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Performance evaluation of pneumatic seed metering device for paddy in puddle

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Abstract **:** The pneumatic seed-metering concept is based upon the air pressure developed on the inner surface of rotating cylindrical drum. One end of the seed tubes are fixed to the seed cups placed near top dead center and another end is open to the atmosphere in the furrow opener. The seed dropped in the tube at the interaction region of high and low pressure. The desired planting was achieved at injecting pressure of 1300-1350 N/m^2 and operating speed ranged from 0.228 - 0.338 m/s when the depth of seed placement was between 0.76-0.77 cm in puddle. No seed loss was observed through the cup holes during the lab test. The nozzles of the seed tubes were installed with flexible and straight cone to inject the seeds close in the hills in puddle. The increase in injecting pressure increased the depth of seed placement in puddle. The higher depth of seed placement decreased the germination.

Key words **:** Pneumatic planting, Seed metering, Seed placement depth

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Paddy (*Oryza sativa*) is a major food grain in India. The cultivated area under paddy is about 44.36 million ha with production of 84.87 million tones with productivity 1913 kg/ha (Anonymous, 2001). During the past decades, considerable progress has been made in developing the paddy planting technology but with limited success. The conventional method of paddy cultivation involves growing nursery and transplanting in the puddle; the seeding, manually in dry as well as in moist soil. An acute shortage of farm labours is experienced during transplanting season. Mechanical transplanting can help to alleviate the human drudgery. The labour shortage during transplanting season deprives the farmers to go for multi cropping where as the directly sown paddy ensure better yield, mature early, making multi cropping possible.

METHODOLOGY

Pradhan (1970), Anonymous (1970 and 1971) and Krishnaiah (1991 and 1999) developed manually operated pre germinated seeder, manually operated fast seeder and individual hopper seeder. The above units gave continuous drilling in rows but suffer from grain bridging in hopper. Further while planting in wet land, seed float and get displaced from rows. Though many bullock and power operated seed drills are available in the market, yet none gave the satisfactory result for paddy. Italian researchers tried to develop rice transplanters for working in flooded as well as dry soil conditions, in which a group of four row separated seedlings were placed between disks for transplanting. It required 15-20 days for nursery preparation which delay the transplanting. Due to their high operational cost, this machine did not gain wide acceptance.

Little work has been done on the pneumatic seed-metering device for planting paddy (Yadav, 1974 and 1979). The efficiency of the manually operated machine was low. No approach was made for the development of a pneumatically controlled seed metering device to inject the seed on the puddle land to avoid the grain metal friction practically zero. In order to resolve the above problems, further effort were essential to develop a pneumatic seed metering device for injecting paddy in puddle and to study the metering device in the laboratory to select the final design data and other relevant factors. The study was conducted at Central Institute of Agricultural Engineering, Bhopal, India to improve the various design parameters of pneumatic seed metering device for planting paddy in puddle.

Experimental test set-up for pneumatic seed metering:

The set-up for pneumatic seed metering for planting paddy was designed and fabricated. The pneumatic seed-metering concept was based upon the air pressure developed

Table A : Physical characteristics of few selected varieties of paddy

Variety	Average* length (mm)	Average* width (mm)	Average* thickness (mm)	Weight of half top grain (g)	Weight of half bottom grain (g)	Average weight (g)/ 1000 grains
Basmati	8.75	2.54	1.62	1.42×10^{-2}	1.60×10^{-2}	13.72
Local paddy (Desi)	9.80	3.05	1.95	2.67×10^{-2}	2.87×10^{-2}	30.71

* Average of 100 grains.

on the inner surface of revolving cylindrical drum. The force retaining the seeds is related to the static pressure in the drum. The seed tubes mounted on the central shaft releases the air continuously from the rotating drum. The heart of the pneumatic seed metering system is the pressurized drum and delivery system. The experimental test set-up for pneumatic seed metering is shown in Fig. A as it consisted of following major parts 1, 2,3,4,5,6,7,8,9,10, 11, and 12. The seed cups were formed in the drum made of gun metal having diameter of 29.6 cm and 16.5 cm length, to achieve the accurate seed rate injecting 2-3 seeds per hill. The diameter of the cups was made accordingly to suit the size of the grains. The seed-metering drum (6) on its inner periphery contained 12 mm diameter cups with two holes of 2mm diameter drilled through at a distance of 4mm. The holes were drilled in the cups for creating air leakage.

