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DEVELOPMENT AND EVALUATION OF SELF-PROPELLED RICE RIDGE SEEDER FOR PRE-GERMINATED SEEDING

S. K. Mathankar [*], K. P. Saha[♦], S. K. Rautaray[♣] and V. V. Singh[♣]

ABSTRACT

Seeding of pre-germinated rice seeds is increasingly considered an alternate to manual transplanting because of reduced labour and drudgeries; higher profit and comparable yields. Traditionally farmers practice manual broadcasting of pre-germinated seeds. For line sowing many designs of manual drum seeders have been developed but pulling them on puddle fields involves drudgeries and is classified as heavy work. Besides this, their capacity is rather low. To address the issue, development of self-propelled rice ridge seeder was taken up and its performance was compared. Lab testing of seed metering mechanism revealed that seeding rate variation within permissible 10% limit is possible by maintaining a desirable drum fill condition. The developed unit is designed for ridge seeding of pre-germinated seeds in 8 rows at 24 cm spacing. A 4.5 hp diesel engine was selected taking into consideration the draft requirement in puddle field. The seed metering mechanism with provision of varying seed rate is driven by rear shaft from engine. The effective field capacity was 0.30 ha/h at 2 km/h forward speed. The developed unit is suited to operate in shallow puddled fields just after the drainage of surface water, when the moisture content of topsoil layer is nearer to liquid limit. The yield of crop sown by the developed unit was 5.3 t/ha and it was comparable to manual transplanting (5.7 t/ha) and manual drum seeder (5.1 t/ha) and it was higher than manual broadcasting (4.4 t/ha). Seeding by developed unit helped in avoiding nursery raising; in eliminating the labour for rice transplanting; in reducing the drudgery of labourers both in pulling the manual drum seeder or in manual transplanting of rice seedlings and in reducing the cost of cultivation. The net return was higher by Rs. 3,093 (US $ 67.2) per ha for crop sown by the developed unit in comparison to transplanting. The pre-germinated ridge seeding by the developed unit provides a viable option for cultivation of rice as an alternate both to broadcasted rice and transplanted rice.

Keywords: *Self-propelled rice ridge seeder, rice, pre-germinated ridge seeding and wet ridge seeding*

1. INTRODUCTION

Rice is the main cereal crop grown in India and several other Asian countries. India is the second largest producer of rice in the world, only next to China. But the average yield of rice is very low (2 t/ha) as compared to other countries. Rice is largely grown by manual transplanting of seedlings in puddle fields because of higher yield and low weeds. Apart from this, rice is also sown by manual broadcasting of pre-germinated seeds in puddle fields. Direct sowing of pre-germinated seeds on puddle field avoids nursery raising in hot summer which requires considerable irrigation water - a scarce resource. In addition, it eliminates manual transplanting, which is very drudgerous and labour intensive operation. Manual broadcasting of pre-germinated seeds results in uneven plant stand, hinders farm operations and results in lower yields. Line seeding of pre-germinated seeds in puddle field by different designs of manual drum seeder have been reported by Singh et al. (1983), Srivastava and Panwar (1991), Rautaray et al. (2002), Devnani (2002) and Das (2003) with field capacity in the range of 0.06-0.1 ha/h. They reported pre-germinated line seeding comparable in yield to rice transplanting and better when compared to manual broadcasting. They also reported that the pre-germinated line seeding resulted not only in labour and cost saving but also in higher net returns.

But, walking in puddled fields while pulling the manual drum seeder is extremely drudgerous. Nag and Dutt (1980) reported energy expenditure of 33.4 kJ/min while seeding with manual drum seeder in puddle fields whereas the limit for acceptable workload for Indian workers is 14.6 kJ/min and classified pulling of drum seeder as heavy work. Low capacity of manual drum seeder and drudgery involved calls for development of suitable machines. Mathankar et al. (2004) reported that a self-propelled rice seeder is technically and economically feasible

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considering draft requirement, less turning radius, farm size and manoeuvrability. Self-propelled units for specialized operations like rice transplanting, weeding and harvesting are in use. Therefore, to address the above issues the present study for development of a self-propelled rice ridge seeder was undertaken.

