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Effect of Different Crop Establishment Methods on Rice Productivity and Profitability

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ABSTRACT

In order to work out the effect of different crop establishment methods on rice yield and yield attributes, monetary gains, production efficiency, field and growth duration, fuel consumption, time required and cost comparisons for seed bed preparation and sowing, field experiments were conducted with farmers' participatory research mode at Amrik Farm, Hajwana (Kaithal, Haryana, India) during 2012-2016 *kharif* seasons. Seven different crop establishment methods (DSR under *vattar* condition, DSR under dry condition, DSR under ZT condition, DSR puddle drum sowing, DSR un puddle drum sowing, mechanical transplanting un- puddle and manual transplanting in puddle condition) were replicated thrice in RBD. Manually transplanted rice registered maximum grain yield (3654 kg/ha) which was statistically at par to DSR under *vattar* condition. Growth duration of manually transplanted rice in puddle condition was seven days longer than DSR under *vattar* condition. Time saving for seed bed preparation and sowing and fuel consumption reduction in DSR under *vattar* condition was 66.7% and 33.3% as compared to manual transplanting in puddle condition. Highest returns over variable cost (₹ 89019/ha) and B:C ratio(3.59) were achieved under DSR in *vattar* condition.

Key Words: Direct seeded rice, Mechanically transplanted rice, Crop establishment, Rice, Productivity, Puddle

INTRODUCTION

Risotto in Italy to Nasi Goreng in Indonesia, rice is the main food for more than half of the world population (Davla *et al,* 2013), China is the largest producer, accounting for 30 per cent of the production followed by India (24%), Bangladesh (7%), Indonesia (7%), Vietnam (5%) and Thailand (4%) (Anonymous, 2020). In India rice was grown over an area of approximately 43.79 m ha with a total production of 116.42 m t and productivity 2659 kg/ha during 2018-19(Anonymous, 2019).

The most common practice of establishing rice in the rice-wheat cropping system is through puddling followed by manual transplanting. Repeated intensive tillage for puddling leads to soil erosion, organic matter loss, nutrient loss, release of soil carbon to atmosphere, undesirable changes in soil structure, reduced water infiltration and moisture-holding capacity. Crop establishment with traditional flooded irrigation is main reasons for 4.5 m t of methane (a gas which damages the ozone layer 23 times more adversely than CO2) emission in India annually. The size of the workforce in agriculture declined by nearly 30 million between 2004–05 and 2011–12 due to rapid economic growth in Asia in non-agricultural sectors and increased labor wages (Anonymous, 2016). Due to water and labour scarcity, farmers are really concerned about the existing practices of puddling and manual transplanting rice and have started thinking about direct seeding of rice or mechanically transplanted rice in un-puddled condition. Since in direct seeding there is no water at the base of the crop, there is a substantial reduction in methane emissions. These beneficial effects of reduced tillage practices related to soil

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Table 1. Treatments and details of tillage and crop establishment.

Treatment	Treatment description	Tillage (dry)	Tillage (wet)	Crop establishment method
T1	Direct seeded rice (DSR) under vattar condition (un-puddle)	Two harrowings + one cultivator + one planking	-	Sowing with DSR drill
T2	Direct seeded rice (DSR) under dry condition (un-puddle)	Two harrowings + one cultivator + one planking	-	Sowing with DSR drill
T3	Direct seeded rice (DSR) under vattar condition (Zero till)	-	-	Sowing with DSR drill
T4	Direct seeded rice (DSR) in wet condition (puddle)	Two harrowings + one cultivator	Puddling twice + one planking	Sowing with drum
T5	Direct seeded rice (DSR) in wet condition (un-puddle)	Two harrowings + one cultivator + one planking	-	Sowing with drum
T6	Mechanical transplanting rice in un- puddle condition	Two harrowings + one cultivator + one planking	-	Transplanting with machine
T7	Manual Transplanting in puddle condition	Two harrowings + one cultivator	Puddling twice + one planking	Manual transplanting

and water management can enhance environmental quality and improve the natural resource base on which a large portion of agricultural economy depends. The hike in fuel prices also promoted reduced tillage systems for economic reasons as well. These technologies are labour, fuel, time and water saving technologies which are cost effective compared to manually transplanted rice and also help in mitigation of green-house gas emission, and adaptability to climatic risks. Direct seeded rice has received much attention, because of low input demand including labor and water and both of them are going to be scarce in the coming years (Farooq *et al,* 2011)

Direct seeded rice and mechanically transplanted rice has potentiality to increase the productivity of the subsequent non-rice crop i.e. wheat mainly in rice-wheat cropping system, the prevailing cropping system in South Asia. Both the direct seeded methods of rice, being at par, recorded significantly higher mean grain yield and other growth parameters of rice as compared to conventional transplanting or SRI method (Sharma *et al,* 2016). Labour and cost saving of 97 and 80 per cent were observed in direct seeded rice (DSR) as compared to manual puddled transplanted rice in sowing/transplanting (Kumar *et al,* 2015).

