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CONTENTS

Modification and evaluation of Pant-ICAR controlled traffic seed-cum-deep fertilizer applicator for multi-crop seeder-cum-deep placement of fertilizers applicator

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ABSTRACT: The current study deals with the modification of Pant-ICAR controlled traffic deep fertilizer applicator-cum-crop seeder as a multi-crop seeder-cum-deep placement of fertilizers applicator for multiple crops (Maize, paddy, soybean, pigeon pea and pea) grown in Uttarakhand.The Pant-ICAR controlled traffic deep fertilizer applicator-cum-crop seeder is converted to a multi-crop seeder-cum-fertilizer applicator.The modified machine was evaluated for maize, paddy, soybean, pigeon pea and pea in the laboratory at two gear ratios (5.73:1 and 6.23:1), four hopper heights (70, 80, 90, 100 and 110 mm) and the location of PVC adjusting fertilizer sleeve (0, 10, 20, 30 and 40 mm) with roller type metering mechanism and conical seed tube was used for the study. The adjustable PVC sleeve position was provided for changing the rate for a particular seed and their recommended fertilizer rate. The machine has been modified and the results of the laboratory study are presented in this paper. PVC sleeve was incorporated for more effective height for preciseapplication of fertilizer at a particular setting. The settings to get the desired seed and matching fertilizer rates for different crops were found very user-friendly.

Key words: Fertilizer rate, multi-crop seeder, seed-cum-fertilizer applicator, seed rate

Maize, wheat and paddy are the top three major crops cultivated in Uttarakhand state, which contributed 20700 ha equivalent to 89.2% of total cereal crop (Raghav and Srivastava, 2013). Soybean has been traditionally grown on a small scale in Uttarakhand (Agarwal *et al.,* 2013). Cowpea is one of the potential crops for this system because a number of high yielding cowpea varieties have recently been developed which mature in 60-70 days (Singh *et al.,* 2010). Other crops such as barley, pea, green gram and sunflower are also grown in Uttrakhand region (Anonymous, 2012). The vast increase of mechanization in Uttarakhand has not yet led to the development of a seed drill used in diverse cropping systems and with a wide range of crops. Despite several promising developments in recent years, none of the present seed drill scan seed of various crops by a single machine. The research aimed to develop a multi-crop seeder that could be used in Uttrakhand region. This seeder included a new idea of row-controlled reduced-tillage as well as controlled traffic. The existing machine developed at GBPUAT, Pantnagar was taken for modification for multi-crop as it had been designed for maize crop (Murmu, 2011). Farm mechanization, in general, plays a vital role in enhancing agricultural production and productivity; however, the need for hi-tech and high productive equipment. The rapid spread of mechanization on small farms in India has not yet led to the development of a range of low-cost seed drill that can be used as multi-crop seed drill. Singh *et al.*(2007) designed and developed a six-row*, multi-crop seed-cum-*fertilizer drill. Performance of the seed drill was evaluated with pearl millet, green gram, moth bean and cluster bean crops. Haque *et al.*(2011) developed a range of low-cost planters for two-wheel tractors (2-WT) in diverse cropping systems which need to be capable of operating in multiple planting modes for a wide range of crops. The purpose of this multi-crop seeder was to set different row spacing, seed depth and the calibration of seed and fertilizer rates as quickly as possible by the operator in the field.

The machine is needed to develop for small farms, and in diverse cropping systems, they need to be capable of operating in multiple modes and with a wide range of crops. The machine can accomplish various operations, such as controlled traffic, furrow opening, and deep placement of fertilizer, covering the fertilizer, seed sowing, covering the seed and pressing the soil in a single pass. The aim of the research was to develop a multi-crop seeder on which setting up of row spacing, seed depth and the calibration of seed and fertilizer rates could be accomplished quickly by the operator in the field. Incorporating design parameters from earlier developed tractors operated seed drills, a versatile multi-seeder was designed for application of seed and fertilizer application in the lines. The present study includes refinement of machine components according to different crops to meet out the recommended seed and fertilizer rate of different crops.

