	0.92
Total (1 ha)		**22925**	**12055**	**1.62**

Table.4 Economics of gardenland IFS and CFS (Average of two year)

Enterprises	Area (ha)	Water usage (m^3)	Unit Yield (kg)	Gross Income (Rs.)	Economic WP($Rs.m^{-3}$)
Integrated Farming System (IFS)					
Sugarcane	0.2	2866	22250	52581	18.35
Banana	0.2	3174	3325	116375	36.70
Turmeric	0.2	2047	5338	64056	31.31
Maize	0.2	1076	1258	16348	15.33
Fodder sorghum		2039	5450	8175	4.01
Cumbu Napier grass	0.18	2942	2942	81365	27.66
Dairy	2 Nos.	99.12	5017 lit	175595	1771.51
Poultry	50 Nos.	1.49	148	29500	19803.92
Vermicompost	2 units	4.48	1805	18050	4032.96
Total (1 ha)		**14249**	**117784**	**562044**	**39.44**
Conventional Farming System (CFS)					
Rice	1	11655	5225	78375	6.74
Groundnut	1	5275	1343	67125	12.69
Maize	1	5995	5488	71338	11.93
Total (1 ha)		**22925**	**12055**	**216838**	**9.46**

Economics of integrated farming system

Economic analysis of technology clearly showed advantage over conventional system of cropping under rainfed conditions. A net profit of about 200% of the total cost indicates the economic viability of the technology. It has considerable potential to provide food security, nutritional benefits, employment generation and providing additional income to resource poor small farmers. Ramrao *et al.,* (2006) studied crop-livestock integrated farming system for the marginal farmers in rainfed regions of Chhattisgarh in Central India to find out a sustainable mixed farming model which is economically viable integrating the different component like crop, livestock, poultry and duck on 1.5- acre land holding.

The inclusion of animal component in the system set a positive link on sustainability by generating cash income, improving family nutrition and recycling crop residues and livestock refuse into valuable nutrient source for crops (Saxena *et al.,* 2003). Integration of livestock with crops on watershed and individual holding basis has been reported to improve the traditional farming system on sustainable and eco-friendly basis (Dhiman *et al.,* 2003).

From the Table 4, the higher gross income of Rs. 562044/- recorded under IFS compared to CFS (Rs.216838/-). In gardenland situation, the higher economic water productivity (39.44 Rs.m^{-3}) were recorded in IFS compared to CFS (9.46 Rs.m^{-3}). This might be due to efficient utilisation of resources.

In Haryana, Sheokand *et al.,* (2000) conducted studies of various farming systems on 1 ha of irrigated and 1.5 ha of unirrigated land and found that under irrigated conditions of mixed farming with crossbred cows yielded the highest net profit (Rs. 20581) followed by mixed farming with buffaloes (Rs.6218) and lowest in arable farming (Rs. 4615). In another study conducted with 240 farmers of Rohtak (wheat-sugarcane), Hisar (wheat-cotton) and Bhiwani (chickpea-pearl millet) districts in Haryana which represented zones of different crop rotations revealed that maximum returns of Rs.12593, 6746 and 2317/ha was obtained from 1 ha with buffaloes in Rohtak, Hisar and Bhiwani, respectively. The highest net returns from Rohtak was attributed to the existence of a better soil fertility type and of irrigation facilities coupled with better control measures compared to other zones. Livestock also constitutes "living bank" providing flexible financial reserve in times of emergency and serve as "insurance" against crop failure for survival (Ramrao *et al.,* 2005).

In conclusion the results of water productivity in integrated farming system in western zone of Tamil Nadu revealed that the gardenland IFS recorded lower water consumed (14249 m^3) compared to conventional farming system (22925 m^3). The higher gross income of Rs.562044/-, physical water productivity (8.26 kgm^{-3}) and economic water productivity (39.44 Rs.m^{-3}) recorded under IFS compared to CFS. It is concluded from the study that Integrated Farming system favourably influenced the yield which resulted in higher irrigation water productivity against lower amounts of water applied. Moreover it indicated that Integrated Farming system in gardenland situation is economically significant.

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