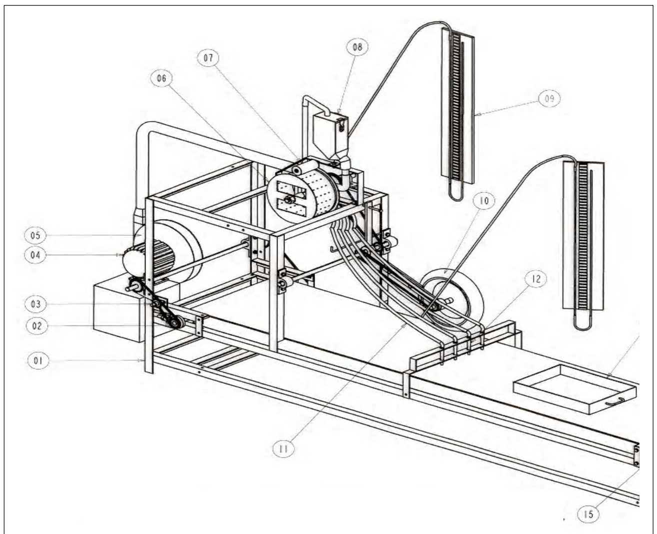

Fig. A : Test set-up of pneumatic seed metering for planting paddy

Working principle:

Fig. A shows the experimental set up for pneumatic seed metering for injecting paddy in puddle. When blower was put on, pressure builds up inside the drum and air starts leaking through seed tubes and holes on the cup. The conveyor belt was powered with an electric motor and pneumatic wheel to revolve the seed-metering drum, through chain and sprocket arrangement.

Due to the static pressure inside the seed-metering drum, grain starts entering the cup and sealing cup holes. The air pressure holds up the bunch of seeds in its cup until the drum rotation brings the seed over the manifolds attached to the seed tubes placed in the drum. When the seed under the rubber, cut -off wheels reaches over the manifold, seeds released due to drop in pressure generated in the interaction region. Rubber cut-of wheel makes the contact with each cup and then releases the seeds from the cup into the manifold. The seed then caught in the airflow carried through discharge manifold to the delivery tube and 3 to 4 seeds were injected in the puddle on the ground. The spacing between the hills was maintained by the radial spacing and number of holes in the drum.

Laboratory test conditions:

Experiment was conducted in the year 2001-2002, clay soil was taken from experimental field of CIAE farm. The soil was collected in the tray from the 5-10 cm layer of experimental field of paddy for the laboratory-planting test. The percentage of fine clay and silt was more whereas the bulk density and moisture content of soil used under study was 1.88 g/cc and 56.96 per cent, respectively during the test. The puddling index of the puddled soil was 48.46 per cent.

As per the availability paddy seeds of *Basmati* and local (*Desi*) were used in this study. The physical properties (physical dimensions of grain are the length, width, thickness etc. were recorded (Table A). Germination percentage for *Basmati* and *Desi* was determined on the basis of four replications of one hundred seeds of each variety by keeping eight days germination period. The average seed germination of *Basmati* was 85 per cent.

The depth of seed placement was measured by cutting the seedlings at ground level and uprooting the seedlings. The distance from the seed attachment point to the end of cut plant was taken as the effective seeding depth. An average value was determined from these measurements. To examine the different measures of pneumatic seed metering device, the three operating speeds 0.197, 0.228 and 0.338 m/s were used for this study.

RESULTS AND DISCUSSION

Numbers of plant per hill were counted in each tray of the laboratory planting test on 12-13 days after planting at different speed. The average numbers of plant stand per hill

Table 1 : Comparative study of injecting pressure, depth of seed placement and seed germination of pneumatic seed metering for paddy in puddle

Sr. No.	Injecting pressure (N/m^2)		Depth of seed placement in puddle in each hill* (cm)				Germination per cent (%)			
	Seed metering drum	Seed tube	Depth of seed in hill**	Max	Min	Avg	Germination in hill**	Max	Min	Avg
1.	2299	870	0.42	0.50	0.42	0.46	75.0	75	72	73.8
2.	2340	878	0.47				75.0			
3.	2350	885	0.48				72.0			
4.	2450	890	0.50				75.0			
5.	2500	910	0.45				72.0			
6.	2800	1229	0.71	0.78	0.71	0.76	69.0	71.78	63	67.9
7.	2840	1236	0.77				70.8			
8.	2958	1350	0.76				71.8			
9.	2960	1370	0.77				65.0			
10.	2962	1372	0.78				63.0			
11.	3512	1505	1.22	1.22	1.15	1.18	31.25	31.25	25.0	28.7
12.	3180	1420	1.15				30.0			
13.	3430	1430	1.18				25.0			
14.	3924	1510	-				-			

* The above observations are for the average of each hill at 12 days after laboratory planting test.
** Average of four readings at particular pressure

are given in Table 1. The results of laboratory test were used to select the final design data on the relevant factors of the pneumatic seed metering device.

