RESEARCH PAPER International Journal of Agricultural Engineering | Volume 8 | Issue 2 | October, 2015 | 210-214
e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/8.2/210-214**

Comparative performance of different puddling equipments

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Received : 19.08.2015; **Revised :** 20.08.2015; **Accepted :** 16.09.2015

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ABSTRACT : This study was conducted at farmer's field as well as at KVK farm in Gurdaspur district of Punjab to evaluate the performance of various puddling implements *viz.*, pulverizing roller (T_1) and rotavator (T_2) with comparison to conventional method of puddling (T_3) being used by the farmers in the various parts of the state. In T_1 the puddling was done by two passes of pulversing roller whereas in T_2 it was done with only single pass of rotavator and in T_3 by two passes of cultivator followed by two passes of planker. The puddling index (PI) was highest in T_2 (71.5%) followed by T_1 (69.3 %) and T_3 (49.8 %). The PI of all the treatments differed significantly from each other, though the PI in T_1 and T_2 was far better than T_3. The infiltration rate in case of T_1 and T_2 was 11.8 and 17.6 per cent lower than T_3, respectively. The net returns (Rs. 52,250/ha) and benefit cost ratio (3.1) was highest in case of T_1, followed by T_3 (Rs. 52,100/ha and 2.7) and T_2 (Rs. 51970/ha and 2.5) treatments, respectively.

KEY WORDS : Puddling index, Infiltration rate, Pulverizing roller, Rotavator, Net returns

HOW TO CITE THIS PAPER : Chhina, R.S. (2015). Comparative performance of different puddling equipments. *Internat. J. Agric. Engg.*, **8**(2) : 210-214.

In Punjab rice is grown on an area of 28.51 lakh ha with production of 169.1 lakh tons (Anonymous, 2015). Paddy cultivation needs high energy input particularly for seed bed preparation and irrigation. As a practice, shallow standing water in the field during early months of crop growth is a pre-requisite for the success of crop. This practice results in huge losses of water due to deep percolation. Approximately 75 per cent of water applied to rice crop is lost through deep percolation during submergence of fields (Swaminathan, 1972). Hence, it is cultivated under puddled conditions to minimize the percolation losses and to enhance the water and nutrient use efficiency. Puddling has been defined as the reduction in the apparent specific volume of a soil by doing mechanical work on it (Bodman and Rubin, 1948).

Puddling in standing water before transplanting paddy seedling is a common practice to reduce water infiltration. It facilitates transplanting and helps to maintain standing water in the field by decreasing infiltration losses. Ultimately, it also helps to conserve water, the most precious natural resource. By puddling, a mellow soil structure is obtained and soil becomes soft. The seedlings can be placed into the mud with little resistance and without any damage. Puddling causes the soil to go in suspension in water for some time. It slowly settles in 48-72 hours in such a way that the large size particles (sandy) settle first and lighter one (clay) later with the passage of time. As a result a clay layer is formed over the top surface and also the clay particles plug the pores between the sandy particles. This impervious clay layer helps to reduce infiltration rate and hence, decreases deep percolation losses. The extent of reduction in percolation losses depends on the level of puddling. In a sandy loam soil, percolation rate decreases significantly with increase in puddling level from low to high (Aggarwal *et al.*, 1995). Shallow puddling may result in development of sub-surface compact layer at a shallow depth, which may be loosened during cultivation for wheat seed-bed preparation. Thus, shallow puddling may be one practical way of reducing water requirements of rice without having any adverse effect on yield of following wheat crop. Effects of depth of puddling on percolation rate are contradictory (Bhadoria, 1986; Kar *et al.*, 1986; Singh *et al.*, 1993 and Sharma and Bhagat, 1993). Thus, by a quality puddling water requirement is reduced along with saving movement of nutrients like nitrogen (N) beyond the root zone. It also helps to reduce the risk of ground water contamination with nitrates and other chemicals. In addition to this puddling offers many advantages like weed control, easier transplanting, reduced percolation and even soil surface for transplanting (De Datta and Barker, 1978)

Various methods and implements have been used to achieve the required level of puddling. Number of puddlers have been developed and compared by various scientists and they have found that the rotary pudllers performed better as compared to conventional puddling methods in terms of quality (Singh *et al.,* 1973; Tyagi *et al.*, 1975; Singh, 1983 and Verma and Dewangan, 2006). In Punjab, farmers mainly use tractor mounted cultivators and plankers for puddling operations. Planking generally follows the cultivator operation to seal the soil at the surface. Infact, the rice crop requires a well prepared soil with a compact layer of low infiltration rate below the root zone to impede water leaching. So a study was conducted to get a good puddled field with different puddling implements *viz.*, pulverizing roller (attachment of roller behind the cultivator) and rotavator in comparison to the conventional method being used by the farmers.

