MM 2.5 Ergonomically Efficient Implements for Cotton Production

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Target & Achievements

Target	Achievements
Spray deposition studies of different spray nozzles	Triple action (TA), bi-action (BA) and hollow cone (HC) nozzles of ASPEE were tested in the laboratory. The minimum coefficient of variation in spray distribution was obtained at working pressure of 3.5 kg cm^{-2}
Development and evaluation of sprayers for cotton	• Self-propelled air assisted boom sprayer was developed and tested in field based on lab parameters. The cost of operation was Rs. 260 compared to conventional method of spraying Rs. 300. The saving in cost of operation was 10 to 20 per cent, labour was 20 to 30 per cent and saving in time was 45 to 55 per cent. • Tractor-operated air-assisted sprayer was designed and developed and tested for better spray deposition in laboratory. Better deposition was at air velocity of 50 km h^{-1} at all the forward speeds.
Development and Field evaluation of Planters	Pneumatic planter was tested in field and compared with the inclined plate planter. Pneumatic planter was more accurate as it gave least percentage deviation from recommended spacing (13 cm) than that of inclined plate planter (30 cm).
Development and evaluation of a tractor operated cotton stalk shredder cum insitu applicator	A front mounted tractor operated prototype cotton stalk shredder (2 blades, 0 deg rake angle and 12 mm blade thickness) was developed and evaluated and optimized for maximum shredding efficiency

Testing of different types of spray nozzles

❖ **Spray deposition studies of different spray nozzles (CICR, Nagpur)**

Spray deposition study was conducted for different nozzles, pressures and at different part of the compact released cotton variety Kirti (CNH 120 MB). Ammonium sulphate 5 ppm was sprayed and collected by repeated washings and estimated colorometrically the concentration per unit area at different pressures i.e. 10, 20, 30 PSI, with three nozzles i.e. BCN single, NMDS nozzle and hollow cone nozzle in three replications. The spray deposition was estimated on cotton plants at different locations such as bottom, middle and top by selecting 5 leaves at each location. The leaves were washed estimated area and collected Ammonium sulphate was subjected to Nesslerization. The loss of spray over ground was also studied by spreading the polythelene sheet beneath the canopy of the plant. The speed of application was maintained at 1.5 KMPH. Spectrophotometer was used to measure the color at 410 um wave length and calculated spray deposition in ppm. The data were analysed for variance in split plot design.

The analysis shows that the there is no significant differences among different nozzles under study although NMDS was superior to BCN and HC nozzles. Therefore, to confirm the superiority of different nozzles spray deposition in terms of particle distribution is necessary. Such studies need to be done with the help of Image analyzer and leaf area meter, which is presently not available in the institute.

The spray deposition and particle size distribution at different locations over cotton plant is the interaction of leaf orientation, pressure, and wind speed besides nozzles. The pressure 30 PSI is minimum required for knapsack sprayers as confirmed from previous experiences of researchers. The 30 PSI was sufficient to give minimum depositions in all nozzles as maximum deposition on the site of egg laying (top). Presently monitors are not available on the sprayers at farmers levels. The study needs confirmation next year.

There was no significant influence of leaf orientation on the plant. However, the foliage significantly blocked the ground losses 5% despite its compact plant. The spray deposition at bottom, middle and top was 36, 36 and 23% among the total amount of solute (Table 2.5.1 & 2). The studies need confirmation with most common bushy type of plants always used by the farmers.

Table 2.5.1: Spray deposition in PPM per cm^{-2}

	BCN	NMDS	HC	MEAN	BOTTOM	MIDDLE	TOP	GROUND	MEAN
10	0.031	0.03	0.036	0.032	0.047	0.049	0.025	0.08	0.051
20	0.035	0.029	0.038	0.034	0.049	0.048	0.034	0.005	0.029
30	0.028	0.021	0.045	0.031	0.045	0.042	0.032	0.006	0.027
MEAN	0.031	0.027	0.040	0.033	0.047	0.046	0.031	0.006	

Table 2.5.2 : Spray deposition in PPM per cm^{-2}

	10	20	30	MEAN
BOTTOM	0.051	0.033	0.057	0.047
MIDDLE	0.047	0.048	0.044	0.046
TOP	0.019	0.021	0.052	0.031
GROUND	0.007	0.006	0.006	0.006
MEAN	0.031	0.027	0.040	

- **Testing of triple action, double action and hollow cone nozzle (PAU, Ludhiana) :**

