

Direct Seeded Rice in Haryana, and Options for Pre-Emergence Herbicides

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Abstract

The grain yields obtained under direct seeded rice (DSR) in farmers' participatory multi locational trials in Karnal, Kaithal, Ambala, Sonapat and Yamuna Nagar districts during 2008 and 2009 indicated suitability of this technique in Haryana. The grain yields were almost similar under wet DSR (cultivar CSR 30) using pre-germinated seed under puddle conditions and the puddle transplant rice (PTR) during 2008 in Karnal district. Similarly, grain yields of rice cultivars CSR30 and PB 1121 obtained under wet DSR in unpuddle conditions (34.0 q/ha) were also comparable to PTR (33.8 q/ha) in Kaithal, Karnal and Yamuna Nagar districts during 2009. The overall grain yield of rice cultivars (PBI, PBI121 and CSR 30) under dry DSR in *vattar* conditions (broadcast or drill sown) during 2009 was 34.4 q/ha compared to 33.7 q/ha under PTR based on 5, 3, 10 and 9 locations in Kaithal, Ambala, Sonapat and Karnal districts, respectively. In addition, there was approximately 30—40% saving of water in dry DSR than conventional puddle transplanted rice, as it was feasible to safely delay first irrigation for 7—25 days after sowing under dry DSR. Besides this, saving under dry DSR was due to no puddling requirement (saving equivalent to 5 irrigations) and wide interval (7—10 days) in follow up irrigations. Basmati cultivars PB1, PB 1121 and CSR 30 with a seed rate of 20 kg/ha were found suitable under direct seeding. Performance of coarse grain cultivars/hybrids (PAU201, HKR47 H999 and Arize 6444) was poor under wet DSR compared to PTR in Yamuna Nagar. Field experiments conducted during *kharif* of 2007 and other experiments during *kharif* of 2006—2009, indicated that pendimethalin 1.0—1.5 kg/ha, pretilachlor 1.0 kg/ha and butachlor 1.5 kg/ha applied as sand-mix or spray at 3—8 DAS were phytotoxic to the wet DSR in puddle or un-puddle conditions. The phytotoxicity was more in basmati cultivars than coarse grain cultivars. Pendimethalin had phytotoxic effects even when used up to 13 DAS in wet DSR. However, these herbicides were found in dry DSR but satisfactory weed control could be achieved only with pendimethalin.

Key words : Rice, Options, Pre-emergence herbicides.

Out of different cropping systems in India, share of rice and wheat together is the highest, contributing about 65% to the food grain production (1), while rice-wheat cropping system contributes 40%. Unfortunately, most of the high productivity systems are cereal-based, having high resource demand and continuously practiced over the decades in major parts of the country. In most of north-west India including Haryana, common practice of establishing rice in the rice-wheat systems is through puddling followed by manual transplanting. Puddling helps in reducing water losses through percolation and controlling weeds by water stagnation in rice fields. But besides being costly, cumbersome and time consuming, it results in degradation of soil and other natural resources and subsequently poses difficulties in seedbed preparation for succeeding wheat crop in rotation. Break-

ing of soil aggregates, alteration of particle orientation and development of hard pan at a depth of 10—40 cm, increase in bulk density and soil compaction (2), impediment in root growth of wheat due to formation of hard pan in rice crop (3), labor scarcity and drudgery among women workers (4) are some of the other disadvantages associated with puddle transplant rice (PTR). It is, therefore, important that alternate methods that are more water efficient and less labor intensive like direct seeded rice (DSR) should be developed which may also be helpful in management of reclaimed alkali soils on sustainable basis.

Direct seeding can be done as dry DSR after field preparation or as wet DSR using pre-germinated seed placed almost on the surface under puddle or un-puddle conditions. Weed infestation due to poor management of irrigation water is one of the major

Table 1. Performance of wet DSR (basmati) under puddle and unpuddle conditions at farmers' fields in Haryana during *khariif* of 2008 and 2009.