2. DEVELOPMENT OF SELF-PROPELLED RICE RIDGE SEEDER

Pre-germinated seeds are sown on puddle fields after drainage of surface water. Even after drainage of surface water there will be patches of standing water and this may also be due to rains or submergence of rice fields. The emergence is adversely affected if the pre-germinated seeds are submerged as it cuts oxygen supply to the seeds. Slow oxygen releasing coating of calcium peroxide was reported by Nakamura et al. (1983) for submerged sowing but it adds to cost besides having several other constraints. The ridge seeding in such a situation can be helpful. So in order to reduce submergence of seeds, faster drainage and golden snail attack the unit was designed for ridge seeding. The detailed design considerations of various components are discussed in following subheadings

2.1 Development of Seed Metering Mechanism

The rotating drum with orifices along the periphery of the drum was selected for metering of pre-germinated seeds. This type of metering has been reported and found successful by many researchers [Singh et al. (1983), Srivastava and Panwar (1991), Rautaray et al. (2002) and Das (2003)]. They reported drum diameter from 15 to 20 cm. Probably, the diameter of drum was kept smaller mainly because they were manually operated equipment. In order to have lesser number of fillings, a drum diameter of 25 cm was selected with 30 cm length. Mild steel was used for fabricating drum. Two rows, 24 cm apart, of the metering orifices (16 nos., 10x18 mm slot size) were made on the cylindrical surface of the drum with an orifice spacing of 5 cm (Das, 2003). The seeding

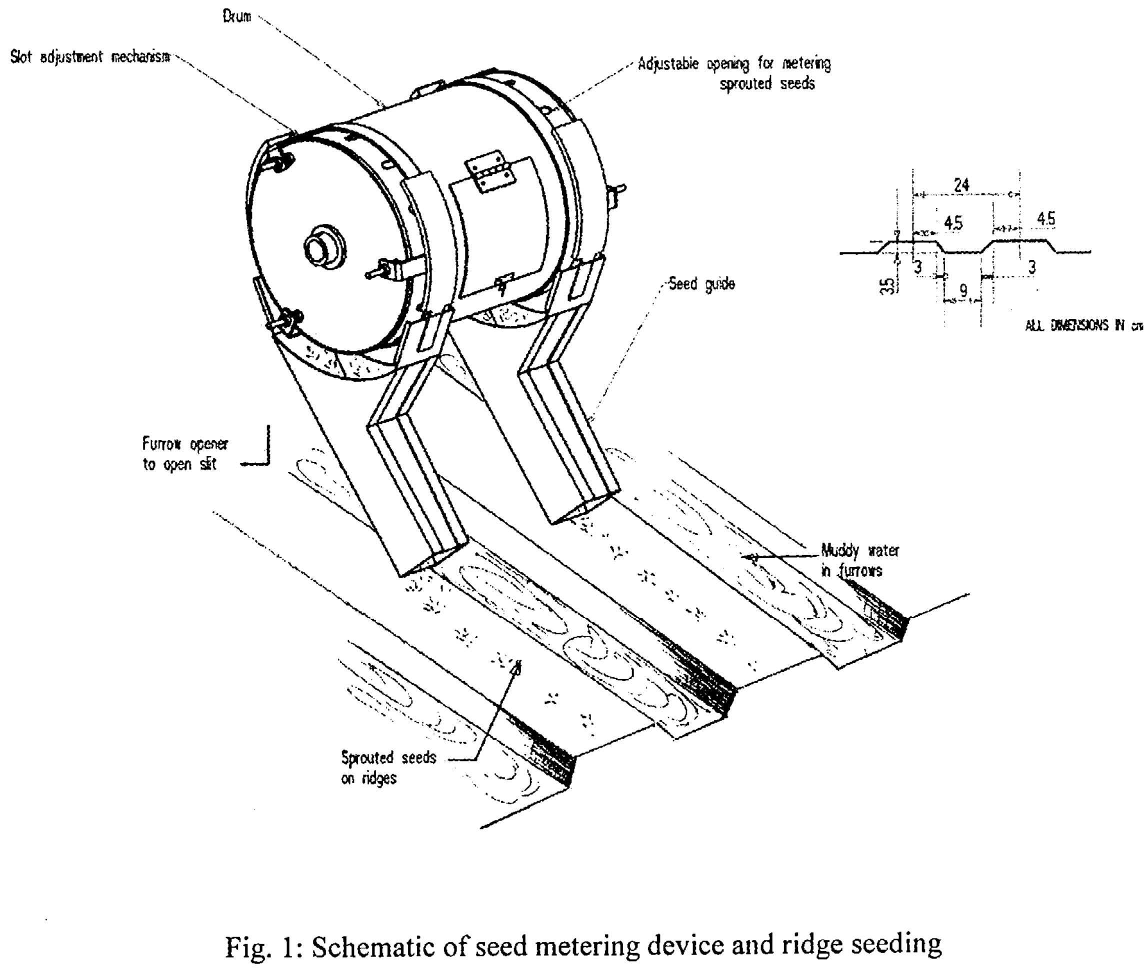
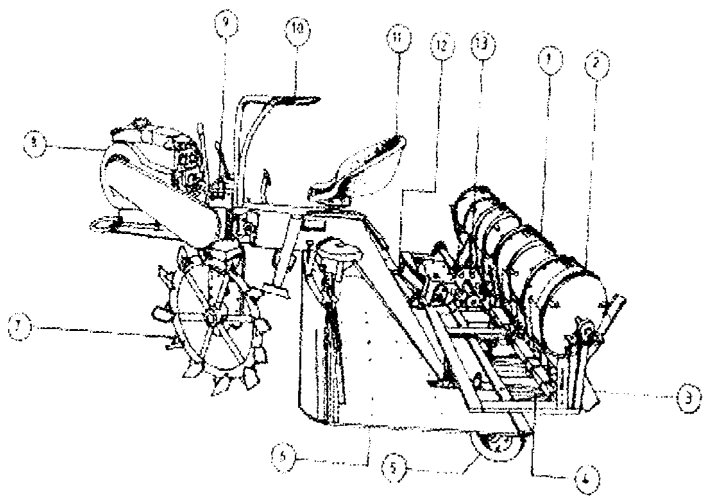


