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Growth and yield of direct-seeded basmati rice under different ICM modules

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Abstract

A field experiment was conducted during *Kharif* season of 2016, to study the plant height, dry matter accumulation at different growth stages and grain yield of direct-seeded basmati rice under different integrated crop management (ICM) modules. The experiment was laid out in a randomized block design with three replications and eight treatment combinations *i.e.*, ICM modules (ICM_1 to ICM_8). The study revealed that the plant height, dry matter accumulation at different growth stages and grain yield (4.03 t ha^{-1}) of direct-seeded basmati rice under different ICM modules were statistically and numerically higher in the ICM_7 *i.e.*, zero till (ZT)-summer mungbean residue retention (SMB-RR) + ZT- direct seeded rice (DSR) + wheat residue @ 3 t ha^{-1} + 75% of recommended dose of fertilizers @ 100:50:50 N: P_2O_5: K_2O kg ha^{-1} (RDF) (N through Zn coated urea / ZCU) + glyphosate as pre-plant (PP) @ 1 kg *a.i.* ha^{-1} + pretilachlor as pre-emergence (PE) @ 0.75 kg *a.i.* ha^{-1} followed by bispyribac-sodium @ 25 g *a.i.* ha^{-1} as post emergence (POE) at 25 days after sowing (DAS) + need based water management, disease and integrated pest management, with comparison to other modules. Direct seeding of rice in ICM_7 module increased grain yield by 4.13, 9.51 and 19.9% over direct seeding / transplanting under ICM_8 (ZT-SMB-RR + ZT- DSR + wheat residue @ 3 t ha^{-1} + 50% RDF + AMF + NPK-biofertilizers (liquid formulation) + glyphosate as PP @ 1 kg *a.i.* ha^{-1} + pretilachlor-PE @ 0.75 kg *a.i.* ha^{-1} *fb* bispyribac-sodium @ 25 g *a.i.* ha^{-1} as POE at 25 DAS + 1 HW), ICM_1 (Conventional transplanting / TPR + 100% of RDF + butachlor-PE @ 1 kg *a.i.* / ha + 1 HW) and ICM_2 (TPR + 75% RDF (N as ZCU) + NPK- biofertilizers + butachlor as PE @ 1 kg *a.i.* ha^{-1} + 1 HW) modules. This study suggests that zero-tilled direct-seeded rice in wheat and summer mungbean residue retained plots (ICM_7) with adoption of suitable weed management practices produced comparable yields as in transplanted rice (ICM_1).

Key words: Dry matter accumulation, integrated crop management, LAI, plant height.

Rice (*Oryza sativa* L.) constitutes principal food commodity for more than 50% of the global population (Fageria 2007; Dass *et al.* 2017) and governs the world food security. In India rice is the staple food for around 60% of the population and also governs country's food security. It contributes about 40% to the total food grain production of the country and accounts for 29.1% of calories and 22.4% of protein intake daily by Indian population (GRiSP, 2013). The higher water need for the conventional transplanted rice is alarmingly receding the ground water table in upper and trans Indo-Gangetic Plains Region (IGPR) every year (Das *et al.*, 2017) and inefficient

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input use and irrational production practices resulting in decline system productivity and resource-use-efficiency. Pumping excessive water for puddling during peak summer in north-western Indo-Gangetic plains leads to declining water table. In India, traditional transplanting practices having drawbacks like higher loss of water in puddling, more time and labour requirement, surface evaporation, root injury due to uprooting of seedling and adversely affect soil physical properties through puddling operations and more water requirement on other hand. Direct-seeded rice (DSR) is the potential alternative to the traditional transplanting and offers advantages like faster and easier planting, reduced labour and less drudgery, earlier crop maturity by 7-10 days, more efficient water use and less methane emission with higher profitability (Farooq *et al.*, 2008). In above context, DSR in integrated crop management (ICM) practices hold great promises which take into account economical, social and environment sustainability.