The productivity and sustainability of rice-based systems are threatened because of the inefficient use of inputs; increasing scarcity of resources, especially water and labour; changing climate; the emerging energy crisis and rising fuel prices; the rising cost of cultivation and emerging socio-economic changes such as urbanization, migration of labour, preferences of non-agricultural work, concerns about farm-related pollution (Kumar and Ladha, 2011). Keeping in view, the present study was conducted to evaluate different crop establishment methods compared to manual puddle transplanting rice for crop productivity and profitability.

MATERIALS AND METHODS

Site characteristics

Long term field experiments were conducted with farmers' participatory research mode at Amrik Farm, Hajwana (Kaithal, Haryana, India) during 2012, 2013, 2014, 2015 and 2016 *kharif* season. The soil of the experimental field was clay loam in texture, medium in organic carbon (0.48%), medium in available phosphorus (14.0 kg/ ha) and medium in available potassium (191 kg/ ha) with a pH of 8.3. The whole field was laser levelled.

Treatments: The experiment was laid out in randomized block design with seven treatments replicated thrice. The detail of treatments is presented in Table1.

Seeding and seed rate

Scented basmati rice variety CSR-30 was used for the experiment purpose. The seed treated with recommended fungicide @ 20 kg/ha was used for direct drilling as well as for nursery raising. The nursery sowing for manual transplanting in puddle condition and mechanical transplanting in un- puddle condition was done on the day of direct drilling between 10^{th} to 15^{th} of June. Manual transplanting at a spacing of 20x15 cm^2 was done after 30 days of nursery sowing maintaining 2-3 plants per hill, whereas in mechanically transplanted rice the row to row spacing was 23.5cm. The direct seeding of rice was also done maintaining a row spacing of 20 cm. Sowing of direct seeded rice (DSR) under *vattar* condition was done in the evening maintaining sowing depth of 3-5 cm and light planking was done immediately after drilling to avoid loss of moisture. Sowing depth was 2-3 cm in direct seeded rice (DSR) under dry condition and no planking was done after drilling the seed. A light irrigation was applied just after drilling. In drum sowing the treated seed was air-dried in shade prior to sowing for easy dispensing through the holes in the drum seeder. Excess water from field was drained out ensuring the soil surface is moist. Drums were filled with treated seeds ($2/3^{rd}$ full) and pulled across the field maintaining a steady speed for evenly sowing.

Irrigation Management

In DSR under *vattar* condition (un-puddle) after pre-sowing irrigation the first irrigation was applied 10-15 d after sowing depending on the field condition with follow up irrigations at 7-10 d interval. In case of DSR under dry condition (un-puddle) first irrigation was applied just after sowing followed by irrigation at an interval of 3-5 d during crop establishment phase. Subsequent irrigations were applied at an interval of 7-10 d. During active tillering phase *i.e.,* 30-45 DAS and reproductive phase (Panicle emergence to grain filling stage) optimum moisture (irrigation at 2-3 d interval) was maintained to harvest optimum yields from DSR crop (Kamboj *et al*, 2012). Irrigation was not applied for 2-3 d after sowing to allow rooting and anchoring to soil under drum sowing and intermittent irrigation was given till the panicle initiation stage. Under transplanting condition the standing water was held in the field up-to tillering phase and almost 15-20 irrigations were applied depending on the rain.

Fertilizer Management

A fertilizer dose of 75kg N, 30 kg P_2O_5 and 25 kg $ZnSO_4$ /ha was applied in all the treatments except transplanting and drum sowing treatments, where N @ 60 kg/ha was applied. In transplanting 1/3 N and full dose of P and Zn fertilizers were applied at the time of puddling, whereas, in DSR $1/3^{rd}$ N and full dose of P and Zn were drilled at the time of seeding. Remaining $2/3^{rd}$ N was applied in two equal splits at 15 and 50 d after sowing (DAS).Solution of 0.5% FeSO4 was also sprayed.

