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LABORATORY EVALUATION AND OPTIMIZATION OF BATTERY OPERATED MULTI-CROP PLANTER

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ABSTRACT

Traditional methods of sowing have many disadvantages like no uniformity in seed to seed placement, require greater number of seed, require more time and labour for operation. Most of the farmers in India are small and marginal land holder hence, tractor drawn planter have been eliminated acceptability. Also, to reduce dependency on fossil fuel in current situation need to concentrate on EVs in agricultural in order to boost productivity, achieve energy independence. In view of above developed battery operated multi-crop planter was tested for laboratory performance. The vertical rotor cell type seed metering mechanism was used in multi-crop planter. Testing of multi-crop planter was carried at Department of Farm Power and Machinery, Dr. PDKV, Akola by using sticky belt setup. In laboratory trial calibration of planter for cotton seed rate, miss index, multiple indexes, quality feed index, uniformity index was determined. The experimental optimization of parameters was done by using Response Surface Methodology (RSM). Three levels of forward speed are 2 km/h, 2.5 km/h, 3 km/h and three level of sub-hopper opening 50%, 75%, 100% were chosen for laboratory trial. The RSM results showed that planter optimized with forward speed 3 km/h and 75% sub-hopper opening for cotton seed. Based on the analysis it is observed that as the forward speed increased from 2 km/h to 3 km/h and sub-hopper opening from 50% to 100%. The quality feed index and uniformity index was increased up to certain level and then gradually decreased.

Key words : Planter, Cotton, Performance evaluation, Laboratory trial, Response Surface Methodology.

Introduction

Planting is one of the basic and most important operations in crop production. Improvement in the planting techniques could ensure adequate establishment of uniform crop stands and make subsequent operations easier and effective; and thus, increase yield (Gambari *et al.*, 2017). The objective of planting operation is to put the seed in rows at desired depth and intra-row spacing cover the seeds with soil and provide proper compaction over the seed (Kyada and Patel, 2014).

Due to the wide range in farm holding sizes and socioeconomic inequalities, India has a complex farm mechanisation scenario. Most of the farmers in India are small and marginal land holder hence, tractor drawn planter have been eliminated acceptability (Kankal *et al.*, 2016).

Kamble *et al.* (2003) evaluated multi-power operated cotton planter. The planter's actual field capacity and field efficiency were 0.138 ha/h and 66.34 percent, respectively, when powered by bullocks and 0.312 ha/h and 68.87 percent, respectively, when powered by tractors.

Singh *et al.* (2013) conducted performance evaluation of manually operated no-till drill for chickpea pulses was carried out. The average number of seeds sown per meter length was found to be 15 sowing depth of 40 mm. The effective field capacity of no-till drill was 0.045 ha/h and the field efficiency of this equipment was about 85 per cent.

Thakare *et al.* (2014) evaluated performance of bullock drawn cotton planter on the field of department of Farm Power and machinery, Dr. PDKV, Akola using

NHH-44 variety of cotton. Average moisture content of the soil was 33%. The field performance tests conducted over a 0.182 ha area revealed that the average horse power for the planter was 0.467 for an average draft of 48.53 kgf and average speed of 2.6 km/h. The theoretical field capacity (T.F.C), effective field capacity (E.F.C), field efficiency (F.E) obtained for continuous operations of planter were 0.47 ha/day, 0.34 ha/day and 72.51%, respectively.

Singh *et al.* (2019) evaluated e-powered multi-purpose two row seeder for small holders. E-powered seeder was tested in laboratory for four forward speed i.e. 1.45, 1.85, 1.98, 2.64 km/h for assessing the uniformity of seed metering. During field evaluation output with the seeded was 1130 m2/h at speed about 2.9 km/h with 90.3% field efficiency.

Materials and Methods

The battery operated multi-crop planter has the following main components is shown in Fig. 1.

Seed metering mechanism

Metering mechanism consist of vertical rotor having grooves on periphery with suitable size of cell for holding and delivering seed into opening of tube at specific interval. The 3 cell vertical rotor was selected based on the design considerations for cotton seed.

