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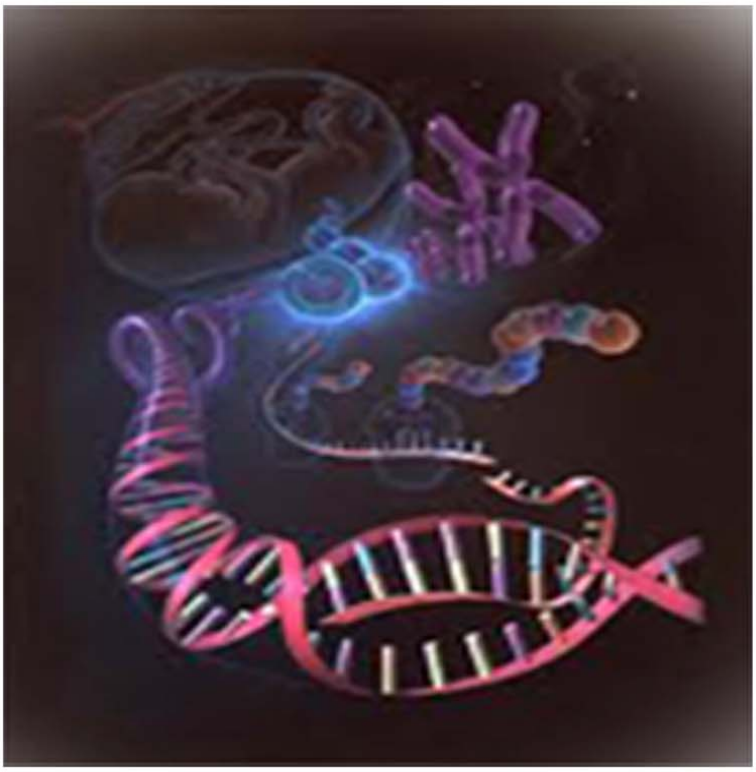

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Research Paper

ROLE OF PRECISION FARMING FOR SUSTAINABILITY OF RICE-WHEAT CROPPING SYSTEM IN WESTERN INDO GANGETIC PLAINS

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Precision farming is basically designed to optimize agricultural inputs viz., fertilizers, pesticides, water etc., in tune with micro level/ field requirements. Optimization is focused on increased yields, reduced cost of cultivation and to minimized environmental impacts through location-specific management. Precision farming in the context of development efforts has to meet production efficiency, sensitivity of ecosystems, appropriate technology,and maintenance of the environment, cultural diversity and satisfaction of the basic needs. Now Modern agricultural management practices are changing from assuming homogenous fields to attempting to address field variability by dividing the field into smaller zones and managing these zones separately. Precision farming has focused on the development of techniques that primarily aid the convention farming system (i.e., tilling the soil to prepare for planting, and heavy reliance on chemical inputs, such as pesticides and fertilizers). However, some farmers, that use conservation tillage practices can also use precision farming practices. The small size of farms and fields in most of Indian agriculture limits economic gains from currently available precision farming technology, while the population density, and public concerns for the environment, food safety those potential benefits of precision farming are being given more attention. While adoption of precision farming in wide concept has been modest in India the potential for using precision farming to address environmental, food safety, and sustainability problems seems to be attracting political attention in India conditions. Current paper deals with the applicability, opportunity of precision farming in Western IGP.

Keywords: Precision farming, Sustanability, Profitability, Resource conservation technologies

INTRODUCTION

Rice and wheat are the two principal food crops in the region that contribute 80%, in the food pool of the region.These crops are grown in sequence on 13.5 million hectares of the Indo- Gangetic Plains.The total water requirement for rice- wheat

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system is estimated to vary between 1382 mm to 1838 mm in the Indo-Gangetic Plains, accounting to more than 80% for the rice growing season. Thus to save on water, saving must be effected during rice growing season, the major water user in rice-wheat system. Future food security in this region is severely threatened by unsustainable groundwater use and inappropriate water management practices. For the rice-wheat system several water-saving technologies for water-short irrigated enviroments which besides the development of irrigation schedules and frequency, crop choices and their appropriate cultivars also included the technology known as precision land leveling. In irrigated and rainfed environments, precision land leveling improves uniform application of water, betters the crop stangs and helps reduce abiotic stress intensities, enhancing survival of young seedlings and robustness of the crop to withstand stress and stablize yields through improved nutrient-water interactions.