On the basis of results obtained from laboratory studies on different types of nozzles it was observed that with the increase in pressure from 2.5 to 4.0 kg/cm^2 swath width, spray angle and discharge rate increased for all the three nozzles. At each working pressure the triple action nozzle covered larger width but discharge was more than the required for cotton crop. With the variation in the pressure between 2.5 to 4.0 kg/cm^2 there was very little variation in coefficient of variation for triple action nozzle. The average discharge rate varied from 369.4 to 477.3 ml/min and swath width increased from 78 to 87cm with the increase in pressure from 2.5 to 4.0 kg/cm$^{2.}$

The minimum coefficient of variation in spray distribution was obtained at working pressure of 3.5 kg cm^{-2}. For hollow cone nozzle the swath width was smaller as compared to triple action and double action nozzles. The average discharge rate increased from 474.5 to 606.2 ml/min as the working pressure increased from 2.5 to 4.0 kg cm^{-2}. Thus, the discharge rate of hollow cone nozzle was good but the coverage width was less and also the coefficient of variations in spray distribution was high as compared to triple action and double action nozzle. At pressure of 3.5 kg cm^{-2}, the nozzle heights of 40 and 50 cm gave better coefficient of variations (60.56 and 61.76%). The swath width was more at nozzle height of 50 cm than at 40 cm.

Theoretically it was found that the coefficient of variation in spray distribution in the space between two adjacent nozzles decreased drastically as the nozzle spacing reduced from 84 to 48 cm. With further reduction in spacing, coefficient of variation decreased but variation was less. At the same time the volume of liquid per centimeter width increased with reduction in spacing, which could results in excess pesticide application. The best result was obtained between the nozzle spacing of 39 to 51 cm. The test results revealed that the better coefficient of variation (10.18%) was obtained at nozzle spacing of 45 cm.

Development and evaluation of sprayers for cotton

- **Development and evaluation of a power tiller operated gaseous energy sprayer (TNAU, Coimbatore)**

A laboratory simulator was developed to study the spray depositional characteristics and the droplet size as applied on artificial and potted plant targets as influenced by the system, operational and target parameters. The deposition efficiency of spray was quantified by tracer wash procedure and measuring absorbance on spectrophotometer. The deposition efficiency was maximum (36.223 per cent) at spray fluid discharge rat of 200 $mlmin^{-1}$, forward speed of operation of 1.0 kmh^{-1}, nozzle height 50 cm from the canopy and nozzle orientation of 60 degree with the vertical. An identical trend of relationship was observed for both artificial plants (36.223 per cent) and potted plants (34.473 per cent) with negligible reduction in deposition efficiency for the latter. Analysis of variance for deposition efficiency of spray confirmed that the selected variables and their interactions significantly affected at 1 per cent level for both artificial and potted plants.The droplet size of spray was measured by using 'IMAGE ANALYSER 1.20.2' software. The droplet size obtained at spray fluid discharge rate of 200 $mlmin^{-1}$, nozzle height of 50 cm and nozzle orientation of 60 degree with vertical was ideal (150 to 175 μm) for maximum deposition efficiency of spray. The prototype self propelled air assisted boom sprayer was developed based on the optimized variables and evaluated in the field as per RNAM test procedure.

The effective field capacity of the self propelled air assisted boom sprayer was 0.220 to 0.250 hah^{-1} for operational speeds of 1.0 to 2.0 kmh^{-1} and it was about three times more than that of conventional method of spraying (0.120 hah^{-1} with average operational speed of 1.6 kmh^{-1}). The higher effective field capacity could be justified by the higher width (3.0 m) of operation. The field efficiency of the developed system was observed to be less (40 to 60 per cent at operational speeds of 1.0 to 2.0 kmh^{-1} respectively) because of time lost during the turning in the head land and minor adjustments. The field efficiency of the developed system varied with the geometry of the field. Lengthwise passes reduced the number of turnings and thereby the higher efficiency. But the ease of operation of the developed system was reported as 'good'. The major advantage of the developed system was both spraying and weeding operations can be carried out simultaneously whenever necessary.

The cost of operation of the self propelled air assisted boom sprayer was less (Rs. 259.37) with the conventional method of spraying (Rs. 297.5). The saving in cost of operation was 10 to 20 per cent. The saving in labour was 20 to 30 per cent and saving in time was 45 to 55 per cent at the corresponding forward speed of operation.

The economical advantages of the developed system over the conventional method (spraying with powered knapsack sprayer) was calculates as follows.

