Madras Agric. J., 95 (1-6): 129-140 January-June 2008

https://doi.org/10.29321/MAJ.10.100548

Performance evaluation of basin lister cum seeder

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Abstract : A basin lister cum seeder was developed as a rear mounted attachment to four wheel tractor of 35-45 hp range. It consists of common cultivator components, a three bottom basin lister and a cup feed type seeder. In laboratory calibration and field performance evaluation, the seed rate increased with increase in peripheral velocity of cup from 0.122 m/s to 0.356 m/s and further increase in peripheral velocity reduced the seed rate. The recommended seed rate was obtained for a forward speed of operation of 1.11 m/s. The seed spacing was influenced by forward speed of operation in laboratory condition. The forward speed of operation of 1.06 m/s registered the minimum standard deviation (0.83 per cent) from recommended spacing. The deviation of the basin profile was minimum upto a forward speed of operation of 1.11 m/s and thereafter the deviation was higher. Hence, the forward speed of operation was optimized as 1.11 m / s, considering the desired seed rate, seed spacing and basin profile. The average draft and fuel consumption of the unit was 2600 N and 4.11 I / h respectively. The field capacity of the unit was 0.49 ha/h with a field efficiency of 68.06 per cent. The basin lister cum seeder registered minimum value of (1.03) per cent deviation from the recommended spacing in the field. The standard deviation (1.211), coefficient of variation (0.0399) were the least for basin lister cum seeder treatment, in the field. This unit planted majority of hills with the recommended number of seeds. This unit also gave more uniform depth of seed placement when compared to conventional method. The basin lister cum seeder recorded the minimum deviation of (+) 35.05 per cent and (-) 4.74 per cent from recommended plant population before and after thinning respectively.

Key words : Basin lights, seeds, evaluation, performance, peripheral velocity.

Introduction

The sowing of the major crops raised under rainfed condition like groundnut, cotton, sorghum, pearl millet, maize, pulses, *etc.*, are seasonal and has to be completed before moisture gets depleted. In the existing methods of land preparation, the moisture retained by the soil is less, since more water is wasted in the form of runoff. Hence, the available time for sowing is minimised due to immediate depletion of moisture. Moreover before operating the sowing unit the land has to be ploughed once. Development of separate units for each operation will be a costly one. So if a basin lister cum seeder as an attachment to tractor drawn cultivator is developed, it can perform ploughing, basin formation and sowing simultaneously. Keeping the above fact in view, the basin lister cum seeder was developed as a rear mounted attachment to four wheel tractor of 35-45 hp range. In this paper, the design requirements for the basin lister and constructional features are described. The procedure followed for laboratory calibration and for field performance evaluation of the basin lister cum seeder attachment and their results are discussed.

Materials and Methods

Selection of prime mover

It is evident that the increase of tractor population is healthier than the power tiller growth and also the power required for the implement is higher than the power range of walking type tractors. Hence it was decided to design the proposed implement for four wheel tractors. It is also seen from the statistics of sale of tractors that 35-45 hp range tractors occupied the major share in the agricultural sector. Hence the implement was designed to suit the 35-45 hp tractors and help the major percentage of tractor users.

Factors influencing design of basin lister cum seeder

As the major components of the implements used in the mechanized agricultural production have to negotiate different soil conditions, various machine-soil-plant properties have to be taken into account for the design of the basin lister cum seeder. The factors are explained under different sub headings as mentioned below.

1. Soil type and conditions

The majority of tillage efforts require an optimum soil working condition, *i.e.,* soil moisture and bulk density. The type of soil and depth of operation, affect the draft requirement of the implement. Hence, soil moisture, bulk density and type of soil have to be considered for the design of the basin lister cum seeder.

2. Crop parameters

It is essential to consider the crop parameters and seed properties. The recommended row to row spacing, plant to plant spacing, number of seeds per hill, seed rate (delinted seeds), depth of planting, normal germination percentage of seeds are 0.45 to 1.20 m, 0.30 to 0.60 m, 1 to 2 seeds, 2.5 to 7.5kg / ha, 30 mm and 65 to 80 per cent respectively for rainfed cotton crop (Anon., 1994).