District	Village	Location	Area (acre)	Variety	Method of sowing	Grain yield (q/ha)	
						DSR	PTR
Year 2008							
Karnal	Sagga	Location-1	1.0	CSR30	Wet-DSR (Puddle-Drum seeded)	24.5	26.5
		Location-2	4.5	CSR30	Wet-DSR (Puddle-Broadcast)	30.0	30.0
		Location-3	5.0	CSR30	„	24.0	27.5
		Location-4	7.0	CSR30	„	20.5	20.5
		Location-5	1.0	CSR30	Wet-DSR (Puddle-Drum seeded)	30.0	28.8
		Location-6	1.0	CSR30	Wet-DSR (Puddle-Broadcast)	30.0	28.8
		Location-7	4.0	CSR30	„	22.0	23.0
	Average/average		23.5			25.9	26.0
Year 2009							
Kaithal	Naina	Location-1	2.5	CSR30	Wet-DSR (Un-puddle-Broadcast)	30.0	30.0
		Location-2	3.0	PBI121	„	35.0	34.0
		Location-3	2.0	PB1121	„	34.0	-
		Location-3	4.0	CSR30	„	34.0	29.0
		Location-4	5.0	PB 1121	„	37.0	35.0
		Location-5	3.0	PB 1121	„	35.0	34.0
Karnal	Bhaini	Location-1	1.0	CSR30	Wet-DSR (Puddle-Broadcast)	33.5	36.0
		Location-1	1.5	CSR30	Wet-DSR (Puddle-Drum seeded)	34.0	35.0
Yamuna	Kashmirgarh	Location-1	3.0	CSR30	„	30.0	31.0
Nagar	Kharwan	Location-1	3.0	PB1121	Wet-DSR (Un-puddle-Broadcast)	35.0	36.0
	Average/average		29.0			34.0	33.8

constraints in direct seeded rice (5). Post-emergence herbicide bispyribac has been recommended to be used for control of weeds in direct seeded rice (6). But some of the non-target grassy weeds still pose problem and thus inclusion of pre-emergence herbicides has to be an important component of chemical weed control strategy under DSR. However, use of pre-emergence herbicides is not suitable under all the situations, as contact of herbicide with seed or emerging seedling may be phytotoxic. Hence, efforts were made by through large scale trials at farmers' fields on different methods of direct seeding in Karnal, Kaithal, Ambala, Sonapat and Yamuna Nagar districts of Haryana, along with studies on phytotoxicity of pre-emergence herbicides on DSR at research farm.

Methods

Multi-locational farmers' field trials (one acre size) on wet direct seeded basmati rice (CSR30 and PB1121) under puddle and unpuddle conditions (drum-seeded or broadcast) using pre-germinated seed were com-

pared with PTR in Karnal, Kaithal and Yamuna Nagar districts of Haryana (17 locations) during *khariif* 2008 and 2009. The seed rate used was 25 kg/ha.

During 2009, 51 trials (each of acre size) on dry DSR under *vattar* conditions (drill sown or broadcast) were conducted in four districts (Kaithal, Ambala, Yamuna Nagar and Sonapat) comprising 14 villages at 27 locations. Field preparation under dry DSR in *vattar* conditions included 1-2 ploughings before pre-sowing irrigation *fb* two ploughings and one planking. Treated seed (20 kg/ha) of basmati cultivars (CSR30, PBI121 and PBI) was sown with seed-cum-fertilizer drill/broadcasting. In broadcast method, seed was manually broadcast followed by one shallow tilling (with harrow or cultivator) along with planking. Planking was also given after seeding with seed drill. Planking was done to avoid moisture loss from desiccating winds and also to make firm contact of seed with soil. Sowing was done during first fortnight of June in district Kaithal and Ambala; whereas during second fortnight in Sonapat and Yamuna Nagar districts. By and large, first irrigation was applied at

Table 2. Performance of dry and wet direct seeded rice (DSR) under different establishment methods at farmers' fields in Karnal, Kaithal and Ambala, Sonapat and Yamuna Nagar districts of Haryana (*khari*f of 2009).

