Journal of Crop and Weed, 10(1):56-60(2014)

On-farm assessment of direct-seeded rice production system under central Punjab conditions

A. S. SIDHU, R. KOONER AND A. VERMA

Krishi Vigyan Kendra, Rupnagar and Ludhiana, Punjab,
Directorate of Extension Education,
Punjab Agricultural University, Ludhiana-141 004, Punjab

Received :18-12-2013, Revised:21-4-2014, Accepted:7-5-2014

ABSTRACT

The field experiments were conducted at farmer's fields at nine different locations in district Ludhiana and Rupnagar of central Punjab during kharif 2012. Puddled Transplanted Rice (PTR) and Direct Seeded Rice (DSR) production systems were compared in respect of weed infestation, grain yield and economics. The results revealed that plant height, panicle length, number of grains per panicle, number of empty grains per panicle and test weight of two systems was not significantly affected. Average Plant population/m^2 was significantly more in DSR (24.0) than PTR (19.2). Number of effective tillers which are the major determinants of grain yield were significantly higher in puddled transplanted rice (272.9/m^2) than direct seeded rice (263.3/ m^2). Significantly higher grain yield (55.56 q/ha) was observed with Puddled Transplanted Rice (PTR) than Direct Seeded Rice (53.72 q/ha) when averaged over 9 locations. The population of weeds at 30 days after sowing was significantly more in DSR (24.3/m^2) than PTR (13.8/m^2). The average net returns under PTR (47.71 X 10^3 Rs/ha) were higher than DSR (47.08 X 10^3 Rs/ha) but benefit cost ratio was significantly more in DSR plots.

Keywords: Benefit cost ratio, direct seeded rice, effective tillers, grain yield and puddled transplanted rice

Rice (*Oryza sativa* L.)-wheat (*Triticum aesitivum* L. emend. Fiori & Paol.) is the pre-dominant cropping system in Northern India alone occupying 13.5 million hectare in the Indo-Gangetic Plain (IGP) of South Asia (Gupta and Seth, 2007). The productivity of rice-wheat rotation of the Indo-Gangetic plain is critical to India's food security. Rice (*Oryza sativa* L.) is a major food of the world and more than half of the population subsists on it (Biswas and Bhattacharya, 2013). It is the main livelihood of rural population living in subtropical and tropical Asia and hundreds of millions people living in Africa and Latin America. Rice is generally cultivated in northern India by transplanting 25-30 days old nursery seedlings in to the puddled field which requires heavy amount of labour in raising, uprooting of seedlings, puddling and transplanting in the main field leading to a substantial rise in the production cost. Transplanting of rice seedlings into flooded fields gives the crop a major competitive advantage over weeds as the majority of the weeds are suppressed by the standing water. Rising costs of labour, high water use and energy required for nursery establishment, puddling of fields and transplanting, coupled with labour scarcity during the peak period of activity are the compelling factors to seek an alternative to transplanting of rice. Before the start of rice cultivation during 1960's, the level of underground water in various districts of Punjab was shallow (varied from 5-20 feet in different parts). But during the green revolution era, due to cultivation of short duration high yielding fertilizer responsive varieties of wheat and rice, negative effect on level of underground water table was observed. Indiscriminate cultivation of rice was main culprit for declining water table. The scientists have reported a decline of 55 cm per year in the underground water table from 1993 to 2007.

Direct seeding is an alternative rice cultivation technology that can reduce the labour and energy requirements for crop establishment and the demand for irrigation water. It offers faster and easier planting, reduces labour requirement, earlier crop maturity by 7– 10 days, more efficient water use and higher tolerance of water deficit, less methane emission and often higher profit in areas with an assured water supply. In order to check the declining water table, a new technique of direct-seeding is now fast replacing traditional transplanted rice in areas with good drainage and irrigation facilities (Balasubramanian and Hill, 2000). The alternative to puddling and transplanting could be different methods of direct seeding because these do not require heavy amount of labour and crop matures early (7-10 days) than transplanted allowing timely planting of succeeding wheat crop (Giri, 1998). The water productivity of direct seeded rice was more than that of crop transplanted on the day of direct sowing had an