MATERIALS AND METHODS

Selection of crops

The various crops such as paddy, wheat, barley, maize, pigeon pea, green gram, peas, cowpea, soybean and sunflower were selected based on their popularity in the state of Uttarakhand (Anonymous, 2012). The seed and their fertilizer rate for different crops are given in Table 1.

Modification in existing machine

The existing machine "Pant-ICAR controlled traffic deep seed-cum-fertilizer applicator for multi-crop seeds and deep placement of fertilizers" is modified to multi-crop seeder-cum-fertilizer application through various approaches.

Modification in fertilizer applicator

The cup type positive feed roller metering device was selected for fertilizer as it was already mounted in the previous machine. It could be seen from Table 1 that the fertilizer rate is relatively higher than its seed rate. A metering mechanism with a single roller did not satisfy the requirement of fertilizer rate for their crop. Therefore, a pair of metering roller was used to deliver fertilizer to meet various range of fertilizer rates. The arrangement of rollers on the metering shaft and its housing is shown in Fig. 1. The metering device was provided with three different speed ratios to vary the seeds and fertilizer rates according to type of crops. The metering rollers used in the fertilizer metering mechanism were of cell type, having a diameter of 130 mm with ten cells on its periphery. The capacity of each cell was 4.75x 10^{-6} m^3. The core diameter of the metering roller was 25 mm.

Table 1: Seed and their fertilizer rate of different selected crops

Crops	Seed rate, kg/ha	Fertilizer rate, kg/ha
Paddy	25	175
Wheat	100	150
Barley	80	110
Maize	20	160
Pigeon pea	25	65
Green gram	30	55
Pea	100	120
Cowpeas	30	80
Soybean	75	120
Sunflower	10	180

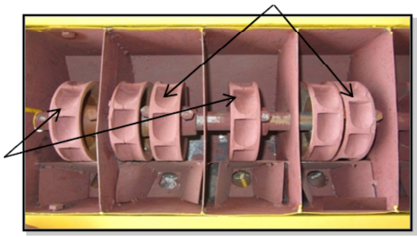

Fig. 1: Metering rollers for seeds and fertilizer

Modification in tubes for seeds and fertilizer delivery tube

Earlier cylindrical type tubes were used for both seed and fertilizer delivery from the main box to the metering device housing. It had been observed from preliminary trials that cylindrical type tubes restrict the flowability of seeds from the hopper and caused bridging, especially in the case of maize and paddy seeds. Therefore, cylindrical seed tubes were replaced by conical shape. The tubes for seed and fertilizer are shown in Fig. 2. The quantities of seeds and fertilizers for different crops were measured and its coefficient of determination (R^2) was determined, shown in Table 2.

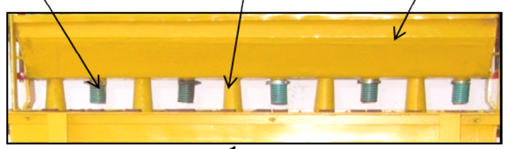

Fig. 2: Different tubes for seed and fertilizer delivery

Hopper height adjustment system

The rate of seeds and fertilizer is varied from the combination of hopper height and changing the sprocket on the main shaft with a different number of teeth,*i.e.*, transmission ratio. It has also been observed that for a particular seed rate of the crop, it was difficult to match its fertilizer application rate due to the low volume of fertilizer delivered by the combination. So, an additional option was provided to fertilizer tubes to deliver a high/ low amount of fertilizer at the same setting. For this purpose, a PVC fertilizer adjustment sleeve was mounted on the fertilizer tube that can be slide onto it, which offered variable hopper height for fertilizer. A graduated scale was mounted on the housing frame to fix the hopper height according to desired seed and fertilizer rates. This scale helps to decide the seed and fertilizer rates for a particular crop. To measure the hopper height, a pointer is mounted on a plate of 40 x 40 x 5 mm size on both sides of hopper. The height of the hopper was varied by adjusting the handheld screw levers mounted at both sides of the hopper with two supporting plates of 150 x 6 x 6 mm size as shown in Fig. 3. Seed-cum-fertilizer hopper screw lever consisted of adjusting wheels of 87 mm diameter and spoke length 50 x 6 x 6 mm size with three spokes. The diameter of the adjusting wheel is decided such that it can be held by hand easily. The spoke was provided for strengthening the adjusting wheel. Different terminologies related to height adjustment are illustrated in Fig. 4.