METHODOLOGY

The field experiments were done on the farmer's field as well as at KVK Gurdaspur farm to evaluate the performance of different puddling equipments. The soil type of the experimental field was clay loam. The puddling was done with the help of three different equipments as given in Table A.

In T_1 the puddling was done by two passes of pulversing roller whereas in T_2 it was done with only single pass of rotavator and in T_3 by two passes of cultivator followed by two passes of planker. The puddling index, infiltration rate and yield were taken as dependent parameters to evaluate the performance of these equipments. The B:C ratio was also calculated in each of the treatment for the comparative performance.

Table A : Independent parameters of the study

T_1	Pulverising roller (two passes)
T_2	Rotavator (single pass)
T_3	Cultivator (two passes) + Planker (two passes)

Brief description of the implements used for puddling :

Pulverizing roller :

Pulverizing roller is an attachment to the commercially available tine cultivators (Fig. A). It is suitable for puddling as well as dry seed bed preparation. The roller consists of 6 pulverising members made of MS Steel flats. These members pass through the slots in the star wheels. The attachment of roller to cultivator is made with the help of two links having bearing housing on one side and tensile springs on the other side. The distance between the hinge point and central axle is 67.5 cm (Garg and Singh, 2002). Technical specifications of the machine are given in Table B.

Table B : Specifications of the Pulverising roller

Type	Tractor operated
Power source	Minimum of 35 h.p tractor
Overall dimensions (cm)	207 × 85 × 55
Number of star wheels	6
Distance between star wheels	37.0 cm
Number of pulverizing members	6
Operating width (cm)	180 or 220
Size of soil working components (cm)	MS flats of 185 × 2.5 × 0.6
Weight (kg)	90

Fig. A : A stationary and working view of pulverizing roller

Rotavator :

It is suitable for preparing seedbed in single operation both in dry and wet land conditions. It consisted of a frame, a rotary shaft mounted with blades and power transmission system from the gearbox to the shaft (Fig. B).

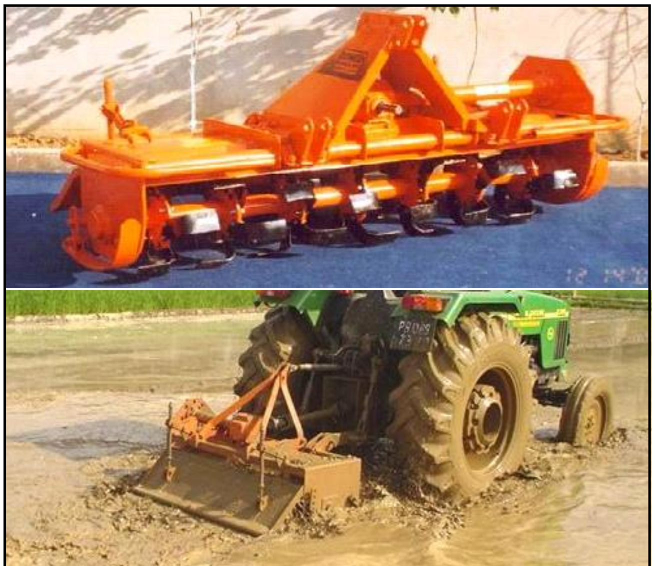

Fig. B : A stationary and working view of rotavator

Puddling index :

Puddling index was determined according to ISI specifications IS: 11531(1985). For this the samples of soil water suspension were taken by immersing a glass tube upto a depth of about 10 cm. These samples were collected from four points in a plot and collected in glass cylinder after a particular tillage treatment. These cylinders were kept undisturbed for 48 hours to allow soil particles to settle. Then volume of settled soil as well as the volume of total sample was recorded and puddling index was determined with the equation given by Bengali, 1976.