General design requirements

Considering the factors discussed above, the following general design requirements were arrived for the basin lister cum seeder.

i. The unit should reduce the number of operations in the field by combining the required secondary tillage operations along with planting

ii. As mechanical handling of the fuzzy seeds is a problematic one, either the delinted seeds or pelletised seeds have to be used.

iii. The most common row to row spacing for the major rainfed crop is 0.45 m (Anon., 1994). As the implement should be suitable for other crops, in addition to cotton crop, the row to row spacing was set as 0.45 m.

iv. For general design, a value of 0.30 m which is the usual spacing for rainfed varieties was considered.

v. The recommended depth of planting of cotton seed is 30 mm. So, the unit should have suitable mechanism, to place the seed at this desired depth.

vi. Since the sowing and basin listing are done simultaneously, the top width of basin was restricted to 0.30 m.

Table 1. Analysis of variance for seed rate

Source	df	SS	MS	F
Row	3	1.5927	0.5309	1.82 ns
Cup speed	5	297.4098	59.4820	207.36**
Error	15	4.3029	0.2869	
Total	23	303.3054		

ns - Non significant ** - Significant at 1 per cent level

Table 2. Uniformity of seed distribution in soil bin

S.No.	Forward speed, m/s	Avg. spacing m	SD	CV	% deviation from thr rev, spacing
1.	0.36	0.3065	1.7251	0.0537	2.17
2.	0.61	0.3090	1.9072	0.0596	3.00
3.	1.06	0.3025	1.1431	0.0378	0.83
4.	1.53	0.3080	1.8543	0.0732	2.67

Table 3. Plant population

S.No.	Description	Treatments				
		T_1	T_2	T_3	T_4	T_5
1.	Actual population, Nos./ha					
	Before thinning	100060	100040	100780	100440	189220
	After thinning	69510	70560	69210	69830	68860
2.	Recommended population Nos./ha	74074	74074	74074	74074	74074
3.	Per cent deviation from recommended population					
	Before thinning	(+) 35.08	(+) 35.05	(+) 36.05	(+) 35.59	(+) 155.45
	After thinning	(-) 6.16	(-) 4.74	(-) 6.57	(-) 5.73	(-) 7.04

vii. As the lister was made of curved mild steel sheet fitted with shovel of 75 mm width at the centre, which enters into the soil, the bottom width of basin will be 75 mm.

viii. The depth of the basin was taken as 0.15 m after giving due consideration to the rainfall intensity, soil type and power availability.

ix. Since it was decided to plant the seeds in four rows in one pass at 0.45 m row to row spacing, the width of the unit is arrived as 1.80 m which is the normal width of tractor drawn cultivator.

x. The basins should be in between two adjacent rows such that there will be three rows of basin in one pass.

xi. To minimize the draft requirement for listing, the three cams were set in such a way that when one lister was at the center of the basin, another lister will be lifted from the basin while the third lister will be starting the formation of basin. This was achieved by fixing the three cams on the cam shaft at an angle of 120° to two adjacent cams.

xii. Taking into consideration of the diameter of ground wheels on which the cam shaft is mounted it was decided to form basins of length 1.60 m and an interspace of 0.80 m length between two adjacent basins in the direction of motion. Based on these lengths, the cam profile was designed.

Selection of functional components

In cotton cultivation, several operations are performed in the field prior to planting. The basin lister cum seeder has to eliminate or combine several of these operations along with planting. Considering these, the following mechanisms were selected for the basin lister cum seeder.

i. Tilling mechanism

The field operation performed in cotton fields prior to basin formation include ploughing with disc plough, and with cultivator twice. Keeping in view the concept of minimum tillage which does not negatively affect the crop yield (Sheikh *et al,* 1983 and Zhang *et al,* 1986), it was decided to combine one cultivator ploughing operation with the succeeding operations of basin formation and planting. Since cultivator is the commonly available with the tractor owning farmers as an attachment to tractor, it was selected as the tilling mechanism for the basin lister cum seeder.

