

Sustainability of rice-wheat cropping system through natural resource management in Haryana

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Abstract

The study was undertaken in Haryana state (North India) in rice (*Oryza sativa* L)-wheat (*Triticum aestivum* L) cropping system. Four rice-wheat growing districts i.e. Karnal Kurukshetra, Kaithal and Ambala were selected for the study. From each district two blocks and from each block two villages were selected randomly. From each village 20 farmers were selected by using stratified random sampling technique, thus constituting a sample size of 160 farmers. Data were collected by using personal interview method during 2011 from the small, medium and large categories of the farmers on the basis of land holding size. Results indicated that Rice-wheat cropping system was found to be stable in terms of its yield potential as indicated by a higher sustainability yield index of rice (0.78) and wheat (0.80). The farmers observation inferred that the resource conservation technologies have the potential to decrease the cultivation costs and making rice-wheat cropping system more resource-use-efficient, profitable and sustainable.

Keywords: Resource management, rice-wheat cropping system, sustainability, sustainability yield index

1. Introduction

Haryana has followed rice-wheat crop rotation for several decades and the contrasting edaphic needs of these two crops have resulted in increased pest pressure, nutrient mining, inappropriate use and management of chemical fertilizers, input use efficiency is low and soil organic matter content has reduced (Abrol *et al.*, 2011). In many areas, yields have stagnated at below potential level. Erratic rainfall, decline in water table, poor soil health, changing pest scenario, lack of innovative technologies are some of the important reasons for yield stagnation. The crop residue which can increase organic matter in soil is being burnt which increased environment pollution. The groundwater table has receded at the rate of one meter per year in rice-wheat belt of Haryana covering north-eastern districts (Gupta, 2011). In Haryana, over-exploitation of groundwater has threatened agricultural sustainability. Water is a major concern for the sustainability of the rice-wheat production systems (Erenstein, 2009). In both Haryana and Punjab groundwater has become the prevailing irrigation source, placing tremendous pressure

on groundwater supplies (Abrol, 1999; Ahmad *et al.*, 2007). This is aggravated by the increasing competition for water from other sectors (Briscoe and Malik, 2006; Kijne, *et al.*, 2003; Meinzen-Dick and Rosegrant, 2005; Molden, 2007).

Conservation Agriculture (CA) is an integrated approach to crop, soil and water management to achieve sustainable agriculture goals. It seeks to conserve, improve and make more efficient use of natural resources through integrated management of soil, water, crops and other biological resources in combination with selected external inputs. It has the potential to address increasing concerns of serious and widespread problems of natural resource degradation and environmental pollution, while enhancing system productivity (Abrol *et al.*, 2005; Gupta, 2011; Yadav, 2012). Initial sustainability concerns in rice-wheat systems were flagged two decades ago and have generated significant research and policy interest. Yet despite some progress, the intrinsic incompatibility of an aerobic wheat and anaerobic rice crop has not been altered. Perhaps the clearest exponent of this is that, compared to other wheat production systems, the lowest growth in productivity

over the last decades took place in the rice-wheat system (Murgai *et al.*, 2001). This is contrary to the popular perception, but reflects that rice-wheat output growth was largely due to input growth and partly offset by resource degradation (Byerlee *et al.*, 2003). The root cause of land degradation in the rice-wheat system is not agricultural intensification *per se*, but rather the policy environment and associated incentives that encouraged inappropriate land use and injudicious use of water and other resources (Datta and Jong, 2002; Pingali and Shah, 2001). Murgai *et al.* (2001) reported that natural resource base has been stretched and contributed to soil degradation, salinity problems and over exploitation of groundwater. He mentioned that there is a need for policies that (i) promote agricultural productivity and sustainability through public investments in education, research and extension and (ii) reduce resource degradation by decreasing or eliminating subsidies.

So, there is an urgent need to make detail probe on all these relevant issues through empirical research. Hence, the study was conducted in the rice-wheat cropping system of four districts *viz*, Karnal Kurukshetra, Kaithal and Ambala of Haryana with the objectives: (i) to study the sustainability index of rice-wheat cropping system and (ii) adoption of resource conservation technologies to sustain the rice-wheat cropping system.