Fig. 3: Seed and fertilizer hopper height adjustment system

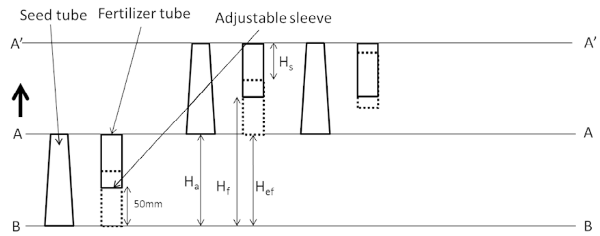

Fig. 4: Different height adjustment terminology

Terminologies

A-A: It is the line where the upper part of seed and fertilizer tubes are joined at the bottom of the hopper.

B-B: It is the line where the seed tube (conical) rests at the bottom of the metering box when the seeds/fertilizer hopper is at its lowest position.

Hopper height for seeds/fertilizer

H_a: It is the distance between the B-B line and A-A line when the hopper height is increased to A'-A' line for the seed tube.

H_f: It is the distance between B-B line and A-A line when the hopper height is increased to A'-A' line for cylindrical fertilizer tube. Initially, a gap of 50 mm between the seed tubes and fertilizer tubes is kept to ensure higher fertilizer rate than seed rate.

So, $H_f = H_a + 50\text{mm}$

Table 2: Amount of seed delivered (g) in 20 rev. of ground drive wheel at different hopper heights and metering transmission ratio

Seeds	Transmission ratio	Hopper height, mm					R^2
		40	50	60	70	80	
Paddy	G_7	8.63	25.27	39.57	52.40	59.30	0.9804
	G_8	6.70	15.80	30.57	35.30	54.40	0.9723
Wheat	G_7	36.67	50.33	59.63	78.00	87.00	0.9865
	G_8	15.90	38.50	48.27	63.43	81.00	0.9858
Barley	G_7	21.70	36.73	44.73	53.83	61.10	0.9794
	G_8	10.83	22.30	31.20	43.43	55.53	0.9973
Maize	G_7	21.70	33.23	52.00	57.73	78.77	0.9782
	G_8	17.43	29.43	41.57	45.00	73.97	0.9238
Pigeon pea	G_7	34.87	49.17	61.03	73.20	78.50	0.9796
	G_8	21.47	36.53	50.53	67.70	73.40	0.9821
Green gram	G_7	52.73	60.10	69.67	88.77	103.03	0.9706
	G_8	34.10	45.57	58.27	75.47	92.10	0.9921
Pea	G_7	18.70	43.50	55.87	69.23	85.67	0.9721
	G_8	14.40	30.60	49.60	59.00	82.00	0.9850
Cowpeas	G_7	29.07	54.70	68.03	80.53	88.87	0.9551
	G_8	19.83	37.80	43.83	60.63	78.33	0.9804
Soybean	G_7	29.80	38.57	59.60	87.10	102.80	0.9838

H_s: It is the height obtained by the downward movement of sleeve on the fertilizer tube.

H_{ef}: It is the effective height of fertilizer tube considering its sleeve movement from B-B line

In general, $H_{ef} = H_f - H_s$

or, $H_{ef} = H_a - H_s + 50$ mm

The prototype with multi-crop seeder-cum-fertilizer applicator developed seeder is shown in Fig. 5.

