Bed planting: A new technique to diversify/intensify rice-wheat system in India

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Abstract

A field study of eight crop sequences was done at the Directorate of Wheat Research, Karnal during 2001-2003 with the objective to diversify/intensify the rice-wheat system for higher productivity and profitability. Rice, berseem and sorghum were grown by conventional flat planting whereas other crops were grown on raised bed planting. The experiment was conducted in randomized block design with four replications. Combined analysis of three years showed that diversification/interruption of rice -wheat system, once in three years, always enhanced the net return, when all crops (except rice) were grown on raised bed in a system approach. Inclusion of oilseed or pulses once in three years or intensification by growing vegetable pea in between rice and wheat or green gram after wheat showed higher return and sustainable value index (SVI) as compared to conventional rice-wheat system. Maximum SVI and benefit cost ratio was recorded in pigeon pea-wheat-rice-wheat-rice-wheat (CS8) crop sequence whereas maximum net return (Rs 60952/ha/year) was in rice-mustard-greengram-rice-wheat-greengram-rice-wheat-greengram crop sequence. Growing of berseem crop in the rotation reduced weed population in subsequent wheat cycle. Diversification and/or intensification options enhanced the protein content of wheat grain in subsequent crop cycle.

Media summary

In the Indo Gangetic plain, diversification of rice-wheat system could be possible by growing crops on raised beds, which will reduce the cost of cultivation and enhance profit of the farmers.

Key words

Cropping system, productivity, profitability, equivalent wheat yield and quality

Introduction

In South Asia, rice (*Oryza sativa* L.)- wheat (*Triticum aestivum* L. emend. Fiori and Paol.) crop sequence is the largest agriculture production system and occupies about 13.5 million hectare area including 10 million hectare in India, extending from Indo-Gangetic plain to Himalayan foothills. Rice and wheat contribute 80 % of total cereal production in the region. In India, approximately 23% and 40 % of total rice and wheat area, respectively, is represented by rice-wheat system alone (Timsina and Connor, 2001), which requires contrasting edaphic conditions. Rice is generally transplanted in puddled soil and is given continued submergence whereas wheat is grown in upland well-drained soils having good tilth. Continuous adoption of this system has been reported to decline soil and crop productivity (Nambiar and Abrol, 1989). Recently, analysis of several long-term experiments on rice-wheat (Dawe et al., 2000, Duxbury et al., 2000 and Yadav et al., 1998) indicated a negative average yield trend of rice (–0.02 t ha^{-1} yr^{-1} or 0.5 % yr^{-1}).

In India, most of the oilseed and pulse crops are grown on flat by broadcasting with flood irrigation and/or under continental monsoonal type climate resulting in low productivity. Generally, these crops are susceptible to water stagnation, experienced during rainy season or flood irrigation. This prompted us to investigate innovative planting techniques for these crops, which could be helpful in diversification of rice-wheat system. In 'bed planting technology', which was modified at DWR, Karnal, on the pattern of CIMMYT, Mexico, the crop is grown on top of bed and irrigation is applied in furrows. Additionally, these furrows can also be used for drainage when there is excess irrigation or rainfall (Sayre and Moreno Ramos, 1997). In a recent study conducted by Connor et al. (2003) in a farmers participatory trial in India showed that following crops planted on bed gave higher grain yield: maize (37.4 %), urdbean (33.6), mungbean (21.8 %), greenpeas (14.5 %), wheat (6.4 %), rice (6.2 %), pigeon pea (46.7 %) and gram (37.0 %) as compared to flat planting. Moreover, there was a saving of 26 to 42 % water under bed as compared to flat planting by various crops. This paper reports our study of a series of crop sequences that utilize bed planting and designed to diversify the conventional rice-wheat system.

Methods

Eight crop sequences (Table 1) were studied at Karnal during 2001-2003 in a randomized block design with four replications. The focus was to diversify/intensify the rice-wheat during first year and evaluate its effect on succeeding rice-wheat system in subsequent years. In this planting system, crops were grown on the top of 40 cm wide raised beds and irrigation was given in 30 cm wide furrows. Number of rows differed according to the crops. Three rows of wheat, two rows of vegetable pea, green gram, soybean, mustard and one row of maize and pigeon pea were grown on bed whereas other crops were cultivated as recommended. The varieties used for different crops were UPAS 120 (pigeon pea), SL 295 (soybean), PC 9 (sorghum) and Naveen (maize) in Kharif; Agrani (mustard), Arkel (vegetable pea), PBW 343 for timely and Raj 3765 for late sown (wheat) in Rabi; and Narendra 1 (green gram) in spring/summer season. Wheat after pigeon pea/maize/soybean/vegetable pea and green gram after mustard/wheat was sown just by reshaping of the beds to reduce the tillage cost. Green gram was incorporated into the soil after picking of mature pods. Irrigation was applied in furrows between two beds under bed planting whereas flood irrigation was given under flat planting.