Fig. 1: Schematic of seed metering device and ridge seeding



1	Drum with two rows of orifices
2	Orifice adjustment system
3	Seed guide
4	Row ridgers
5	Transport wheels
6	Main float
7	Traction wheel
8	Engine
9	Seed metering engage /disengage lever
10	Steering
11	Operators seat
12	Rear shaft for driving seed metering mechanism
13	Drive to seed metering mechanism from rear shaft

Fig. 2: Schematic diagram of self-propelled rice ridge seeder

rate can be varied by changing orifice size, by screwing or unscrewing of the bolts (Fig. 1). Ryuji (1998) and Jinfu and Te (1997) used ground wheel for rotating drums, which needs to be raised or lowered at headlands. The raising and lowering becomes much difficult when ground wheels and drums are mounted on the same shaft because of weight. Soil accumulations on ground wheel and blocking of orifices by mud splashes from ground wheel, were the other constraints, when ground wheel was used for rotating the drum in addition to traction. The drive from ground wheel also increases overall length of the machine causing operational difficulties. To avoid raising and lowering of the ground wheel and other constraints, the drive to drums was given through the rear shaft. Verma (2004) also reported a similarly driven (power tiller axle) metering device for sowing. The linear speed of drum in the developed unit was kept 10+0.5 m/min, which is within the recommended speed for metering devices. A lever was provided to engage and to disengage the metering device.

2.2 Development of Seed Guide

Seed guides were provided for collecting and guiding the pre-germinated seeds falling from drum openings to the field so as to make rows. In the absence of seed guides the seeds get spread randomly and clear rows are not formed. Tewari and Dutta (1983) reported the seeds dispersion in the range of 4 to 18.6 cm. Two sides of the seed guide were used to collect the seeds dropping from the drum openings. The gap between opposing sides of the seed guide's upper portion was kept greater than the drum diameter. The seed guides, made of mild steel, were fitted just below the drum and the centreline of the drum openings was parallel to the width wise centreline of the seed guide so that the falling of the seeds out side the funnel was minimized. A schematic of arrangement is shown in Fig. 1.

2.3 Float and Row Ridgers

The bearing capacity of the soil is greatly reduced

Table 1: Brief specifications of self propelled rice ridge seeder

Sr. No.	Parameter	
1.	Dimensions (length x width x height)	3.0 x 2.2 x 1.5 m
2.	Power source	4.5 hp diesel engine
3.	Turning radius	3.0 m
4.	Field speed	1.8 and 2.2 km/h
5.	Traction wheel	0.67 m diameter, lug spacing 24^0
6.	Suitable seeds	Pre-germinated rice seeds

Table 2: Physical properties of rice seeds variety *Sungandha*

Sr. No.	Parameter	Dry	Wet	Pre-germinated
1.	Length, mm	11.53	11.89	11.89
2.	Width, mm	2.30	2.39	2.39
3.	Thickness, mm	2.01	2.10	2.10
4.	Bulk density, kg/m^3	529	565	557
5.	Moisture content (wet), %	10.38	32.53	31.23
6.	Repose angle, ^{0}	35.60	39.03	38.05