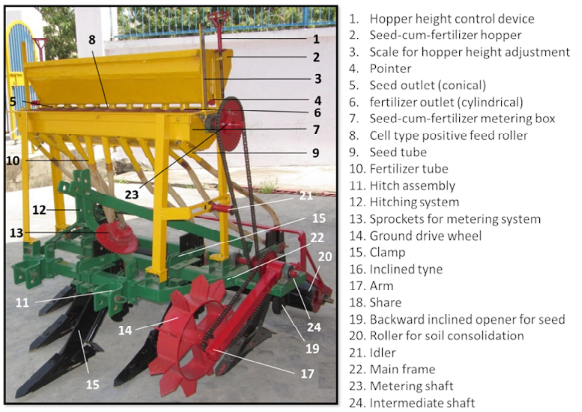

Fig. 5: Prototype with multi-crop seeder-cum-fertilizer applicator

Calibration of the metering system

Calibration of seeds and fertilizers in a laboratory was done as per the standard procedure described by Kumar *et al.* (2019). For the calculation of seeds and fertilizer rate for different crops, related information hasbeen taken from Pantnagar Kisaan Diary 2012. The seeds and fertilizer rate required at different hopper heights and different gear ratios of the metering device have also been calculated. Seed and fertilizer were filled in the different boxes separately. The polythene bags at the outlet of seed and fertilizer tube were tagged. The seed-cum-fertilizer box with different combinations of hopper height at 10 mm intervals was fixed. The gear ratio of the metering unit was changed with the different sprockets on main shaft. Slide the PVC fertilizer adjusting to 0 mm, 10 mm, 20 mm, 30 mm, and 40 mm at first, second, third, fourth and

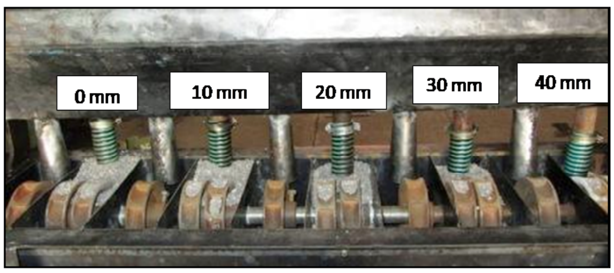

Fig. 6: Calibration of fertilizer at different fertilizer adjusting sleeve

fifth fertilizer tube respectively with different combinations of hopper height and metering gear ratio as step three is shown in Fig. 6. The ground wheel was raised so that it becomes free to be turned. A mark by chalk was made on the rim of the wheel, and the wheel was rotated by twenty turns. The weight of seed and fertilizer dropped from each opener was measured and recorded on the datasheet to know the variation with different combinations.

Calculation for calibration of Seed and Fertilizer in Laboratory

Calibration of seed cum fertilizer for different row spacing and number of rows for different seeds and fertilizer rates which is given in Table 2.The procedure for calibration is given below:

Let,

Quantity of seeds in 20 revolutions of ground wheel (g) = Q_s

Quantity of fertilizer in 20 revolutions of ground wheel (g) = Q_f

Number of rows = R

Row to row spacing (m) = S

Therefore, the total effective width of machine, W (m) = R x S

Total distance traveled by machine per hectare, L (m) = $\frac{10,000}{W}$

Diameter of ground drive wheel = D_g = 450 mm = 0.45m

So, Total distance covered by ground wheel in its one revolution considering 10 percent of skid in actual condition, $T = \pi \times D_g \times 1.1 = 3.14 \times 0.45 \times 1.1 = 1.5543$ m

Number of revolutions of ground drive wheel required to cover one-hectare land, N (rpm) = $\frac{L}{T}$

