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Research Paper :

The field performance evaluation of tractor operated combination tillage implement

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ABSTRACT

An implement made up of a combination of soil working tools was developed and tested. The implement was intended to enable 45-55 hp tractors to complete a seedbed in a single pass for both dry and wet land crops. It was envisaged that such an implement would affect considerable saving of time, fuel and energy. This would also reduce the cost of operation. The combination of rotary tiller and disc harrow for using good seed bed preparation in short time. The prototype clearly indicated a potential for improvement performance in terms of time, fuel consumption, field capacity and cost operation. Effects of depth of cut, velocity ratio, and forward speed on mean weight diameter of soil aggregates and draft of the implement were studied. Field studies indicated that the prototype had an effective single pass capability and the average mean weight diameter of the soil clods achieved was 4.5 to 5 mm. The field capacity of the machine for the first treatment *i.e.* MB plough + combination tillage implement was 0.25 ha/h. In case of other remaining treatments where primary and secondary tillage operations covered by direct combination implement. The field capacity was observed to be 0.78 ha/h. In case of cost of operation in the treatment first *i.e.* (MB plough + combination tillage implement) was Rs. 1200/ha. In case of second treatment for direct use combination implement the cost of operations was Rs. 510/ha in medium black soil.

Key words : Combination tillage implement, Seedbed, Pulverization in terms MWD, Field capacity, Fuel consumption

Over the next few decades agriculture in our country will be called upon to maintain an increasing level of output in the face of constraints like land, fuel and time.

Mechanization plays an important role in agriculture for increased production, productivity and profitability through timeliness in operation.

Preparation of seedbed includes operation such as ploughing, disking, cultivating, harrowing etc. These operations give better-pulverized soil leading to friable and properly aerated soil ideal for better germination of seed. Many seedbed preparation implements such M.B. plough, disc plough for primary tillage and harrows and cultivators are used for secondary tillage tools.

As farmers turn increasingly to multiple cropping systems to boost their incomes and meet increased demand for their produce, the time available for seedbed preparation has decreased considerably.

Combination implements:

The concept that a combination of tillage tool in sequence can substantially reduce the total time and energy for achieving a desired soil condition is fairly well established. However most of such equipment which can prepare a seedbed in a single pass of the tractor has been developed for tractors in the range of 70 to 90 hp. The initial cost of this equipment is also high. The development of combination implements which reduce overall power requirements to enable tractors in the range of 45 to 55 hp to achieve single pass seedbed preparation to suit the economics of Indian farming has not been attempted.

The active elements of combination implements can produce negative draft, which requires further energy inputs to control tractor steering and the three-point hitch and is also harmful to the drive train of tractor (Wismer et al., 1968). A few researchers have also conducted studies on the performance of semi-mounted and trailed type passive–passive combination tillage implements (Bukhari *et al.*, 1981; Yusuf and Asota, 1998). It was observed that the use of combination tillage implements in land preparation outperformed the conventional land preparing practices in fuel consumption, time requirement and cost of operation and did not produce negative draft. A few studies on development and performance evaluation of 2WD tractor drawn active–passive combination tillage implements have also been conducted in India (Kumar and Manian, 1986, Manian *et al.*, 1999; Kailappan *et al.*, 2001a and Kailappan *et al.*, 2001b) and confirmed the same results as obtained in western countries.

METHODOLOGY

A field experiment was conducted to study the performance of tractor operated combination tillage implement. The field tests were carried out in black medium soil at the farm of the FMP Department at Dr.Annasaheb Shinde College of Agril. Engineering, M.P.K.V, Rahuri as per RNAM Test code. The tests were carried out in two phases in manner so that all observations could be carried out in a two day for each set of trials. In the first phase was used MB plough for primary tillage operation and combination implement for secondary tillage operation, second phase used single pass combination implement use for primary and secondary tillage operation.

Parameters:

Two treatments were marked in the field. The size for each treatment 25 meter x 10 meter marked out with ranging rods. The tractor and all the implements were brought to the field. The tractor PTO speed was checked at 540 rpm with the digital Tachometer, and throttle setting on the dash board. The trials were carried out outside the mark treatment for depth and forward speed decided for the test. All final settings and adjustments were done during these trials. The test tractor with implement was then positioned at one end of the 15 meter side of the treatment.

Draft measurment:

The X tractor along with the Hydraulic pull type dynamometer was positioned in front of the test tractor and the rear of the dynamometer was connected to the Y tractor front axle with wire rope and clamps. The chart recorder of the dynamometer was tied firmly to the Mahindra fender.