2. Materials and methods

Haryana is a land locked state in northern India. It is located between 27°39' to 30°35' N latitude and between 74°28' and 77°36' E longitude with an area of 42 thousand sq. km. The altitude of Haryana varies between 200 to 1200 metres above sea level. The state has divided into two regions: sub Himalyan Zone and Indo-Gangetic Plains. The plains are fertile. The south western part of the state is arid and sandy. The climate is very hot in summer and cold in winters. Average rainfall ranges from 400 to 1200 mm. About 80 percent of the rainfall occurs in the month of July-September. Agriculture is the main occupation of the people of Haryana. About 86 percent of the geographical area is cultivable, out of which 87.6 percent is irrigated. The cropping intensity in the state is nearly 180 percent as the national average of 137 percent. The Karnal, Kurukshetra, Kaithal and Ambala districts are the study area; these are located in North-eastern part of Haryana state. The topography of these districts is flat. Mixed livestock-crop production is the major production system. Wheat, rice, potato, greengram, sugarcane, sunflower are the main crops, while sorghum and berseem are the two major fodder grown in the study area.

2.1 Methods: A survey was conducted in four districts of Haryana *viz*; based on their crop productivity. Then two blocks from each district and from each block one village and from each village 20 rice-wheat growing

farmers were selected by using stratified random sampling technique, thereby constituting a sample of 160 farmers respondents. The respondents were divided into three categories of equal numbers on proportionate basis of their land holdings *viz*; small (upto 2 ha) medium (2-4 ha) and large (> 4 ha). For the purpose of data collection from the farmers, interview schedule was developed by incorporating all the items related to variables for which information were required to be collected. The schedule was pre-tested (pilot study) in the non sampled area. On the basis of responses, necessary modification was made. All the farmers were interviewed personally with the help of modified interview schedule during January to June 2011. The family head of selected households who yielded maximum influence in decision making with regard to crop cultivation constituted the respondents of the study. The responses were recorded on memory recall basis.

2.2 Data analysis: The collected data were scored, compiled, tabulated and subjected to statistical tools to draw meaningful results and conclusions.

3. Results and discussions

Sustainability of Rice-Wheat Cropping System: Sustainability was assessed quantitatively with a sustainable yield index (SYI), which denotes the minimum guaranteed yield as a percent to the maximum observed value with high probability as Singh *et al.*, (1990). Sustainability was quantitative assessed based on the Sustainable Yield Index (SYI).

$$\text{Sustainable Yield Index (SYI)} = \frac{Y - \sigma}{Y_{\max}}$$

- Y - The estimated average yield of the farmer over the years
 σ - Estimated standard deviation
 Y_{\max} - Maximum yield of the farmer

In this study, the sustainability of the system was assessed in relation to available nutrient (NPK) status of soil and given practices adopted by the farmers in terms of yield over a period of time in the study area. The good average grain yield of rice and wheat at the farmers' fields during the last 5 years is a good indicator of the sustainability of this very system (Table-1).

Table 1. Average yield of rice and wheat of the farmers during the last 5 years

Year	Rice (t ha ⁻¹)	Wheat (t ha ⁻¹)
2005-06	6.19	4.60
2006-07	6.39	4.65
2007-08	6.10	4.68
2008-09	6.14	4.34
2009-10	5.97	4.48
Mean	6.15	4.55

Maximum yield of the farmers

Rice (mean) - 6.63 (t ha⁻¹)

Wheat (mean) - 4.95 (t ha⁻¹)

Sustainability yield index of rice and wheat: The study indicated that rice-wheat cropping system was found to be stable in terms of its yield potential as indicated by a higher sustainability yield index of rice (0.78) and wheat (0.80) in the present status of the soil.

$$\text{Sustainability Yield Index of Rice} = \frac{6.15 - 0.95}{6.63} = \frac{5.20}{6.63} = 0.78$$

$$\text{Sustainability Yield Index of Wheat} = \frac{4.55 - 0.59}{4.95} = \frac{3.96}{4.95} = 0.80$$

Chitale *et al.*, (2011) reported that rice-wheat-fallow and rice-onion-GM recorded the highest sustainability index (0.84). Rice-potato-cowpea sequence was found to be most appropriate system in terms of profit as well as sustainability over the years

The study revealed that the productivity of wheat can be increased with the mean monthly maximum temperature upto 21°C and minimum temperature of 6.5°C in the months of December, January and February. High intensity rainfall in the month of September affected the yield of rice adversely. The study found that majority of the farmers responded to deep groundwater depth, tube

well as a source of irrigation with good quality water and medium to heavy soils in the area. The data further indicated that majority of the farmers were applying appropriate number and depth of irrigation water, following minimum tillage and incorporating crop residue in the field. About 49 % farmers adopted zero-tillage/direct seeding for sowing of wheat/rice crop whereas 33.12 % farmers adopting green manuring before rice transplanting. It was further observed that 78 % rice and 80 % wheat were found stable in the study area in terms of its yield potential as indicated by Sustainability Yield Index of rice and wheat in the present status of the soil.