Pest Management

In zero till treatment existing weeds, prior to the seeding of rice, were killed by application of glyphosate 1.0 % + 0.1 % surfactant 7-10 d before

Table 2. Effect of different crop establishment methods on yield and yield attributing characters (Five years' pooled data).

Treatment	Effective panicles/ m^2	Panicle length (cm)	Grains / panicle	1000 grain weight (g)	Grain Yield (kg/ ha)	Straw Yield (kg/ ha)	Biological Yield (kg/ ha)	Harvest Index (%)
T1	284	25.8	72.4	22.52	3630	5560	9190	39.5
T2	282	26.0	72.0	22.50	3572	5480	9052	39.5
T3	277	26.0	72.0	22.46	3519	5360	8879	39.6
T4	274	26.1	71.2	22.47	3469	5290	8759	39.6
T5	271	25.9	70.0	21.54	3296	5060	8356	39.4
T6	288	26.0	72.2	21.92	3583	5500	9083	39.4
T7	286	26.2	72.8	22.48	3654	5558	9212	39.7
CD (0.05)	9	NS	0.8	NS	192	80	166	-

sowing. Weeds were managed by spraying different herbicides as suggested by Khippal *et al* (2019) and Anonymous (2013). Insects and diseases were controlled by adopting the recommended insecticide or fungicide as per packages of practices for *kharif* crop, CCS Haryana Agricultural University, Hisar.

Yield and yield attributes

Four plants were tagged for recording effective tillers and then converted into per square meter. Panicle length (cm) was measured from ten randomly selected tillers of tagged plants from each plot at harvest and averaged to get length of panicle. The numbers of grains from ten panicles selected at random from each plot were counted. One thousand filled grains from the produce of the net plots were counted and their weight was recorded. Produce of net plots was sun dried and threshed grains thus obtained were winnowed, cleaned and weighed. Dry weight of straw collected from net plots was recorded after sun drying for seven days.

Cost, time and fuel required for seed bed preparation and sowing/transplanting

Fuel consumption was calculated using full tank method for both seed bed preparation and sowing operations. Total time required for these operations in each treatment was measured by adding time spent in each operation and similarly money spent in these operations was calculated by adding the cost incurred in each treatment.

Statistical analysis: The data was analyzed using OPSTAT. Online Statistical Analysis was available on CCSHAU, Hisar website.

RESULTS AND DISCUSSION

Grain yield and yield attributing characters

Manually transplanted rice registered maximum panicle length (26.2 cm), grains per panicle (72.8), grain yield (3654 kg/ha), straw yield (5558 kg/ ha), biological yield (9212 kg/ ha) and harvest index (39.7%) which were statistically at par to mechanically transplanting of rice and direct seeding of rice under *vattar* or dry or zero till condition. The yield was at par among these treatments mainly due to non- significant difference in different yield attributing characters. There was non- significant difference among all the treatments as far as panicle length and 1000 grain weight is considered (Table 2). Almost similar results were also reported by Gill *et al* (2006 [a] and 2006[b]), Gill *et al* (2014) and Sharma *et al* (2016).

Production efficiency, field and growth duration

During experiments, field, growth durations

Table 3.Effect of different crop establishment method on field duration, growth duration and production efficiency (Five years' pooled data).

Treatment	Field duration	Growth duration	Production efficiency	
	Days	Days	Grain (Kg/ha/d)	Bio mass (Kg/ha/d)
T1	143	143	25.39	64.27
T2	143	143	24.98	63.30
T3	144	144	24.44	61.66
T4	144	144	24.09	60.83
T5	144	144	22.89	58.03
T6	126	147	28.44	72.09
T7	120	150	30.45	76.77
CD(0.05)	3	4	1.15	1.81

and production efficiency were affected by crop establishment methods and vary due to variation in climate during different seasons. On mean basis the growth duration of manually transplanted rice in puddle condition and mechanically transplanted rice in un puddle condition was seven and four days longer than direct seeding of rice under *vattar* and dry condition respectively (Table 3). The main field duration was also reduced by 23 and 17 d under manually transplanted rice in puddle condition and mechanically transplanted rice in un puddle condition respectively. Kumar *et al* (2015) also reported the similar results. The longer duration in transplanted rice is due to transplanting shock (Dingkuhn *et al*, 1991). The manually transplanted rice in puddle condition recorded significantly high grain production efficiency (30.45Kg/ha/d) and biomass production efficiency (76.77 Kg/ha/d) due to higher grain yield and shorter main field duration. Almost similar results were also reported by Gill *et al* (2014) and Kumar *et al* (2015).