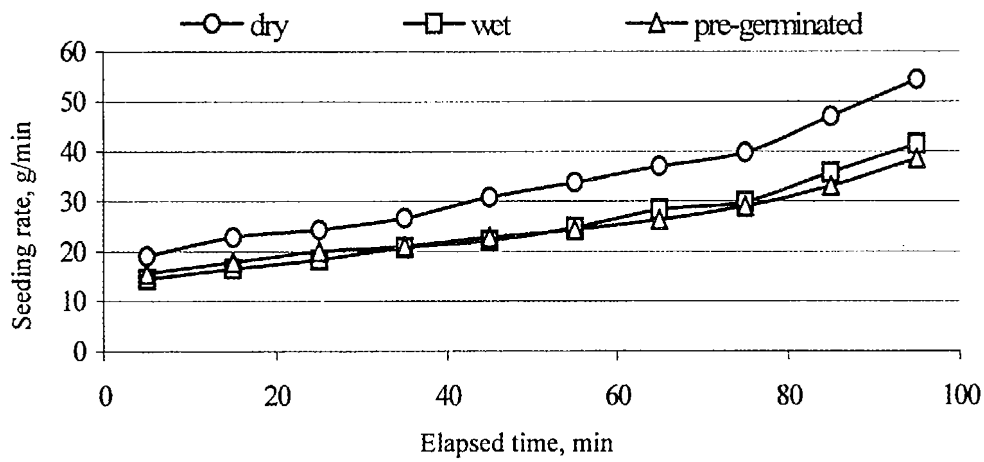


Fig. 3: Seedomg rate variations with 100% openings for different seed conditions

Table 3: Coefficient of variation and standard deviation of seed dropped for different opening and seed conditions

Parameter	Quarter of emptying time	Full opening (100%)			Half opening (50%)		
		Dry	wet	pre-germinated	dry	Wet	pre-germinated
Standard deviation (g)	I	2.74	1.94	1.63	1.00	0.70	0.84
	II	4.41	3.30	2.21	2.12	1.39	1.09
	III	7.28	5.83	4.81	3.24	2.31	2.11
	I & II	6.38	4.79	3.55	2.72	1.78	1.60
	II & III	9.57	7.49	6.18	5.66	3.77	2.91
	All	11.21	8.67	7.01	6.34	4.19	3.34
Coefficient of variation (%)	I	12.46	11.84	9.09	8.24	7.47	8.50
	II	13.76	13.79	9.37	12.99	11.53	8.77
	III	15.49	16.34	14.30	12.51	12.54	12.40
	I & II	23.00	23.11	16.79	19.14	16.63	14.30
	II & III	24.90	25.84	22.20	26.77	24.76	19.80
	All	33.43	34.36	28.21	35.01	31.62	25.50

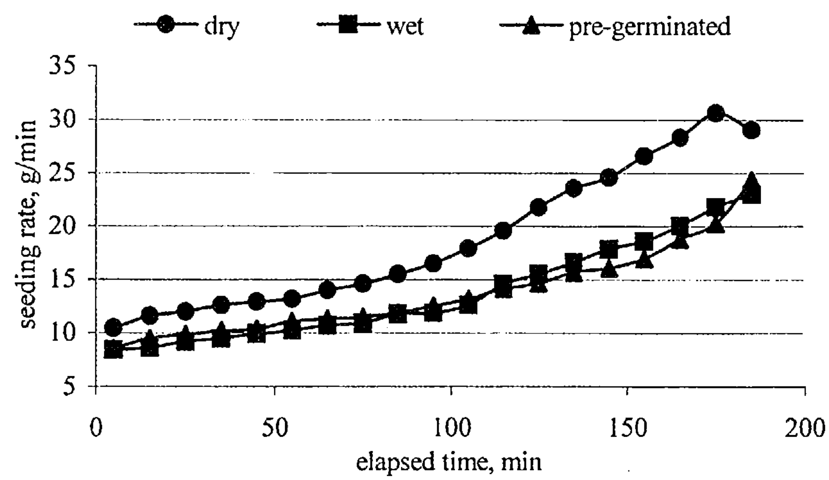


Fig. 4: Seeding rate variations with 50 % openings for different seed conditions

Table 4: Soil properties of test site

Sr. No.	Parameter		
1.	Type of soil		Silty-clay
2.	Predominant clay mElapsed time, min		ontomorillonite
3.	Texture	Sand	14.79%
		Silt	30.51%
		Clay	54.70%
4.	Dry density, kg/m^3		1530
5.	Saturated density, kg/m^3		1930
6.	Liquid limit		48.62%
7.	Field capacity		30.86%