Experimentation

The experiment was conducted in the laboratory of the department of Farm Power and Machinery of GB Pant Agricultural University. To test the coefficient of uniformity described by Maleki *et al.*(2006) and Kumar *et al.*(2019) of the seeds and fertilizer, ten different types of seedpaddy, wheat, barley, maize, pigeon pea, green gram, pea, cowpea, soybean, sunflower crops were taken. In this study, NPK fertilizer was taken. The metering mechanism was run with two gear ratios of G_7 (5.73:1) and G_8 (6.23:1). The hopper height is adjusted to 70–110 mm and location of PVC adjusting fertilizer sleeve was 0–40 mm with an interval of 10 mm were selected to achieve the desired seed and fertilizer rate. There was one metering roller for seeds and two for fertilizers were selected for the experimental trial. The shape of tubes selected for seed and fertilizer was conical and cylindrical, respectively.The coefficient of determination (R^2) for each

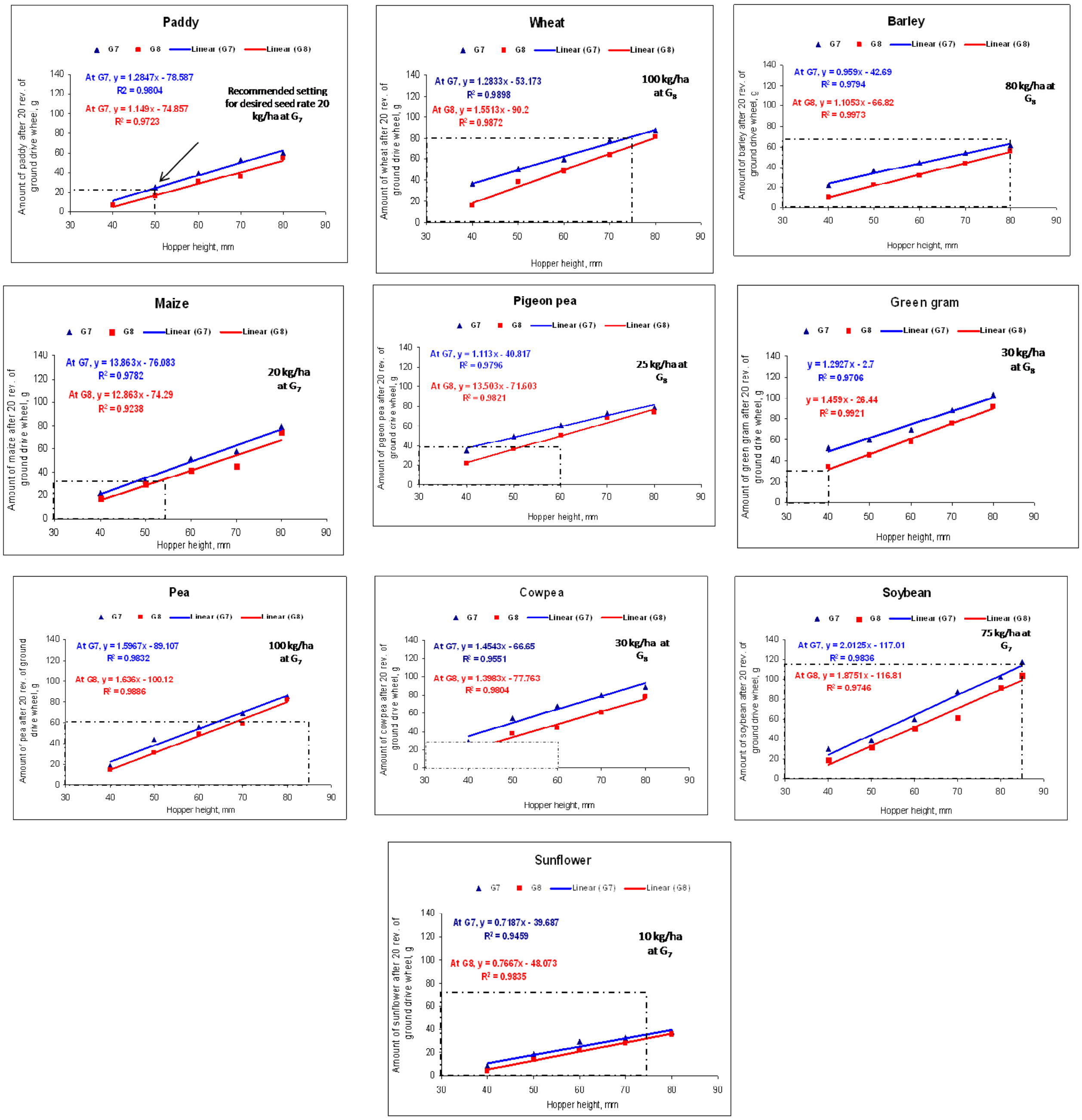

Fig. 7: Quantity of different seeds in twenty revolutions of ground drive wheel with different hopper heights and different metering ratios: The recommended setting for seed rate of different crops is shown with broken lines

setting was determined for each trial as per statistical data analysis and explained in the result and discussion section.

RESULTS AND DISCUSSION

Calibration of seed and fertilizer

Seed and fertilizer have been calibrated at each setting for seeds and fertilizer (NPK) and variations in amount seeds and fertilizer in different setting combinations have been calculated.

Variations in quantity of seeds in different setting combinations

Amount of seeds delivered (g) in 20 revolutions (rev.) of

Table 3: Actual vs predicted for seeds

Hopper height, mm	G7			G8		
	Actual	Predicted	% Error	Actual	Predicted	% Error
Paddy						
40	8.63	11.34	31.37	6.70	5.57	16.82
50	25.27	24.19	4.27	15.80	17.06	7.99