Time required for seed bed preparation and sowing

Maximum time in seed bed preparation and sowing was required for manual transplanting of rice in puddle condition (1237.5 min/ ha) followed by drum sowing in puddle condition

(812.5 min/ha), whereas minimum time was required in DSR under zero till condition (75 min/ ha). Time saving in DSR under zero till condition was 93.9% as compared to manual transplanting in puddle condition (Fig 1). The time saving in DSR under zero till condition was due to the reason as

Figure 1: Time required for seed bed preparation and sowing/ transplanting
(Five years' pooled data)

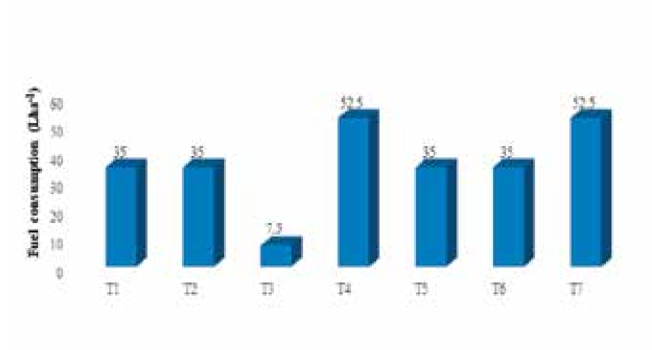

Figure 2: Fuel consumption for seed bed preparation and sowing/ transplanting
(Five years' pooled data)

no operation was required for seed bed preparation before sowing of rice. Afzalinia *et al* (2011) and Khippal *et al* (2018) also reported 73.9 and 88 per cent time saving respectively in zero tillage planting as compare to conventional tillage. Time saving of 66.7 per cent was also registered in DSR under vattar condition and DSR under dry condition.

Fuel consumption

Fuel consumption during seed bed preparation and sowing is presented in figure 2. Both the methods *i.e.,* manual transplanting of rice and drum sowing in puddle condition where puddling was done consumed maximum fuel (52.5 L/ ha) ie 45 L/ ha more than DSR in zero till condition as no operation was needed for seed bed preparation in this crop establishment method. The reduction in fuel consumption in DSR under *vattar* condition and DSR under dry condition was 33.3 per cent as compared to conventional method of transplanting rice. Fuel consumption saving of 77.3 and 91.7 per cent were also reported by Afzalinia *et al* (2011) and Khippal *et al* (2018) respectively in cotton crop using zero tillage method.

Cost comparisons in seedbed preparation and sowing/ transplanting

Maximum cost for seedbed preparation and sowing/ transplanting was recorded in manual transplanting of rice in puddle condition (₹ 10775/ ha) followed by drum sowing in puddle condition (₹ 7775/ ha), whereas minimum cost was observed in DSR under zero till condition (₹ 3680/ha). The reduction in cost for seedbed preparation and sowing was 65.8 and 44.7 per cent in DSR under zero till condition and DSR under *vattar* condition respectively compared to manual transplanting of rice in puddle condition (Fig 3). The cost reduction in DSR under zero till condition was due to the reason as no mechanical operation was needed for seed bed preparation, but ₹ 2000/ha were spent for making the seedbed weed free by spraying herbicide before sowing of rice.

Monetary Gain

Highest returns over variable cost (₹ 89019/ ha) were achieved under direct seeding of rice in *vattar* condition followed by direct seeding of rice in dry condition (₹ 87072/ ha). The lowest returns over variable cost (₹ 80777/ha) were achieved under manual transplanting of rice. Direct seeding of rice under *vattar* condition registered 2.24,4.39, 10.2, 14.81, 6.08 and 10.2 per cent higher returns over variable cost over DSR under