Table 5: Average draft for different field conditions

Sr. No.	Field condition		Draft, kN	Moisture content, % (dry basis)	Cone Index, Mpa
1	Dry field		1.560	14.21	1.26
2	Soaked field	With surface water	2.580	48.94	0.36
		No surface water	4.042	46.78	0.36
3	Puddled field with Peg type puddler	With surface water	1.562	45.89	0.62
		No surface water	1.962	44.69	0.67
		Left for 24 h after removal of surface water	2.981	38.19	0.92
4.	Puddled field with Rotary tiller	Surface water	1.638	46.12	0.55
		No surface water	2.017	43.86	0.55
		Left for 24 h after removal of surface water	3.148	36.91	0.87

in soft or puddle condition. So the load of the machine needs to be distributed over a larger area. A float measuring 2.2 x 1 x 0.015 m size with one end raised up to 0.15 m, in the direction of travel was provided to support the main frame on one end and to mount seed metering mechanisms along-with furrow openers and row ridgers on the other end. On the main float, nine row ridgers were fixed to form eight ridges in the puddled field. On these trapezoidal ridges (average top width 9 cm and height 3.5 cm) seeds fall from seed guides forming lines. Removable sweep type furrow openers were provided for each row with the provision of varying depth of individual furrow opener. The furrow openers, seed guides and drums were mounted on a frame, which was hinged to the main float having the provision of raising or lowering the whole assembly.

2.4 Design of Power Unit

The drawbar power or propulsion power for self-propelled implements (ASAE EP496.2) is given as

$$P = \frac{DS}{3.6 * \eta m * \eta t} \quad ..(1)$$

Where,

- P = power, kW
- D = draft, kN
- S = travel speed km/h
- ηm = mechanical efficiency of transmission and power train,
- ηt = traction efficiency.

Ojha and Pandey (1974) reported the tractive efficiency in the range of 32.5% to 55.0% for different normal loads and wheel type in puddle fields. ASAE D 497.4 reported minimum tractive efficiency of 55% for soft soil condition for two wheel drive tractors. Based on above refereed studies (Ojha and Pandey (1974) and ASAE D 497.4) 40% tractive efficiency and 96% transmission efficiency of power transmission and power train were assumed. The machine was powered through gear train from the engine. Two field speeds (1.8 and 2.2 km/h) and one transport speed were selected. The schematic diagram of the developed unit is shown in Fig. 2 and brief specifications are given in Table 1.

3. MATERIALS AND METHODS

3.1 Laboratory Testing

Seed rate variations in drum type metering mechanisms are a major concern. For a given seed condition, opening size and shape; the variations are mainly due to drum fill condition and to study the variations lab tests were conducted. The test set-up consisted of drum with seed guides, a pneumatic wheel running over a belt to rotate the drum and an electric motor to drive the belt. When the drum rotates the seeds get released, pass through the seed guides and finally get collected in containers (plastic bags). Three seed conditions dry, wet and pre-germinated and two conditions of the openings i.e. with all openings open (100%) and half of the openings open (50%) (alternate openings were blocked) were taken and the tests were replicated thrice. The wet seeds were soaked in water for 24 h. Pre-germinates seeds were obtained by incubating wet seeds for another 24 h. The drum was rotated at a constant linear speed of 10 m/min and falling seeds were collected for every 10 min time interval. The moisture content of seeds was maintained within + 0.5 percent. The weight of collected seeds was converted to 11.5% moisture content for comparisons.

3.2 Draft Measurement

A strain gauge load cell (0-5 kN) and data logger was used to measure the draft required to pull the developed unit (with 30 kg engine weight and 70 kg operator weight and rear shaft for seed metering in engaged position). Traction wheel of diameter 0.67 m having 15 lugs (0.1x0.1 m size and 22^0 upward lug angle) was used and a tractor pulled the developed unit. About 15 observations were recorded over a stretch of 15 m and replicated thrice. The draft was measured in dry, soaked (24 h), puddle (24 h soaking + 24 h settlement after puddling) and puddle (24 h soaking + 24 h settlement after puddling + left for 24 h after drainage of surface water) conditions. In puddle and soaked conditions the draft was recorded with and without surface water (about 5 cm). Two passes of tractor operated peg type puddler or lightweight power tiller operated rotary tiller puddled the fields, after 24 h of soaking with 10 cm standing water. All the plots were previously tilled with two passes of tractor-operated cultivator. The cone index was measured by penetrologger set with 60^0 top angle and 3.3 cm^2 base area cone, operated at a speed of 2 cm per second.

