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Research Paper :

Comparative performance of single pass implement with a conventional machine system

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ABSTRACT

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. The combination of rotary tiller and disc harrow was used for seed bed preparation in short time. Comparison of implement performance was done with conventional implements like disc harrow, rotary tiller and MB plough. The prototype clearly indicated a potential for improvement performance in terms of different parameters like time, fuel consumption, field capacity and cost operation. Effect of depth of cut, velocity ratio, and forward speed on mean weight diameter of soil aggregates and draft of the implement was 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 5 mm. The field capacities of the implements for first three same treatments were MB plough + Disc harrow (0.16ha/h), MB plough + rotary tiller (0.19ha/h) and MB plough + Prototype (combination implement 0.25ha/h). The combination tillage implement has the advantage of 0.09 ha/h over the disc harrow and 0.06 ha/h over rotary tiller. In case of other two remaining treatments where primary and secondary tillage operations were covered by direct rotary tiller and direct combination implement. The field capacity was observed 0.34 ha/h for rotary tiller and 0.78 ha/h for combination implement. Thus, there was also an advantage far combination implement of 0.44 ha/h. As for as cost of operation is concerned, the comparison between (MB plough + Disc Harrow), (MB plough + rotary tiller) and (MB plough + Prototype) the prototype implement saved the Rs. 434.52 /ha between disc harrow and prototype and Rs. 298.52 /ha compared to rotary tiller. In case of rotary tiller and combination implement, the combination implement saved Rs. 476/ha compared to rotary tiller in medium black soil.

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Key words : Single pass combination implement, MB plough, Seedbed, Field capacity, Fuel consumption etc.

Mechanization plays an important role in agriculture for increased production, productivity and profitability through timeliness in operation. During fourth and fifth five year plans, more sophisticated implements were introduced. The major thrust of agricultural mechanization is to reduce drudgery in the field operation and provide better quality of life to rural people. Many changes in tillage practices have been found during the last 15 years. Conservation tillage practices are replacing moldboard plowing and other major seedbed preparation practices on a large portion of the total area under cropping in the developed countries (Harrigan and Rotz, 1995).

Preparation of seedbed includes operations such as ploughing, disking, cultivating and harrowing etc good crop establishment depends on the quality of seeds sown as well as good seedbed and weather conditions. The time span between harvesting and sowing is less although good seeding with fertilizer application is developed. In view of minimizing the total cost of operation on the field, the reduction in the cost of tillage operations without impairing the soil tilth is a must. Therefore, it is the need of the farmers to perform all the seedbed preparation operations by a single machine saving time, money and mechanized tillage. The use of combination tillage implements for land preparation is one such practice that combines multiple tillage operations in a single pass, and thus reduces the number of field trips as compared to conventional tillage practices resulting in a reduction of labour and fuel cost and saving in time.

Most of the studies on draft, energy and tillage performance of different combination tillage implements have been carried out in America and European countries. Several combination tillage implements comprising of rotary and passive elements were developed and found to be more energy efficient than a similar single passive tillage implement when tested in actual field conditions (Chamen *et al.*, 1979, Wilkes and Addai, 1988, Shinners *et al.*, 1990, Shinners *et al.*, 1993, Sigitov, 1992, Weise, 1993 and Upadhyaya *et al.*, 2001).

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 to establish the basic performance parameters of the implement. This would include the contribution of the individual soil working elements towards the overall draft and pulverization of the implement. The performance parameters to be establishment would be:

- Draft (kg)
- Pulverization in terms MWD
- Field capacity (ha/h)
- Fuel consumption (l/ha)
- Cost of operation (Rs/ha).

METHODOLOGY

To compare the performance of the prototype implement with a commonly used conventional machine system under similar soil and field conditions, four machine systems were tested. These were the prototype test system and other three implements using today for seedbed preparation.

M.B. plough

Disc harrow

Rotary tiller

Single pass combination implement

- Mould board plough- Two bottom reversible MB plough.
- Disc harrow- Offset disc harrow.
- Rotary tiller- L- type blades.

Single pass combination implement- (Disc harrow + Rotary tiller)

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 five phases in such a manner so that all the observations could be carried out in two days for each set of trials. In the first phase, single pass combination implement was used for primary and secondary tillage operation. In second phase used the rotary tiller for primary and secondary tillage operation, Third phase used MB plough for primary tillage operation and disc harrow used for secondary tillage operation, Forth phase used MB plough used for primary tillage operation and rotary tiller used for secondary tillage operation, Fifth

phase used MB plough for primary tillage operation and combination implement for secondary tillage operation.