Table 1: Year wise treatment details

Crop sequences (CS)	2000-2001 2003-2004	2001-2002	2002-2003
CS1	Rice-wheat	Rice-wheat	Rice-wheat
CS2	Rice-berseem	Rice-wheat	Rice-wheat
CS3	Sorghum(Fodder) -wheat (BED)-greengram (BED)	Rice-wheat (BED)	Rice-wheat (BED)
CS4	Rice-mustard (BED)-green gram (BED)	Rice-wheat (BED) -green gram (BED)	Rice-wheat (BED) -green gram (BED)
CS5	Soybean (BED) –wheat (BED)	Rice-wheat (BED)	Rice-wheat (BED)
CS6	Rice-vegetable pea (BED)-wheat (BED)- green gram (BED)	Rice- vegetable pea (BED)-wheat (BED)- green gram (BED)	Rice- vegetable pea (BED)-wheat (BED)- green gram (BED)
CS7	Maize (BED)- vegetable pea (BED) -wheat (BED)	Rice-wheat (BED) –green gram (BED)	Rice-wheat (BED) –green gram (BED)

CS8	Pigeon pea (BED)-wheat (BED)	Rice-wheat (BED)	Rice-wheat (BED)

The cost of cultivation was calculated by taking into account the prevailing price of inputs like fertilizer, seed, herbicides, irrigations, tillage operations, transportation charges, interest on working capital, risk factor, management charges and depreciation cost of implements. The returns were calculated by using the minimum support price of important crops and prevailing market price of vegetable pea, berseem, sorghum fodder and wheat straw etc on yearly basis. Different crop sequences were compared by converting the yield of all the crops in a sequence into equivalent wheat yield on price basis and then averaged. The minimum support prices were used for paddy, wheat, maize, soybean, pigeon pea, green gram and mustard whereas market prices were taken into consideration for wheat straw, berseem and sorghum fodder and green pea pod. Sustainability value index (SVI) was calculated as per procedure described by Singh et al. (1990)

SVI= $(\mu-\delta)/Y_{max}$, where, μ= mean of particular treatment in monetary terms, δ= standard deviation of particular treatment in monetary terms and Y_{max} = potential maximum monetary returns (by converting potential maximum yield in monetary terms) over the years.

Results

Systems productivity and profitability rather than individual crop yield play a vital role in determining the most useful and profitable crop sequence. Hence equivalent wheat yield and economics of each cropping sequence was calculated. Three years data of eight crop sequences showed significant differences in equivalent wheat yield in yearly as well as in pooled analysis (Table 2). The crop sequence CS4 (157.7 q/ha) and CS6 (155.9 q/ha) produced non-significant equivalent wheat yield, which was significantly higher than other crop sequences. On the other hand, lowest equivalent wheat yield was recorded in CS5 having soybean as a component crop. During the second year of crop cycle (2001-2002), the equivalent wheat yields of all the crop sequences were high due to high paddy yield compared to previous or subsequent year. Additionally, it was found that wheat grain protein content was higher in the crop sequences where the crop was diversified in previous year or intensified with inclusion of short duration crops.

Table 2: Equivalent wheat yield and protein content of crop sequences (mean of three years)

Cropping sequences	Equivalent wheat yield (q/ha)				Protein content* (%)
	2000-01	2001-02	2002-03	Pooled	
CS1	117.6	148.7	133.8	133.4	9.8
CS2	113.0	152.7	136.2	134.0	10.3
CS3	110.4	155.2	138.4	134.7	10.7
CS4	146.8	160.5	165.9	157.7	11.3
CS5	98.1	152.2	130.5	126.9	10.8

CS6	139.8	186.4	141.6	155.9	10.6
CS7	126.2	149.6	151.5	142.4	10.5
CS8	119.4	147.4	131.3	132.7	10.5
CD at 5 %	4.6	9.0	9.2	4.0	