3.3 Field Performance of Developed Unit

The new unit was tested in three field condition i) 6 h of settlement period after puddling + just after visible surface water got drained, ii) 24 h of settlement

Table 6: Field performance parameters of developed unit for different soil conditions

Sr. No.	Parameter		6 h	24 h	24+24h
1.	Puddling depth, cm		15.96	16.35	16.43
2.	Water depth, cm		10.53	11.25	10.67
3.	Puddling Index, %		53.93	55.46	54.58
4.	Cone Index at 20 cm depth, Mpa		0.62	0.67	0.66
5.	Moisture content, %	0-5 cm	47.64	45.89	38.19
		5-10 cm	37.41	36.91	34.84
		10-15 cm	34.63	34.39	31.58
6.	Row spacing, cm		24	24	24
7.	Speed of operation, km/h		2.06	2.0	1.8
8.	Effective field capacity, ha/h		0.31	0.30	0.25
9.	Field efficiency, %		79.2	78.0	72.3
10.	Fuel consumption, l/h		0.67	0.70	0.95
11.	Seeds dropped, no. per m		79	85	94
12.	Depth of hardpan, cm		21.1	20.4	19.7
13.	Slip, %		8.93	12.78	17.6
14.	Sinkage depth of traction wheel, cm		23.14	21.67	20.35
15.	Sinkage depth of main float, cm		3.86	2.92	2.05

Table 7: Plant parameters of crop sown by the developed unit

Sr. No.	Plant parameters	6 h	24 h	24+24 h	C.D. (P = 0.05)
1.	Plant population, no./ m^2	292	351	387	0.75
2.	Plant emergence, %	73.73	82.58	82.60	3.96
3.	Weed intensity (dry wt. g/m^2)	11.02	10.78	9.64	0.69
4.	Plant height after 45 day, cm	48.2	50.33	48.3	1.56

Table 8: Field performance of different crop establishment methods

Sr. No.	Operational parameters	Developed unit	Manual broad-casting	Manual trans-planting	Manual drum seeder	C.D. (P = 0.05)
1.	Time per ha for seeding/transplanting	3.3 h	10 man-h	300 man-h	16.9 h	---
2.	Plant population, No/ m^2	312.7	304.7	124.0	299.3	15.69
3.	Plant emergence, %	78.0	68.6	N.A.	74.0	---
4.	Weed intensity (dry wt, g/m^2)	10.78	8.09	4.00	10.85	0.22
5.	Plant height at 45 days, cm	50.33	49.69	77.72	49.60	1.88
6.	Plant height at maturity, cm	95.23	86.51	94.69	95.00	0.40
7.	No. of effective tillers/m^2	496.33	467.67	427.33	479.67	8.65

Table 9: Yield and economics of different crop establishment methods

Economic parameters	Developed unit	Manual broadcasting	Manual transplanting	Manual drum seeder	C.D. (P = 0.05)
Grain yield, kg/ha	5,327	4,408	5,688	5,139	55.99
Straw yield, kg/ha	3,947	3,302	3,925	3,806	33.05
Grain: Straw Ratio	1: 1.35	1: 1.33	1: 1.45	1:1.35	N.A.
Gross Return, Rs.*/ ha	31,810	26,301	33,815	30,683	---
Gross cost of cultivation, Rs./ha	14,651	15,667	19,150	14,717	---
Net return, Rs./ha	17,158	10,633	14,665	15,966	35.86
Benefit: Cost ratio	2.17	1.68	1.77	2.08	N.A.

* US $ = Rs. 46

period after puddling + just after visible surface water got drained and iii) 24 h of settlement period after puddling + 24 h after surface water drained. The machine test parameters and crop parameters were recorded up to 45 days in 65x10m plots and replicated thrice. Two passes of tractor-operated cultivator tilled all the plots. The plots were soaked for 24 h and puddled with two passes of tractor operated peg type puddler.

3.4 Comparison of different Crop Establishment Methods

A field experiment was conducted to compare four crop establishment methods i) sowing by the developed rice ridge seeder, ii) sowing by 4 row manual drum seeder, iii) manual broadcasting (control) and iv) manual transplanting (control). Tillage and puddling was done as mentioned in section 3.3. Seeding or transplanting was done after 24 h of puddling. Surface water was drained before seeding except in case of transplanting. Completely randomised design of experiment was adopted for the field experiment. The treatments were replicated thrice in experimental plots of size of 20 m x 20 m. The seed rate was 100 kg/ha (variety Kranti) for both pre-germinated rice seeders and it was 125 kg/ha for manual broadcasting. The seeds were soaked in water for 24 h and then wet seeds were incubated in jute cloth placed in plastic trays to have uniform thickness of seed layer and also uniform incubation condition for another 24 h; so as to get pre-germinated seeds with 1-2 mm long sprout. Manual transplanting of twenty-one days old rice seedlings was done in the puddled field; the seed rate was 40 kg/ha. Identical cultivation practices were followed for all the four treatments for rest of the period. The fertilizer was applied at the rate of 120 kg nitrogen, 60 kg phosphorus and 40 kg of potash per hectare in the form of urea, di-ammonium phosphate and murate of potash with 20 kg of zinc sulphate per hectare. Half of the nitrogenous fertilizer (urea) was applied by two top dressing of equal quantity at 30 and 60 days after sowing/transplanting. The observations on machine, crop and yield parameters were recorded.

