Use of raised beds for increasing wheat production in rice-wheat cropping systems.

M.Ilias. Hossain[1], Craig Meisner[2], J.M. Duxbury[3], J.G. Lauren[3], M.M. Rahman[4], M.M. Meer[5] and M.H. Rashid[6]

[1]Scientific Officer (Agronomy), Regional Wheat Research Center, Rajshahi, Bangladesh, Email : iliasrwrc@yahoo.com
[2]NRG, Agronomist, CIMMYT, Bangladesh & Adjunct International Associate Professor, Cornell University, USA
[3]Professor, Soil Science Department, 917 Brad Field Hall, Cornell University, Ithaca, NY 14853 USA
[4]Principal Scientific Officer (Plant Breeding), Regional Wheat Research Center, Rajshahi, Bangladesh
[5]Principal Scientific Officer (Agronomy), Rice Research Institute, Regional Station, Rajshahi, Bangladesh
[6] Director, Wheat Research Center, Dinajpur Bangladesh

Abstract

The combined effects of tillage options, nitrogen management and levels on wheat yield (*Triticum aestivum* L.) as a winter crop on raised beds has increased productivity in the temperate world but has not been investigated in lesser developed countries, like Bangladesh. Therefore, a study was conducted during 3 wheat seasons at the Regional Wheat Research Center experimental field in Rajshahi NW Bangladesh, to compare the effects of tillage options, nitrogen levels and management strategies on wheat. In a strip-split plot design, two tillage systems were tested: manually prepared, permanent bed (PB) and conventionally tilled on the flat (CTF). Within each tillage system, two nitrogen management practices were used: broadcast, (BC) and furrow placement (FP) between wheat rows. Three N levels (50, 100 and 150% of recommended N) representing 60, 120 and 180 kg N/ha were used. PB increased wheat yield by 18% when compared with CTF. Predictably, wheat yields responded to N fertilizer rates in all years over all treatments. There were no statistical differences between the two nitrogen managements in 2 out of 3 years, *i.e*. BC and FP. Using raised beds at 150% N rate, yield was statistically higher in all years. Using raised beds at 50% N rate, yield was statistically equal to 150% conventionally tilled in all years. The data indicate that by using raised beds compared to conventional tillage, nitrogen uptake and efficiency can be increased. The maximum N uptake by the grain and straw was recorded in PB where the highest dose of N was applied. Permanent bed tillage systems also showed substantial water saving (32%) over the CTF treatments. Thus, in warmer areas where water resources are often limited and nutrient uptake and efficiencies are low, the use of raised beds in a permanent bed cropping system would be a distinct advantage.

Media Summary

Research in Bangladesh has shown that permanent raised beds produced 18% higher wheat yield and reduced irrigation water requirement by 32% relative to conventionally tilled wheat grown on the flat.

Key words

Tillage Options, Nitrogen levels, Wheat yields, Weeds, N-uptake, Lodging, Permanent beds.

Introduction

Rice-wheat is a major cropping system in Bangladesh. With the introduction of high yielding varieties of rice and wheat, double cropping of these two crops becomes feasible. Area and productivity under the two crops has increased (Hobbs and Morris, 1996). In high productivity, irrigated areas, rice is transplanted after puddling the fields (ploughing when fields are saturated). This practice destroys the soil physical structure that has implications for the following wheat crop (Hobbs *et al* 2000). Alternate methods of growing crops that require less labour, water, fertilizer etc. without sacrificing productivity are needed, especially in this crop sequence. Bed planting has been shown to improve water distribution and efficiency, fertilizer use efficiency, reduced weed infestation and lodging and it also reduces seed rate

without sacrificing yield (Hobbs *et al*. 2000). There are indications that the yield of crops on beds can be further increased through nutrient management and later irrigation because of the reduced risk of lodging (Sayre *et al*. 1997). We have hypothesized that dry seeding of rice and wheat in beds is an appropriate alternative for our country. Additionally, once the beds are established there are new opportunities to reduce crop turn-around time by re-using the same bed without tillage (Sayre, 2003). Research has shown that changing to a raised bed planting system with furrow irrigation from conventional flat planting with flood irrigation can give savings in water of 35%. It also eliminated the formation of a crust on the soil surface (Fahong, *et al*, 2003). The information available so far, regarding this practice is inadequate in Bangladesh. This paper reports on research undertaken to evaluate the effect of bed planting, N fertilizer management and rate on wheat yield.