Parameters:

Five treatments were marked in the field. The size for each treatment was 25 m x 10 m marked out with ranging rods. 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 speeds were 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 m side of the treatment.

RESULTS AND DISCUSSION

The prototype was tested in the field to observe its performance. Also other three existing implements (MB plough, disc harrow and rotary tiller) were tested in the field to observe its performance. The effect of parameters like depth, forward speed, fuel consumption and velocity ratio for primary and secondary operations for each implement were observed during the test. At the end, the economics of the prototype implement was compared with other three implements with regard to seedbed preparation.

Five treatments were marked for testing as detailed below:

– Treatment A- Primary tillage operation used two bottom reversible mould board plough + Secondary tillage operation used discs harrow (3 operations).

– Treatment B- Primary tillage operation used two bottom reversible mould board plough + Secondary tillage operation used combination implement (1 operation).

–Treatment C- Primary tillage operation used two bottom reversible mould board plough + Secondary tillage operation used rotary tiller (2 operations).

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

– Treatment E- Primary and secondary tillage operation used directly rotary tiller (2 operations).

Field performance of the prototype:

The implement was operated in medium black soil, for a total of 30 hrs. A medium black soil is hard so in Maharashtra, generally primary tillage operation was done by Mould board plough and secondary tillage operation by disc harrow and rotary tiller. Hence two readings for prototype (combination implement) were considered treatment B- Primary tillage operation used two bottom reversible Mould board plough + Secondary tillage operation used combination implement and treatment D- Primary and secondary tillage operation used directly combination implement. The field data observed have been shown in Table 1. The average forward speed was 3.73 Km/h for treatment B and 3.2 Km/h for treatment D and the 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 was observed as 84 %.

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

The implement was tested in the fields where wheat had been harvested. The moisture content was in between 22.21 to 22.77 %(dry basis) in medium black soil. The

Table 1 comparatives performance

Sr. No.	Five treatments	M.B.Plough+ Disc harrow (3 operations) I	M.B.Plough+ combination implement (1 operation) II	M.B.Plough+ Rotary tiller (2 operations) III	Combination implement (1 operations) IV	Rotary tiller (2 operations) V
1.	Soil type	Medium black soil	Medium black soil	Medium black soil	Medium black soil	Medium black soil
2.	Moisture (%)	22.77	21.12	22.12	22.21	22.11
3.	Bulk density (gm/cc)	1.48	1.46	1.47	1.48	1.47
4.	Field capacity (ha/h)	0.16	0.25	0.19	0.78	0.34
5.	Fuel consumption (l/ha)	39.48	11.9	22.88	24.52	36.16
6.	Depth of cut (cm)	15	18	16	13	8
7.	Soil inversion (%)	86.37	98	95	88.75	75
8.	Time required (h/ha)	6.16	3.88	5.01	1.28	2.9