4. RESULTS & DISCUSSION

4.1 Laboratory Testing of Seed Metering Mechanism

The physical properties of the rice seeds used in testing are given in Table 2. The moisture content of the seed was maintained with a variation of 0.5%. The average moisture content of dry, wet and pre-germinated seeds was 10.38, 32.53 and 31.23 per cent respectively on wet basis.

The seeding rate (g/min) from initial charge to complete emptying is shown in Fig. 3 and Fig. 4. The seeding rate was highest in case of dry seeds among all seed conditions; this may be due to better flow of seeds mainly because of lowest moisture content. There was less difference in highest and lowest seeding rate of wet and pre-germinated seeds as compared to dry seeds; this again appears to be mainly on account of moisture content of seeds. For further analysis, the total emptying time was divided into three quarters and they were named as I, II and III quarter. The coefficient of variation and standard deviation of seeding rate were calculated for all three quarters individually and for quarter I & II and quarter II & III and for all three quarters (Table 3). The standard deviation and coefficient of variations were higher in all cases of 100% opening when compared to 50% opening; this obviously seems to be due to number of opening contributing to seeding rate. Seeding rate variations were minimum in I quarter followed by quarter II and III for all cases. The

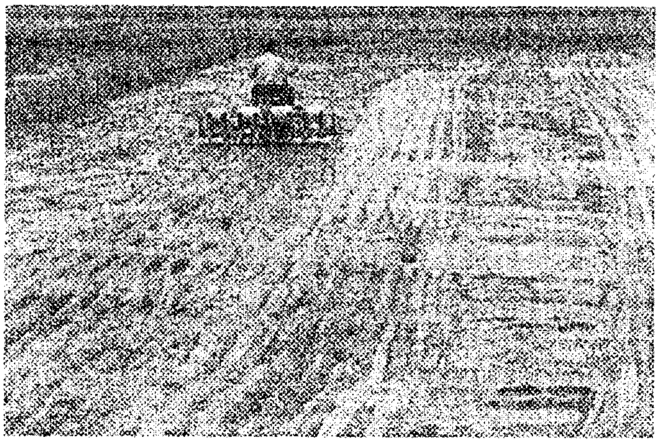


Fig. 5: View of field operation by the developed unit

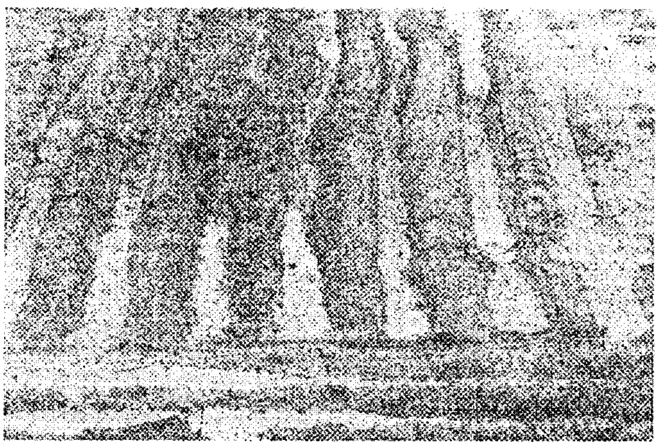


Fig. 6: View of ridges formed by the developed unit and seeds sown over them

variations in any individual quarter were lesser when compared to two continuous or all three quarters. The variations in quarter II and I separately, in case of both 100% and 50% openings for pre-germinated seeds were less than 10%, hence it is recommended to operate the drum in either of these two quarter for better seeding uniformity.

4.2 Draft Measurement

The basic soil properties of the test site are given in Table 4. The soil has predominantly montomorillonite clay having swelling and shrinkage with change of moisture regime. The Table 5 shows average measured values of draft for different field conditions. The draft was highest in soaked field with no surface water (4.042 kN) followed by in puddle field (3.148 kN) when left for 24 h after removal of surface water. In former case, it was due to lack of traction and in later case, it was due to lower moisture content of top soil layer which resulted in sticking of soil mass on traction wheel. The average draft was 1.962 kN and 2.017 kN in field puddled by peg type puddler and rotary tiller respectively, just after the removal of excess surface water. In this condition, topsoil layer was in semi-liquid to liquid state and provided flotation, resulting in reduced draft. In addition, the traction was better due to development of hardpan at about 20 cm depth, which is evident from higher cone index values.