Cost of developed unit	-	Rs. 4000.00.
Average saving in cost of operation	-	10 to 20 per cent per hectare.
Average saving in labour	-	20 to 30 per cent per hectare.
Average saving in time	-	45 to 55 per cent per hectare.
Field capacity	-	0.20 to 0.25 hah^{-1}.
Field efficiency	-	40 to 70 per cent.
Deposition efficiency	-	15 to 25 per cent.
Droplet size	-	150 to 175 µm.

- **Development and evaluation of tractor-operated air assisted sprayer (PAU, Ludhiana)**

A tractor-operated air-assisted sprayer was designed and developed for better spray deposition on the target surface in the cotton crop. An axial flow fan and sleeves on either side of fan casing were designed and fabricated according to the discharge required to supply pre-determined air velocity over the entire length of the nozzle boom. The total length of fan casing plus the sleeves was kept equal to the length of nozzle boom. The air-assisted sprayer was tested in the laboratory, at different combinations of forward speed (2.4, 3.5 and 4.0 km h^{-1}) and air velocity (0, 20, 35, 50 and 71 km h^{-1}). Droplet size (NMD and VMD), uniformity coefficient, droplet density, percent area covered by droplet spots per square centimeter of glossy paper and volume of spray deposition per square centimeter were determined. The droplet size (VMD) varied from 232 to 284 µm. Maximum uniformity coefficient (3.36) was obtained at forward speed of 2.4 km h^{-1} without air assistance and minimum (1.78) at forward speed of 4.0 km h^{-1} with air velocity of 50 km h^{-1}. The droplet deposition by conventional sprayer on the underside of the leaves in any section of plant was negligible but with air-assistance an effective deposition of droplets on underside of leaves was obtained. Better deposition was obtained at air velocity of 50 km h^{-1} at all the forward speeds.

Development and Field evaluation of Planters

- **Development and evaluation of tractor operated belt type seed metering planter for cotton (TNAU, Coimbatore)**

Precision planting is the proper placement of seeds in row at uniform depth and recommended seed rate with less visible seed damage and missing hills. The performance of the planters depends on the cell size, peripheral velocity, inclination of seed metering mechanism and seed dropping height. In belt type planter, seed singulation produced more consistent row to row distribution of seeds and a numerical reduction in plant stand variability. The performance of belt type seed metering mainly mechanism depends on the design of belt hole. For achieving precision planting of cotton, the variables viz., diameter of belt hole, peripheral velocity of metering belt, inclination of seed metering mechanism, height between ground level and belt hole were selected. An experimental test rig was constructed to investigate the influence of the selected variables on the seed rate, visible seed damage, missing hills, number of seeds per hill and seed spacing. The optimized levels of variable for achieving the maximum percentage of two seeds per hill, minimum percentage of visible seed damage, missing hills, one, multiple seeds per hill and recommended seed spacing are furnished below. A prototype tractor operated cotton planter was developed with optimized levels of variables.

Peripheral velocity of metering belt	=	0.22 ms^{-1}
Diameter of belt hole	=	10 mm
Inclination of seed metering mechanism	=	0 deg
Height between ground level and belt hole	=	150 mm

- **Field evaluation of pneumatic planter**

A pneumatic planter was purchased from the Central Institute of Agricultural Engineering, Bhopal. The machine was set at 1m row spacing (3 rows) to facilitate mechanical picking of cotton. It was calibrated for a seed rate of 3.25 kg/ha and seed spacing of 45 cm in laboratory. Sowing with pneumatic planter was done at the Research Farm of Dept. of Farm Power & Machinery in May 2004. The experiment was abandoned due to very poor germination count in the field. Modifications in the metering mechanism of the machine have been made for sowing in 2005. Sowing with both pneumatic and inclined plate planter was done in May 2005 in the departmental research farm and the results were compared

(Table 2.5.3). The average spacing between the plants sown with inclined plate planter and pneumatic planter were 0.313 and 0.51 m respectively. Pneumatic plate planter was more accurate as it gave least percentage deviation from recommended spacing (13.00) than that of inclined plate planter (30.4). Number of missing, number of hills with one plant, number of hills with two plants and number of hills with three plants were recorded for 10 m length of run. The average number of missing and average percentage missing hills was higher for pneumatic planter (4.67 and 22.8, respectively) than inclined plate planter (1.33 and 4.18, respectively). Percentage of singles was higher for inclined plate planter (77.62) than pneumatic planter (77.13) and percentage of doubles was higher in case of inclined plate planter (16.30).

