MM 2.5: Ergonomically efficient implements for cotton production

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Technical programme for the year 2006-2007

TNAU, Coimbatore

- Development and evaluation of tractor operated subsoil coir pith applicator
- Evaluation of battery operated knapsack sprayer
- Evaluation of weeders
- Development and evaluation of rotary spading machine for rice fallow cotton

PAU, Ludhiana

- Field evaluation of pneumatic planter
- Development and evaluation of tractor-operated cotton stalk puller
- Development and evaluation of self-propelled cotton weeder

CICR, Nagpur

- Evaluation of battery operated sprayer
- Evaluation of *Trifali* (local weeding and interculture tool) with existing wooden *bakhar* for cotton crop
- Evaluation and modification of multipurpose tool bar for interculture and sowing operations in cotton based cropping systems.

Development and evaluation of tractor operated subsoil coirpith applicator

Subsoil mulching with coirpith is a new concept. Deep loosening of soil and placement of coirpith in the subsoil layers as mulch directly below the crop rows would improve the root zone which would not re compact during subsequent years. The unique property of coirpith to hold 7-8 times its weight of moisture helps in improving the moisture status of root zone.

A Prototype subsoil coir pith applicator was developed at TNAU, Coimbatore. The coir pith applicator placed the coirpith at a depth of 15 to 30 cm below the ground level. This technique ensured that the coirpith filled trenches are not dispersed by subsequent ploughing thus preventing the dispersion and disintegration of coirpith. The subsoil coirpith applicator is built around a chisel plough which formed the tool for loosening the soil and also provided the frame for mounting the attachment. Coirpith is fed from a hopper through a rotary vane type feeding device and is funneled into the furrow bottom. A pair of furrow opener wings open the furrow open behind the chisel plough for placement of the subsoil mulch. The coirpith is fed by a vane type metering device rotated by a ground wheel. This arrangement ensured uniform placement of coirpith inside the furrow. The performance of the machine and the effect of subsoil mulching on crop growth was investigated in terms of soil moisture distribution, crop attributes *viz.*,

Subsoil coir pith applicator in operation

Battery operated sprayer in operation

height of the plant, number of leaves, number of branches, number of lateral roots, lateral root spread length, root length, number of bolls and yield. It is observed that the subsoil mulching opened up a triangular furrow in which the coirpith is placed to a depth of 15-30 cm at an application rate of 24 t ha^{-1} and at row to row spacing of 0.75 m. The effect of subsoil mulching is compared with chisel ploughing and control treatments. The soil moisture at 15-30 cm under the subsurface mulched plots were significantly higher that the other two treatments. All the indices of plant growth *viz.*, height of the plant, number of leaves, number of branches, number of lateral roots, lateral root spread length, root length were significantly higher under subsoil mulched plots than the other two treatments. The cost of the subsoil coir pith applicator is Rs. 10000 and the cost of operation for subsoil mulching for one hectare is Rs. 6800.

Ergonomical evaluation of battery operated sprayer for cotton

The commercially available AGRIMATE make sprayer was evaluated at TNAU. It is a DC motor operated electric rechargeable battery type back pack model. It eliminates the usual constant tiresome manual pumping required with conventional backpack lever operated sprayers. It consists of 16 lit HDPE tank having well designed comfort fit back harness, 12 volt rechargeable battery, strap for shoulder mounting, spray pump, trigger and lance with nozzle. The pressure discharge characteristic was evaluated to determine the flow rate at the operating pressure range of 3 kg cm-2 (double nozzle) and 5 kg cm-2 (single nozzle). The spray pattern was evaluated by using standard patternator constructed to confirm to standard specifications. The droplet size was determined by measuring the diameter of circles formed by droplet deposition. The battery operated sprayer was evaluated for its performance in cotton field and compared with the conventional knapsack lever operated sprayer. The ergonomic parameters for the operation of conventional knapsack lever operated sprayer and the ergonomically improved battery operated sprayer were measured and compared. The spray characteristics of the battery operated sprayer was evaluated and found to be acceptable. The operation of battery operated sprayer resulted in 11.6 % and 28.5 % saving in cost and time respectively when compared to conventional knapsack lever operated sprayer. The battery operated sprayer with improved ergonomic design features enhanced the comfort of the subject with 13.6, 25.50, 25.0, 10.1, 9.2 and 12.8 per cent reduction in heart rate, oxygen consumption, energy expenditure, AWL, LCP, Overall Discomfort Rating and Body Part Discomfort Score respectively when compared to conventional knapsack lever operated sprayer.