District	Village	Location	Area (Acre)	Variety	Method of sowing	1st irriga- tion (DAS)	Grain yield (q/ha)		
							DSR	PTR	
Kaithal	Naina	Location-1	2.0	PB1121	Dry-DSR (Un-puddle-Broadcast)	12	33.0	33.0	
		Location-2	4.0	PB1	Dry-DSR (Vattar-Broadcast)	12	43.0	38.0	
		Location-3	1.5	CSR30	„	18	36.0	29.0	
		Location-4	2.5	PB1121	„	18	38.0	35.0	
		Location-5	2.0	PB1121	„	12	37.0	34.0	
		Acerage/average		12.0				37.4	33.8
Ambala	Khudda	Location-1	5.0	PB1121	Dry-DSR (Vattar-Drill)	16	38.0	35.0	
		Location-2	1.0	PB1121	Dry-DSR (Vattar-Broadcast)	15	37.0	35.0	
		Location-3	2.0	PB1121	„	35	25.0	-	
		Acerage/average		8.0				33.3	35.0
Sonapat	Khanda	Location-1	1.0	PB1121	Dry-DSR (Vattar-Drill)	15	40.0	41.3	
		Location-2	1.0	PB1121	Dry-DSR (Vattar- Broadcast)	18	35.0	38.3	
		Location-3	1.0	PB1121	„	20	41.0	35.5	
		Location-4	1.0	PB1121	„	17	34.0	36.8	
		Location-5	1.0	PB1121	„	25	38.3	31.0	
	Rattangarh	Location-1	1.0	CSR30	„	16	20.0	23.0	
	Bhatana	Location-1	1.0	CSR30	„	15	22.3	20.5	
	Baghdu	Location-1	3.0	CSR30	„	20	31.0	26.0	
		Location-2	3.0	CSR30	Dry-DSR (Vattar-Drill)	20	22.3	20.5	
		Location-3	2.0	CSR30	„	19	25.8	23.0	
		Acerage/average		15.0				31.0	29.6
Yamuna Nagar	Unheri	Location-1	1.0	PB1121	Dry-DSR (Vattar-Drill)	7	40.0	40.8	
	Bahadurpur	Location-1	2.0	PB1121	„	14	39.0	40.0	
		Location-2	1.0	PB1	„	12	40.0	41.5	
	Antawa	Location-1	1.0	CSR30	„	7	35.0	34.1	
	Fatehpur	Location-1	2.0	CSR30	„	25	32.5	33.0	
	Nagla	Location-1	1.0	CSR30	„	15	37.5	37.5	
	Bhoot Majra	Location-1	1.0	CSR30	„	10	32.5	33.0	
	Kharwan	Location-1	3.0	CSR30	„	10	35.5	36.2	
	Khundewala	Location-1	4.0	CSR30	„	25	32.5	33.4	
		Acerage/average		16.0				36.0	36.6
	Overall Acerage/average		51.0					34.4	33.7

10-15 DAS ; however it was possible to delay first irrigation even up to 25 DAS under delayed sowing.

For phytotoxicity studies, field experiments were conducted during *khari*f of 2007 at CCS Haryana Agricultural University, Regional Research Station, Karnal on efficacy of pre-emergence herbicides (pendimethalin, butachlor and pretilachlor) in dry and wet direct seeded rice. In first experiment, sowing of pre-germinated seed of two cultivars HKR47 (dwarf) and CSR30 (basmati) was done by broadcast in puddle and un-puddle conditions in standing water. Sowing was done using the seed rate of 50 g/m². Herbicidal treatments including pendimethalin at 1.0 and 1.5 kg/ha, butachlor at 1.5 kg/ha and pretilachlor at 1.0 kg/ha as sand-mix application at 8 days after sowing

(DAS) along with untreated check were laid out in randomized block design with three replicates. In the second experiment, sowing of two cultivars 'HKR120' (dwarf) and 'Super Basmati' (basmati) was done as dry direct seeding in lines with hand drill in prepared field using seed rate of 50 g/m², immediately followed by irrigation. The treatments included pendimethalin 1.0 and 1.5 kg/ha at 3 and 7 DAS applied as spray, butachlor 1.5 kg/ha and pretilachlor 1.0 kg/ha at 7 DAS as sand-mix application, in comparison to untreated check, were laid out in randomized block design with four replicates.