Seed hopper and sub-hopper

Seed hopper has trapezoidal shape. The sub-hopper fitted to main seed hopper by means of screw from all side. Half portion of sub-hopper having a circular hole in which hub of seed rotor attached and rotate within it. Volume of seed hopper was 5687.5 cm^3. The capacity of hopper was found to be 2.79 kg for cotton.

Power transmission

Power transmission system consists of ground wheel, chain and sprocket, power transmission shaft. Ground wheel is made up of steel flat of 40 mm wide and 5 mm thickness. Pegs are provided on the periphery of ground wheel. There are 12 pegs of 50 mm height welded on periphery of ground wheel.

Furrow opener

Shovel type furrow opener made up of mild steel used for multi-crop planter.

Seed covering device

Covering device is used for covering the seed after it is placed at desired depth. It is made up of mile steel.

Seed tube

Seed tube made up of transparent plastic is used for

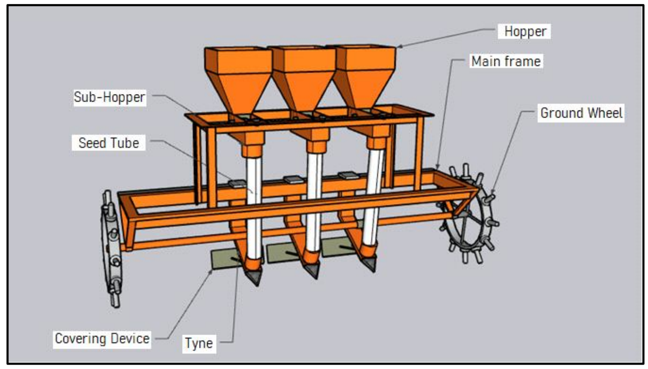

Fig. 1 : CAD view of multi-crop planter.

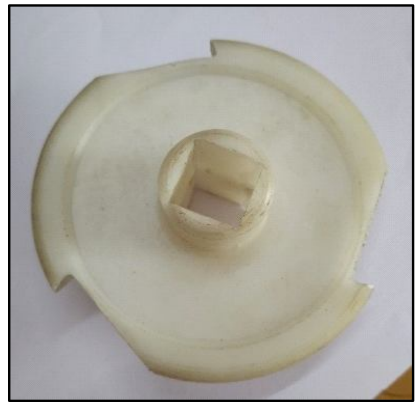

Fig. 2 : Seed metering rotor for cotton.

multi-crop planter. The upper end of seed tube was attached to discharge chute of sub-hopper and lower part was attached to boot of furrow opener.

Performance evaluation of Battery operated multi-crop planter

The planter was calibrated to determine seed rate for different crop seed. Evenness of seed spacing on sticky belt also examined. Two independent parameter. The two independent parameters each having three levels were taken i.e., forward speed (3km/h, 2.5km/h and 2 km/h) and sub-hopper opening (50%, 75% and 100%) were selected and the effect of these parameters on four dependent parameters *viz.*, miss index, multiple index, quality feed index and uniformity feed index was studied.

Laboratory test

The dependent parameters were selected that was the indicators of performance of seed metering unit. In order to analyses the dependent parameters, measurements of the seed spacing between the seeds delivered on sticky belt by seed metering mechanism were recorded.

The experimental optimization of parameters was done by using Design Expert 11.0 edition software for Response Surface Methodology (RSM). For optimizing operating parameters response surface methodology has


Fig. 3 : Sticky belt setup and arrangement of planter on sticky belt.

Table 1 : Test Results of Laboratory Trial.

	Factor 1	Factor 2	Response 1	Response 2	Response 3	Response 4
Run	A:Forward Speed	B: sub-hopper opening	Miss Index (MI)	Multiple Index (DI)	Quality Feed Index (QFI)	Uniformity Index (UI)
	km/h	%	%	%	%	%
1	3	50	27.33	4.67	68	71.06
2	2.5	75	4.67	8.67	86.67	70.89
3	2	100	2.67	30.67	66.67	61.87
4	2.5	75	4	10	86	72.96
5	2.5	75	4.67	8.67	86.67	71.91
6	3	100	4	28.67	67.33	59.87
7	2	75	6	12.67	81.33	68.15
8	2.5	75	5.33	10.67	84	68.18
9	2	50	24.67	6.67	68.67	71
10	2.5	75	5.33	9.33	85.33	71.91
11	2.5	50	25.33	6.67	68	67.99
12	3	75	3.33	5.33	91.33	80.98
13	2.5	100	3.33	28.67	68	59.27

been reported to be an effective tool when the independent variables have combined effect on the desired response. Although, several studies were done by applying response surface methodology (RSM) for optimization (Bhimani *et al*., 2014; Yazgi *et al*., 2010). During the analysis of the data by using response surface methodology; the experimental design was studied by thirteen treatment combinations of three level of sub-hopper opening and three forward speed as shown in Table 1.

