Indian Journal of Agricultural Sciences **80** (1): 24–28, January 2010

Effect of rice (*Oryza sativa*) crop establishment technique on succeeding crops

K S GANGWAR and H R SINGH

Project Directorate for Farming Systems Research, Modipuram, Meerut, Uttar Pradesh 250 110

Received: 14 November 2009; Accepted: 29 October 2009

ABSTRACT

A field study was undertaken during 2003–07 at Modipuram to assess the effect of rice (*Oryza sativa* L.) crop establishment methods (direct seeding, drum seeding, mechanical transplanting puddle, mechanical transplanting un puddle and manual transplanting) on 'PHB 71' hybrid rice and their carry over effect on wheat (*Triticum aestivum* L. emend. Fiori & Paol), mustard (*Brassica juncea* L. Czernj. Coss), and Chickpea (*Cicer arietinum* L.) yield and soil properties. Maximum mean yield of rice (8.5 tonnes/ha) was obtained with drum seeding-wet bed. The direct seeding-dry bed adopted in rice crop resulted in higher yield of succeeding crops of wheat (5.71 tonnes/ha), chickpea (2.20 tonnes/ha) and mustard (1.86 tonnes/ha). Significantly higher weed intensify and weed dry matter were recorded in mustard under direct seeding-dry bed. Wet bed changes in soil physio-chemical properties after fours year indicated that the highest infiltration rate (1.32 cm/ha) and lowest bulk density (1.46 Mg/M^3) were recorded under direct seeding-dry bed, while organic C, total N, available P and K were increased by 4.08, 31.82, 7.59 and 30.5% over their initial content under mechanical transplanting–puddle.

Key words: Bulk density, Crop yield, Direct dry seeding, Drum seeding, Infiltration, Mechanical and manual transplanting

Rice is the principal food for Indian people, being grown in about 42.0 million ha with a production of 91.05 million tonnes (Economic Survey 2007). There is enormous variability in rice yield, ranging from 0.95 tonnes/ha to 3.55 tones/ha. The area under direct-seeded rice in India, Pakistan and Bangladesh is 14.2 million ha of the total rice area of 55.5 million ha (Gupta *et al.* 2006). Presently, rice is mainly grown as transplanted crop in puddle field. This technique is however, cumbersome, labour intensive and requires continuous ponding of water. This in turn, leads to nutrient loss through leaching. Pudding over decades has led to deterioration in soil physical properties through structural breakdown of soil aggregates and capillary pore, and clay dispersion. Puddle form a compacted layer (plough pan) which restricts the percolation of water and create temporary waterlogging resulting poor root penetration and growth of succeeding crops (Tomar *et al.* 2006). The direct seeding in rows under dry conditions offers a useful option to reduce the adverse effect of puddle. This method is being practised in many developed countries where manpower is expensive. Direct-seeded rice has good potential to replace traditional transplanted rice in areas where fields are well drained and farmers can adopt good weed control measures. Evolution of a large number of high-yielding and short-duration varieties coupled with advent of efficient tools and implements for tillage has paved the path to substitute wheat with a number of crops like pulses (chickpea) and oilseeds (mustard) as an alternative cropping system after cereals. In addition, the legumes are reported to have favourable impact on the soil fertility and help in increasing the yield of succeeding rice crop. The present investigation was therefore, undertaken to study the effect of crop establishment methods on the performance of hybrid rice and subsequent crops.

[1]Senior Scientist (Agronomy) Project Directorate for farming Systems Research, Modipuram, Meerut Utter Pradesh 250 110.

[2]Associate Director (Agronomy) SVPUA&T, Modipuram (Meerut).

MATERIALS AND METHODS

The field study was conducted for four years (2003–07) at Modipuram (29° 4'N, 77° 46'E and 237 m above sea level). The climate is semi-arid sub-tropical, characterized by hot summers and cold winters. The hottest months are May and June (maximum temperature 45–46°C), whereas during December and January, the minimum temperature often goes below 5° C. The average annual rainfall is 863 mm, 75–80% of which is received through the north-west monsoon during July –September. The soil was sandy loam in texture (64.2% sand, 18.5% silt and 17.3% clay) having *p*H 8.1, electrical conductivity 0.44 dS/m, organic carbon 0.49%, available N 74 mg/kg, available P 12.6 mg/kg and available K 69.1 mg/kg of soil.

