Validation of IPM strategy for rainfed upland rice (*Oryza sativa* L.) under medium rainfall plateau of Eastern India through on-farm trials

D. Maiti*, V. D. Shukla, M. Variar, Md. Mokhtar Mehdi and P. C. Rath

Central Rainfed Upland Rice Research Station, PB 48, Hazaribag-825 301, Jharkhand, India

ABSTRACT

Farmers' participatory on-farm trial was conducted on integrated pest management (IPM) schedule for upland rice during wet seasons (WS) of 2001, 02 and 03 in five locations of Hazaribag District (Chotanagpur plateau) in Jharkhand state. The IPM package (Improved practice; IP) was compared with the farmers' practice (FP) with both improved variety (Vandana) and traditional variety (Brown Gora; BG). Adoption of IPM package significantly enhanced rice grain yield in both improved (44.6%) and traditional (41.1%) varieties with highest average grain yield of 2.24 t ha^{-1} in Vandana grown under improved practice. Improved practice with variety Vandana also showed higher benefit : cost ratio (average 0.61) with higher return over paid out cost.

Key words: *Blast, brown spot, gundhi bug, integrated pest management, sheath rot, termites, upland rice, weeds*

The upland rice in medium rainfall (average 1150 mm annum^{-1}) plateau of Jharkhand state (comprising the Chotanagpur plateau), representing major uplands of Eastern India are grown under rainfed, unfavorable soil and weather conditions. Out of 6.5 m ha under upland rice in India, 5.2 m ha is in Eastern India. Upland rice in Chotanagpur plateau is predominantly grown as mono-crop in rotation of 3 (legume-rice-fallow) or 4 (legume-rice-millet-fallow) years. It is grown as direct sown crop under aerobic soil conditions. Weeds constitute the most economically important biotic constraint (pest) accounting for about 20% loss in grain yield. Other pests (insects and diseases) account for about 15-20% additional loss (Widowsky and O'Toole, 1990).

Aerobic soil conditions encourage grassy weed followed by sedges and broad leaved weeds in direct sown upland rice. Termites (*Odentotermes obesus* and *Micotermes obesi*) are most important insects in red, light textured soils with low water holding capacity under prolonged drought conditions. Rice gundhi bug (*Leptocorisa oratorius* and *L. acuta*) is important irrespective of upland conditions. The nymphs and adults of gundhi bug feed on milk of developing grains rendering them chaffy. Other minor insect pests occur only sporadically. Among diseases, brown spot (*Bipolaris oryzae*) is most important under poor soil conditions and prolonged drought spells. Blast (*Pyricularia grisea*), however, causes significant damage under better nutrient management. Sheath rot (*Sarocladium oryzae*) is another disease commonly noticed with lower intensity.

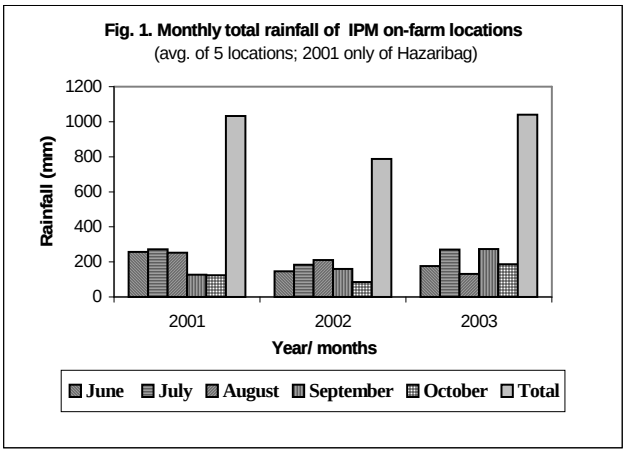
The IPM concept refers to 3 conditions associated with pest control. These are, (i) environmental impact of indiscriminate use of plant protection chemicals, (ii) introduction of management concept (reduction of pest population below threshold level, rather than total eradication to maintain ecological equilibrium) and (iii) the overall ecological considerations. The environmental consideration, however, is not that alarming in upland rice, unlike other ecosystems where over-use of pesticides has already been in practice. IPM has been considered not only to generate technology package but also to develop awareness about the IPM considerations among farmers to enable them to take *ad-hoc* decisions on additional intervention or withdrawal of schedules independently. So, attempts have been made in the present study to validate the IPM strategy through farmers' participatory on-farm trials in several villages during the wet seasons of 2001, 02 and 03. The IPM strategies for rainfed upland rice have earlier been

developed (Maiti *et al*., 1996) at this research station. Crop management practices with multiple benefits were considered with highest priority while formulating the IPM strategy.