The trials were now carried out at the three depths with the X tractor towing the test system with the Y in neutral. This procedure carried for MB plough and combination implement. For No load reading the implement was lifted out of ground contact, and draft recorded. For on load readings the Y tractor was kept in neutral with the implement in operating position. The tractor PTO shaft was engaged and rotary tiller allowed to rotate. The test tractor was then towed by the X at the forward speed established during the initial trials. The width and depth of cut were also noted after each run.

Draft = on load draft – No load draft

Wheel slip and operating speed:

Outside the long boundary of the test treatment, two poles 20 m apart (A, B) was placed approximately in the middle of the test run. On the opposite side also two poles were placed in a similar position, 20 m apart (C, D) so that all four poles form corners of a rectangle. The speed was calculated from the time required for the machine to travel the distance (20 m) between the assumed line connecting two poles on opposite sides AC and BD.

Tractor drive wheels slip in all – field operations. A simple method of determining the amount of wheel slip was to marked on the tractor drive wheel with colored tapes and the distance the tractor moves forward was measured, say 10 revolutions under no load (A) and on the same surface and with the same number of revolutions with load (B). Pins of adequate length was used for marking on the field.

$$\text{Percentage of wheel slip} = \frac{(A-B)}{A} \times 100$$

Soil pulverization:

Clod size as a measure of soil pulverization was measured by the Mean Weight Diameter. The sieve set was used. Sieve size selected like 4.75 mm, 2.0 mm, 1.00 mm, 0.5mm, 0.3mm, 0.125mm, 0.063mm, Pan. A 25x 25 cm area was marked out on the surface of tilled soil. The weight of the individual sieves along with the pan was first measured on the individual sieves along with the pan was first measured on the Salter balance. The largest clod was measured along its major and minor dimensions and placed on the most top sieves. The soil up to the tilling depth in the marked out 25x25 cm area was placed on the top most sieve. The sieve set was thoroughly shaken for 15 min.

The weight of the individual sieves along with the soil retained was then taken and noted. Then calculating a) percentage of soil retained, b) cumulative percentage soil retained c) percentage of finer particles

Moisture content:

Soil samples were taken from the field from the surface to the tilling depth, in moisture boxes which provided sealing against moisture loss. The samples were taken to the laboratory and weighed on the electronic balance. The samples were then placed in the oven which was maintained at 105^0 c for 24 hours. Weights of the samples were taken on removal from the oven. The weight of the empty boxes was also taken and noted against their serial numbers.

$$\text{Moisture content} = \frac{\text{(Weight of soil sample – weight of oven dry soil sample)}}{\text{(weight of oven dry soil sample)}} \times 100$$

Soil inversion:

Soil inversion was taken as ratio of number of weeds or stubbles of last crop left on soil surface after operation to that before it. A square frame having sides 100 cm was used for counting weed or the stubbles.

$$F = \frac{(W_P - W_E)}{(W_P)} \text{ x } 100$$

where,

F= Indicator for soil inversion; ratio of weed or crop stubbles being filled-up.

W_P = No. of weed or crop stubble before operation per unit area.

W_E = No. of weed or stubble exposed on the surface after operation.

Bulk density of soil:

It is the mass after oven drying of soil of a unit volume. For measurement of bulk density of soil cylindrical core samples of soil were taken from at least three locations selected randomly in the test treatment. The diameter and length of cylindrical soil sample were measured.

$$\text{Bulk density} = \frac{\text{Mass}}{\text{Volume}}$$

Fig. 1 : Tractor Mounted combination Tillage implement

RESULTS AND DISCUSSION

The prototype (combination implement) was tried out in the field to observe its performance. The effect of parameters like depth, forward speed, fuel consumption and velocity ratio for primary and secondary operation for implement on performance were observed during the test.

Two treatments were marked for testing all the details below:

Treatment A- Primary tillage operation operation used two bottom reversible Mould board plough+ secondary tillage operation used combination implement (1 opeartion).

Treatment B- Primary and secondary tillage operation used directly combination implement (1operation).

Field performance of prototype:

The implement was operated in medium black soil. for a total of 30 hrs. A black medium soil was hard so in Maharashtra generally primary tillage operation was done by Mould board plough treatment, A- Primary tillage operation used two bottom reversible Mould board plough + Secondary tillage operation used combination implement and treatment B- Primary and secondary tillage operation used directly combination implement. The average forward speed was 3.73 km/h for Treatment A and 3.2 km/h for Treatment B and depth of operation was maintained at 18 cm and 13 cm, respectively. The average width of cut was 1.62m and the turning time at each end was on an average 15 seconds. The field efficiency is 84 per cent.