Adoption of resource conservation practices to sustain rice-wheat system: Adoption of improved technologies has been used to reduce some of the adverse impact of nature and enhance the stabilized crop productivity. These technologies which were very simple in earlier years have become more and more complex on account of newly emerging issues related to sustainability and enhancement at higher level of productivity which have been achieved in several regions.

The data given in table-2 indicated that 82.5 per cent farmers were applying appropriate number and depth of irrigation water and 70.62 per cent farmers following minimum tillage. About 61 per cent farmers were incorporating crop residue in the field. About 49 per cent farmers adopted zero-tillage/direct seeding for sowing of wheat as well as rice crop whereas 33.12 per cent farmers growing green manuring before rice transplanting.

Table 2. Use of resource conservation practices

Resources conservation practices	Frequency (%)			
	Small	Medium	Large	Total
Adopting zero-tillage/ direct seeding	21 (13.12)	26 (16.25)	31 (19.38)	78 (48.75)
Following minimum tillage	35 (21.87)	33 (20.62)	45 (28.13)	113 (70.62)
Incorporating crop residue in the field	32 (20.00)	31 (19.37)	34 (21.25)	97 (60.62)
Using appropriate no. and depth of irrigation water	44 (27.50)	45 (28.12)	43 (26.88)	132 (82.50)
Growing green manure crops before rice transplanting	16 (10.00)	18 (11.25)	19 (11.87)	53 (33.12)

In rice-wheat cropping system, these two crops have contrasting edaphic requirements. Rice is commonly transplanted into puddle soils and gets continued submergence; wheat is grown in upland well drained soils, having good tilth. Direct seeded rice saves energy and water for rice establishment and eliminates labour in transplanting. It can result in earlier maturity of rice, which helps in improved wheat productivity through early sowing/establishment of the crop. The direct seeded rice has less emission of methane gas as compared to puddle rice, but vice versa is true for the emission of nitrous oxide gas in the atmosphere (Abrol *et al.*, 2011). Zero

tillage also helps in solving the problem of late planting and excessive costs of production in wheat, but if rice can be grown without puddling, the total system productivity would be ever greater. Zero tillage technology reduces the cost of cultivation, advances time of wheat sowing (4-5 days), requires less water for first irrigation and less infestation of *Phalaris minor*, which is a burning problem in North-West India.

Instead of burning rice residue (varying from 5.5 to 6.5 t ha⁻¹), it could be effectively managed by incorporating it into the soil. The disc harrow mixes the residue in 0-10 cm soil (surface), mould board plough/disc plough inverts

the residue down to 20-25 cm depth (sub surface). Rice residue incorporation had no deleterious effect on wheat yield compared to its burning/removal irrespective of soil type, mode of incorporation (surface/sub-surface), time of incorporation prior to wheat seeding and date of sowing.

After wheat harvest, short duration green gram/cowpea/green manure/any other crop which can be harvested before the onset of monsoon is viable option for fixing of atmospheric nitrogen through biological nitrogen fixation thereby reducing the N requirement of succeeding crop. The water-use-efficiency could be improved both under transplanted rice as well as rice grown with other new established techniques. Likewise in wheat, application of water based on climatic approach (depth of irrigation water/cumulative pan evaporation value) seems more effective for realizing the high wheat yield. It is inferred that the farmers had perceived that the resource conservation technologies has the potential to decrease the cultivation costs and making rice-wheat system more resource-use-efficient, competitive, sustainable, profitable and environmental friendly.

Ladha *et al.*, (2003) supported the findings of the study that the conventional production practices used in the area need to be improved or replaced by resource conserving technologies (RCTs) to adapt to emerging changes and to enhance system productivity, input-use-efficiency, and farm profitability on a sustainable basis. Gupta & Seth (2007) reported that resource conserving technologies (RCTs) such as zero-tillage (ZT), raised beds, and laser land leveling have been found beneficial in the western IGP in reducing cultivation cost, energy consumption and improving crop productivity, input-use efficiency, and farmers' income.

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