Precision land leveling saves irrigation water, nutrients and agro-chemicals. It also enhances environmental quality and crop yields. In spite of the known benefits of precision land leveling, Indian farmers are unable to take full advantages of it and have to rely on traditional methods of land leveling which are labour-intensive and crude, and do not achieving a high level of smoothness of land surface. It is estimated that precision land leveling system to just two million hectares of area under rice-wheat system could save diesel upto 200 million liters (equal to US$ 1600),and improve crop yields amounting to US$ 650 million in two years and reduce GHG emissions equivalent to 500 million kg. Precision land leveling system is also likely to increase the cultivable area in the range of 3-6% (due to reduction in bunds and channels in the field).

Decling irrigation water availability and crop productivity and increasing food demand necessitate quick adoption of modern scientific technologies for efficient water management. The water and food productivity are low in the region, causing serious concerns for food security. Farmers have been practicing irrigated and intensive agriculture on alluvial soils of the IGP, for many years. Use efficiency of water at the field level has been poor in the IGP due to water loss in conveyance application and distribution. Modern intensive agriculture relies on the timely planting for enhanced crop yields and profits. For high crop yields, farmers must ensure good seedling emergence, better crop stand and early crop vigor. Smoothness of land surface meets the objectives of achieving better crop stand, saving irrigation water and improving the use efficiency of precious inputs. The common practices of irrigation in intensively cultivated irrigated areas are flood basin and check basin irrigation systems. These practices on unleveled lands lead to waterlogging conditions in low-lying areas and soil water deficit at higher spots. Significant amounts (10-25%) of irrigation water is lost during application at the farm due to poor management and uneven fields (Kahlown *et al.,* 2000). Conservation agriculture practices coupled with precision land leveling facilitate uniform water application and reduce deep percolation losses of water. Precision land leveling is known to enhance water-use efficiency and consequently water productivity. Conventional surface irrigation practices in unleveled bunded units normally result in over irrigation (Corey and Clyma, 1973). This results in excessive loss of irrigation water through deep percolation and reduces the application efficiency upto 25% (Sattar *et al.*, 2003). Precision land leveling helps even distribution of soluble salts in salt- affected soils (Khan, 1986), increases cultivable land area upto 3-5% (Choudhary *et al.*, 2002; Naresh *et al.*, 2011), improves crop establishment,reduces weed intensity (Rickman, 2002) and results in saving in irrigation water (Khattak *et al.*, 1981). The objectives of this study were to evaluate the effects of various tillage and seeding methods on productivity, irrigation requirement and sustanability of the rice-wheat cropping system of the western IGP.

MATERIALS AND METHODS

An experiment on different tillage and crop establishment techniques involving permanent beds were conducted under farmer managed trials in Ghaziabad district of Uttar Pradesh in western Gangetic Plain during 2008-09 and 2009-10 of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh), India. Field was laser land leveling and traditional leveling for experimental purpose. The water table depth of the experimental sites is 23 m with very good quality of water. The climate of the area is semiarid, with an average annual rainfall of 805 mm (75-80% of which is received during July to September), minimum temperature of 0 to 4°C in January,maximum temperature of 41 to 45°C in June, and relative humidity of 67 to 83% throughout the year. The experimental soil (0-15 cm) was silty loam in texture.

The permanent beds and double no till systems in rice-wheat rotation used. A randomized block design (RBD) with three replications was used in the study. A combination of six tillage and crop establishment techniques. [**1** Puddled transplanted rice (TPR) - zero till wheat planted by zero till drill (ZTW), **2** zero tillage direct seeded rice (ZTDSR) - zero till wheat (ZTW), **3** conventional tillage direct seeded rice (CTDSR) - zero till wheat (ZTW), **4** direct seeded rice on raised beds (Bed DSR) - zero till wheat on permanent raised beds (ZTWBed), **5** transplanted rice on raised beds (BedTR) - zero till wheat on permanent raised beds (ZTWBed), **6** Conventional puddled transplanted rice (TPR) - Conventional tillage wheat (CTW) in RW system was used along with laser land leveling (+LL) in rice and rice residues (+R) in wheat]. The details of the treatments are as follows:

Transplanted rice after conventional puddling and zero till wheat (TPR- ZTW)

Rice (TPR): Conventional puddling (2 dry-harrowing, 3 passes of cultivator followed by 2 wet-tillage and planking) were performed followed by manual transplanting of 21 days seedling at 20 x 20 cm spacing. The plots are kept flooded (5±2 cm submergence) for initial 2 weeks to establish the seedling, and the subsequent irrigations (5±2 cm) were applied at the appearance of hair-line cracks on soil surface.