The fuel consumption ranged between (treatment A) 9.17 lit/h and (treatment B) 14.47 lit/h. In terms of fuel consumption per unit area for (treatment A) 35.22 lit/ha and (treatment B) 15 lit/ha. The draft requirements for the prototype combination implement were between 310 kgf to 370 kgf in medium black soil.

The implement was tested in fields in which wheat had been harvested. The moisture content was between 22.21 to 22.77 %(dry basis) in medium black soil. The implement was able to give a satisfactory single pass performance with regard to the quality of soil pulverization in medium black soil. The soil pulverization was compared with particle size (mm) and % finer. treatment A for % finer was 90.48 and particle size 4.79 mm. In case second treatment B for % finer was 89.05 and particle size 4.5 mm

Good clearance between the PTO propeller shaft and the implement frame caused less turning time as the operator has not stop the PTO shaft before lifting, and after turn dropping the implement.

The implement penetrated into the soil easily, the gauge wheels effectively controlled the depth of operation of the disc gangs was maintained by hydraulic assisted position control of the lower links of the tractor. The force transfer linkage was found to operate effectively as the disc gangs were observed at their lowest position in medium black soil. All tests were carried out at 540 PTO rpm. During the initial field trials scrapper modify to the disc harrow for removing material from disc.

Effect on performance of implement soil parameters:

The effect of forward speed, depth of operation, and velocity ratio on draft and soil pulverization (% finer particle) was studied.

Effects of depth and forward speed on draft:

Fig. 2 indicates the variation of draft with respect to the depth of operation and the forward speed for medium black soil. It is seen that all three forward speeds the draft decreased with an increases of depth from 8 to15 cm. This because the soil was more hard and has greater shear strength. Under these conditions, greater forward thrust developed by the rotary tiller blades as they worked deeper in the soil was high enough to cause an overall reduction in the draft and mask the effects of increased rolling resistance of the disc harrow and soil resistance at the planker. In Fig. 2 the speed of first low gear was 2.2 km/h and draft decreased with an increase of depth and also same in second low gear but speed was 3.6 km/ h. and in third low gear speed was 4.3 km/h and draft decreased with increase depth up to 10 cm after draft also decreased with decreasing depth of soil.

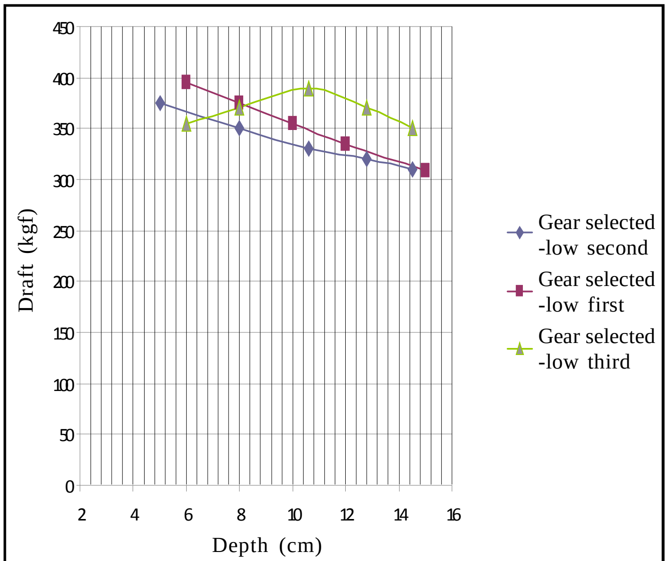

Fig. 2 : Draft verses depth of opeartion medium black soil

Draft of different implements:

Fig. 3 indicates the two different implements on the draft for medium black soil. First one is the combination implement (disc harrow + rotary tiller + planker). It is seen that in cases a combination implement effect a reduction in the draft because combination of the (disc harrow + rotary tiller + planker) rotary tiller produced,

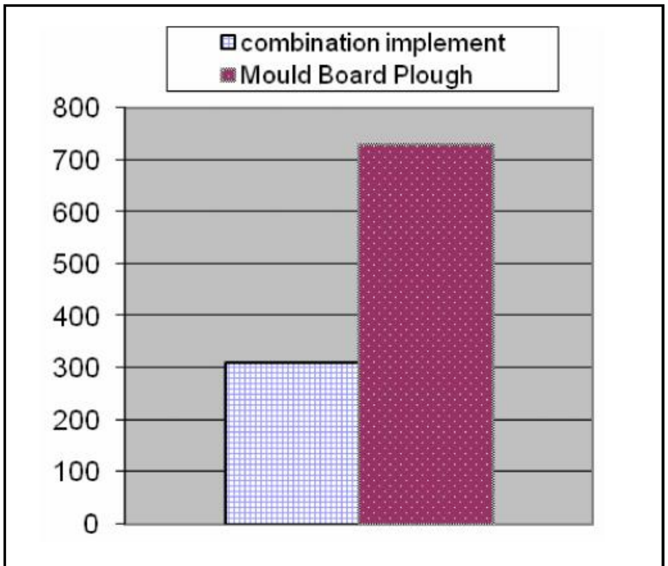

Fig. 3 : Draft of individual implement

forward thrust. However, due to greater soil strength of medium black soil, so reduction in draft. In case of MB plough the draft was 730 kgf it's higher than combination implement.