Table 2.5.3 : Comparative results of the field experiments of cotton planters

Particulars	Inclined Plate Type Planter			Mean	Pneumatic planter			Mean
	Replications				Replications			
	1	2	3		1	2	3	
No of seedlings in 10 m length	32	28	37	32.33	17	20	22	19.67
Average seed to seed spacing*, m	0.31	0.36	0.27	0.313	0.58	0.5	0.45	0.51
No of missing hills	0	2	2	1.33	2	5	7	4.67
Number of hills with one plant/10 m	26	22	27	25	15	15	15	15
Number of hills with two plants/10 m	5	4	7	5.33	0	0	0	0
Number of hills with three or more plants/10 m	1	0	1	0.67	0	0	0	0
Missing hills (%)	0.0	7.15	5.4	4.18	11.7	25	31.8	22.8
Percentage of singles	81.25	78.6	73.0	77.62	88.2	75.0	68.2	77.13
Percentage of doubles	15.6	14.3	18.9	16.3	0.0	0.0	0.0	0.0

- **Testing of CIAE precision plot drill and pneumatic planter (CICR, Nagpur):**

Precision plot drill was tested. The machine performed well with satisfactory field germination comparable to laboratory paper towel method.

The CIAE pneumatic planter was also tested in the same situation but the planter didn't perform well as the power drive mechanism from ground wheel to seed metering plate is slipping, jerking and not in smooth operation which results in non-uniform distribution of seed in the row. Further it was also observed that the ground drive wheel is not capable to move all eight seed metering plates smoothly and at constant speed which results in variation seed to seed distances among different rows. Earlier the same planter was tested in the month of August 2004 and found a major problem of ground drive wheel, which was later on rectified at a small amount. But the problem was not solved fully.

The planter needs correction in power transmission system (chain and sprocket mechanism) and ground drive wheel, which is expected to rectify in the coming season.

- **Development and evaluation of a tractor operated cotton stalk shredder cum insitu applicator**

Incorporation of cotton stalks into the soil ensures rapid decomposition. The most rapid decomposition occurs when residue is placed 10 cm deep and shredding stalks as finely as possible also allows for rapid decomposition. An experimental cotton stalk shredder was developed and the investigation was carried out with three levels of number of blades viz. 2, 3 and 4, four levels of peripheral velocity viz. 21.52, 23.80, 26.58 and 28.60 ms^{-1}, three levels of blade thickness of 2, 4 and 6 mm and four levels of blade rake angle of 0, 15, 30 and 45 deg.

The influence of the selected level of variables on shredding efficiency in terms of length of cut of shredded cotton stalk was investigated. For achieving maximum shredding efficiency the combination of 2 number of blades, 28.60 ms^{-1} peripheral velocity, 6 mm blade thickness (model) and 0 deg blade rake angle ($N_1S_4T_3\theta_1$) was selected. Based on the optimized values for the shredder, a front mounted tractor operated prototype cotton stalk shredder (2 blades, 0 deg rake angle and 12 mm blade thickness) has been developed and evaluated for its performance with three forward speeds of 2.0, 2.5 and 3.0 km h^{-1} and optimized for maximum shredding efficiency. A tractor operated (rear mounted) commercially available rotavator was selected as insitu applicator for incorporation of shredded cotton stalks. Increase in operating speed from 2.0 to 3.0 km h^{-1} resulted in decreased shredding efficiency from 91.63 to 82.18 percent. Increase in operating speed from 2.0 to 3.0 km h^{-1} resulted in increased mean length of shredded cotton stalk from 108 to 205 mm. The actual field capacity of the prototype tractor operated cotton stalk shredder cum insitu applicator was 0.24 ha h^{-1}.

Experiments were conducted with 4 treatments viz. disc ploughing with the standing cotton stalks, operation with prototype cotton stalk shredder cum insitu applicator with 2.0, 2.5 and 3.0 km h^{-1} of forward speed, to find out the efficient method of cotton stalk shredding and insitu application. The influence on the soil physical and chemical properties was recorded for all the treatments of the investigation. Operation with prototype cotton stalk shredder cum *insitu* application at 2 km h^{-1} forward speed is judged as the best among all the treatments tested as it recorded favorable increase in hydraulic conductivity (1.38 to 2.30 cm hr^{-1}), decrease in bulk density (1.33 to 1.25 Mg m^{-3}), increased available N (199.0 to 252.0 kg ha^{-1}), P (12.6 to 20.1 kg ha^{-1}), K (541.0 to 640.0 kg ha^{-1}) and organic carbon (0.36 to 0.54 kg ha^{-1}) of the soil.