Calibration of multi-crop planter

Calibration of battery operated multi-crop planter was carried at Department of Farm Power and Machinery, Dr. PDKV, Akola. The procedure of testing of planter for correct amount of seed rate is called calibration of planter. It is necessary to calibrate the planter before putting it in the actual use to find desired rate. The ground wheel was made free to rotate by raising planter. Mark was put on the one of the peg of ground wheel so that revolution can be counted easily. Polythene bag was tied at the end of discharge spot to collected seed. Hopper was filled full with cotton seed. Ground wheel rotated with desired speed. Stop watch was used to measure time taken to complete revolution. The procedure repeated for three times. Seed rate was calculated as per the test code.

Results and Discussion

The present study was conducted at Department of Farm Power and Machinery, Dr. PDKV, Akola. In laboratory test calibration for seed rate, seed to seed spacing on sticky belt set up were examined at different treatment combinations.

Optimization of operational parameters of battery operated multi-crop planter

Effect of input parameters on miss index (MI) for cotton : From the Fig. 4, it can be clearly seem that miss index increases as forward speed increases from 2 km/h to 3 km/h., it is maximum at 3 km/h with 50% sub-hopper opening. Miss index decreases with increase in sub hopper opening from 50% to 100%. It was observed adequate at 75% sub-hopper opening. The optimized Solution to get minimum miss index was found to be 4.05 with 0.978 desirability at forward Speed 3 km/ h with 73.85% sub-hopper opening.

Final equation in terms of coded values

The response surface equation was obtained for the model of second degree in terms of coded factors as under.

Miss Index (MI) = +4.73 - 1.33A -11.00 B - 0.332AB +0.093 A^2 +9.76 B^2 - 0.332A^2B + 2.33 AB^2 (1)

The equation 1 in terms of coded factor can be used to make predictions about the response for given of each other factor. By default, the high levels of the factors are coded as +1 and the low levels of the factors. The linear negative terms in equation 1 indicated that the miss index increased with increase in forward speed up to certain level (3.0 km/h) and decrease in sub-hopper opening (73.85). The positive value of quadratic terms indicated that high value of these variables further reduced the miss index. To visualize the combined effect of two variables on the miss index, the response surface 3D map were generated for fitted model as shown in Fig. D.

A. Effect of input parameters on multiple index (DI) for cotton : From the Fig. 5, it can be clearly seem that multiple index increases as sub-hopper opening increases from 50% to 100% and as forward speed Increases from 2 km/h to 3 km/h multiple index decreases. It was maximum at 2 km/h with 100% sub-hopper opening. It was observed minimum at forward speed 3 km/h and 50% opening. It was optimum at 75% sub-hopper opening with 3 km/h forward speed. The optimized Solution to get minimum multiple index was found to be 4.96 with 0.978 desirability at forward Speed 3 km/h with 73.85% sub-hopper opening.

Final equation in terms of coded values

The response surface equation was obtained for the model of second degree in terms of coded factors as under.

Multiple index (DI) = +9.40 - 3.67A+11.00B+ 0.000AB- 0.242A^2+ 8.43B^2 + 1.000A^2B+ 2.67AB^2 (2)

The linear positive terms in equation 2 indicated that the multiple index decreases with increase in forward speed and decrease in sub-hopper opening. The negative value of quadratic terms indicates decreases in the multiple indexes up to certain level. Positive value of quadratic terms indicate that further increase in multiple index.