Email: amansidhu_80@rediffmail.com

advantage of 25 days and it was less by 0.025 kg grains m^{-2} (Gill, 2008). To harness higher yield of rice, plant population plays an important role. The recommended plant population density for transplanted rice is 33 hills m^{-2} whereas under farmer's fields 20-24 hills m^{-2} are kept (AICRP, 2006). Direct seeding of rice ensures recommended plant population. However, for cultivation of direct-seeded rice, weeds are major hurdle for its success (Rao *et al*., 2007: Rao and Nagamani, 2007) as nearly all *kharif* season weeds depending upon seed bank in the field infest this crop. Weeds pose major problem in rice production due to the prevalence of congenial atmosphere during *kharif* season and uncontrolled weeds compete with dry-seeded rice and reduce yield upto 30.17 % (Singh *et al:* 2005). With direct seeded rice, water saving to the extent of 20-30 per cent has been reported by Tabbal *et. al.* (2002). Farmers commonly face several constraints related to transplanted rice *e.g.*

1. lack of labour in time,
2. late planting of rice,
3. drudgery for farm workers,
4. low rice plant populations,
5. high production costs,
6. high water use for puddling,
7. restricted root system of wheat due to puddling for rice and
8. adverse effects of puddling on soil physical conditions,

India's agriculture has the problems of limited labour availability because of more off-farm jobs being created due to economic growth, putting pressure on supplies of agricultural labour. Alternate methods of rice establishment requiring less labour need to be developed to maintain the productivity of the systems. Direct seeding offers certain advantages although constraints are also associated with it.

The advantages of direct seeding are

1. savege of labour at transplanting,
2. faster and easier crop establishment,
3. less drudgery,
4. rice crop matures 7–10 days earlier than transplanted crops,
5. less irrigation water requirement,
6. higher tolerance to water stress condition,
7. higher yield, a lower production cost, and more profit,
8. better soil physical conditions for following crops and lesser omission of methane.

Some constraints to direct seeding are

1. fields are occupied lesser time as compared to transplanted crops,
2. higher weed pressure,
3. good crop establishment may be difficult,
4. precise water management and level fields are necessary,
5. crop lodging may be greater,
6. higher pest and disease incidence is likely in dense canopies because of less ventilation around plants and more variability and risk.

To address some of the above considerations, an agronomic evaluation of direct seeded rice production system with puddled transplanted rice was conducted.

MATERIALS AND METHODS

The field experiments were conducted at farmer's fields at nine different locations in the district of Ludhiana and Rupnagar of central Punjab during *kharif,* 2012. The climate of the experimental sites is sub-tropical characterized by hot summer with mean maximum temperature of 42 ± 5^0C during June and cool winter with mean minimum temperature of 4 ± 2^0C during December. The average annual rainfall (AAR) in the study area varies from 650-1300 mm of which 75-80% is received during summer season extending from July to September and rest during the winter season. The relative humidity in the districts varies from 36.3-93.7% demarcating a peak during July-August, the days when '*monsoon'* in the area is on full swing. The soil of experiment locations was sandy loam to loam in texture, normal in soil reaction (pH 7.65-8.06) and electrical conductivity (0.141-0.315 dSm^{-1}), medium in organic carbon (0.358 -0.421%), available phosphorus (11.5-24.1 kg/ha) and available potassium (118-163.7 kg/ha^{-1}). Seeds of short duration rice cultivar PR 115 were drilled in rows 20 cm apart in first fortnight of June @ 30 kg/ha^{-1}. The direct seeder was operated using a 45 hp tractor. The tractor was operated with the forward speed of 1.7 kms hr^{-1} and the average depth of seed placement was 3.1 cm. After 40-48 hrs of direct sowing, pre-emergence application of pendimethalin @ 750 gha^{-1} was done and post-emergence application of bispyribac @ 25g ha^{-1} was done 24-27 days after sowing. Nitrogen @ 150 kg ha^{-1} was applied in four splits after 2, 4, 7 and 10 weeks of crop sowing. Whole phosphorus (30 kg ha^{-1}) and potassium (30 kg ha^{-1}) was applied at sowing. Iron deficiency was noticed in DSR plots which was counteracted by two sprays of ferrous sulphate @ 2.5 kg in 250 litres of water per ha at 10 days interval. The direct seeded rice plots were kept moist throughout and 5 cm irrigation was applied at around 10 days interval and irrigation was withheld 10 days before crop harvest. In transplanting (control) treatment the same variety was used for which sowing in the nursery was done within 8-13th May, 2012 and thereafter it was transplanted in the field on 7-12th June, 2012 at the age of 30-35 days. The weed control was done by applying recommended herbicide, butachlor 50 EC @ 3.0 litres per hectare by mixing in 150 kg sand after 3 days of transplantation. All other practices during crop growth period were as per the package of practices for *kharif* crops recommended by Punjab Agricultural University, Ludhiana (Punjab). The crop was harvested and threshed manually and yield was computed at 8% moisture content. The total rainfall received during the growing season was 0.5 mm, 146.5 mm, 79.5 mm, 11.5 mm and 1.5 mm during the month of June, July, August, September and October respectively. The irrigation intervals were extended according to the intensity and frequency of rainfall. The mean maximum temperature during the growth season was 44.0ºC, 44.3ºC, 38.1ºC, 33.8ºC, 33.8ºC and 32.2ºC whereas the mean minimum temperature was 16.2ºC, 22.8ºC, 21.6ºC, 24.1ºC, 20.2ºC, 11.6ºC during the month of May, June, July, August, September and October respectively. Data on crop-plant height, effective tillers, panicle length, number of grains per panicle and grain yield were recorded at the time of crop harvest to draw valid conclusions. Data on weed density was recorded at 30 days after seeding from (1 m × 1 m) quadrate. *Students't test* was employed to test the significant of the differences in different parameters.