Wheat (ZTW): Wheat crop was sown in rows 20 cm apart using zero till cum ferti -seed drill with enclined type seed metering devices planter without any preparatory tillage. Five irrigations (5 ± 2 cm) were applied on tensiometer reading (70 milli bar) depending on the winter rainfall at critical stages.

Zero till direct seeded rice and zero-tillage wheat (ZTDSR-ZTW)

Rice (ZTDSR): Rice was direct-seeded in flat plots at 20-cm row spacing using a zero till cum ferti -seed drill with enclined type seed metering devices planter. The seeding was done on the same day when the nursery sowing for transplanted rice. The irrigation was applied just after seeding, and the plots were irrigated daily for 2 week after germination to maintain saturation. Subsequent irrigations (5 cm) were applied at the appearance of hairline cracks at the soil surface.

Wheat (ZTW): Wheat crop was sown in rows 20 cm apart using turbo happy seeder without any preparatory tillage. Five irrigations (5 ± 2 cm) were applied on tensiometer reading (70 milli bar) depending on the winter rainfall at critical stages.

Direct seeded rice after conventional tillage and zero-tillage wheat (CTDSR-ZTW)

Rice (CTDSR): Tillage operations in rice were restricted to dry tillage (2 dry-harrowing followed 2 cultivator and 1 planking) and rice seeding was done in dry soil in rows 20 cm on the same day of nursery sowing for transplanted rice using zero till cum ferti-seed drill with cup type seed metering devices planter. The irrigation was applied just after sowing following second irrigation 3 days after first irrigation and the subsequent irrigations (5 cm) were applied at the appearance of hairline cracks at the soil surface.

Wheat (ZTW): Wheat crop was sown in rows 20 cm apart using zero till cum ferti -seed drill with enclined type seed metering devices planter without any preparatory tillage. Five irrigations (5±2 m) were applied on tensiometer reading (70 milli bar) depending on the winter rainfall at critical stages.

Direct Seeded rice on raised beds and wheat on permanent raised beds(Bed DSR-ZTW Bed)

Rice (BedDSR): At the beginning of the experiment soil was tilled by three harrowings and three plowings followed by one field leveling with a wooden plank, and raised beds were made using a tractor-drawn multi crop zero till cum raised bed planter with enclined plate seed metering devices. The dimension of the wide beds were 107 cm wide (top of the bed) x 12 cm height x 30 cm furrow width (at top) and the spacing from centre of the furrow to another centre of the furrow was kept at 137 cm. Six rows of rice were direct-seeded on each raised bed at 20-cm row-to-row spacing. The raised beds were seeded using a bed planter, which placed seeds and fertilizer simultaneously. The first irrigation was applied at 1 day after seeding (DAS), followed by daily irrigations for 2 week after germination to maintain soil saturation. The irrigations were applied to completely fill the furrows. Subsequent irrigations (completely filling the furrows) were given at the appearance of hair-line cracks at the soil surface and at the bottom of the furrow.

Wheat (ZTW Bed): After rice, six rows of wheat was seeded directly after reshaping the beds using a multi crop zero till cum raised bed planter with enclined plate seed metering devices without any preparatory tillage. Five irrigations (5 ± 2 cm) were applied on tensiometer reading (70 milli bar) depending on the winter rainfall at critical stages.