Effect of velocity ratio and depth on pulverization:

Fig. 4 gives the variation of MWD with the velocity ratio and depth for medium black soil. As the soil was harder, a drastic increase in MWD was observed as the velocity ratio decreased below 6.03 due to longer soil slices. A decrease in MWD with depth was due to deeper work of the rotary tiller causing a greater part of the soil to be pulverized and also because at deeper levels the planker came closer to the soil surface thereby pulverizing the soil not only by impact but also by compressing it.

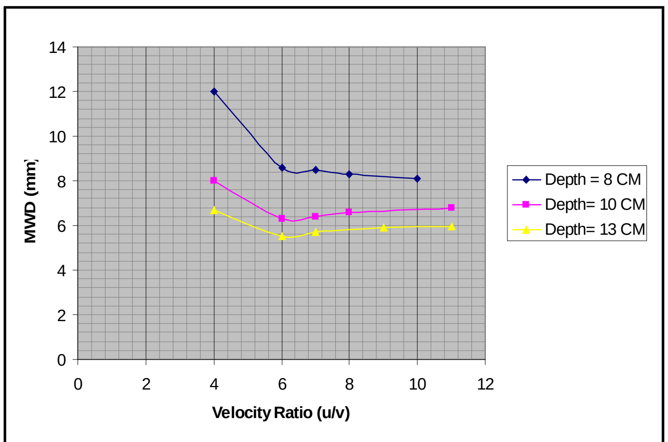

Fig. 4 : Mean weight diameter V_s velocity ratio

Sieve analysis for implements:

Effect of depth of operation on MWD at various forward speeds:

Fig. 5 indicates the effect of forward speed on MWD in medium black soil. It is seen that the MWD first decreased and then increased with greater speed, this was because the velocity ratio decreased with higher forward speed to an optimum value and then further increase caused large soil slices and greater MWD.

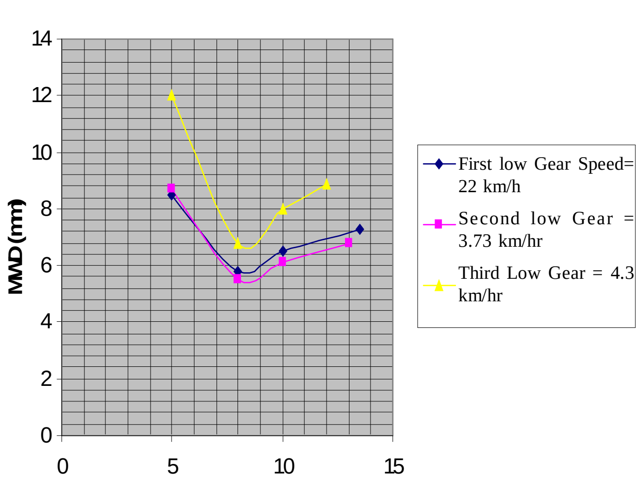

Fig. 5 : Mean weight diameter V_s depth

Effect of sieve analysis after combination of mould board plough and combination implement-

All the procedures and sieve set were the same for sieve analysis. The most of the soil was retained on 1 mm sieve size its 31.07 % soil retained. The maximum soil retained on range of 1mm to 0.3mm. There it was observed that 9.52 % soil was retained on 4.75 mm sieve size and also 19.49 % soil was retained on 0.5 mm. The % soil retained on sieve size from 1mm to 0.125 increased because the good combination implements (disc harrow+rotary tiller+Planker) first the soil was cut by disc harrow and second operation by rotary tiller to pulverization of soil and then last to level the soil by planker. The % finer particle of soil was 90.48 and particle size was 4.78 mm. It indicates the good pulverization of soil with in single pass operation after ploughing by Mould board plough.