MATERIALS AND METHODS

The experiment was conducted at the experimental farm of ICAR-Indian Agricultural Research Institute (IARI), New Delhi, situated at latitude of 28°63' N and longitude of 77°15' E and 228.6 m above the mean sea level. During the crop growth period, the temperature and RH ranged between 21°C to 39.2°C and 42 to 98%, respectively. Total rainfall received during crop season was 1153.5 mm. The soil of experimental site was sandy-clay-loam in texture with pH 7.9. The experiment was laid out in randomized block design with 8 treatment combinations *i.e.* ICM modules with 3 replications. ICM modules include ICM_1: Conventional transplanting (TPR) + 100% of recommended dose of fertilizers @ 100:50:50 kg N: P_2O_5: K_2O ha^{-1} (RDF) + butachlor as pre-emergence (PE) @ 1 kg *a.i.* ha^{-1} + 1 hand-weeding (HW), ICM_2: TPR + 75% RDF (N as zinc coated urea / ZCU + NPK-biofertilizers (liquid formulation) + butachlor as PE @ 1 kg *a.i.* ha^{-1} + 1 HW, ICM_3: Direct seeded rice (DSR) + 100% of RDF (N through ZCU) + pretilachlor as PE @ 0.75 kg *a.i.* ha^{-1} followed by *(fb)* bispyribac-sodium @ 25 g *a.i.* ha^{-1} as post-emergence (POE) at 25 DAS, ICM_4: DSR + 75% RDF + AM fungi (AMF) + NPK-*bf* + pretilachlor as PE @ 0.75 kg *a.i.* ha^{-1} *fb* bispyribac-sodium @ 25 g *a.i.* ha^{-1} as POE at 25 DAS + 1 HW, ICM_5: Zero tillage (ZT)- DSR + wheat residue @ 3 t ha^{-1} + 100% of RDF (N through ZCU) + glyphosate as pre-plant application (PP) @ 1 kg *a.i.* ha^{-1} + pretilachlor as PE @ 0.75 kg *a.i.* ha^{-1} *fb* bispyribac-sodium @ 25 g *a.i.* ha^{-1} as POE at 25 DAS, ICM_6: ZT-DSR + wheat residue @ 3 t ha^{-1} + 75% RDF + AMF + NPK-*bf* + glyphosate as PP @ 1 kg *a.i.* ha^{-1} + pretilachlor-PE @ 0.75 kg *a.i.* ha^{-1} *fb* bispyribac-sodium @ 25 g *a.i.* ha^{-1} as POE at 25 DAS + 1 HW, ICM_7: ZT-summer mungbean residue retention (SMB-RR) + ZT- DSR + wheat residue @ 3 t ha^{-1} + 75% RDF (N through ZCU) + glyphosate as PP @ 1 kg *a.i.* ha^{-1} + pretilachlor-PE @ 0.75 kg *a.i.* ha^{-1} *fb* bispyribac-sodium @ 25 g *a.i.* / ha as POE at 25 DAS and ICM_8: ZT-SMB-RR + ZT- DSR + wheat residue @ 3 t ha^{-1} + 50% RDF + AMF + NPK-*bf* + glyphosate as PP @ 1 kg *a.i.* ha^{-1} + pretilachlor-PE @ 0.75 kg *a.i.* ha^{-1} *fb* bispyribac-sodium @ 25 g *a.i.* ha^{-1} as POE at 25 DAS + 1 HW and need based water disease pest management followed in all modules. The mungbean residue was retained using paraquat spray on standing mungbean crops 4-5 days before sowing of direct-seeded rice. Rice variety 'Pusa Basmati 1509' was sown using a seed rate of 30 kg ha^{-1}.

The plant height was measured from the base of the plant at ground surface to the tip of the tallest leaf / panicle. Heights of five plants were taken from each replication and the mean values were computed and expressed in cm. For dry matter accumulation plants from 50 cm row length from third row were cut close to ground from each plot at 30, 60 days after sowing / transplanting and at harvest and then samples were oven dried at 65 ± 5°C till constant weight was obtained. The dry weight was expressed in g m^{-2}. Leaf area meter (Model LICOR 3000, USA) was used to calculate leaf area (cm^2) of leaves detached from the plants selected for recording the dry matter accumulation. The leaves were separated from the stem and cleaned with tap water and after that with de-ionized water and then dried with tissue paper. The leaf area was expressed in cm^2 per plant. Leaf area index (LAI) was calculated at 30 and 60 DAS / DAT using the formula as suggested by Evans (1972). LAI was expressed as the ratio of leaf area (one side only) to the ground area occupied by the plant.

Finally at maturity plot wise crop was harvested and sun-dried for three days in the field and then after threshing and cleaning grain yield was recorded in t ha^{-1} and reported at 15% moisture content.

Results and Discussion

Plant height

Data pertaining to mean plant height of rice is presented in Table 1. Plant height increased consistently with the advancement of crop growth stages *i.e.* 30 days after sowing (DAS)/ transplanting (DAT) to harvest stage. Plant height at all three stages was significantly influenced under different integrated crop management (ICM) modules, however, ICM_7 a conservation agriculture (CA) based practice had tallest plants at all stages while ICM_2 a conventional transplanting based ICM module had shortest plants at 30 and 60 DAT. However, ICM_7 recorded significantly higher plant height over ICM_1, ICM_2, ICM_3, ICM_4, and ICM_6 at harvest but remained at par with ICM_5 and ICM_8.