There were other experiments at RRS, Karnal and at farmers' fields in Kaithal during 2006—2009 on wet DSR using pre-germinated seed of basmati and coarse

Table 3. Performance of different cultivars/sowing methods of rice at farmers' fields in Yamuna Nagar district of Haryana during *kharif* of 2009. *Sowing with drill under un-puddle dry conditions immediately *fb* irrigation.

District	Village	Location	Area (acre)	Variety	Method of sowing	Grain yield (q/ha)	
						DSR	PTR
Yamuna Nagar	Jeewarheri	Location-1	1.0	PB1121	Dry DSR (Dry-Drill)*	35.0	36.0
	Jamalpur	Location-1	1.0	Arize6444	„	70.0	78.0
	Khera	Location-1	1.0	PAU201	Wet-DSR (Puddle-Drum seeded)	50.0	75.0
	Khera	Location-1	1.0	HKR47	Wet-DSR (Un-puddle-Drum seeded)	60.0	67.5
	Hartan	Location-1	1.0	H999	Wet-DSR (Puddle-Broadcast)	40.0	60.0

grain cultivars, where pendimethalin 1.0 and 1.5 kg/ha and pretilachlor 1.0 kg/ha were applied as spray or sand-mix at 3, 7, 10 and 13 DAS.

Results and Discussion

Methods of DSR

The grain yields obtained under direct seeded rice (DSR) in farmers' participatory multi-localational trials in Karnal, Kaithal, Ambala, Sonapat and Yamuna Nagar districts during 2008 and 2009 indicated suitability of this technique in Haryana. Based on data recorded at seven locations in Karnal district during 2008 (Table 1), the average grain yields were similar under wet DSR (cultivar CSR 30) in puddle conditions (25.9 q/ha) and puddle transplant rice (26.0 q/ha). Similarly, grain yields of rice cultivars CSR30 and PB 1121 obtained under wet DSR in unpuddle condi-

tions (34.0 q/ha) were also comparable to PTR (33.8 q/ha) in Kaithal (6 locations), Karnal (2 locations) and Yamuna Nagar (2 locations) districts during 2009.

On an overall average of 51 farmers' field trials (Table 2), the grain yield of rice under *vattar* DSR (34.4 q/ha) was comparable with conventional transplanted rice under puddle conditions (33.7 q/ha). There was around 30–40% water saving under *vattar*. In addition, there was approximately 30–40% saving of water in dry DSR than conventional puddle transplanted rice, as it was possible to safely delay first irrigation for 7–25 days after sowing under dry DSR. Besides this, saving under dry DSR was due to no puddling requirement (saving equivalent to 5 irrigations) and wide interval (7–10 days) in follow up irrigations. Basmati cultivars PBI, PB1121 and CSR30 with a seed rate of 20 kg/ha were found suitable under direct seeding. Dry DSR appeared to be a bet-

Table 4. Phytotoxic effects of pre-emergence herbicides in wet seeded rice under puddle and un-puddle conditions (*kharif* of 2007).

Treatments	Dose (kg/ha)	Time (DAS)	Mode of application	Phytotoxicity (%)		Plant height (cm)		Plant density (no./m ²)		Fresh weight (g/m ²)	
				HKR47	CSR30	HKR47	CSR30	HKR47	CSR30	HKR47	CSR30
Puddle											
Pendimethalin	1.0	8	Sand mix	5	50	10.6	10.7	1508	698	319	161
Pendimethalin	1.5	8	„	20	55	10.0	10.2	1268	641	207	158
Pretilachlor	1.0	8	„	10	40	10.7	10.9	1449	940	285	197
Butachlor	1.5	8	„	10	40	10.9	11.0	1428	971	309	215
Untreated check	-	-	-	0	0	11.0	11.3	1718	1655	346	374
Un-Puddle											
Pendimethalin	1.0	8	Sand mix	10	50	9.6	9.9	1360	637	275	167
Pendimethalin	1.5	8	„	35	70	9.3	9.9	1032	488	167	101
Pretilachlor	1.0	8	„	5	35	9.7	10.0	1462	961	284	200
Butachlor	1.5	8	„	5	35	9.7	10.6	1440	1023	290	213
Untreated check	-	-	-	0	0	10.0	11.0	1530	1538	316	332
CD at 5%	-	-	-	-	-	NS	NS	158	129	30	34

Table 5. Phytotoxic effects of pre-emergence herbicides in dry direct seeded rice (*kharif* of 2007).