Transplanted rice on raised beds and wheat on permanent raised beds (BedTR-ZTW Bed)

Rice(BedTR): At the beginning of the experiment soil was tilled by three harrowings and three plowings followed by one field leveling with a wooden plank, and raised beds were made using a tractor-drawn multi crop zero till cum raised bed planter with enclined plate seed metering devices. The dimension of the wide beds were 107 cm wide (top of the bed) x 12 cm height x 30 cm furrow width (at top) and the spacing from centre of the furrow to another centre of the furrow was kept at 137 cm. Transplanting of

21-day old seedling per hill in six rows at 20 cm spacing on the wide raised beds. Plant-to-plant spacing was 12 cm to maintain the population equal to that of the conventional transplanted method. The plots were kept flooded for 2 weeks after seeding and subsequent irrigations were applied to completely fill the furrows at the appearance of hair-line cracks at the soil surface at the bottom of the furrow.

Wheat (ZTW Bed): After rice, six rows of wheat was seeded directly after reshaping the beds using a multi crop zero till cum raised bed planter with enclined plate seed metering devices without any preparatory tillage. Five irrigations (5 ± 2 cm) were applied on tensiometer reading (70 milli bar) depending on the winter rainfall at critical stages.

Conventional puddled transplanted rice and conventional tillage wheat (TPR-CTW)

Rice (TPR): Conventional puddling involving 2 dry-harrowings, 2 passes of cultivator followed by 2 wet-tillage operations and one field leveling with a wooden plank was done after that water was imponded, followed by manual transplanting of 21-day old seedlings at 20 by 20 cm spacing. The plots were kept flooded (5 cm submergence) for an initial 2 week, and in subsequent irrigations, which were applied at the appearance of hair-line cracks at the soil surface, the field was flooded up to the point where 5 cm water was standing. Farmers in the study area commonly use the appearance of hairline cracks at the soil surface as an indicator to initiate irrigation. In the soil used in presentstudy, the hair-line cracks appear at field capacity moisture regime.

Wheat (CTW): Tillage operations in wheat were restricted to dry tillage (2 dry-harrowing followed 3 cultivator and planking) and wheat sowing was done in rows 20 cm using zero till cum ferti-seed drill with enclined type seed metering devices. wheat was irrigated at the crown root initiation, tillering, jointing, and dough growth stages. Each field was flooded up to the point where 5 cm water was standing in the field.

Crop Residue Management: The rice residue was managed at 6.0 t ha^{-1} (partially anchored and partially loose).

SEEDING AND SEED RATE

Pusa Sugandha-4 (1121) rice variety was seeded on 1st and 3rd June in direct-seeded plots,where as transplanting was done on 22nd and 24th June in 2008 and 2009, respectively. Rice was seeded in flat beds as well as in raised beds after seed priming (soaking seeds in water for 12 hr's followed by air drying). A seed rate of 25 kg and 20 kg ha^{-1} was used for direct-seeded rice on flat and raised beds, respectively. 'PBW 343' wheat was seeded on 7th and 9th Nov.2008 and 2009, respectively. A seed rate of 80 kg ha^{-1} was used in treatments where wheat was seeded on beds, and 100 kg ha^{-1} was used in the rest of the treatments. The multi crop zero till cum raised bed planter with enclined plate seed metering device machine was calibrated every time before seeding to adjust the seeding rate.

RESULTS AND DISCUSSION

Concerns about the Sustainability of Rice-Wheat Systems

Decline in the yield on experimental plots, stagnating farmer yields, declining productivity growth rates, and factor productivity in both farm and research settings and degrading soil and water resources have raised questions about the sustainability of rice- wheat rotation systems. This is a serious concern especially at a time when the production of staple food in whole of South

Asia must increase at a rate of 2.5% per year to meet the projected population growth. However, an analysis of statistics from Punjab, Haryana and Western Uttar Pradesh over the past 20 years shows that the North Western Green Revolution miracle is over; with currently available germplasms, and crop/soil management practices growth in rice-wheat system productivity seems unlikely to exceed the current levels of 2 per cent per annum. A major concern arising out of intensive rice and wheat cropping with a corresponding decline in pulses and coarse grain has been nutritional imbalance, especially micronutrient malnutrition among the people. This situation has developed because the production of micronutrient rich crops (coarse grains, pulses) has not matched the increasing output of wheat and rice. Fears have been expressed that the continuing intensive practice of this system could seriously impair soil health, create problems of alkalinity/ salinity, deteriorate soil texture, excessively mine soil nutrients, lead to new pests, disease and weed problems, and ultimately affect agricultural production in the long run. The signs of deterioration in agricultural production systems are already evident in high productivity areas.