Material and Methods

The experiment was carried at the research field of Regional Wheat Research Center of BARI, Shyampur, Rajshahi, Bangladesh during winter season of 2000-2001, 2001-2002, 2002-2003 using wheat variety Protiva. The soil contained low organic matter and had a low nitrogen supply capacity. Texturally the soil was silty clay loam and neutral in nature (BARC, 1995). This study compared the effect of tillage options, nitrogen levels and management strategies on wheat in strip-split plot design. Two tillage systems were tested: (i) manually prepared, permanent bed (PB) and (ii) conventionally tilled on the flat (CTF). Within each tillage system, two nitrogen management practices were used: broadcast, (BC) and furrow placement (FP) between wheat rows in sub plots and three levels of nitrogen 50, 100 and 150% of the recommended N (representing 60, 120 and 180 kg N/ha) in sub sub plots. A blanket dose of phosphorus (60 kg P/ha) from triple super phosphate, potassium (40 kg K/ha) from muriate of potash and sulfur (45 kg Ca/ha) from gypsum and two third of nitrogen was applied at the time of final land preparation. The remaining nitrogen was top dressed at CRI stage after 1st irrigation. The experiment was laid out in strip-split plot design with three replications. The plot dimension was 5m x 3m. Sufficient irrigation water was applied just to fill the furrow in PB and conventional flood irrigation was used in CTF. Different amounts of irrigation water were applied in PB and CTF plots. Three irrigations and one weeding were done. Data were collected from 15m^2 (whole plot) of each plot and statistically analyzed. Duncan's Multiple Range Test (DMRT) was used to compare the treatment findings.

Results

Effect of tillage Options

Significant differences in all the yield parameters were observed with different tillage options (Table 1). Bed planting showed significantly higher spike length, grains/spike & 1000 grain weight than conventional tillage. Grain yield (3.77 t/ha) was 18% higher in PB than in CTF due to higher yield components. However, plant/m^2, spike/m^2 and harvest index were not influenced by tillage options. Nitrogen placed in the row or broadcast did not influence the yield or yield attributes.

Effect of N-levels

Plant/m^2, spikes/m^2 and grain/spike all showed significant increases with each increase in N rate (Table 2). However, grain weight was only significantly increased at the highest N rate. Grain yield, biomass and harvest index all increased significantly with each increase in N rate.

Table 1: Effect of Tillage options on yield characters.

Tillage options	Initial plant population (plants/m^2)	Spike/m^2	Spike length (cm)	Grain/ spike	1000 grain wt.(g)	Grain yield (t/ha)	Biomass (t/ha)	HI (%)

Bed planting	207	283	9.8	45.7	45.9	3.77	9.38	38.6
Conventional	228	305	8.8	40.3	42.7	3.20	9.05	32.9
CV (%)	2.54	4.07	3.21	3.99	2.28	3.94	3.37	4.71

Table 2: Effect of N-levels on plant growth parameters.