ii. Basin listing mechanism

The basin listing mechanism is the main functional mechanism through which the desired basins are formed in the field to achieve the goal (Anon., 1987). The lister is used to form basins in the field by lifting and lowering the lister along with shank by hinging the shank holding frame with the cultivator main frame. The shape of the lister was optimized for lower draft. The cam and follower is the mechanism through which rotary motion of ground wheel shaft is converted into oscillatory motion of the lister so as to form basins intermittently. The cam is driven by the power gained from the self propelled ground wheel through cam shaft.

iii. Planting mechanism

The planting mechanism consists of seed hopper, seed metering device, ground wheel, power transmission system from ground wheel to seed metering shaft and provision for accurate seed placement device. Cup feed type of seed metering device was selected as it was found effective for various types of seeds (Anon., 1986). The cup feed mechanism also has the advantage of minimum seed damage compared to other common types of seed metering devices (Anon., 1988).

Final assembling of the unit

Nine numbers of tyne were mounted on the cultivator mainframe in such a way that five of them were mounted in the front row at 450 mm interval and remaining four were mounted in the rear row at 450 mm interval so as to fix four seed tubes at the rear side to sow seeds in four rows at 450 mm row spacing. The seed hopper was mounted on the main frame of cultivator. The ground wheel assembly of seeder was mounted at the left hand side of the cultivator, so that the basins formed were not disturbed. The lister bottoms were fixed with shanks and the shanks were fixed with follower arms. The three follower arms were hinged independently to the cultivator frame, at 450 mm interval. The cams of dimensions as arrived from design, were mounted on the cam shaft at 450 mm linear interval as well as 120° radial interval. Two ground wheels of diameter 764 mm each were provided on cam shaft, and 15 numbers of lugs of 60 x 40 mm size were riveted on their rim. Among these two wheels, one was made as drive wheel by fixing to the cam shaft rigidly.

Thus the basin lister unit consists of four main assembly i.e. three sets of lister with shank and follower arms, each set hinged separately to the cultivator frame at 450 mm intervals such that each set oscillates independently. The fourth item consists of two wheels with shaft where cams are mounted at 450 mm intervals such that they are directly below the cam follower when assembled. The set up was also hinged to the cultivator frame independently.

Laboratory tests

Before conducting the performance evaluation of the unit in the field, laboratory tests were carried out for obtaining the correct seed rate and uniformity of seed distribution at different forward speeds. For this purpose, two tests *viz.*, calibration of unit and uniformity of seed distribution were conducted.

i) Calibration of unit

The calibration of the unit was done to obtain the seed rate at various speeds of the rotor, corresponding to the different forward speeds of unit. A pulley of 0.42m diameter was mounted on the seed metering shaft to which power was taken from a seed drill test rig with the help of a V-belt. The test rig consists of 0.75 kW electric motor and a variable speed drive mechanism. The seed hoppers were filled with seeds and the seed discs were driven for 10 minutes and the seeds obtained at the bottom of each seed tube were collected separately by placing containers. The experiment was conducted at six different speeds from 10 to 60 rpm, corresponding to forward speeds of 0.381 to 2.279 m / s. The seed rate obtained by the seed drill attachment was determined by the following expression. To analyse the variation in seed rate statistically, a F-test was performed with the rows as replication and speeds as treatment.

$$\text{Seed rate obtained, kg/ha} = (4\,w \times 10000) / (4.046\,n \times 10)$$

where,

w = weight of seed collected per row, kg

n = Speed of rotation of rotor and ground wheel (1:1), rpm *ii) Uniformity of seed distribution*

To find the uniformity of seed distribution, tests were conducted in soil bin as per Indian Standards IS 6316 : 1993. The unit was operated above the leveled compacted soil by the loading car at four different forward speeds, *viz.*, 0.36, 0.61, 1.06 and 1.53 m/s. The spacing between the seeds placed on the sand and the number of seeds dropped at each point were noted for a length of 15 m. The standard deviation and coefficient of variation were found out using the following formulae. F-test was done with rows as replication and forward speeds as treatment to analyze the variation in seed spacing statistically.