Causes of Stagnation of Productivity Growth-Near Exhaustion of Past Resources

Expansion in area virtually halted

In the past an important element in the growth of rice and wheat production has been the expansion in crop and irrigated areas. In India, rice area grew steadily during 1960s and 1970s, with the total area planted to rice increased from about 34 million ha in 1960 to 40 million ha in 1980.Since 1980, growth in rice area has slowed, with the 1990s showing no growth at all. The wheat area which had been stagnant at 13 million hectares in the early 1960s expanded dramatically beginning 1967. This growth spurt continued for little over a decade and by 1979 the area under wheat in India reached 22 million hectares, with only a marginal increase in area after that.

Irrigation capccity expanded to the maximum viable point

Irrigation expansion, which played a pivotal role in the success of rice-wheat system has also been exploited to the extent that it is economically viable. The area under irrigation in India has increased from 31.4 M hectare to 50.2 M hectares between 1980 and 1995. However, the availability of irrigation water at subsidized rates has led to enormous misuse. In the high intensity zone in rice- wheat systems are being over-irrigated by 15 per cent; this may deplete the ground water table at an alarming high rate.

Degradation of Natural Resources

With the reduction in the rate of yield and growth, there are indications that the natural resource base on which the systems depend is also weakening. Water induced land degradation, salinization, sodification and ground water depletion have become a major problem. Slow loss of soil fertility due to the continuous extraction of nutrients that surpasses the input application and management of organic matter is causing concern.Continuous monocropping has also led to an increased incidence of pests, diseases, and weeds.

Unlaveled Topography

A considerable amount of water is wasted during irrigation of un-leveled fields. Studies have indicated that a significant (20 to 25%) amount of irrigation water is lost during its application at the farm due to poor farm designing and uneven fields The problem is more pronounced in case of paddy fields. It has been noted that most of the farmers apply irrigation water until the highest point in a field is covered. This leads to over-irrigation of low-lying areas and under-irrigation of higher spots,which results in accumulation of salts in such areas. Over irrigation leaches soluble nutrients from the crop root zone, makes the soil less productive and degrades groundwater quality. The fields being not properly levelled cause wastage of land, low irrigation efficiencies, and ultimately results in substantially lesser yield than the potential.

Decline in Soil Fertility

Because most rice-wheat systems are heavy extractors of nutrients, chemical deficiencies are bound to occur after years of continuous cropping unless proper measures are taken to mitigate the problem. Organic matter levels are known to affect soil chemistry. The physical properties of the soil can also affect the productivity of rice-wheat systems. The puddling of rice soil breakes down soil aggregates, resulting in reduced pore sizes and the formation, in some soils,of a plow pan. This restricts water percolation and creates favourable conditions for rice. Soil biological factors may also be contributing to the decline in productivity in rice-wheat systems.

Problems Related to Water Management

The increased demand for irrigation water has surpassed the natural ability of the ecosystem to replenish the ground water. Concern about water availability has mounted,especially in North-Western India. During the past decade, water tables have dropped at a rate of 0.5- 0.8 m per year in Western Uttar Pradesh and Haryana and at a rate of 0.2-1.0 m per year in the neighboring Punjab. Problems relating to the quality of irrigation water have also multiplied; many rice-wheat tracts in North West India are being affected by water borne compounds.Deficiencies in water management at the farm and system level, though not unique to rice-wheat system,are quite pronounced because of the contrasting management for the two crops. Salinity and sodicity problems are sometimes aggravated by poor water management practices in lower reaches of canal irrigation systems, where sufficient water may not be available to leach out salts.

Crop Management Problems

Productivity levels in rice-wheat cropping systems have been negatively affected by the intensification process itself. The management decision taken to increase the productivity of one crop has often adversely affected the other crop in the rotation. Decision to increase rice productivity by introducing a high yielding long-duration variety can lead to late planting of wheat in the rotation. Delayed planting of wheat significantly reduces the yields and decreases the efficiency of fertilizer uptake. Adoption of reduced tillage practices can help to alleviate this problem.