RESULTS AND DISCUSSION

The data given in Table 1, revealed that plant height, panicle length, number of grains per panicle and test weight were not significantly affected by establishment methods according to *Students't-test*. Average plant populationm was significantly higher in direct seeded rice plots than puddled transplanted rice plots according to *Students' t test*, which was due to sowing of more number of seeds per unit area as compared to transplanted plots where labour invariably transplants less number of seedlings per unit area. Number of effective tillersm which are determining factors for grain yield were significantly more in puddled PTR than DSR on the basis of *students't test*. There was no significant effect on number of empty grains per panicle due to different establishment methods but number of empty grains was slightly more in direct seeded rice plots. Grain yield is the main criterion for judging the comparative efficacy of different treatments. Significantly higher grain yield (5.55 t ha^{-1}) was observed with puddled transplanted rice than direct seeded rice (5.37 t ha^{-1}) when averaged over 9 locations. The lower grain yield in DSR plots were attributed to uneven depth of sowing, lower number of effective tillers and more infestation of weeds. Mangat *et al*. (2006) also reported significantly higher grain yield (70.8 q ha^{-1}) of rice with manual transplanting as compared to dry seeding with seed drill and zero till drill. Walia *et al*. (2009) also recorded significant differences in grain yields of direct seeded rice and puddled transplanted rice at Ludhiana.

The perusal of data in Table2, indicated much more weed infestation in DSR plots than PTR plots. The weed flora included *Trianthema portulacastrum* L., *Eragrostis tenella* (L.)P. Beauv. *Eragrostis pilosa* (L.) P. Beauv., *Dactyloctenium aegyptium* (L.) Willd., *Eleusine indica* (L.) Gaertn., *Digera arvensis* (L.), *Commelina benghalensis* L., *Echinochloa colona* (L.) Link, *Echinochloa crusgalli* (L.) P. Beauv., *Cyperus rotundus* L., *Cyperus iria* L., *Cyperus diformis* L., *Fimbristylis* sp., *Caesulia axillaris* Roxb., *Leptochloa apnicea* and *Sphenoclea* sp. The population of weeds at 30 days after sowing was significantly higher in DSR (24.3m) than PTR (13.8m). This was due to more congenial conditions for weed growth under DSR production system. In PTR plots normal paddy weeds were present but in DSR plots many non-paddy weeds were observed. *Leptochloa apnicea* was only present in DSR plots and was not controlled with applied herbicides. Singh *et al*. (2005) also reported that establishment methods have marked effect on weed density in rice at pantnagar. This observation is in agreement with the findings of Jana and Mallick (2013). The highest weed density was recorded in direct seeded rice plots and least in transplanted plots at 30 days stages of growth.