$$PI = \frac{Vs}{Vt} \times 100$$

where,

PI = Puddling Index

Vt = Total volume of soil-water suspension in the test tube

Vs = Volume of soil settled in the test tube

Infiltration rate :

For measuring infiltration rate wooden scales of 30 cm length were installed vertically at five different places in each plot immediately after the puddling treatment. Initial reading on the scale was noted down immediately after the scales were fixed in the field. Second reading was noted down after a period of five hours. The amount of water infiltrated in millimeter (mm) was divided by time interval in hours (h) to determine infiltration rate (IR) as mm/h. Infiltration rate was measured in the plots for the number of days till a steady state (basic infiltration rate) was achieved.

Yield :

The yield was recorded by harvesting an area of 5 m^2 from three locations in each treatment. The harvested crop was manually threshed and weighed to obtain a yield.

■ RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Puddling index (PI) :

The observed values of puddling index (PI) were 69.3, 70.5 and 49.8 per cent in $T_{1,}$ T_2 and T_3, respectively (Table 1). The highest PI was recorded in T_2 (71.5%) and lowest in T_3 (49.8%). The PI of all the treatments differed significantly from each other, though the PI in T_1 and T_2 was far better than T_3. The PI in T_1 and T_2 was 39.2 and 41.6 per cent higher than T_3. This might be due to more and more mixing of soil particles with turbulent water resulting in formation of dense slurry of soil and water containing more volume of soil in per unit volume of water in the slurry which resulted in higher PI values. The results of study are in accordance with the findings of Tomar *et al.* (2006).

Infiltration rate :

The observed values of infiltration rate were 0.75,

Table 1 : Effect of puddling methods on different parameters

Treatments	Puddling index	Infiltration rate (mm/h)	Yield (kg/ha)
T_1	69.3	0.75	6820
T_2	70.5	0.70	6790
T_3	49.8	0.85	6800
C.D. (P=0.05)	0.32	0.062	NS

NS=Non-significant

0.70 and 0.85 per cent in T_1, T_2 and T_3, respectively (Table 1). The infiltration rate was lowest in case of rotavator (0.70 mm/h) whereas it was highest in case of cultivator + planker (0.85 mm/h). The infiltration rate in case of T_1 and T_2 was 11.8 and 17.6 per cent lower than T_3, respectively. The maximum dispersion of soil particles was due to more churning of soil particles in water because of rotary action of the pulversing roller and rotavator. The suspended particles settle down after some time. In this process, the coarser particles settled down first followed by finer particles. The finer particles seal the pore space causing cementing action on soil surface. It has the sealing effect on the layers of the soil resulting in hardpan formation, which is almost impervious to water (Tyagi *et al.*, 1975) which results in lower infiltration in case of T_1 and T_2 as compared to T_3. Similar trends were observed by Aggarwal *et al*. (1995); Sur *et al*. *(*1981); Sharma *et al.* (2004) and Dixit (2006).

Yield :

The observed yield was 6820, 6790 and 6800 kg/ha in T_1, T_2 and T_3 treatments, respectively. It is evident that the puddling done with different equipments doesn't have any significant effect on the yield of the crop.

Economics :

The net returns (Rs. 52,250/ha) and benefit cost ratio (3.1) was highest in case of T_1, followed by T_3 (Rs. 52,100/ha and 2.7) and T_2 (Rs. 51970/ha and 2.5), respectively (Table 2). Moreover, there was saving of one operation of planking in T_1 and T_2 as compared to T_3.

Table 2 : Economic performance of different puddling methods

Treatments	Yield (t/ha)	Net returns (Rs./ha)	B:C ratio
T_1	6.82	52,250	3.1
T_2	6.79	51,970	2.5
T_3	6.80	52,100	2.7

Conclusion :

It may be concluded from the study that the quality of puddle affects the water infiltration rate. The puddling with pulverisng roller is as good as puddling done with the rotavator and is better and economical than conventional puddling. So, it is suggested that the improved puddling equipments may be used over conventional equipments for saving water.

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