Five rice crop establishment methods, viz direct seeding-dry bed, drum seeding-wet bed, mechanical transplanting puddle, mechanical transplanting unpuddle and manual transplanting puddle in rice and further these plots were divided into three plots for growing wheat *(Triticum aestivum* L.*),* chickpea *(Cicer aritinum* L.) and mustard (*Brassica juncea* L. Czernj Coss.) were tested in randomized block design with four replications. The 'PHB 71' hybrid rice was sown at 20 cm apart @ 30 kg seed/ha. In *rabi,* 'PBW 343' wheat, 'Avrodhi' chickpea and 'Varuna' mustard were grown at 20, 30 and 45 cm apart using 100, 75 and 6 kg seed rate/ha, respectively.

The nutrients applied for hybrid rice involved, 150 kg N + 34.93 kg P + 50 kg K + 5.5 kg $ZnSO_4$/ha. P, K and Zn were applied as basal, while N applied in four splits (1/4 as basal, ¼ at mid-tillering, ¼ at active tillering and ¼ at panicle initiatrion). Two sprays of $FeSO_4$ (0.2% solution) at 30 and 40 days after planting were also given to direct- and drum-seeded rice to correct iron deficiency. During *rabi* 120 kg N/ha each to wheat and mustard and 20 kg N/ha to chickpea along with 34.93 kg P + 50 kg K/ha to each crop were applied. P and K were applied as basal with N in three splits to wheat (1/2 basal, ¼ at first irrigation and ¼ at ear emergence), three splits to mustard (1/4 as basal, , ¼ at first irrigation and, ¼ at flowering) and whole N to chickpea as basal.

All the crops were grown under assured irrigated conditions. In hybrid rice, 12 irrigation with 5 cm standing water were applied. The mustard received two irrigations at 30 and 60 days after sowing while chickpea received one at pod formation stage. Direct and drum seeding was done on 15 June, while, mechanical and manual transplanting on 7 July. Wheat, mustard and chickpea were sown on 22 October after direct- and drum-seeded rice and on 30 October after mechanical and manual transplanted rice. To control weeds in hybrid rice, pendemethalin @ 1.25 kg/ha mixed in 800 liters of water was sprayed second day after sowing under direct seeding (dry bed) and butacholor @ 1.5 kg ai/ha at 3 days after sowing under drum seeding (wet bed) and mechanical and manual transplanting stand. In addition, one hand weeding was also done 30 days after sowing in all the treatments. In wheat, isoproturon @ 1.25 kg/ha in 600 liters of water was applied after 30 days of sowing. In mustard and chickpea weeds were controlled by one hand weeding at 30 days after sowing. Harvesting of hybrid rice was done on 15 October (direct and drum seeding) and on 25 October (mechanical and manual transplanting), while of succeeding crops in first week of April.

Soil samples were drawn from the 0–15 cm soil layer by a core sampler, 80 mm diameter at 5 places in the experimental field. These 5 samples were thoroughly mixed bulked. The representative sample was drawn for determination of organic C, total N (modified maco-Kjeldal method), extractable P (0.5 M $NaHCO_3$ *p*H 8.5) and extractable K (1N NH4 OAC) by following standard procedures.

RESULTS AND DISCUSSION

Crop growth

The shoot dry matter accumulation and leaf area index in rice, wheat, mustard and chickpea were affected significantly due to different rice crop establishment methods. The maximum dry matter accumulation (507 g/m) and leaf area index (4.82) were accrued in rice under drum seeding. It was statistically at par with direct seeding (unpuddle) and mechanical transplanting (puddle) but higher than mechanical transplanting (unpuddle) and manual transplanting (puddle). Significantly greater shoot dry matter and leaf area index was obtained in succeeding crop of wheat, chickpea and mustard grown after direct-seeded rice which were similar to drum seeding and mechanical transplanting (unpuddle). The more dry matter in unpuddle rice was the result of more plant population/unit area due to better dry/wet tillage in direct/drum-seeded rice over puddle rice (manual transplanting-traditional practices). The leaf are index directly linked with day matter accumulation because it is an important index to strengthen the source-sink relationship (Gill *et al.* 2006). Consistently, higher dry matter accumulation and leaf area index were recorded in succeeding crops when direct seeding of rice was adopted in the proceeding crop as compared to other methods. This superior performance of subsequent crop may be due to better availability of soil moisture and nutrients under direct seeding (Tomer *et al.* 2006).