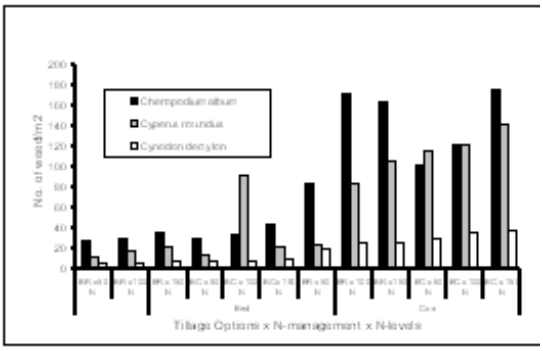
N-Levels	Initial plant population (plants/$m^{2)}$	Spike/m^2	Spike length (cm)	Grain/ spike	1000 grain wt.(g)	Grain yield (t/ha)	Biomass (t/ha)	HI (%)
50%	191 c	268 c	9.05 c	39.9 c	43.6 b	2.98 c	8.95 c	33.5 c
100%	219 b	305 b	9.36 b	42.4 b	43.7 b	3.47 b	9.62 b	36.2 b
150%	243 a	330 a	9.78 a	44.4 a	46.8 a	3.70 a	9.93 a	37.7 a
LSD?(0.05)	4.801	11.00	0.259	1.48	0.87	0.11	0.276	1.45

Combined effect of Tillage options, N-management and N-levels

There was no high order interaction of year, tillage, nitrogen management and levels on wheat yield. PB produced 10-15% higher grain yield in wheat when compared with CTF.

Weeds

Weed pressure was reduced in PB compared to CT treatments for the three years (Figure 1a). This was because the soil was not disturbed in the zero tillage system under PB. Three weed species namely *Chenopodium album*, *Cynodon dectylon* and *Cyperus rotundus* were found in the experimental plot. Maximum weed numbers were found in conventionally treated plot at 150% of the recommended N. Overall, yield loss due to weeds was estimated to be in 15-30% in wheat when grown in sequence.



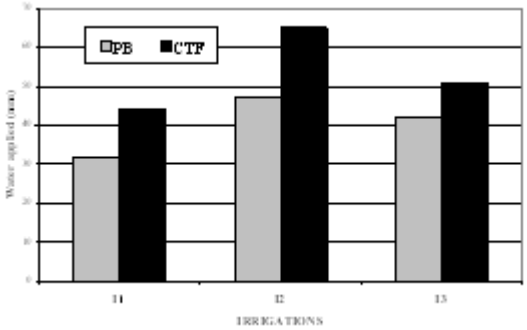


Figure-1 (a) Effect of tillage options, N-levels & management on weed species & no. of

(b) Effect of tillage options on irrigation water

weeds/m^2.

Irrigation

PB reduced irrigation water use by 32% in the three years (Figure 1b) relative to CTF. These advantages come from the fact that irrigation water advances faster in untilled (PB) soil than in a tilled soil (CTF) and less water percolation loss in PB.

Nitrogen Uptake

On average, N uptake in the grain was 44% higher in PB than in CTF (Table 3). A similar increase in N uptake (47%) occurred in the straw. These increases were attributed to better aeration in the surface soil in PB. Although consistent, the increase of 10% in FP when compared with BC was relatively small. There were relatively large increases in N uptake in the grain and straw as the fertilizer rate increased.

Table 3. Effect of the tillage (PB, CTF), N Management (BC, FP) and N level (50%, 100% and 150% recommended rate) on N uptake (kg/ha) in grain and straw.

Plant Part	N Management	PB			CTF		
		50%	100%	150%	50%	100%	150%
Grain	BC	94	108	126	54	72	86
	FP	98	111	132	58	88	107
	Mean	96	109	129	56	80	96
Straw	BC	32	38	42	18	26	31
	FP	36	42	46	22	33	38
	Mean	38	40	44	20	29	34

Conclusion

This study demonstrated that permanent beds increased wheat yield by 18% when compared with conventional tillage on the flat. The increase was attributed to more grain per spike and larger grain. Nitrogen uptake by the grain and straw was 45% higher on PB when compared with CTF. Permanent beds also reduced the irrigation water requirement by 32% and so increased irrigation efficiency. The site was very responsive to N fertilizer but the method of application (broadcast and furrow placement) had little effect on yield. It is likely that the permanent raised bed technique will have long-term soil physical benefits without sacrificing yield and is also likely to be more profitable. Permanent raised beds may also shorten the turn around time between crops, helping farmers to plant on time.

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