MATERIALS AND METHODS

Traditional method of rice production (Farmers' practice; FP) was compared with full recommended package of integrated pest management i.e. improved practice (IP) during 2001, 02 and 03 wet seasons. Total number of 4 treatments were compared in randomized block design with 3 replications in plot size of 50 m^2 in 5 locations (villages). The locations were different in the three seasons. Statistical analysis (RCB) of data was done considering 15 replications (3 replications/ location^{-1} x 5 locations) in each year. The treatments were; T1= FP + Traditional variety (Brown Gora; BG), T2= IP + Traditional variety (BG), T3= FP + Improved variety (Vandana; V), T4= IP + Improved variety (V) (Table 1).

The rainfall during cropping season (June to October), in the experimental sites ranged between 787.2 to 1039.4 mm in 3 years (2001, 02 and 03), on an average (Fig. 1).



The soils of the experimental sites across years were red to gray sandy loam with acidic pH. The soils were poor in organic carbon, very low to moderate available P and adequate K.

RESULTS AND DISCUSION

Brown Gora (BG) allowed less biomass production of weeds at 15-25 and 45-60 days after emergence (DAE) over improved variety; Vandana (V). This was due to early vigor of BG that smothered weeds (Table 2). This reduction, however, was not statistically significant.

Table 1. Details of treatments

Parameter of practice	Farmers' practice	Improved practice
Seed treatment	Nil	MSS*[1]
N:P:K	5+20:14:0; N:P_2O_5:K_2O kg ha^{-1} (DAP & urea) DAP as basal, urea (20 kg N ha^{-1}) as top dressing (TD) at panicle initiation stage	20+20:20:20; N:P_2O_5:K_2O kg ha^{-1}(urea:SSP:MOP) Urea as TD twice; 25-30 days after emergence (DAE) and panicle initiation (PI) stage
Method of seeding	Broadcasting	Behind country plough
Method of P or P:K application	Broadcasting	Drilling in seed furrow
Weed management	1. Tiwai operation*[2] 2. One hand weeding at 25-30 DAE	1. Early post emergence spray of Butachlor @ 1.5 kg ha^{-1} 2. One hand weeding at 25-30 DAE
Plant Protection Furadan for termites,	Nil	MSS*[1] for Sheath rot; Need based application of ; Endosulfan for gundhi bug, Dithane M 45 for brown spot

*[1]Mechanical seed separation (MSS) of healthy seeds using 20% brine solution (Maiti *et al*., 1995)
*[2]Ploughing the field with country plough on 3rd day after seeding

Dosage of pesticides:
Machete 50 EC: 3 l ha^{-1} (butachlor @1.5 kg a.i. ha^{-1})
Furadan 3 G 33 kg ha^{-1} (carbafuran @ 1kg a.i ha^{-1})
Endosulfan 35 EC 1.2 l ha^{-1} (endosulfan @ 420 g a.i. ha^{-1})
Dithane M 45 1.2 kg ha^{-1} (mancozeb @ 540 g a i. ha^{-1})
Hinosan 50 EC 1 l ha^{-1} (ediphenphos @ 500 g a.i. ha^{-1}

Table 2. Influence of IPM schedule on weed biomass production

IPM treatment	Weed biomass (g m^{-2}) at maximum tillering stage*(15-25 DAE)			Weed biomass (g m^{-2}) at PI*(45-60 DAE)		
	2001	2002	2003	2001	2002	2003
FP+BG	68.3 a	14.9 a	32.3 a	151.7 a	40.1 a	107.7 a
IP+BG	29.1 b	6.2 b	19.6 a	77.7 b	20.1 b	22.8 b
FP+V	54.3 a	18.5 a	30.3 a	171.6 a	52.7 a	105.2 a
IP+V	35.1 b	6.8 b	15.3 a	99.5 b	22. 0 b	46.0 b