Grain yield

The grain yield of rice and succeeding crops of wheat, chickpea and mustard was influenced significantly by different rice crop establishment practices (Table 1). The highest pooled yield of hybrid rice was recorded with drum seeding (wet bed), followed by direct seeding under dry bed and mechanical transplanting – puddle compared to manual transplanting – puddle and mechanical transplanting in unpuddle conditions. The more grain yield under drum/direct seeding rice was mainly due to more number of effective tillers/m^2. Direct seeding (dry bed) adopted in preceding rice crop resulted higher pooled yield of wheat (5.71 tonnes/ha), chickpea (2.20 tonnes/ha) and mustard (1.86 tonnes/ha), while lowest yield of wheat, chickpea and mustard was recorded in mechanical transplanting – puddle. Similarly, higher values of yield-contributing characters such as number of panicles/m^2, number of grains/panicle and 1000-grain weight in rice under drum seeding (wet bed), while number of ears/m^2, number of grain/ear, 1000-grain weight in wheat, pods/plant, seeds/pod and 1000-grain weight in chickpea, siliquae/plant, seeds/siliquae and 1000-grain weight in mustard were recorded in succeeding crops under direct seeding dry bed. This was mainly attributable to relatively greater compaction of puddle soil under manual and mechanical transplanting (puddle) and its carry over effect on succeeding crops, ie sown wheat, mustard and chickpea

which demonstrated the disadvantage of puddling and transplanting on succeeding crops. Rice equivalent yield (REY tonnes/ha year) of different cropping systems in terms of systems productivity showed that the maximum systems productivity (14.80 tonnes/ha) was obtained in drum seeding (wet bed), followed by direct seeding-dry bed (14.73 tonnes/ha) under rice–wheat cropping system. The higher systems productivity in this cropping system was due to higher yield of both the crops. The highest system profitability (Rs 52 862/ha) was recorded in drum seeding (wet bed), followed by direct seeding–dry bed, (Rs 52 160/ha) under rice–chickpea and rice–mustard cropping systems, respectively. This might be due to fairly good yield and high price of chickpea and mustard. However, lowest systems productivity and profitability were recorded under manual transplanting in rice–chickpea cropping system.

Weeds dry matter

Among the major weeds, *Eclipta alba* was the most predominant weed infected the rice crop, followed by *Enchinochloa crus-galli* L. Beaur. and *Cyperus iria* L., while other species were of minor significance. Direct-seeded rice recorded the highest density and their dry matter as compared to other methods of crop establishment. Lowest weed

Table 1 Effect of crop establishment methods on yield, system productivity and system profitability of hybrid rice-based systems

Treatment	Crop yield (tonnes/ha)				System productivity (REY tonnes/ha/years)			System profitability (Rs/ha/years)		
	Rice	Wheat	Chickpea	Mustard	Rice–wheat	Rice–chickpea	Rice–mustard	Rice–wheat	Rice–chickpea	Rice–mustard
Direct seeding – dry bed	8.29	5.71 (6.44)	2.20 (5.99)	1.86 (6.08)	14.73	14.28	14.37	49 655	51 297	52 106
Drum seeding – wet bed	8.50	5.59 (6.30)	2.15 (5.87)	1.73 (5.66)	14.80	14.37	14.16	51 107	52 862	51 930
Mechanical transplanting – puddle	8.20	4.86 (5.48)	1.52 (4.13)	1.41 (4.60)	13.68	12.33	12.80	42 494	38 634	41 890
Mechanical transplanting – un puddle	7.63	5.55 (6.26)	2.04 (5.55)	1.70 (5.55)	13.88	13.14	13.17	44 111	44 186	44 509
Manual transplanting – puddle	7.72	5.00 (5.63)	1.57 (4.28)	1.45 (4.73)	13.35	11.99	12.45	40 289	36 381	39 546
SEm (±)	0.34	0.31	0.26	0.16	0.53	0.88	0.69	3 808	5 942	4 770
CD (*P*=0.05)	0.73	0.68	0.57	0.34	1.15	1.93	1.51	8 298	12 947	10 393

Figures in parenthesis are the rice equivalent yield of individual crop.