Crop Yields: The various tillage and crop establishment techniques had a significant effect on rice yield. Treatment conventionally puddled transplanted with laser leveled plot (TPR+LL) was found significantly superior to all the treatments and recorded maximum grain yield. Yield were similar when rice was conventionally puddled transplanted without laser leveled plot (TPR), transplanted on raised beds with laser leveled plot (BedTR+LL), direct seeded on raised beds with laser leveled plot (BedDSR +LL) conventional till direct seeded rice with laser leveled plot (CTDSR+LL) and zero till direct seeded rice with laser leveled plot (ZTDSR+LL). This indicated that puddling of soil, for which normally a large amount of water and labour are required can be avoided without any penalty in rice if fields have laser leveled. Treatment zero till direct seeded rice without laser leveled plot (ZTDSR) had a lower yield than transplanted on beds without laser leveled plot (BedTR) and direct seeded on raised beds without laser leveled plot (BedDSR). Treatments ZTDSR and Bed DSR were at par with each other, however, they recorded higher grain yield over CTDSR treatment which recorded lowest grain yield (4.15 t ha^{-1}). On beds yielded 5 to 28% lower than conventional puddled transplanting with laser leveled plot (TPR+LL).

The wheat yield under all tillage and crop establishment techniques with rice residue didn't differ significantly but the maximum yield was recorded with double no-till practices (Zero till and permanent beds). Under all the tillage and crop establishment techniques, there was significant yield advantage with surface residue retention compared to removal. The crop residues retained as surface mulch (partially anchored and partially loose) @ 6.0 Mg ha^{-1} that helped in regulating the soil temperature and moisture and more response was mainly due the aberration in weather conditions during the crop growth period.

The analysis of system productivity revealed that significant treatment effects on rice + wheat (system) yields were observed (Table 1). The yields of the rice-wheat system were similar in the puddled and nonpuddled systems,but were lower in without laser leveled treatments. Moreover, laser leveled treatments gave higher system yields under both no-tillage and raised bed treatments. The rice plus wheat yields in conventional systems without laser leveled plots was lower by 16% in compared with the conventional systems laser leveled plots. The

Table 1: Productivity of RW Under Various Tillage and Crop Establishment Techniques

Crop Establishment		Grain Yield (tonnes ha^{-1})		
Rice	Wheat	Rice	Wheat	RW System
TPR+LL	ZTW+R	6.25	5.45	11.70
TPR	ZTW	5.69	5.15	10.84
ZTDSR+LL	ZTW+R	4.85	5.60	10.45
ZTDSR	ZTW	4.25	5.25	9.50
CTDSR+LL	ZTW+R	4.55	5.55	10.10
CTDSR	ZTW	4.15	5.35	9.50
BedDSR+LL	BedZTW+R	4.75	5.85	10.60
BedDSR	BedZTW	4.30	5.35	9.65
bedTR+LL	BedZTW+R	5.95	5.80	11.75
bedTR	BedZTW	4.95	5.25	10.20
TPR	CTW	5.71	4.15	9.86
C D at 5%		1.95	1.05	0.98

Note: TPR-puddle transplanted rice, ZTDSR-zero till direct seeded rice, CTDSR-conventional till direct seeded rice,Bed DSR-Direct seeded rice on raised beds,BedTR-Transplanted rice on raised beds, +LL-with laser levelled field, ZTW-zero till wheat,Bed-Raised bed planted wheat, CTW-Conventional till wheat, +R-with rice residue.

data indicated that there is still a need to improve the seed bed-planting systems to increase productivity.

Profitability

The net income rice was higher with ZTDSR+LL followed by CTDSR+LL and TPR+LL and the lowest being recorded with beds (Table 2). The lower net income with the beds was due to the cost on preparing the beds in first season. Profitability of wheat was remarkably higher with double no-till practices with laser leveled (ZTDS-ZTW and permanent beds) due to higher productivity and less cost of production compared to conventional tillage practices. Further, the profitability of wheat was remarkably higher with residue retention compared to residue removal and the difference was more under ZTDSR-ZTW compared to other practices. The maximum net income of the system was recorded with ZTDSR-ZTW followed by CTDSR-ZTW and the lowest being with conventional puddled transplanted rice and conventional wheat system(TPR-CTW).