Dry matter accumulation and LAI

Data pertaining to total dry matter accumulation (DMA) of rice is presented in Table 2. Dry matter accumulation (DMA) increased with increasing duration of crop from 30 DAS/ DAT to till harvest. At 30 and 60 DAS/DAT, the rice plants showed significant differences for total dry matter accumulation under different ICM modules but at harvest ICM modules did not differ significantly, although ICM_7 resulted in maximum DMA. At 30 DAS/ DAT, the highest DMA was recorded under ICM_7 (145.8 g m^{-2}) while ICM_2 exhibited lowest DMA (81.7 g m^{-2}). At 60 days, the highest DMA was found also in

Table 1. Effect of integrated crop management (ICM) modules on plant height of rice.

Treatment	Plant height (cm)		
	30 DAS/DAT*	60 DAS/DAT	Harvest
ICM_1	36.27	74.25	88.56
ICM_2	34.80	72.92	87.33
ICM_3	42.20	77.08	84.56
ICM_4	40.77	77.00	83.44
ICM_5	44.07	76.67	90.22
ICM_6	43.80	75.42	88.89
ICM_7	45.40	81.80	94.00
ICM_8	45.20	79.00	93.31
SEm±	0.86	1.42	1.54
CD (P=0.05)	2.60	4.31	4.68

*DAS: days after sowing; DAT: days after transplanting

Table 2. Dry matter accumulation, LAI and yield of rice under different ICM modules.

Treatment	DM accumulation (g m^{-2})			LAI		Yield (t ha^{-1})
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	
ICM_1	89.17	312.00	961.70	0.317	2.80	3.68
ICM_2	81.67	306.83	941.97	0.305	2.75	3.36
ICM_3	114.33	382.67	861.22	0.259	2.65	3.02
ICM_4	109.67	368.67	885.24	0.247	2.52	3.16
ICM_5	117.83	405.42	887.98	0.317	2.92	3.26
ICM_6	110.83	403.67	936.43	0.308	2.87	3.38
ICM_7	145.83	436.02	984.37	0.339	2.99	4.03
ICM_8	123.67	419.33	964.11	0.325	2.94	3.87
SEm±	11.18	28.33	48.52	0.005	0.09	0.155
CD (P=0.05)	33.91	85.92	NS	0.014	0.27	0.471

ICM_7 (436.1 g m^{-2}) and the lowest was recorded in ICM_2 (306.8 g m^{-2}). DMA at harvest was increased by 2.1, 2.4 and 4.5% with ICM_7 over ICM_8, ICM_1 and ICM_2.

Leaf area index (LAI) of rice recorded at 30 days interval *i.e.*, 30 DAS / DAT and 60 DAS / DAT (Table 2). In general, LAI increased with the advancement of crop growth stages. Both at 30 and 60 DAS / DAT, the rice plants showed significant differences for LAI under different ICM modules; however, ICM_7 conservation agriculture (CA) based ICM module recorded the highest LAI at both stages closely followed by ICM_8, ICM_1 and ICM_5.

Grain yield

Data pertaining to the effect of different ICM modules on grain yield of rice is presented in Table 2. The results revealed that seed yield was significantly higher in ICM_7 (4.03 t ha^{-1}), a CA based ICM module which was followed by ICM_8, ICM_1 and ICM_6. The plots under ICM_7 increased rice yield significantly as compared to the under ICM_2 to ICM_6. Although, direct-seeded rice under ICM_7 produced highest yield but it was remained statistically similar to transplanted rice under ICM_1 module. Similarly, ICM_7 (zero-tilled direct-seeded rice with wheat and mungbean residue) was very close to ICM_8. Direct seeding of rice in ICM_7 module increased grain yield by 4.13, 9.51 and 19.9% over direct seeding / transplanting under ICM_8, ICM_1 and ICM_2 modules. This study suggests that zero-tilled direct-seeded rice in wheat and summer mungbean residue retention with suitable weed management practices produced comparable yield as in transplanted rice (ICM_1). This superior performance may be attributed to better availability of macro and micro nutrients, better soil physical and biological properties which ultimately provide balanced nutrition to the crop plants (Choudhary and Suri, 2014; Dass *et al.*, 2014).

Conclusion

The study clearly demonstrated that zero-tilled direct seeded rice in conjunction with residue retention and weed management practices proved to be an alternate viable option for transplanted rice in realizing better growth and yield. Overall, ICM_7 module was the best performer and it can be useful to farmers. These are important findings for improving rice productivity in the Indo-Gangetic plains of North-western India.

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