*****Replication means
Means in a column followed by common letters are not significantly different at 5% by DMRT

Early post emergence application of Butachlor in IP reduced weed biomass during initial growth period (15-25 DAE) over FP in both varieties in all 3 years. The reductions were statistically significant in 2001 and 2002 (Table 2). In later growth stages (45-60 DAE), however, similar trend with significant difference was observed in all 3 years. This could be attributed to combined effects of initial low population of weeds and subsequent hand weeding being more effective in IP.

Termite infestation was monitored during 2002 and 03. In 2002 the damage was more (Table 3) due to less soil moisture resulting from less rainfall (Fig. 1). BG had significantly less termite damage in 2002 with figuratively less damage in 2003. This indicated some short of tolerance of BG to termites. Need based application of Furadan in 2002 significantly reduced termite damage in IP in both varieties. Need based application of Endosulfan reduced damage caused by gundhi bug in IP in all 3 years (Table 3).

Vandana had less brown spot over BG in all 3 years (Table 4), indicating presence of field resistance in the improved variety. Need based application of Dithane M 45 (IP) in 2001 and 02, significantly reduced the disease in both the varieties. Since the disease onset was very late in 2003 no spraying was done as an IPM *ad hoc* decision. MSS seeds of IP significantly reduced sheath rot intensity in both the varieties in first two years (Table 4). Leaf blast and neck blast were negligible in all 3 years in both the varieties. This was due to field resistance of both the varieties to leaf blast and non

Table 3. Influence of IPM schedule on major insects damage

IPM treatment	Termite(% plant mortality at 50 DAE)		Gundhi bug(% grain damage at maturity)		
	2002	2003	2001	2002	2003
FP+BG	13.5 b	5.1 a	14.4 b	22.8 ab	4.9 a
IP+BG	11.0 a	5.9 a	18.6 a	18.4 a	3.3 a
FP+V	23.6 d	12.7 a	15.0 b	32.0 c	7.9 b
IP+V	17.8 c	9.8 a	15.0 b	28.1 bc	4.8 a

*****Replication means
Means in a column followed by common letters are not significantly different at 5% by DMRT

Table 4. Influence of IPM schedule on major diseases

IPM treatment	Brown spot (% disease intensity in flag leaf at maturity)			Sheath rot(% DI at maturity)		
	2001	2002	2003	2001	2002	2003
FP+BG	61.5 a	49.9 a	57.1 a	38.7 a	19.1 a	22.0 a
IP+BG	43.9 b	41.2 b	44.7 ab	14.6 b	10.0 c	19.4 a
FP+V	30.6 c	22.4 c	39.6 ab	38.9 a	18.4 b	27.8 a
IP+V	15.7 d	14.3 d	32.3 b	10.9 b	4.8 d	21.3 a