Table 2 Yield-attributing characters of rice, wheat, chickpea and mustard as influenced by crop establishment methods (pooled data of 4 years)

Treatment	Rice			Wheat			Chickpea			Mustard		
	Panicles/m^2	Grains/panicle	1 000–grain wt (g)	Ears/m^2	Grains/ear	1 000–grain wt. (g)	Pods/plant	Seeds/pod	1000–grain wt. (g)	Siliqua/plant	Seeds/siliqua	1 000–grain wt. (g)
Direct seeding – dry bed	363	132	27.1	295	49.72	37.82	72.2	1.77	169.6	225.9	12.71	4.76
Drum seeding – wet bed	383	141	27.7	285	48.14	37.59	70.83	1.73	167.5	223.1	12.20	4.62
Mechanical transplanting – puddle	354	131	26.7	272	41.40	36.95	62.32	1.51	161.7	187.3	8.57	3.77
Mechanical transplanting – unpuddle	300	113	26.3	283	46.54	37.37	69.97	1.68	166.1	212.9	10.68	4.51
Manual transplanting – puddle	333	122	26.5	276	41.78	37.06	62.29	1.55	162.5	184.0	8.83	3.70
SEm (±)	3.81	3.10	0.30	1.31	0.30	0.08	0.66	0.01	0.65	0.82	0.22	0.02
CD (*P*=0.05)	11.02	9.16	0.90	4.07	0.91	0.24	1.93	0.04	1.89	2.40	0.64	0.06

Table 3 Weed intensity and their dry matter in rice, wheat, chickpea and mustard as influenced by crop establishment methods at 30 days after planting (pooled data of 4 years)

Treatment to rice	Weed intensity/m^2				Weed dry matter (g/m^2)			
	Rice	Wheat	Chickpea	Mustard	Rice	Wheat	Chickpea	Mustard
Direct seeding – dry bed	17.67 (4.25)	21.00 (4.63)	31.66 (5.67)	111.90 (10.60)	3.58	3.56	3.40	6.59
Drum seeding – wet bed	14.29 (3.83)	18.89 (4.40)	29.66 (5.50)	67.00 (8.23)	2.91	2.24	3.26	5.54
Mechanical transplanting – puddle	2.33 (1.57)	15.11 (3.93)	15.78 (3.93)	22.90 (4.84)	0.87	2.12	2.29	3.89
Mechanical transplanting – unpuddle	3.59 (1.94)	18.67 (4.37)	29.11 (5.49)	34.73 (5.94)	1.24	2.63	3.22	4.40
Manual transplanting – puddle	7.69 (2.82)	17.67 (4.25)	22.46 (4.78)	31.10 (5.62)	1.98	2.09	3.02	4.23
SEm (±)	0.21	0.28	0.36	0.31	0.06	0.07	0.08	0.34
CD (*P*=0.05)	0.62	0.81	1.04	0.87	0.17	0.22	0.20	0.99

Figures in parenthesis indicated original value "X +0.5

Table 4 Changes in physio-chemical properties of soil after 4 years as influenced by crop establishment methods

Treatment to rice	Infiltration rate (cm/hr)	Bulk density (Mg/m^3)	Organic carbon (%)	Total N (%)	Available P (kg/ha)	Available K (kg/ha)
Direct seeding – dry bed	1.32	1.46	0.47	0.025	20.96	151.93
Drum seeding – wet bed	1.11	1.46	0.48	0.026	21.56	154.12
Mechanical transplanting – puddle	0.70	1.49	0.51	0.029	23.28	168.30
Mechanical transplanting – unpuddle	1.01	1.47	0.49	0.025	21.60	158.60
Manual transplanting – puddle	0.82	1.48	0.50	0.028	22.67	166.23
SEm (±)	0.07	0.01	0.001	0.002	0.63	2.09
CD (*P*=0.05)	0.28	0.03	0.09	0.006	1.82	6.07