$SD = (x_i - x^2)/n$ and $CV = SD/x$

where,

SD = standard deviation
CV = coefficient of variation
n = total number of seeding actions
xi = i^{th} spacing
x = mean spacing

Field tests

The unit was evaluated for its performance in the field. The tests were conducted in black cotton soils at Tamil Nadu Agricultural University, Coimbatore. The unit was operated at a forward speed optimized in the laboratory tests. The draft, fuel consumption, basin profile, ground wheel slip and field capacity and field efficiency were observed during field test.

i) Draft

The draft of the unit was measured by rolling method as given by RNAM test code (Anon, 1995). A hydraulic dynamometer of capacity ranging from 0 to 1000 kg was attached to the front of the tractor to which the unit was hitched. Using another tractor the implement mounted tractor was pulled through dynamometer. Draft was recorded in a measured distance by operating the pulling tractor at speed optimized in the laboratory tests and with the implement mounted tractor in neutral gear. The same procedure was done by removing the implement in the same condition. The difference between the readings indicate the draft requirement to pull implement at the optimized speed.

ii) Fuel consumption

For measuring fuel consumption, a tractor attached with fuel consumption meter was used (Jesudas, 1994). The over flow from the engine was diverted back to the jar. Fuel consumption was measured by operating the unit to cover a known area. The time taken to cover this area was also recorded. The difference in the volume of fuel in the measuring jar before and after the operation gave the volume of fuel consumed.

iii) Basin profile

The basin profile formed was measured by using a furrow profilemeter developed by Jesudas (1994). The furrow profilemeter consists of a frame plotting board, measuring pins, pin holding and release mechanism and paper feeding arrangement. The furrow profile meter was placed across the basins and the measuring pins were released by operating the release lever. The furrow profile was recorded on graph sheet by drawing a line over the top level of all measuring pins. The procedure was repeated at different forward speeds of operation.

iv) Ground wheel slip

The number of revolutions of the ground wheel of both seeder and basin lister for a distance of 20 m covered by the unit was recorded for calculating the wheel slip.