The average net returns under transplanted plots (47.71 X 10^{3} Rs ha^{-1}) were higher than direct seeded

Table-1 : Effect of methods of establishment on yield attributes and grain yield of rice

Location	Plant height (cm)		Plant population (m^{-2})		Tillers (m^{-2})		Panicle length (cm)		Grains $panicle^{-1}$		Empty grains. $panicle^{-1}$		Test weight (g)		Grain yield ($t.ha^{-1}$)	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
L_1	80.50	81.00	18	25	285	269	23.20	22.70	181	187	8	8	22.00	21.80	5.50	5.35
L_2	79.00	78.80	20	24	268	257	20.90	20.10	196	190	8	7	20.50	21.00	5.75	5.65
L_3	82.50	82.00	19	22	274	265	24.00	23.80	184	186	9	9	21.80	19.00	5.35	5.05
L_4	81.00	81.00	17	23	286	272	22.80	22.90	199	191	6	6	22.20	21.50	5.80	5.60
L_5	80.00	81.00	21	25	280	268	23.20	22.80	195	189	7	6	21.80	20.90	5.25	5.10
L_6	83.50	82.00	20	25	278	275	22.10	21.50	202	189	5	8	20.00	21.00	5.30	5.25
L_7	79.50	80.00	18	25	261	250	22.60	22.50	206	204	5	5	19.80	20.00	5.50	5.30
L_8	80.50	81.50	19	24	264	262	23.10	24.90	198	196	6	9	20.30	20.00	5.70	5.45
L_9	80.00	79.00	21	23	260	252	22.80	22.10	176	186	9	7	21.10	22.00	5.85	5.60
Mean	**80.7**	**80.6**	**19.2**	**24.0**	**272.9**	**263.3**	**22.7**	**22.6**	**193**	**190.8**	**7**	**7.2**	**21.0**	**20.8**	**5.55**	**5.37**
t-value	**0.081**		**8.86**		**6.52**		**0.63**		**0.94**		**0.41**		**0.70**		**7.38**	

Note: 1:PTR, 2: DSR

Table 2: Density of weeds in rice as influenced by methods of establishment

Location	Weed density (number m^{-2})30 DAS	
	PTR	DSR
L_1	25	10
L_2	31	15
L_3	28	13
L_4	18	20
L_5	26	08
L_6	23	13
L_7	29	15
L_8	21	18
L_9	18	12
Mean	**24.3**	**13.8**
t-value	**4.92**	

rice plots (47.08 X 10^3 symbol of $Rs.ha^{-1}$) but differences were non significant. Average benefit cost ratio (2.17) was significantly more in direct seeded rice plots as compared to transplanted plots. This was due to less cost involved in land preparation and crop establishment in direct seeded rice than transplanted rice. Gangawar *et al*. (2008) also recorded higher benefit: cost ratio with direct seeded rice as compared to transplanted rice.

The grain yields of both the systems were comparable but due to less input cost involved benefit cost ratio was more in DSR system. If weeds can be controlled effectively through integrated approach, then direct seeded rice can be a success under Punjab conditions. There is also a need to study the shift in weed flora due to change from transplanted to direct seeded rice production system.

Table 3: Comparison of economics of direct seeded rice (DSR) and puddled transplanted rice (PTR)

Location	Production unit (t ha^{-1})		Gross return (10^3 Rs ha^{-1})		Input cost (10^3 Rs ha^{-1})		Net return (10^3 Rs ha^{-1})		B:C	
	DSR	PTR	DSR	PTR	DSR	PTR	DSR	PTR	DSR	PTR
L_1	5.35	5.5	68.48	70.40	21.25	23.25	47.23	47.15	2.22	2.03
L_2	5.65	5.75	72.32	73.60	22.00	23.55	50.32	50.05	2.29	2.13
L_3	5.05	5.35	64.64	68.48	21.75	22.68	42.89	45.80	1.97	2.02
L_4	5.6	5.8	71.68	74.24	21.54	23.10	50.14	51.14	2.33	2.21
L_5	5.1	5.25	65.28	67.20	20.72	22.34	44.56	44.86	2.15	2.01
L_6	5.25	5.3	67.20	67.84	21.66	23.78	45.54	44.06	2.10	1.85
L_7	5.3	5.5	67.84	70.40	22.20	23.95	45.64	46.45	2.06	1.94
L_8	5.45	5.7	69.76	72.96	21.85	23.74	47.91	49.22	2.19	2.07
L_9	5.6	5.85	71.68	74.88	22.15	24.05	49.53	50.63	2.24	2.11
Mean	**5.37**	**5.55**	**68.76**	**71.11**	**21.68**	**23.38**	**47.08**	**47.71**	**2.17**	**2.04**
p value	**7.38**		**7.38**		**15.4**		**1.62**		**5.19**	

Note: Minimum support price of paddy – Rs. 1280 per quintal

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