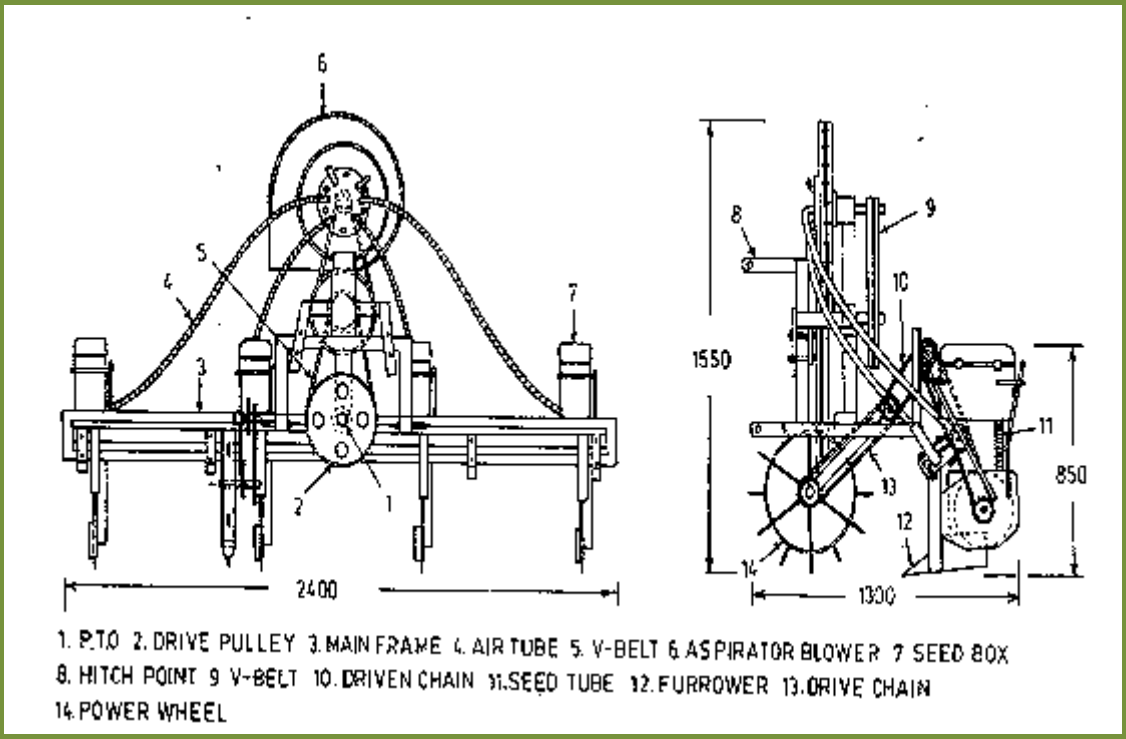
Development and evaluation of spading machine for rice fallow cotton

A spading machine was developed at TNAU for rice fallow cotton prevalent in the Thanjavur district of Tamil Nadu. The manual spading operation in rice fallow cotton is a highly labour intensive operation. The success of the crop depends on this crucial operation. The labor availability for such work is very limited and manual operation is costly. The spading machine provides an exciting alternative to till under such conditions where other tillage techniques cannot be adopted. A tractor operated rotary spading machine for rice fallow cotton was developed. The unit consists of a main frame, gearbox., crank shaft assembly, digger arm and shovel assembly and depth control wheel. The shovel with digging arms are thrown into the soil with in the help of 4 bar linkage mechanism and loose broken topsoil with crop residues and surface applications are well mixed so that air and moisture speed the decomposition of vegetation. The performance of the rotary spading machine was evaluated and compared with the existing practice of manual digging with spade. The operation of spading machine resulted in 26.20 to and 97.9 per cent saving in cost and time respectively when compared to spading with female worker. Also the operation of spading machine resulted in 38.50 to and 96.50 per cent saving in cost and

time respectively when compared to spading with male worker. The cost of the spading machine is Rs.60,000. It can cover one ha per day.