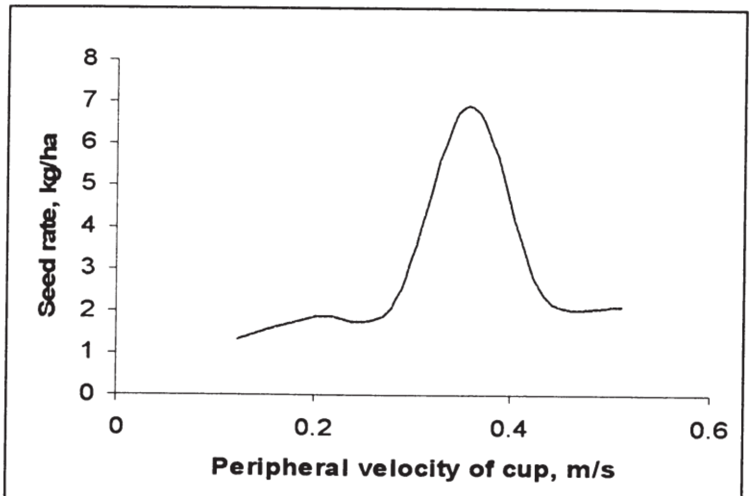

Fig.1 Peripheral velocity and seed rate

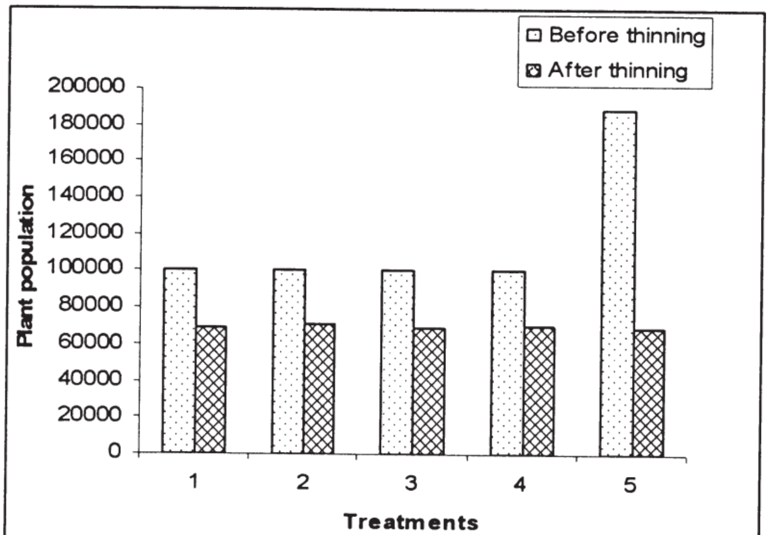

Fig.2 Plant population

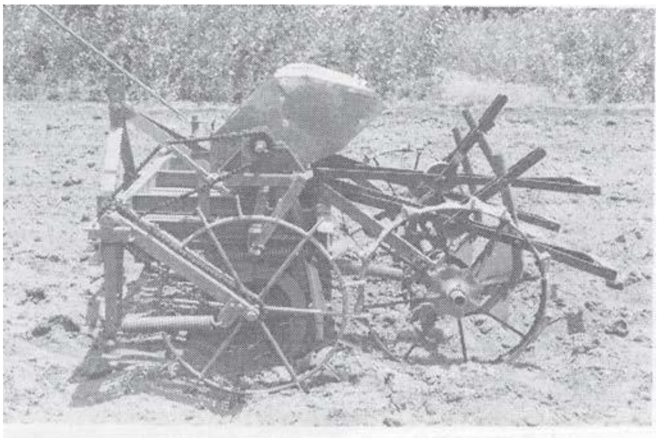

Fig. 3 Basin lister cum seeder

The slip was calculated using the following expression.

$$\text{Slippage} = [(d_u - d_g) / d_u] \times 100$$

where,

d_u = actual distance traveled by unit, m

d_g = actual distance traveled by ground wheel, m.

v) Field capacity

The field capacity and field efficiency of the unit was found out by operating of the unit in an area of 0.4 ha. The total time taken to cover the area, time lost for running at head lands and other time losses were recorded for the calculation of field capacity and field efficiency.

Field performance evaluation

Tests were conducted in black cotton soil at Tamil Nadu Agricultural University for evaluating the performance of the unit by taking five treatments *viz.*, broad bed former cum seeder (Tl), basin lister cum seeder (T2), ridger seeder (T3), cultivator seeder (T4) and control (sowing behind country plough, T5). Cotton variety LRA 5166 was planted as a rainfed crop in an area of 0.55 ha. The time required to cover the area, the time lost for turning, average travel speed, actual quantity of seeds used were measured during the operation. The crop parameters *viz.*, uniformity of plant spacing, depth of seed placement and plant population were measured after 20 days of planting.

i) Uniformity of plant spacing

The spacing between the plants and the number of plants per hill for a known length were measured to analyse the uniformity of plant spacing. The coefficient of variation and standard deviation were calculated. The per cent missing, single plant per hill and multiples were also found. The values obtained for each unit (treatment) and conventional method were compared.

ii) Depth of seed placement

Depth of seed placement was measured by removing the plant from soil and measuring the depth at which the seed was placed.

iii) Plant population

The plant population was assessed by counting the number of plants in a known area both before and after thinning. The readings were recorded from randomly selected six different locations in the field.

iv) Germination test

A germination test was conducted to study the actual germination percentage of LRA 5166 cotton seeds which was used for the field evaluation of the unit. Hundred numbers of seed were planted in an experimental plot of size 0.75 x 0.50 m in the field. The number of seeds germinated was counted, which gave the germination percentage of the variety. The germination test was replicated five times and the mean value was taken.