60	39.57	37.04	6.40	30.57	28.55	6.59
70	52.40	49.88	4.80	35.30	40.04	13.44
80	59.30	62.73	5.78	54.40	51.53	5.27
Wheat						
40	36.67	36.53	0.39	15.90	18.20	14.48
50	50.33	49.33	1.99	38.50	33.70	12.46
60	59.63	63.04	5.71	48.27	50.29	4.18
70	78.00	74.95	3.91	63.43	64.70	2.00
80	87.00	87.76	0.87	81.00	80.20	0.99
Barley						
40	21.70	24.44	12.63	10.83	10.55	2.61
50	36.73	34.03	7.36	22.30	21.60	3.12
60	44.73	43.62	2.49	31.20	32.66	4.67
70	53.83	53.21	1.16	43.43	43.71	0.64
80	61.10	62.80	2.78	55.53	54.76	1.39
Maize						
40	21.70	20.99	3.26	17.43	15.75	9.65
50	33.23	34.86	4.90	29.43	28.61	2.78
60	52.00	48.73	6.29	41.57	41.48	0.22
70	57.73	62.60	8.42	45.00	54.34	20.76
80	78.77	76.47	2.92	73.97	67.20	9.14
Pigeon pea						
40	34.87	37.09	6.39	21.47	22.92	6.76
50	49.17	48.22	1.92	**36.53**	**36.42**	0.31
60	61.03	59.35	2.75	50.53	49.92	1.21
70	73.20	70.48	3.71	67.70	63.43	6.31
80	78.50	81.61	3.97	73.40	76.93	4.81
Green gram						
40	52.73	49.01	7.06	**34.10**	**31.92**	6.39
50	60.10	61.94	3.05	45.57	46.51	2.07
60	69.67	74.86	7.46	58.27	61.10	4.86
70	88.77	87.79	1.10	75.47	75.69	0.30
80	103.03	100.72	2.25	92.10	90.28	1.98
Peas						
40	18.70	23.80	27.28	14.40	15.45	7.27
50	43.50	37.03	14.87	30.60	29.06	5.04
60	55.87	54.93	1.67	49.60	47.47	4.29
70	69.23	71.12	2.73	59.00	64.12	8.68
80	85.67	86.07	0.46	82.00	79.50	3.05
Cowpea						
40	29.07	35.15	20.93	19.83	20.12	1.44
50	54.70	49.69	9.15	37.80	34.10	9.79
60	68.03	64.24	5.58	43.83	48.08	9.70
70	80.53	78.78	2.18	60.63	62.07	2.36
80	88.87	93.32	5.01	78.33	76.05	2.91
Soybean						
40	29.80	23.8	20.13	19.40	14.415	25.70
50	38.57	43.99	14.06	31.30	33.22	6.13
60	59.60	64.18	7.68	50.60	52.025	2.82
70	87.10	84.37	3.13	61.80	70.83	14.61
80	102.80	103.95	1.12	91.60	89.07	2.76
Sunflower						
40	8.17	10.62	30.04	4.10	5.59	36.44
50	18.20	17.81	2.16	13.77	13.26	3.68
60	29.20	24.99	14.41	23.40	20.93	10.57
70	32.40	32.18	0.68	28.10	28.59	1.76
80	37.00	39.37	6.40	35.27	36.26	2.82