Field evaluation of pneumatic planter

Tractor-operated pneumatic planter was tested in the laboratory and field at PAU Ludhiana and following shortcomings were observed i) Slipping and excessive heating of V-belt drive from PTO drive to aspirator blower, ii) Slipping and frequent removal of chain from the sprocket in the chain drive from main transmission shaft to the cross bar and iii) Insufficient suction at the seed-plates. Due to slipping of belt and excessive heating, there was wear and tear of the belt as well as there was problem of development
of insufficient suction pressure. To overcome this problem the existing belts were replaced with new belts of appropriate size (No. 53, B-section). Removal of chain resulted in complete cut-off of that particular seed plate from the transmission due to which seed could not be stuck with the seed plate and missing occurred till the machine was stopped and the chain was loaded on the sprocket manually. This trouble was rectified by adding a keyway at sprocket over each furrow opener. A self setting bearing (P-205) along with bracket was also mounted at the chain drive of each furrow opener. Insufficient suction at the seed plate resulted in missing and it was corrected by proper tightening of the seed plate and replacing the damaged suction cut-off rubber flaps with new ones.



Rear and side-views of Tractor-operated Pneumatic planter

Stationary view of Tractor-operated Pneumatic planter

Both the planters were calibrated in the laboratory to give a seed to seed spacing of 45 cm and were made 4-row by changing the row to row spacing to 67.5 cm (as per recommendations of PAU, Ludhiana). Planting of cotton variety LH 1556 was done with both the machines viz. pneumatic planter as well as inclined plate planter at the departmental research farm in an area of 0.24 ha each. The field capacity of the pneumatic planter was 0.49 ha/h and inclined plate planter was 0.35 ha/h and field efficiency were 77% and 76.08% respectively. The average spacing between the plants sown with inclined plate planter and cotton planter with vertical roller were 0.303 and 0.307 m respectively, which are slightly higher than the recommended spacing of 0.3 m in all the cases. Pneumatic plate planter was more accurate as it gave least percentage deviation from recommended spacing (3.60) than that of inclined plate planter (19.38). 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 hills was lower for pneumatic planter (0.33) than inclined plate planter (1.33). Percentage of singles was higher for pneumatic planter (94.20%) as compared to inclined plate planter (85.54%) and percentage of doubles was higher in case of inclined plate planter (9.64). The yield for the inclined plate planter was 1167 kg/ha and for the pneumatic planter it was 1262 kg/ha. The variation in the yield could be attributed to the fact that tractor-drawn inclined plate planter had greater percentage of missing as compared to the pneumatic plate planter.

Development and evaluation of tractor-operated cotton stalk puller

The cotton stalk puller developed at PAU, Ludhiana was tested at Departmental research farm with FARMTRAC tractor of 45 hp. Prior to the operation of the machine, the wheel pull angle was set at 10 degrees to the vertical plane and then machine was run for 20 m length. For next 20 m run, the angle was kept at 20 degrees and for the last segment of 20 m the pull angle was changed to 30 degrees. Wheel pull angle was changed by adjusting top link of hitch system of the tractor. For these three angles (10°, 20° and 30°) the peripheral speed (rotational speed) was kept 3.14 m/s (150 rpm). Similarly, the experiment was repeated for the peripheral speed (rotational speed) of 3.66 m/s (175 rpm) and 4.19 m/s (200 rpm). Variation in peripheral speed (rotational speed) was achieved by changing the sprocket on sub-main shaft of the machine. The forward speed of the machine for three levels of pull angle and peripheral speed was kept 2 km/h. For remaining two forward speeds i.e. 2.5 km/h and 3.0 km/h the same procedure was followed. During field operation the tractor was operated in first low gear. The variation in forward speed of operation was obtained by adjusting the throttle of the tractor. Each experiment was replicated three times. At the end of each experiment, observations i.e. number of plants uprooted, number of broken plants, quantity of fuel used etc were recorded. These observations were noted down for three replications. Apart from above, soil moisture, soil bulk density and stalk moisture content were also recorded. Plant pulling efficiency of the machine was largely affected by pull angle and peripheral speed. With the increase in pull angle, plant pulling efficiency increased. Plant pulling efficiency was highest (61.0%) at 30 degree pull angle and 4.19 m/s peripheral speed of pulling wheels for 2 km/h forward speed of