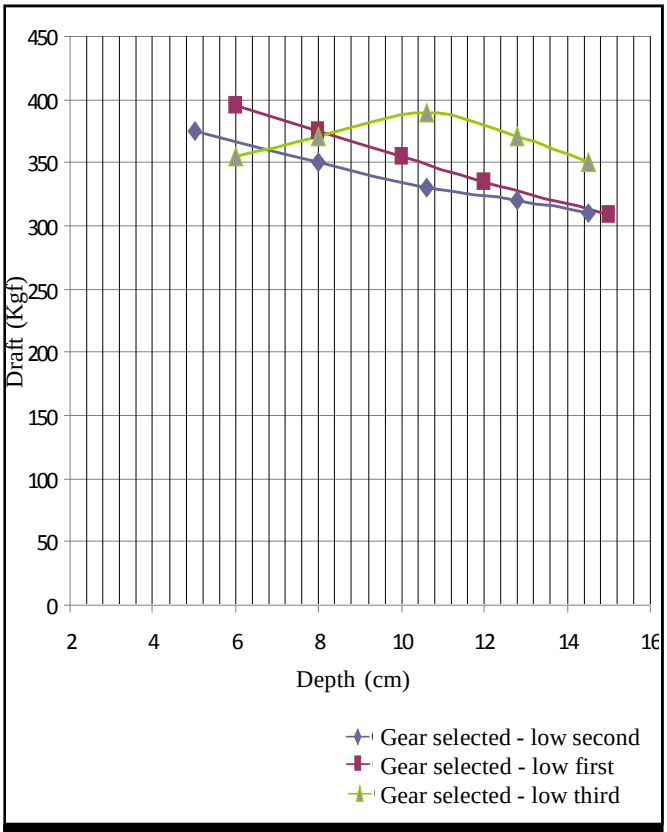

Fig. 1 : Draft versus depth of operation medium black soil

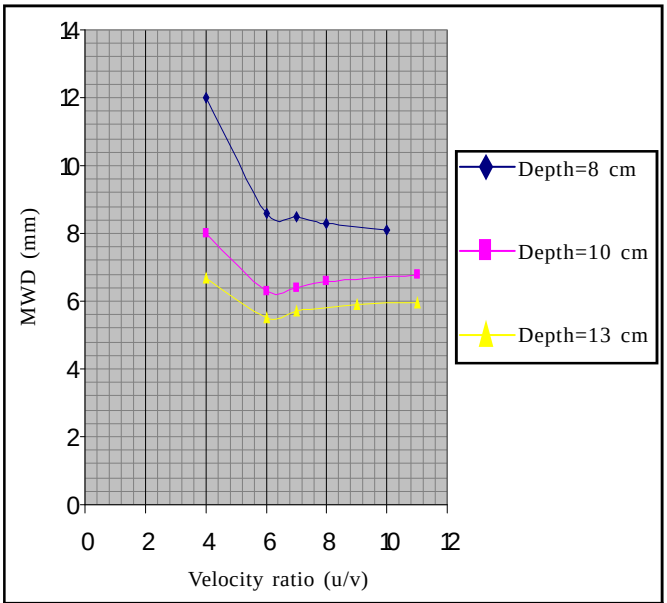

Fig. 2 : Mean weight diameter vs velocity ratio

implement was able to give a satisfactory single pass was performance with regard to the quality of soil pulverization in medium black soil. The soil pulverization was compared with % finer soil particle. treatment D for % finer was 90.48 and treatment E for % finer was 89.05.

Draft of different implements:

Fig. 3 indicates the three different implements on the draft for medium black soil. First one is the combination implement *i.e.* (disc harrow + rotary tiller + planker). It is seen that a combination implement reduced the draft because of combination of the (disc harrow + rotary tiller + planker) rotary tiller produce forward thrust. However due to greater soil strength of medium black soil, reduced the draft. But in disc harrow the draft was 370 kgf which is higher than combination implement. As compared to disc harrow and combination implement the draft Difference was 60 kgf was more required to disc harrow. In case of MB plough the draft was 730 kgf which was higher than disc harrow and combination implement.

Effect of velocity ratio and depth on pulverization:

Fig. 2 shows 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 decreases 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.

Comparative performance:

The comparison was carried out between five treatments with different parameters like fuel consumption, depth of cut, wheel slippage, and soil inversion. At Rahuri region there was medium black soil which was hard to plough. Hence, generally ploughing