intensity and weed dry matter were noticed in puddle soil. In wheat, chickpea and mustard, majority of weeds were: *Phalaris minor* L., *Anagallis arvensis* L., *Cyperus rotundus* L., *Chenopodium album* L., *Melilotus indica* L., and *Lathyrus aphaca* L. Significantly higher and lower weed density and weed dry matter were recorded in succeeding crops under the similar treatment as that of preceding crops. This might be due to greater weed competition than crop plants and weeds come up vigorously under direct seeding dry bed than in puddle conditions because puddling avoided burial of weed seeds and preserve inside the soil (Singh and Singh 2006).

Physico-chemical properties

Significantly higher infiltration rate (1.32 cm/ha) was recorded in direct seeding (dry bed) and lowest (0.70 cm/ha) under mechanical transplanting puddle. The lower and higher values of bulk density (1.46–1.49 Mg/m^3) were recorded in direct seeding dry bed and mechanical transplanting-puddle conditions, respectively (Table 5). The higher infiltration rate and lower bulk density under direct seeding dry bed revealed the quality of seed-bed preparation which permitted more amount of water to perpetrate into the field and the succeeding crops grow vigorously. The soil organic C in 0–15 cm increased by 4% in mechanical transplanting-puddle and it decreased by 3.40% under direct seeding, dry wet. The higher organic carbon in mechanical transplanting – puddle condition was because of flooding and puddling of rice field which caused major chemical changes in the soil that affect transformation and availability of nutrients, organic C dynamics and growth of rice and subsequent crops. Puddle creates an aerobiosis in soil which, in turn helps in relative proliferation of anaerobic micro flora responsible for slow degradation of soil organic carbon in contrast to aerobic soil (Takahasi *et al*. 2003). The total N, available P and K content of surface soil (0–15 cm) increased by 32, 7, 59 and 30% over initial values under mechanical transplanting (puddle) soil on account of increased availability of these nutrients (Singh *et al.* 2002)

Drum/direct-seeded rice for obtaining higher grain yield of hybrid rice growing to better land preparation, more infiltration rate, low bulk density and better crop establishment while for succeeding crops greater yield advantage due to favourable soil physical environment which enhanced shoot dry matter accumulation, leaf area index and overall growth of crop plants.

REFERENCES

Economic Survey. 2007. Ministry of Finance, Govt. of India.

Gill M S, Kumar Pardeep and Kumar A. 2006. Growth and yield of direct seeded rice (O*ryza sativa*) as influenced by seeding techynique and seed rate under inrrigated conditions. *Indian Journal of Agronomy* **51** (4): 283–7.

Gupta R K, Ladha J K, Singh S, Singh R G, Jat M L, Saharawat Y,

Singh V P, Singh S S, Singh G, Sah G, Gathala M, Sharma R K, Gill M S, Alam Murshad, Mujeeb Ur Rehman Hafiz, Singh U P, Mann, Riaz A Pathak, Chauhan H, Bhattacharya B S and Malik P R K. 2006. Production Technology for direct seeded rice. *Rice–Wheat Consortium for the Indogangetic Plains*, pp 16. New Delhi.

Singh P and Singh S S. 2006. Effect of establishment method, fertility levels and weed management practices on aromatic rice (*Oryza sativa*). *Indian Journal of Agronomy* **51** (4): 288–92.

Singh V K, Sharma B B and Dwivedi B S 2002. The impact of diversification of rice-wheat cropping system on crop productivity and soil fertility. *Journal of Agricultural Sciences* **139**: 405–12.

Takahasi S and Lienasono Ono S. 2003. Short and long-term effects of rice straw application on uptake by crop and mineralization under flooded and upland condition. *Plant and Soil* **251**: 291–301.

Tomar R K, Singh D, Gangwar K S, Garg R N, Gupta V K, Sahoo R N, Chakraborty D and Kalra Naveen. 2006. Influence of tillage systems and moisture regims on soil physical environment, growth and productivity of rice-wheat system in upper gangatic plains of Western Uttar Pradesh. *The Indian Journal of Crop Science* **1** (1& 2): 146–50.