Treatments	Dose (kg/ha)	Time (DAS)	Mode of application	Phytotoxicity (%)		Plant height (cm)		Plant density/m ²		Fresh weight (g/m ²)	
				HKR120	Super Basmati	HKR120	Super Basmati	HKR120	Super Basmati	HKR120	Super Basmati
Pendimethalin	1.0	3	Spray	0	0	9.5	9.9	1447	1496	302	315
Pendimethalin	1.5	3	Spray	5	0	9.4	9.7	1425	1472	286	309
Pendimethalin	1.0	7	Spray	0	0	9.7	10.0	1470	1510	310	324
Pendimethalin	1.5	7	Spray	0	0	9.6	9.8	1452	1469	299	317
Pretilachlor	1.0	7	Sand mix	0	0	9.5	9.7	1475	1446	308	301
Butachlor	1.5	7	Sand mix	0	0	9.4	9.7	1444	1490	295	316
Untreated check	-	-	-	-	-	9.7	10.0	1462	1503	304	321
CD at 5%				-	-	NS	NS	NS	NS	NS	NS

ter option as it may be helpful in conservation of soil and water resources, mechanization of sowing, labor saving along with comparable grain yields.

Basmati cultivars PBI, PB1121 and CSR30 were found suitable under direct seeding and the seed rate of 20 kg/ha was realized to be optimum (Table 2). Whereas, the performance of coarse grain cultivars/hybrids (PAU201, HKR47 H999 and Arize 6444) was poor under wet DSR as compared to PTR in Yamuna Nagar district (Table 3). This is in continuation with earlier findings during last ten years that scopes of

DSR are more ample in basmati group of rice than coarse grain cultivars in Haryana (6). Grain yield of rice under dry DSR (drill sown) immediately followed by irrigation was also comparable to PTR in district Yamuna Nagar (Table 3); but possibilities of water saving under such practice will be limited as frequent irrigations were required to ensure satisfactory germination and plant stand.

Options for Pre-Emergence Herbicides

There was phytotoxicity on rice seedlings by sand mix application of pendimethalin 1.0 and 1.5 kg/

Table 6. Phytotoxicity of pre-emergence herbicides in wet direct seeded rice at different locations (*kharif* of 2006–2008).

Site	Method of sowing	Field condition	Variety	Treatments	Dose (g/ha)	Time (DAS)	Mode of application	Phyto-toxicity (%)
Kharif, 2006								
RRS, Karnal	Drum seeding	Un-puddle	Gobind	Pendimethalin	1000	3	Spray	100
RRS, Karnal	„	Puddle	Gobind	„	1000	3	„	100
Kharif, 2007								
RRS, Karnal	Drum seeding	Un-puddle	CSR30	Pendimethalin	1000	7	Spray	95
RRS, Karnal	„	„	CSR30	„	1500	7	„	95
RRS, Karnal	„	„	CSR30	Pretilachlor	1000	7	„	40
Kaithal-I	„	„	Basmati cultivars	Pendimethalin	1500	10	Sand-mix	85
Kaithal-I	„	„	Coarse-grain cultivars	„	1500	10	„	60
Kaithal-II	Broadcasting	Puddle	HBC19, CSR 30	„	1500	13	„	40
Kharif, 2008								
RRS, Karnal	Drum seeding	Puddle	CSR 30	„	1000	7	„	45
RKS, Karnal	„	„	CSR 30	„	1500	7	„	76.5
RRS, Karnal	„	„	CSR 30	Pretilachlor	1000	7	„	70
Kharif, 2009								
RRS, Karnal	„	„	CSR 30	„	1000	10	„	0