operation. The effect of pull angle on plant pulling efficiency was significant at 5% level of significance and plant pulling efficiency was not affected by peripheral speeds of pulling wheels. Plank breakage was found minimum at 30 degree pull angle and 4.19 m/s peripheral speed. The plant breakage decreased with increase in pull angle. Fuel consumption of the machine increased with the increase in peripheral speed of pulling wheels. At 30o pull angle, the fuel consumption was 5.53, 6.78 and 7.15 l/h for 3.14, 3.66 and 4.19 m/s peripheral speeds respectively. The fuel consumption increased with the increase in peripheral speed but there was not much difference in the value of fuel consumption for a particular peripheral speed at different pull angles. Thus, it can be said that to get best performance of the machine, it should be operated at 30 degrees pull angle, 4.19 m/s peripheral speed and 2 km/h forward speed.

Development and evaluation of self-propelled cotton weeder

The PAU model of self propelled cotton weeder was evaluated by three subjects. All the three subjects were equally trained in all the operations. The subjects were given information about the experimental requirements so as to join up their full support during the experiments. They were given 30 minutes rest before starting the experiments. After resting, subject was asked to operate the machine for the given duration. The duration of experiments was fixed on the basis of preliminary trials. The dependent variable viz. heart rate, postural configuration, vibration, body discomfort were measured during the machine operation. Three subjects A1, A2 and A3 operated the power weeder at forward speeds of 1.0, 1.5 and 2.0 km/h for two time durations i.e. 40 min and 50 min. For all the three subjects the heart rate, body part discomfort score, overall discomfort rating, and energy expenditure were minimum at forward speed of 1.0 km/h for 40 min time duration but at this speed the vibration in machine was more as compared to that of 1.5 km/h and also the work done by the subject was very less. The heart rate, body part discomfort score, overall discomfort rating, and energy expenditure were slightly more at forward speed of 1.5 km/h than that at 1.0 km/h and they were even higher at forward speed of 2.0 km/h. Therefore, for the subject to work for the 40 min time duration, the optimum speed should be 1.5 km/h and when the time duration was increased to 50 min, the optimum speed suggested was 1.0 km/h.

Performance evaluation of weeders in cotton crop

The imported Oleo make power weeder is compact and lightweight machine ideal for working in confined spaces. Its performance was evaluated at TNAU. The unit is powered by 5.5 hp petrol engine. The rotary weeder consists of four discs mounted with 6 numbers of curved blades in opposite directions alternatively in each disc. These blades when rotating enable cutting and mulching the soil. The width of coverage of the rotary weeder is adjustable by removing or adding the disc with blades. A front wheel with vertical tip-up mechanism is provided for easy transport and can be lifted to facilitate tillage work. Two side protection discs ensure that crops remain undamaged while also maximizing operator safety. The transmission guard is reinforced to withstand projected stones and accidental impact. In addition to the rotary tiller blades, a ridger can be fitted to the unit for earthing up operations. The cost of the machine is Rs.55000 and the field capacity is 0.05 ha per day. The unit was evaluated for weeding in cotton crop and compared with long handled weeder and conventional method of weeding with hand hoe. The weeding efficiency of self-propelled power weeder was 73.4% (wet basis). Manual weeding with hand hoe registered the maximum efficiency of 94.8 % (wet basis). The saving in cost and time of weeding operation self propelled power weeder when compared to manual weeding was 12.4 and 58.5 per cent respectively. Safety clutch, adjustable height of handle, ease of maneuverability between the standing rows of crops improve the operator ergonomics of the power weeder. Compact and light weight, adjustable working width are the salient features of the weeder.