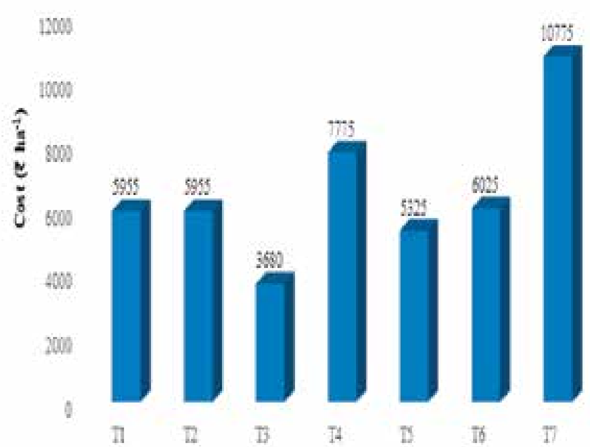

Figure 3: Cost comparisons in seedbed preparation and sowing (₹ ha^{-1}) among different treatments (Mean of five years)

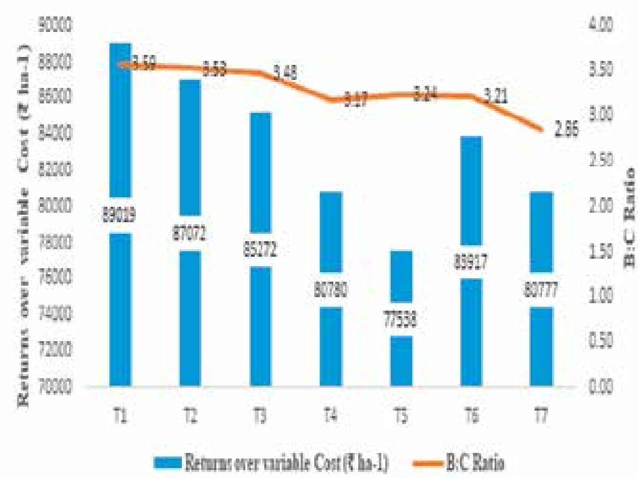

Figure 4: Effect of different crop establishment methods on monetary benefit (Five years' pooled data)

dry condition, DSR under zero till condition, drum sowing in puddle condition, drum sowing in un puddle condition, mechanical transplanting rice in un- puddle condition and manual transplanting in puddle condition, respectively. Maximum (3.59) and minimum (2.86) benefit: cost ratio were also achieved under direct seeding of rice in *vattar* condition and manual transplanting of rice in puddle condition respectively (Figure 4). Swain *et al* (2017) reported that drum sowing of rice was beneficial than conventional method of transplanting rice. Variation in profit may be due to variation in energy requirement, labor cost and fuel consumed in different operations. Similar findings were reported by Prem *et al* (2013), Tripathi *et al* (2014), Gill *et al* (2014), Kumar *et al* (2015), Sharma *et al* (2016), Kumar and Batra (2017). Khippal *et al* (2018, 2016[a], 2016[b], 2016[c]) also reported monetary gains due to adoption of conservation agriculture practices in cotton and sugarcane crop.

CONCLUSION

Based on this long term study, it can be concluded that DSR under *vattar* condition, DSR under dry condition and DSR under zero till condition can be potential alternate methods of crop establishment for rice in comparison to traditional method of transplanting rice under puddle condition. However, weed management and irrigation management are very crucial to attain higher yield under DSR. These methods of crop establishment are most economical as fuel consumption, cost and time in seedbed preparation are reduced without affecting grain yield significantly. Growth duration is also reduced 6-7d enabling timely sowing of succeeding crop.

REFERENCES

Anonymous (2013). *Packages of practices for kharif crops*. Publication section, Directorate of Extension Education, CCS Haryana Agricultural University, Hisar.

Anonymous (2016): Labour in Indian Agriculture: A Growing Challenge. FICCI (Federation of Indian Chambers of Commerce & Industry).2015. Available online: http://ficci.in/spdocument/20550/FICCI-agri-Report%2009-03-2015.pdf

Anonymous (2019). *Agricultural Statistics at a Glance*. Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India, Krishi Bhawan, New Delhi-110 001. 49.

Anonymous (2020): *United States Department of Agriculture*, Foreign Agricultural Services, PSD Reports, World Rice Production, Consumption and Stocks, 10.11.2020.

Afzalinia S, Behaeen, MA, Karami A, Dezfuli A and Ghaisari A (2011). Effect of conservation tillage on soil properties and cotton yield. *J Agril Machinery Sci* **7(1)**: 73-76.

Davla D, Sasidharan N, Macwana S, Chakraborty S, Trivedi R, Ravikiran R and Shah G (2013). Molecular characterization of rice (*Oryza sativa* L.) genotypes for salt tolerance using microsatellite markers. *The Bioscan* **8:** 498-502.