The average draft of 2 kN was taken for selecting the power source. With engine weighing about 30 kg, normal load on traction wheel was 80 kg. Based on the studies of Ojha and Pandey (1974) and ASAE standard, tractive efficiency of 40% (though on lower side) was assumed. Using the equation (1) the power requirement workouts to be 3.86 hp at a speed of 2 kmph and accordingly a 4.5 hp diesel engine was selected.

4.3 Field Evaluation of Developed Unit

Developed self-propelled rice ridge seeder was tested in field for three different field conditions and the results are given in Table 6. The performance of the developed unit was better when operated for 24 h treatment in terms of field capacity 0.3 ha/h and formation of ridges besides other performance parameters (Table 6). The cost of operation was Rs 123 (US $ 2.6; Conversion US $ = Rs. 46) per h. Fig. 5 shows a view of the field operation of the developed unit and Fig. 6 shows ridges formed by the developed unit and seeds sown over them. Higher mudflow was observed for 6 h treatment. Higher soil sticking and choking of traction wheel was observed for 24 h + 24 h treatment (a total of 48 h after puddling). This was mainly due to reduced moisture content of puddled soil profile.

Considering moisture content of soil profile, it appears that the developed unit operated successfully when the moisture content of topsoil layer was in the range of semi-solid to liquid limit. In this range, soil behaved like a semi-liquid or semi-solid substance. It may thus be inferred that immediately after draining the excess surface water is the optimum condition for operating the developed unit.

Table 7 shows plant parameters for above three treatments. The plant population and plant emergence were lower for 6 h treatment. However, the differences in weed intensity and plant height were not much significant, as evident from critical difference values.

4.4 Comparison of different Crop Establishment Methods

The performance of crop for selected crop establishment methods is given in Table 8. The plant emergence was better in case of developed unit than manual broadcasting and manual drum seeder. This was mainly due to submergence of lesser number of seeds because of ridge seeding by the developed unit. Continuous submergence of seeds, reduced the emergence by cutting oxygen supply, which is essential for seed emergence. The number of effective tillers was again highest in case of crop sown by the developed unit and the differences were significant among all the four treatments. However, the crop sown by the developed unit experienced higher weed intensity as compared to manual broadcasting and manual transplanting. The time required to seed or transplant per ha was minimum for the developed unit.

The yield and economics of crop sown by different methods is given in Table 9. The cost of developed unit was taken as Rs. 70,000/-, service life as 10 yrs and working hours 250 per annum for calculating operational cost. The labour wages were taken as Rs. 80/- (US $ 1.7) per day. The grain yield of crop sown by self-propelled ridge rice seeder (5.3 t/ha) was observed much higher than manually broadcasted rice (4.4 t/ha), but it was at par with transplanted rice (5.7 t/ha) and manual drum seeded rice (5.1 t/ha). There was significant difference in the grain and straw yield for various treatments at 5% significant level.

The gross return was highest from the transplanted rice. But, due to high cost of nursery raising and transplanting, the cost of cultivation was also highest. The net return was most favourable for the crop sown by the self-propelled rice ridge seeder and it was higher by Rs. 3,093 (US $ 67.2) per ha compared to transplanting. In addition, highest benefit cost ratio was obtained in the crop sown by the developed unit. Thus, ridge seeding of pre-germinated rice seeds by the developed self-propelled rice ridge seeder was found to be a viable option to both broadcasted rice and transplanted rice.

5. CONCLUSIONS

A self-propelled 8-row rice ridge seeder has been develped and tested for pre-germinated ridge seeding in puddled fields. The effective field capacity was 0.3 ha/h. The developed unit has provision for varying seed rate besides other operational features. The developed unit could be useful in eliminating drudgery in transplanting or pulling of manual drum seeder besides other advantages of pre-germinated line seeding. The study also suggests that it is possible to reduce the seeding rate variations by maintaining a desirable drum fill condition. Crop and yield parameters of crop sown by developed unit, were comparable to transplanted and manual drum seeded crop; whereas they were better in comparison to broadcasted crop. The net return was higher by Rs. 3,093 (US $ 67.2) per ha in case of crop sown by the developed unit compared to prevalent practice of manual transplanting. It may be concluded, that the ridge seeding by the developed self-propelled rice ridge seeder is a better alternate.

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