Effect of input parameters on quality feed index (QFI) for cotton : From the Fig. 6, it can be clearly seem that quality feed index increases from as forward speed increases from 2 km/h to 3 km/h. it is maximum at 3 km/h with 75% sub-hopper opening. Quality feed index increases with increase in sub-hopper opening from 50% to 75% and then decreases from sub-hopper opening 75% to 100%. The optimized condition for solution to get the maximum quality feed index is found to be 90.98. The desirability of the optimized solution provided by software

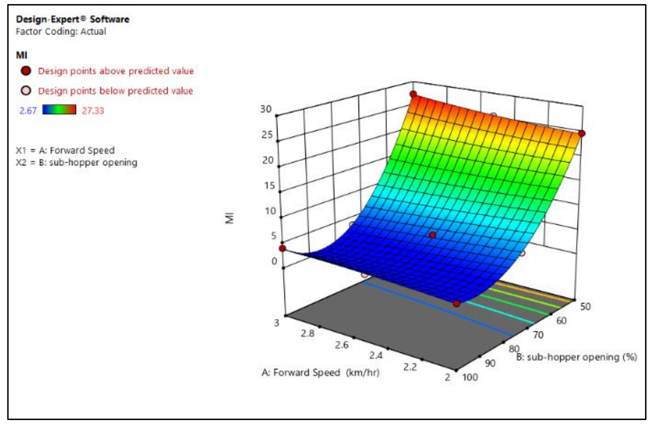

Fig. 4 : Effect of forward speed and sub-hopper opening on miss index.

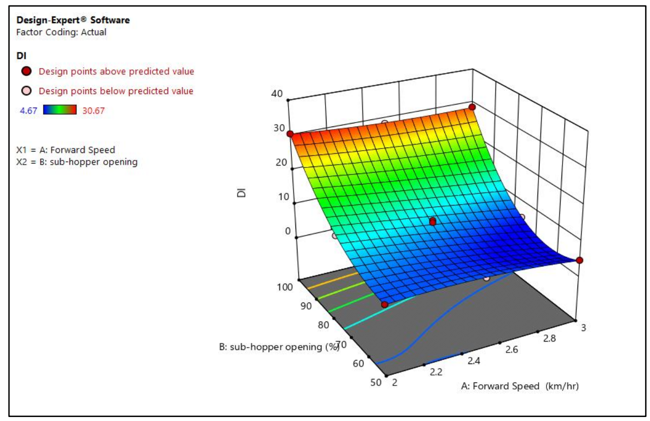

Fig. 5 : Effect of forward speed and sub-hopper opening on multiple index.

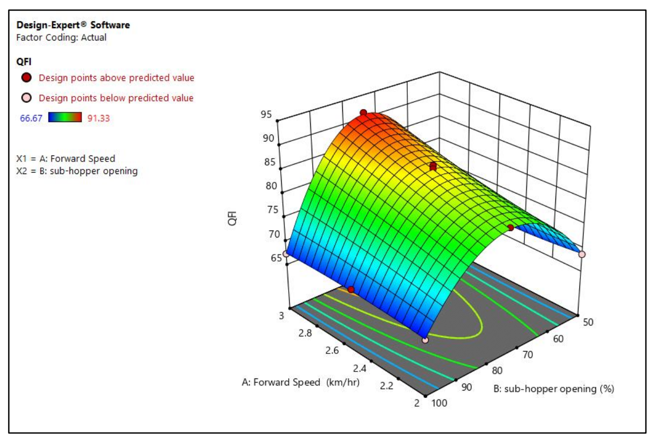

Fig. 6 : Effect of forward speed and sub hopper opening on quality feed index (QFI).

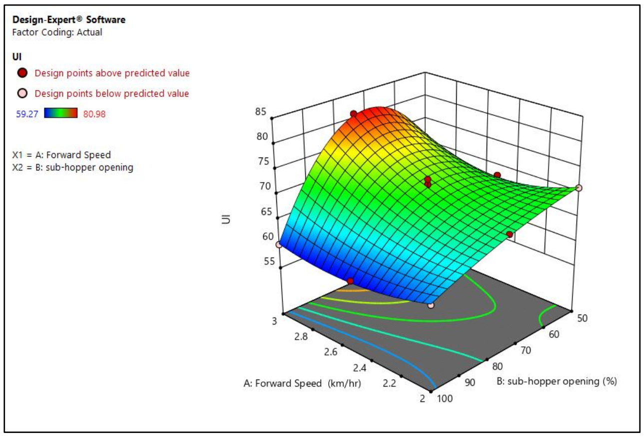

Fig. 7 : Effect of forward speed and sub hopper opening on uniformity index.