*Mean of two years only

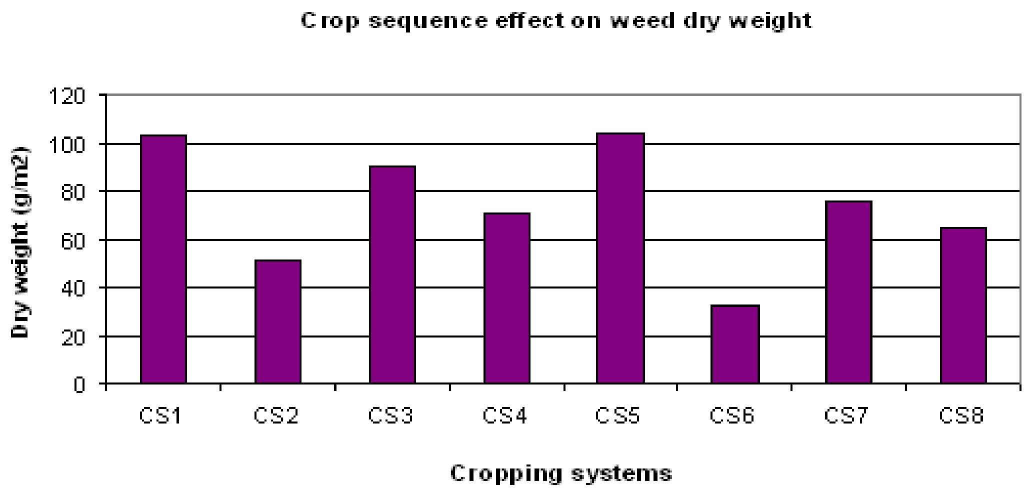
The economic analysis of different crop sequences showed that crop sequence CS4 recorded maximum total return/ha (Rs 97,860/) and net return/ha (Rs 60,952/-) compared to other crop sequences. Higher return in this crop sequence was due to inclusion of green gram in summer during all the three years and mustard in rabi during first year of study. The crop sequences CS7, CS8 and CS6 ranked 2nd, 3rd and 4th in net returns, respectively as compared to other crop sequences. Rice-vegetable pea-wheat crop sequence recorded 2nd highest total return but its highest cost of cultivation (Rs43,640/-) lead to 4th in net return. On the other hand, lowest total return/ha (Rs 78,796/-) was in CS5 owing to inclusion of soybean in first year and minimum cost of cultivation (Rs 27,686/-) in CS8 due to inclusion of pigeon pea. The crop sequence CS8 also recorded maximum benefit cost ratio (2.97) and ranked 3rd in net return (Rs 54,608/-) after CS4 and CS7. The maximum cost of cultivation incurred in CS6 that led to lowest benefit cost ratio (2.21). In nutshell, the crop sequences CS4, CS7, CS8 and CS6 recorded 23.13, 11.61, 10.31 and 7.16 % higher net return, respectively than CS1, rice-wheat system. In this study CS6 recorded 25 % higher net return as compared to the finding of Chauhan et al. (2001) where same sequence was practiced on flat planting. The crop sequence CS8 showed highest sustainability value index (0.81) followed by CS4 (0.70), which were much higher than SVI of rice-wheat system (0.65). Most of the crop rotations under study (except CS2 and CS3) showed higher SVI than conventional rice-wheat (CS1), which suggested that diversification of this system once in three years, or intensification could be sustainable.

Table 3: Economics (Rs/ha) and SVI of crop sequences (mean of three years)

Cropping sequences	Total return	Cost of cultivation	Net return	B:C	SVI
CS1	82756	33254	49502	2.49	0.645
CS2	83152	35405	47747	2.35	0.502
CS3	83605	34790	48814	2.40	0.444
CS4	97860	36906	60952	2.65	0.700
CS5	78796	28351	50448	2.78	0.609
CS6	96689	43640	53048	2.21	0.604
CS7	88395	33005	55390	2.68	0.688

CS8	82295	27686	54608	2.97	0.814

The effect of different crop sequences on weed control has been depicted in figure. Maximum dry weight of weeds was recorded in CS1 (rice-wheat-rice-wheat) and CS5 (soybean (bed)–wheat (bed)-rice-wheat (bed)) sequences, whereas minimum weight was recorded in CS6 (rice-pea-wheat) (32.6 g/m^2) followed by CS2 (rice-berseem-rice-wheat) (50.9 g/m^2) sequence. Lowest weed dry weight in CS^was due to very late wheat sowing whereas in CS2 wheat was sown under timely and flat planting condition. The reduction of weed dry weight in wheat crop in the latter sequence could be the effect of growing berseem crop during previous season.



Conclusion

The eight crop sequences studied showed that diversification of rice-wheat system could be possible with adoption of bed planting, especially by growing oilseed and pulses. This planting technique provides opportunity to take succeeding crop on the same bed just by reshaping. Crop sequences (CS4 to CS8) recorded higher net return and sustainable value index. The CS2 sequence reduced the weed population especially *Phalaris minor* in subsequent wheat cycle due to growing berseem in previous year.

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