Results and Discussion

Design principles and specification

A tractor drawn basin lister cum seeder for rainfed cotton crop was designed and developed based on the general design requirements. The unit was designed and developed to suit various soil conditions and cotton varieties. The developed unit performed several operations simultaneously *viz.*, ploughing once, forming basins and sowing cotton seeds in the centre of two adjacent basins at the desired spacing and depth in a single pass. During the forward movement of the unit, the cultivator tynes till the land, the lister bottom forms the basin and seed planting mechanism meters seed and places it in the desired location. The plant to plant spacing can be varied by altering the speed ratio between the ground wheel and the seed metering shaft by changing the sprockets in the power transmission system of the seeder. This can also be achieved by changing the number of cups in the seed metering disc. The desired depth of placement of seed can be accomplished by moving the seed placement tube vertically up or down.

Laboratory tests

i) Calibration of basin lister cum seeder

From the calibration study, it is evident that there was not much variation in the seed rate obtained in all the four rows at all peripheral velocity. The seed rate increased with the increase in the peripheral velocity of cup from 0.122 m/s to 0.356 m/s and further increase in peripheral velocity decreased the seed rate as shown in Fig 1. This may be attributed to the fact that higher peripheral velocity of the cup resulted in throwing the seeds outside the funnel and at lower velocities some of the seeds taken by the cup will fall back into the seed metering compartment itself. The corresponding peripheral velocity of cup for the recommended seed rate is 0.356 m/s. It is found that at all the forward speeds the seed rate obtained in four rows did not show much variation. The required seed rate in all the four rows was obtained at a forward speed of 1.11 m/s.

In order to confirm the validity of the above results a statistical analysis was carried out. The analysis of variance table for seed rates is given in Table 1. The non significance of F value for rows indicated that the seed rate obtained in different rows at various peripheral velocity of cups did not differ significantly. The F value for seed rates at different peripheral velocity of cups was found significant at one per cent level, which showed that the peripheral velocity of cups significantly affected the seed rate.

ii) Uniformity of seed distribution

The uniformity of seed distribution was observed by conducting trials in soil bin. The average spacing, standard deviation, coefficient of variation and per cent deviation from the recommended spacing at different forward speeds of operation are furnished in Table 2. It is observed from the table that at all the selected forward speeds, the average spacing obtained was slightly higher than the recommended spacing of 0.30 m. This may be due to the variation in the time taken by the seed to reach the final placement point from the metered location. The minimum value of coefficient of variation of 0.0378 and standard deviation of 1.1431 was obtained for the forward speed of 1.06 m/s. This speed also registered the minimum deviation of 0.83 per cent from the recommended spacing.

In order to confirm the validity of the above results, the analysis of variance test was carried out. It is observed from the analysis that the seed spacing at various forward speeds was found to be significant at one per cent level. The non significance of F value for rows indicated that there was not significant difference in speed spacing between the rows at all the forward speeds.

iii) Optimization of forward speed

The minimum deviation from the recommended spacing and uniform distribution of seeds were obtained at a forward speed of 1.06 m/s. But the desired seed rate was obtained at a forward speed of 1.11 m/s and the speed higher than this resulted in reduction of the recommended seed rate. Hence the forward speed of operation was optimized as 1.11 m/s (Durairaj *et al.,* 1992).

Field tests

The average draft requirement to operate the unit at the recommended forward speed of 1.11 m/s was 2600 N. The fuel consumption was measured by using the procedure as explained earlier. The unit was operated in an area of 0.5 ha. The time for covering the area and the fuel consumed were noted. The fuel consumption was obtained as 4.11 1/h. The profile of the basins formed at various forward speeds of operation was measured by using a furrow profilemeter. The deviation of the basin profile was minimum upto a forward speed of operation of 1.11 m/s and thereafter the deviation was higher. The slippage of the ground wheel of seeder was obtained as 6.34 per cent which is well within the recommended value of 18 per cent (Bjerkan, 1947). The slippage of the ground wheel of basin lister was determined as 6.98 per cent. The time required to cover an area of 0.4 ha, time lost for idle run, time lost for adjustments and repair etc. were recorded and the field capacity of the unit obtained was 0.49 ha/h with a field efficiency of 68.06 per cent.