Effect of sieve analysis after primary and secondary operation was done by combination implement:

All the procedures and sieve set were the same for

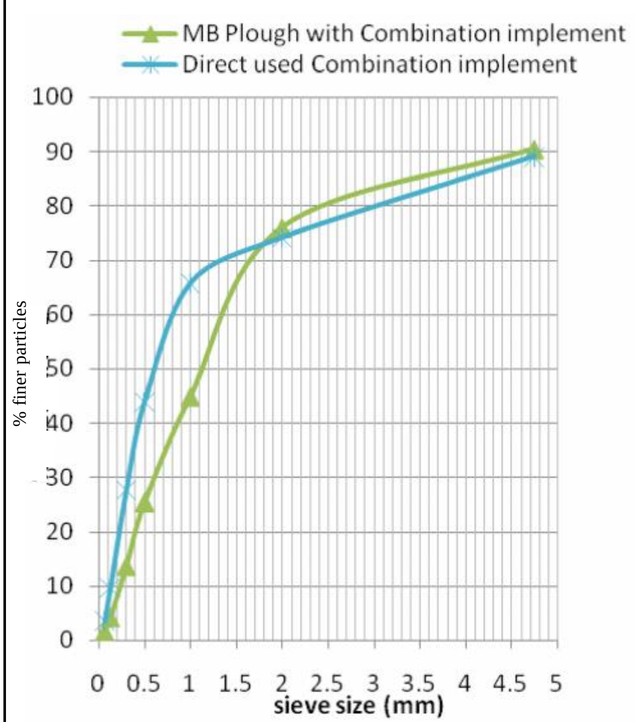

Fig. 6 : Sieve analysis for different tillage operations

sieve analysis. The most of the soil was retained on 0.5 mm sieve size its 21.82 % soil retained. At sieve size 4.75 mm the % soil retained only 10.95 but in case of 0.3mm and 0.125 the % soil retained were 16.28 and 17.99, respectively. The % finer particle of soil was 89.05

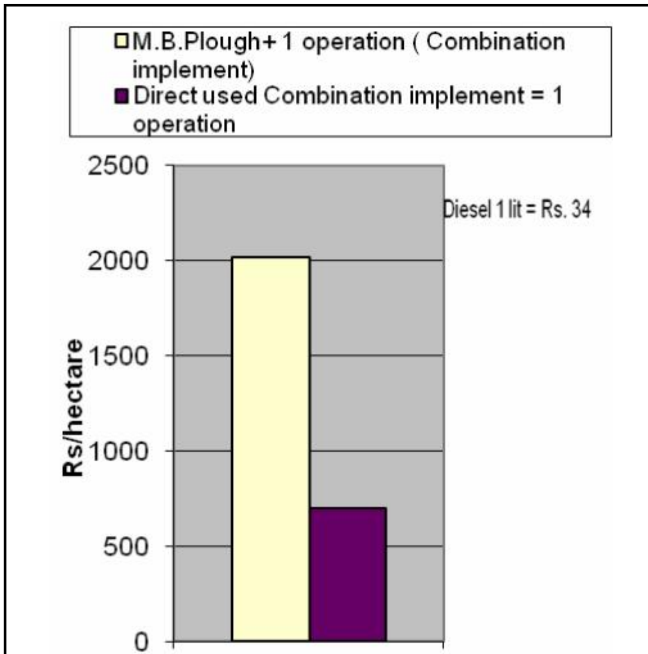

Fig. 7 : Cost of operation per hectare

Table 1 : Comparative field performances of combination tillage implement

Five treatments	M.B. Plough+ combination implement (1 operation)	Combination implement (1 operation)
Soil type	Medium black soil	Medium black soil
Moisture (%)	21.12	22.21
Bulk density (g/cc)	1.46	1.48
Field capacity (ha/h)	0.25	0.78
Fuel consumption (lit/ha)	11.9	24.52
Depth of cut (cm)	18	13
Soil inversion (%)	98	88.75
Time required (h/ha)	3.88	1.28

Table 2 : Different parameters of performance

Implements	M.B. Plough	Combination implement	M.B.Plough + combination implement
Adjustment time (min)	7	8	-
Operating speed (mm/h)	3.1	3.73	3.2
Wheel slippage (%)	40	4.5	-

and particle size was 4.6 mm.

Conclusion:

– The combination of disc harrow, rotary tiller and plank gave an effective single pass capacity in medium black soil. The average clod size achieved 4.75 mm to 5mm, for good seed soil contact.

– The effective functioning of weight transfer linkage and overall reduction of power requirement of the implement, by more efficient use of available energy was clearly demonstrated by the prototype.

– In medium black soil, an increase in depth of operation resulted in a reduction in overall draft force due to increased forward thrust generated by the rotary tiller blades in hard soil. Functionally, the implement operated satisfactorily.

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