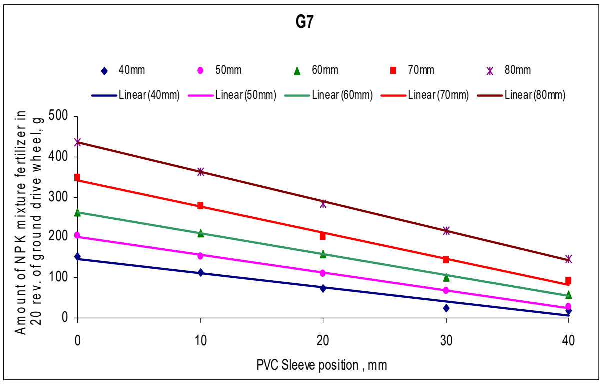

Fig. 8: Amount of NPK mixture (12:32:16) in twenty rev. of ground drive wheel with different hopper height and tube position in G7 gear ratio of metering unit

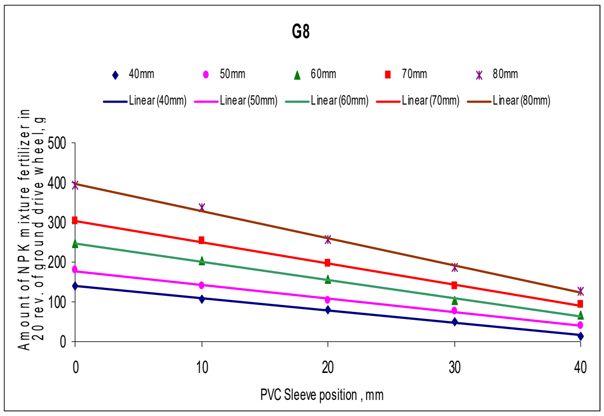

Fig. 9: Amount of NPK mixture (12:32:16) in twenty rev. of ground drive wheel with different hopper height and tube position in G8 gear ratio of metering unit

ground drive wheel at different hopper heights and metering transmission ratio is shown in Table 2. The coefficient of determination was found more than 92% in all the cases for all setting combinations. This shows that there is direct relation between seed rate and hopper height. More uniform and continuous flow of seeds was observed through conical shape seed tubes.

The quantity of seeds in 20 revolutions of ground drive wheel with different hopper heights, roller speed,and metering transmission ratio is depicted in Fig. 7.The R^2 values were found more than 92 % in all the cases with all the combinations of settings. Conical seed tubes delivered a more uniform and continuous flow of seeds. The R^2 values were found more than 95 % in all the combinations of fertilizer with adjustable PVC sleeve positions, hopper heights and transmission ratios.