Dingkuhn M, Schnier H F, DeDatta S K, Kropff M S and Javellana, C (1991). Relationship between ripening phase productivity and crop duration, canopy photosynthesis, and senescence in transplanted and direct seeded lowland rice. *Field Crop Res* **26:** 327-345.

Farooq M., Kadambolt HM, Siddique R, Aziz T, Lee DJ and Wahid A (2011). Rice direct seeding: Experiences, challenges and opportunities. *Soil and Tillage Res* **111**: 87-98.

Kamboj B R, Kumar A, Bishnoi D K, Singla K, Kumar V, Jat M L, Chaudhary N, Jat H S, Gosain D K, Khippal, A, Garg R, Lathwal O P, Goyal S P, Goyal N K, Yadav A, Malik D S, Mishra A and Bhatia R (2012). *Direct seeded rice technology in Western Indo-Gangetic Plains of India* : CSISA Experiences. CSISA, IRRI and CIMMYT.

Khippal Anil, Kumar D, Kumar A, Kumari S, Chuni Lal, Singh Jasbir, Verma R, Sheokand R, Prajapat K, Singh J, Sharma A and Kumar L (2016[c]). Effect of sowing dates and seed rate of feed barley in relay cropping of cotton. *Bhartiya Krishi Anusandhan Patrika* **31**:7-10.

Khippal Anil, Kumari Kamini and Singh Jasbir (2018). Effect of tillage and crop establishment methods on yield and economics of cotton. *J Agri Search* **5(1):**30-33.

Khippal Anil, Singh J and Chhokar R S (2019). Control of complex weed flora in direct seeded rice using bispyribac-sodium in combination with other herbicides. *J Cereal Res* **11(3):** 282-285.

Khippal Anil, Singh S, Meharchand, Sheokand R, Singh J, Verma R and Kumar R (2016[a]). Mechanized and profitable intercropping of legumes in autumn planted sugarcane. *Legume Res* **39 (3):** 411-418.

Khippal Anil, Singh S, Meharchand, Sheokand R, Singh J, Sharma A K and Verma R (2016[b]). Mechanized intercropping of legumes in spring planted sugarcane. *VEGETOS* **29 (Special)**: 52-64.

Kumar A, Kumar S, Dahiya K, Kumar S and Kumar M (2015). Productivity and economics of direct seeded rice (Oryza sativa L.). *J Applied and Natural Sci* **7 (1):** 410 – 416.

Kumar R and Batra S C (2017). A Comparative Analysis of DSR Technology Vs. Transplanted Method in Haryana. *Econ Affairs* **62(1):**169-174.

Kumar V and Ladha J K (2011). Direct seeding of rice: Recent developments and future research needs. *Adv in Agron* **111:** 297-413.

Gill J S, Walia S S and Gill R S (2014). Direct seeded rice: An alternative rice establishment technique in north-west India – A review. *Int J Adv Res* **2(3)**: 375-386.

Gill M S, Kumar, A and Kumar P (2006[a]). Growth and yield of rice (Oryza sativa) cultivars under various methods and times of sowing. *Indian J Agron* **51(1):** 23-27.

Gill M S, Kumar P and Kumar A (2006[b]). Growth and yield of direct-seeded rice (Oryza sativa) as influenced by seedling techniques and seed rate under irrigated conditions. *Indian J Agron* **51(4):** 283-287.

Prem Guru, Afzalahmad, Singh U and Kumar R (2013). Experiences, impact and scope of direct seeded rice in Ambala, Haryana. *Agriculture Update* **8(3):** 419-424.

Sharma V, Bali AS and Kachroo D (2016). Effect of different establishment methods and sowing schedules on growth and yield of hybrid rice (Oryza sativa) and their after effects on succeeding wheat (*Triticum aestivum*) in rice –wheat cropping system. *Econ Affairs* **61(3):** 487-493.

Swain S K, Mohapatra A K, Dash A K, Paikray R K, Jena S and Nayak B R (2017). Evaluation of bullock drawn drum seeder with other rice establishment methods under wet land conditions. *J Krishi Vigyan* **6 (1)**: 88-92.

Tripathi RS, Raju R and Thimmappa K (2014). Economics of direct seeded and transplanted methods of rice production in Haryana. *Oryza* **51(1):** 70-73.

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