Physical dimensions of the paddy grain such as length, width, and thickness vary according to the variety. Due to the impact energy the grains are pushed in hill in soft cushioned puddle. Since the weight of first half of the grain was more than second as given in Table A, the heavier bottom half of paddy grain penetrates in puddle.

Effect of injecting pressure on depth of seed placement:

Table 1 shows the effect of injecting pressure in the seed tubes on depth of seed placement in the puddled soil in laboratory condition. With the increase in injecting pressure in the seed tubes, the depth of seed placement increased. The average was computed on the basis of five observations. Fig. 1 (a) shows that the air pressure in the seed tubes played a significant role for depth of seed placement. The mean of the depth of seed placement was found to be significantly different at 1 per cent significance level.

Usually adequate moisture was observed at the larger planting depth, and the hazard from impedance (if crusting condition develops) increased. The accurate seed depth at 0.71 to 0.78 was observed at an injecting pressure of 1240 to 1372 N/m^2 provides proper seed cover and seed soil contact and soil microenvironment suitable for seed germination. At 1450 N/m^2 injecting pressure the depth of seed placement was 1.18 cm and beyond seeds could not germinate. The injection pressure in the seed tube Fig. 1 (b) at 885, 1325 and 1450 N/m^2

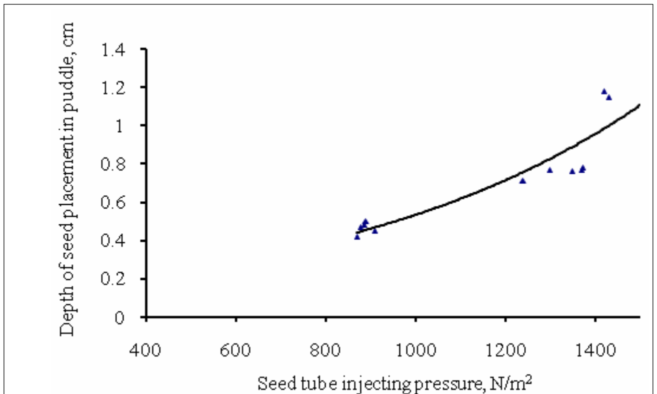

Fig. 1(a) : Effect of injecting pressure on depth of seed placement in puddle

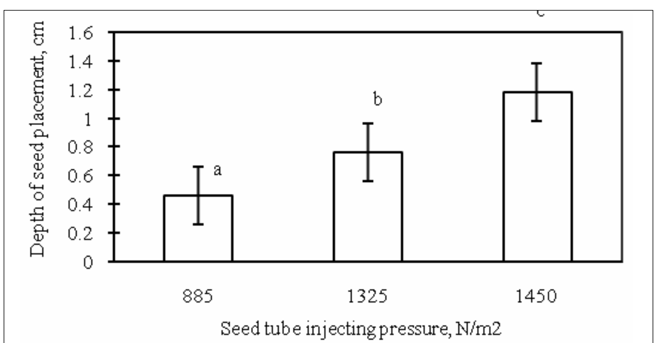

Fig. 1(b) : Effect of injecting pressure on depth of seed placement in puddle

was significantly different at 5 per cent level.

Effect of depth of seed placement in puddle on germination:

The germination percentage was calculated on the basis of plant emergence per hill and number of seeds dropped per hill. The test was replicated five times on different injecting pressures. The depths of seed placement and germination percentage are shown in Fig 2(a). Graph shows the effect of depth of seed placement on seed germination. Higher depth of seed placement affected the germination adversely. Fig.2(b) shows that the increase in depth of seed placement from 0.46 to 0.76 cm, there were no significance difference on seed germination percentage at 5 per cent level. But higher the depth of seed placement (above 1.22 cm) there was significance difference even at 1 per cent level of significance. The seed germination per cent at depth ranging from 0.46 to 0.76 cm and 0.76 to 1.8 cm significantly differed at 5 per cent level of significance, respectively. It is interesting to note that there was no seeding emergence at 1.22 cm depth of planting.