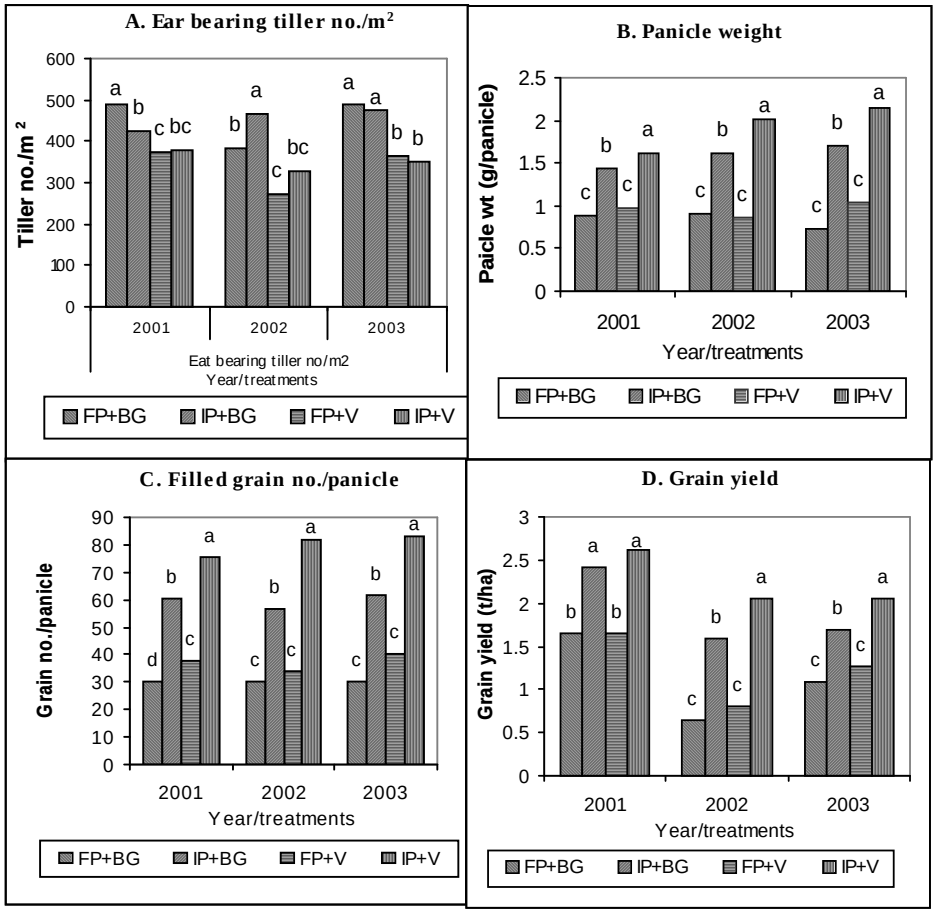
*****Replication means
Means in a column followed by common letters are not significantly different at 5% by DMRT

congenial weather conditions prevailed during flowering for neck blast infestation.

Influence of IP as compared to FP on yield attributing characters like tiller no., panicle no., panicle weight and filled grain number panicle^{-1} were studied in the two varieties. Productive tiller (ear bearing tillers) m^{-2} were more in the traditional variety (BG) than in the improved variety (Vandana) (Fig 2A). Effects of IP on productive tiller production were erratic across years. In moisture stress year (2002), however, IP induced higher production of productive tiller but in near normal years (2001 and 03) the trend was reverse. This was due to effects of IP that supported the crop to withstand moisture stress effects leading to reduction of productive tillers number. On the other hand, IP significantly improved both panicle weight (Fig 2B) and grain filling (Fig. 2C) over FP in both the varieties in all 3 years irrespective of moisture availability. This resulted into significantly higher grain yield in both varieties in 3 years (Fig. 2D). Improvement in panicle weight and grain filling were due to combined effects of direct IP on crop growth and better plant protection induced by pest management components of IP.

Higher benefit : cost ratio and gross return : variable cost ratio was obtained in IP over FP in both varieties with highest in IP + Vandana followed by IP + BG (Table 5). This indicated that agronomic and plant protection components of holistic IPM package are as important as varietal component of the total technology package.

The results of the on-farm trial confirmed that the holistic IPM package was valid under the farmers' conditions. The improved variety with improved practice resulted in highest yield which was



Columns designated by different letters in each year are significantly different at 5 % probability level by DMRT.

Fig 2. Influence of holistic IPM schedule on yield attributing characters and yield of upland rice (average of 5 villages)

Table 5. Economics of IPM

IPM treatment	Benefit : Cost			Gross return : Variable cost		
	2001	2002	2003	2001	2002	2003
FP+BG	0.08	-0.54	-0.29	1.06	0.46	0.70
IP+BG	0.72	0.03	0.32	1.65	1.03	1.32
FP+V	0.03	-0.44	-0.19	1.03	0.56	0.81
IP+V	0.94	0.26	0.63	2.00	1.26	1.63

economically viable and sustainable. Farmers may, however, continue traditional variety for test preference and still get economically viable production with improved practice of holistic IPM package.

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