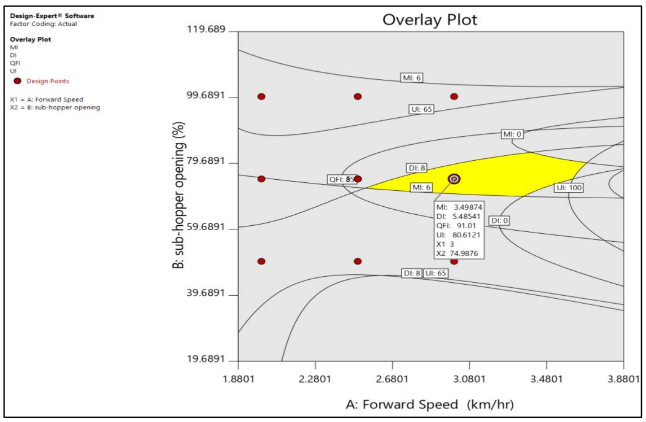

Fig. 8 : Overlay plot of forward speed and sub-hopper opening as actual factor in all responses for cotton.

Table 2 : Calibration of developed multi-crop planter for cotton.

Crop seed	Sample No.	Row 1	Row 2	Total	Seed rate, kg/ha
Cotton	I	5.14	6.87	12.01	
	II	6.54	6.71	13.25	
	III	5.38	7.11	12.49	
	Avg	5.68	6.89	12.57	**3.10**

0.978 with forward speed 3km/h and 73.85% sub-hopper opening.

Final equation in terms of coded values

The response surface equation was obtained for the model of second degree in terms of coded factors as under.

Quality feed index = + 85.86 + 5.00A + 0.000 B + 0.332AB + 0.148 A^2 -18.18B^2 - 0.667A^2B - 5.00AB^2 (3)

The linear positive terms in equation 3 indicated that the quality feed index increased with increase in forward speed and increase in sub-hopper opening up to certain level and then decreases. The negative value of quadratic terms in terms of speed indicated that high value of these variables further reduced quality feed index

Effect of input parameters on uniformity index (UI) for cotton : From the Fig. 7, it can be clearly seem that uniformity index increases as forward speed increases from 2 km/h to 3 km/h., it is maximum at 3 km/h with 75% sub-hopper opening. Uniformity index decreases with increase in sub-hopper opening from 75% to 100%. The optimized condition for solution to get the maximum uniformity index is found to be 80.83. The desirability of the optimized solution provided by software 0.978 for forward speed 3 km/h and 73.85% sub-hopper opening.

Final equation in terms of coded values

The response surface equation was obtained for the model of second degree in terms of coded factors as under.

Uniformity index = +71.32+ 6.42A- 4.36B- 0.515AB+ 2.88A^2- 8.06B^2-0.720A^2B- 6.90 AB^2 (4)

The linear positive terms in equation 4 indicated that the uniformity index increased with increase in forward speed and increase in sub-hopper opening up to certain level. The negative value in linear terms of sub-hopper opening reduced uniformity index and quadratic terms indicated that high value of these variables further reduced the uniformity index.

Fig. 8 showing overlay plot of forward speed and sub-hopper opening for all responses for cotton. The area shaded by yellow colour showing feasible zone of optimum solution obtained by superimposing contour map of all responses. The region that is not fit for optimization criteria is shown in grey colour.

Calibration of planter

The results of calibration test are presented in Table 2.

Conclusion

The objective of study was to evaluate performance of battery operated multi-crop planter in laboratory condition. The test is carried out on sticky belt in laboratory for different treatment combinations of forward speed and sub-hopper opening. Based on results obtained from Design Expert software battery operated multi-crop planter found satisfactory and following conclusion can be drawn. The seed rate calculated was found 3.10 kg/ha for cotton. The RSM results for cotton showed that the planter satisfactory performance for forward speed 3 km/h and 75% sub-hopper opening with maximum quality feed index and uniformity index. Further the battery operated multi-crop planter may be test at field at optimized solution from RSM for cotton crop.

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