Field performance evaluation

The row to row spacing obtained in the field did not show any variation and the recommended spacing of 0.45 m was obtained. It is observed that there was not much variations in average plant spacing in treatments T_1 to T_4. This may be due to the fact that the planting mechanism namely cup feed type used in all the above four treatments were same. However among the treatments T_1 to T_4, the basin lister cum seeder treatment (T_2) registered minimum value of 1.03 per cent deviation from the recommended spacing. The standard deviation (1.211) and the coefficient of variation (0.0399) were the least for the treatment T_2.

In case of missing hills, it is observed that major numbers of hills were planted with single seed in the treatments T_1 to T_4 while only 18.18 per cent of hills were planted with single seed in the control. Majority of hills (68.94 per cent) were planted with two seeds or more in the control. The percentage of missing hills was the highest (12.88 per cent) for control treatment and the lowest (3.79 per cent) for basin lister cum seeder treatment (T_2) which indicated the superiority of performance of the basin lister cum seeder unit.

From the statistical analysis it is evident that the mean depth of seed placement (35.85 mm), standard deviation (10.786), coefficient of variation (0.3009) and per cent deviation from recommended depth (19.50) of the control was the highest among all treatments. It is also observed that the basin lister cum seeder treatment (T_2) registered the minimum mean value of depth of seed placement 30.40 mm as compared to all other treatments. The least values of standard deviation and the coefficient of variation in treatment T_2 indicated that the uniform depth of seed placement was possible for the basin lister cum seeder.

The plant population before and after thinning in all the five treatments are shown in Fig 2 and Table 3. Considering one plant per hill, the required plant population is 74074 per ha. In all the five treatments it is found that the plant population before thinning were higher than the recommended population. This may be due to the higher proportion of hills having two or more plants. But in the control, the plant population was 155.45 per cent higher than the recommended population. This may be due to the fact that 68.94 per cent of the hills were planted with two or more seeds. After thinning, the plant population was maintained close to the recommended plant population in all the treatments.

The basin lister cum seeder treatment (T2) registered minimum deviations of (+) 35.05 per cent and (-)4.74 per cent from the recommended plant population before and after thinning respectively. It is also observed that the control treatment (T5) registered the highest values of per cent deviation of (+) 155.45 and (-) 7.04 from the recommended plant population before and after thinning respectively.

In the germination test for cotton seed variety LRA 5166, the germination was observed as 80 per cent. The minimum germination percentage for the cotton variety recommended was 65 per cent. Hence the germination quality of the seed used for the trial was well within the recommended values.

It is concluded that,

1. There was no significant variation in seed rate and seed spacing in the four rows, in laboratory calibration.
2. The recommend seed rate was obtained in the laboratory test for the peripheral velocity of 0.356 m/s which corresponds to the forward speed of 1.11 m/s.
3. The forward speed of 1.06 m/s in laboratory test registered the minimum deviation of 0.83 per cent from the recommended seed spacing.
4. The row to row spacing of basins formed for various forward speed of operation did not vary from the designed spacing of 0.45 m, in the field.

In field condition, the deviation from the recommended depth and top width of basin was the least (3.33 per cent and 1.67 per cent respectively) at the forward speed of 1.11 m/s.

6. Considering seed rate, uniformity of seed distribution and basin profile, the forward

speed of operation was optimized as 1.11 m/s.

7. The average draft and fuel consumption of the unit were 2600 N and 4.11 1/h respectively .

8. The slip of the ground wheel of seeder and that of ground wheel of basin lister were 6.34 per cent and 6.98 per cent respectively.

9. The field capacity of the unit was 0.49 ha/h with a field efficiency of 68.06 per cent.

10. The basin lister cum seeder registered minimum value of 1.03 per cent deviation from the recommended plant to plant spacing of 0.30 m.

11. The percentage of missing hills was the lowest (3.79 per cent) for basin lister cum seeder treatment and the highest (12.88 per cent) for control treatment.

12. The basin lister cum seeder treatment registered the least values of per cent deviation (1.33) from recommended depth of seed placement and recommended plant population among all treatments.

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