ha, butachlor 1.5 kg/ha and pretilachlor 1.0 kg/ha at 8 DAS in wet DSR (Table 2). The damage to rice seedlings was more in basmati variety CSR30 than the dwarf rice variety HKR47. Slightly higher phytotoxicity was observed in un-puddle than the puddle conditions, which might have been due to slight covering of seed in soil under puddle situations. In CSR30, there was 55% and 70% damage due to pendimethalin 1.5 kg/ha under puddle and un-puddle conditions, respectively. However, there was 50% phytotoxicity at 1.0 kg/ha dose under both the situations. In HKR47, there was 20% and 35% damage due to pendimethalin 1.5 kg/ha under puddle and un-puddle conditions, respectively; however, the respective damage at 1.0 kg/ha was 5 and 10%. Pretilachlor and butachlor caused 35–40% phytotoxicity to CSR 30 and 5–10% to HKR47. Similar effects were also reflected in terms of reduced plant density, height and fresh weight of rice plants. However, differences in plant height were not significant. There was no phytotoxicity of pendimethalin, pretilachlor and butachlor in dry DSR during *kharif* of 2007 (Table 3). Also the plant height, plant density and fresh weight of rice were similar under all the herbicidal treatments in dry DSR.

At RRS, Karnal during *kharif* of 2006, spray of pendimethalin 1.0 kg/ha at 3 DAS caused complete damage to the rice seedlings of 'Gobind' cultivar sown with drum seeder under puddle and un-puddle conditions (Table 4). During *kharif* of 2007, spray of pendimethalin 1.0 and 1.5 kg/ha after 7 DAS caused 95% phytotoxicity to wet direct seeded basmati rice CSR30 under un-puddle conditions sown with drum-seeder. The damage caused by pretilachlor was 40% under these situations. During *kharif* of 2008, sand-mix application of pendimethalin 1.0 and 1.5 kg/ha, and pretilachlor 1.0 kg/ha at 7 DAS resulted in 45, 77 and 70% phytotoxicity on CSR 30 cultivar of rice in wet DSR under puddle conditions. However, there was no damage when pretilachlor application was further delayed up to 10 DAS under similar situations during 2009. In other trials at Kaithal, sand-mix application of pendimethalin 1.5 kg/ha at 10 DAS resulted in 60 and 85% mortality to different coarse grain and basmati rice cultivars, respectively, sown with drum-seeder under un-puddle conditions. Pendimethalin 1.5 kg/ha even at 13 DAS caused 40% damage to pre-germinated broadcast sown basmati rice (HBC19 and

CSR30) under puddle conditions in village Teek, Kaithal.

The earlier workers have reported that pendimethalin provided satisfactory weed control and grain yield of pre-germinated direct seeded rice (7, 8). However, our findings rule out the safe use of pendimethalin, butachlor or pretilachlor as spray or sand-mix application in wet direct seeded rice (both dwarf and basmati cultivars) using pre-germinated seed under puddle as well as un-puddle conditions. Phytotoxicity of pendimethalin has been reported earlier as well (9). However, these herbicides are safe to be applied under dry direct seeded conditions.

Conclusion

Direct seeding was a viable alternate method of basmati rice establishment. Dry direct seeding under *vattar* conditions and wet DSR were comparable to PTR in terms of grain yield. However, compared to wet DSR and PTR, *vattar* DSR could be better as there was water saving (30–40%), puddling was not required and yields were comparable. Performance of basmati cultivars was more satisfactory under DSR compared to coarse grain varieties (yield penalties were more). Seed rate of 20 kg/ha was realized to be optimum under DSR. Pre-emergence herbicides including pendimethalin, pretilachlor and butachlor were phytotoxic to crop in wet DSR, but these were safe under dry DSR. However, among the three herbicides, pendimethalin may be more suitable particularly under *vattar* DSR, as comparatively high soil moisture is required to attain satisfactory efficacy of butachlor and pretilachlor. Since use of pre-emergence herbicides (like pendimethalin) in combination with some post-emergence herbicides (like bispyribac-sodium) is assumed to be a pre-requisite to attain satisfactory weed control; future research efforts are required to exploit such combinations particularly under *vattar* DSR.

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