Table 4: Actual vs predicted for fertilizers (NPK) at different hopper height

Effective hopper height,mm	Actual	Predicted	% Error
	G_7		
50	19.10	15.06	21.14
60	27.31	34.53	26.43
70	66.25	63.53	4.10
80	104.39	102.07	2.22
90	150.35	150.16	0.13
100	207.97	207.78	0.09
110	274.42	274.95	0.19
120	355.33	351.65	1.04
130	437.13	437.89	0.17
	G_8		
50	15.19	19.94	31.26
60	42.75	39.50	7.59
70	71.75	66.78	6.93
80	104.19	101.77	2.33
90	140.76	144.46	2.63
100	191.32	194.87	1.86
110	252.10	252.99	0.35
120	319.48	318.82	0.21
130	393.97	392.36	0.41

Variations in amount of seeds in different setting combinations

The amount of fertilizer (NPK) in twenty revolutions of the ground drive wheel is shown in Tables 3 and 4. The result was made of the combinations of different hopper height and fertilizer PVC sleeve position. These combinations create the same effective hopper height for a different combination of hopper height and PVC sleeve position. The average amounts of NPK mixture with effective hopper height at different metering transmission ratios are shown in Figs. 8 and 9.

Actual vs predicted values relationship

The predicted value has been generated from the equation developed. The actual vs predicted values with percentage error for seeds and fertilizer (NPK mixture) had been shown in Tables 3 and 4. The percentage error was found maximum at the lowest hopper height for both gear ratios for seed and fertilizer. This was may be because, at the lowest height, there was inadequate cell filling of the metering roller. On average, percentage error between actual and predicted value of seed rate at any setting varied in the range of 4–6 % for paddy, 1–4% for wheat, 1–7% for barley, 3–8 % for maize, 2–6% for pigeon pea, 1–7% for green gram, 1–3% for pea, 2–9% for cowpea, 1–8% for soybean and 1–6% for sunflower were found. Similarly, for the fertilizer (NPK), the percentage error of 1–8% were found.

Table 5: Final recommended settings for desired seed and matching fertilizer rates

Type of seeds	Row to row spacing, mm	Transmission ratio	Seed rate, kg/h	Full dose, N:P:K	Hopper height for seed rate, mm	Position of fertilizer PVC sleeve, mm
Wheat	250	(17/36)x(17/50)	100	150:60:40	75	25
Paddy	250	(17/36)x(17/46)	25	150:60:40	50	0
Barley	250	(17/36)x(17/50)	80	60:30:20	80	25
Pea	250	(17/36)x(17/46)	100	20:60:40	85	45
Green gram	250	(17/36)x(17/50)	30	15:40:0	40	15
Maize	500	(17/36)x(17/46)	20	120:60:40	55	0
Pigeon pea	500	(17/36)x(17/50)	25	15:40:0	60	35
Cowpea	500	(17/36)x(17/50)	30	20:30:30	60	20
Soybean	500	(17/36)x(17/46)	175	20:60:40	85	45
Sunflower	500	(17/36)x(17/46)	10	120:60:40	50	50

Recommended seed and fertilizer rate

It was observed that two-speed ratios of G7 and G8 were appropriate to supply recommended seeds and its matching fertilizer rates for different selected crops. Final recommended settings for getting desired seed and their fertilizer rate could be achieved by selecting correct transmission ratio, hopper height by adjusting screw levers at both sides of seed and fertilizer hopper and by sliding the fertilizer adjusting PVC sleeve on fertilizer tube from Table 5 for wheat, paddy, barley, pea, green gram, maize, pigeon pea, cowpea, soybean and sunflower crops. The settings have been kept user friendly so that a farmer could customize the settings according to seed rate and its matching fertilizer rate for any crop.

CONCLUSION

The exiting Pant-ICAR controlled traffic seed-cum-deep fertilizer applicator has been successfully modified for multiple seeding devices.The metering system is designed such that it could meet the requirement of the lowest seed rate (10 kg/ha) and highest fertilizer rate (180 kg/ha) at same operation. The desired seeds and matching fertilizer rate have been found using calibration at different combinations of hopper height, transmission ratios and adjustable PVC sleeve position on fertilizer tubes which was easily selected from the table of final recommended settings. The actual vs. predicted values have been found with less percentage error, generally varied up to 9% for seed rate and up to 8% for fertilizer rate. Therefore, It can be concluded that the develop seed machine may be used as a multi-crop seeder preciously as the seed and fertilizer rates can be achieved quickly by the operator in the field.

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