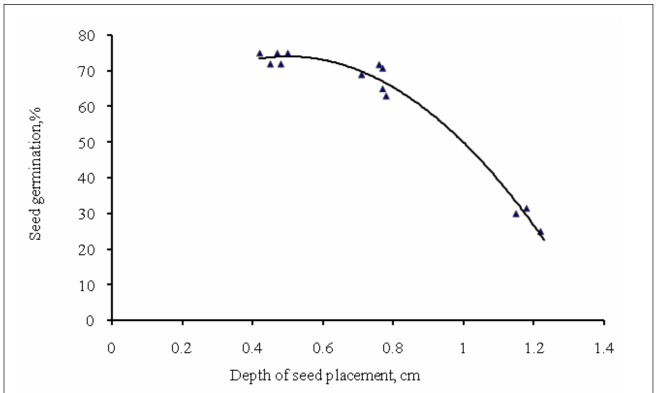

Fig. 2(a) : Effect of depth of seed placement or seed germination in puddle

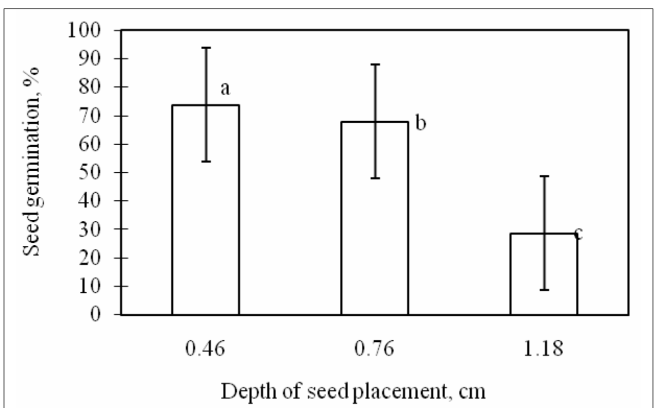

Fig. 2(b) : Effect of depth of seed placement on seed germination in puddle

It was further observed during the study that plumule did not emerge, the radical elongation was not appreciately influenced, when seeds were planted above 1.18 mm depth into the puddled soil. The decreased in seedling emergence was attributed, to mechanical impedance, lack of oxygen and moisture availability (Kumar *et al*., 1978).

The desired seed germination was achieved at the seed placement depth from 0.42 to 0.76 cm. It was also observed that seedling could not stand well in to the soil at 0.42 to 0.45 cm depth of seed placement. It was further observed that the depth of seed placement from 0.71 to 0.78 cm was favourable for proper germination and the seedling could stand better in to the puddled soil on emergence.

Experimental spacing between the hills:

The test was conducted to determine the spacing between the seed hills on the lapse of 12-13 days after planting in the laboratory conditions, when the seed emerged at 3 - 4 leaf stage. The hill spacing at operating speed of 0.197 and 0.228 m/s significantly differed at 5 per cent level of significance, whereas as no significance was observed at operating speed from 0.228 to 0.338 m/s. In other words the planting speed had no influence on the hill spacing and missing hills. The best planting was up to three seedlings per hill and hill spacing of 20 to 22 cm was also achieved at the operating speed of 0.228 to 0.338 m/s (Table 2). It was visualized that as the speed increased the distribution pattern of the seeds was affected.

Table 2 : Effect of forward speed on hill spacing

Sr. No.	Operating speed (m/s)	Replication test	Hill spacing, (cm)		
			Max.	Min.	Avg.
1.	0.197	18.32	18.32	17.37	17.78
		17.37			
		17.65			
2.	0.228	20.17	22.25	20.17	21.31
		21.51			
		22.25			
3.	0.338	20.88	22.20	20.12	20.46
		22.20			
		20.12			

Note: Measurement taken on day 12 after laboratory planting test

Conclusion:

The overall performance of the pneumatic seed metering device was found to be satisfactory for planting paddy seeds in puddle. The desired paddy planting was achieved at injecting pressure of 1300-1350 N/m^2 in the seed tube and operating speed ranged from 0.228 to 0.338 m/s at the depth of seed placement of 0.76-0.77 cm in puddle. The nozzles of the seed tubes were installed with flexible and straight cone to inject the seeds close in the hills in puddle.

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