Water Application and Water Productivity

The input water application includes the irrigation water applied and the rainwater during the rice season (634 mm) and wheat season (71 mm). The total water application in rice varied markedly due to tillage and crop establishment techniques (Table 3). The conventional puddled transplanted rice consumed more water (2950 mm ha^{-1}) compared to conventional till direct seeded rice without laser leveled plots (2790 mm ha^{-1} with CTDSR and 2765 mm ha^{-1} with ZT DSR). The savings in water use with beds with laser leveled plot and without laser leveled plot were 32.8% and 24.6% as compared to conventional puddled transplanted rice.Similarly,the water application in wheat was remarkably lower with permanent beds compared to other practices. The total system water use was remarkably lower with permanent beds compared to other practices but the maximum water use was recorded with TPR-CTW. The system irrigation water productivity under permanent beds was higher compared to

Table 2: Profitability of RW System Under Various Tillage and Crop Establishment Methods

Crop Establishment		Net Returns (Rs ha^{-1})			B:C Ratio		
Rice	Wheat	Rice	Wheat	System	Rice	Wheat	System
TPR+LL	ZTW+R	19080	27405	46485	1.78	2.97	2.32
TPR	ZTW	18450	25920	44370	1.66	2.70	2.14
ZTDSR+LL	ZTW+R	21825	28170	49995	2.20	2.98	2.58
ZTDSR	ZTW	15525	26415	41940	1.51	2.72	2.10
CTDSR+LL	ZTW+R	21555	27900	49455	2.04	2.98	2.53
CTDSR	ZTW	15165	26910	42075	1.43	2.76	2.07
BedDSR+LL	BedZTW+R	17775	28575	46350	2.17	3.08	2.65
BedDSR	BedZTW	15705	27405	43110	1.83	2.87	2.38
BedTR+LL	BedZTW+R	18225	28350	46575	2.11	3.01	2.58
BedTR	BedZTW	16425	26415	43740	1.75	2.69	2.22
TPR	CTW	18540	20880	39420	1.67	2.04	1.98

Table 3: Water Application and Water Productivity in Rice and Wheat with Various Tillage and Crop Establishment Techniques

Crop Establishment		Irrigation Water Applied (mm ha^{-1})			Water Productivity (kg Grain m^{-3})		
Rice	Wheat	Rice	Wheat	System	Rice	Wheat	System
TPR+LL	ZTW+R	2415	345	2760	0.259	1.580	0.424
TPR	ZTW	2950	425	3375	0.193	1.212	0.321
ZTDSR+LL	ZTW +R	2350	320	2670	0.206	1.750	0.391
ZTDSR	ZTW	2765	415	3180	0.154	1.265	0.299
CTDSR+LL	ZTW +R	2355	365	2720	0.193	1.521	0.371
CTDSR	ZTW	2790	430	3220	0.149	1.244	0.295
BedDSR+LL	BedZTW +R	1950	280	2230	0.244	2.090	0.475
BedDSR	BedZTW	2145	355	2500	0.200	1.507	0.386
BedTR+LL	BedZTW +R	2015	295	2310	0.295	1.966	0.509
BedTR	BedZTW	2185	362	2547	0.227	1.450	0.400
TPR	CTW	2950	457	3407	0.194	0.908	0.289

other tillage and crop establishment techniques and lowest system water productivity was recorded with conventional till direct seeded rice without laser leveled plot and zero till wheat without residue retain plot (CTDSR-ZTW).

CONCLUSION

Food production in India must increase by 2.5 per cent each year to meet the demand of the growing population and to reduce malnutrition. A significant part of it has to come from rice-wheat crop based production systems. This assumes special challenge as the data on rice- wheat yield trends indicate plateauing or progressive productivity decline in Punjab, Haryana, and Western Uttar Pradesh. For future productivity growth to keep pace with the increasing demand, it is necessary to address the problem at various levels. It will be important to make investment in developing appropriate technologies, and enable the farmers to take advantage of these in combination with their own ingenuity and age old wisdom. Resource conserving technologies are a key to ensuring sustainable food production in South Asia in the next decade. Precision farming cannot be convincing if only environmental benefits are emphasized.On the other hand, its adoption would be improved if it can be shown to reduce the risk. This technology revolution is seen as one way to sustainably increase food production to meet future demands while conserving natural resources, improving farmer livelihoods and reducing the negative effects on the environment.

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