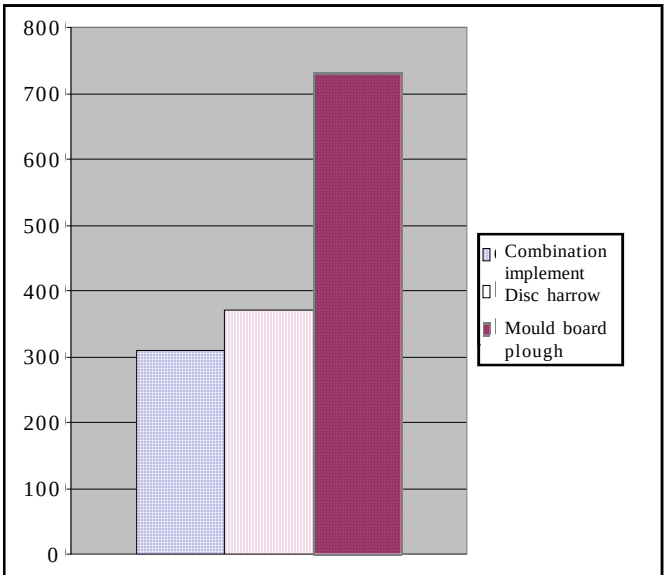

Fig. 3 : Draft of different implements

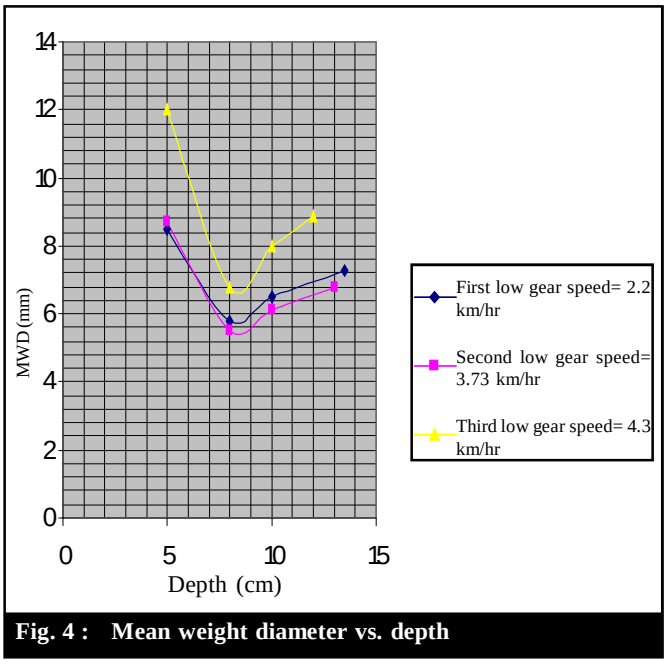

Fig. 4 : Mean weight diameter vs. depth

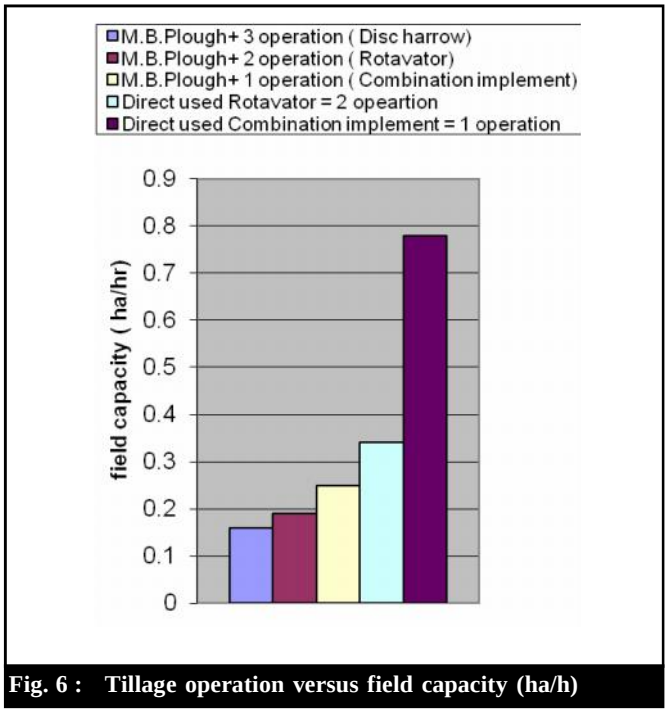

Fig. 6 : Tillage operation versus field capacity (ha/h)

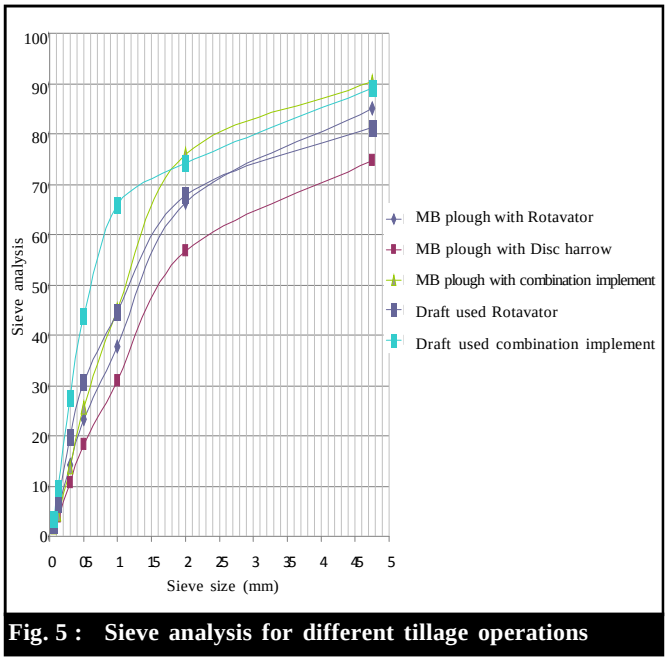

Fig. 5 : Sieve analysis for different tillage operations

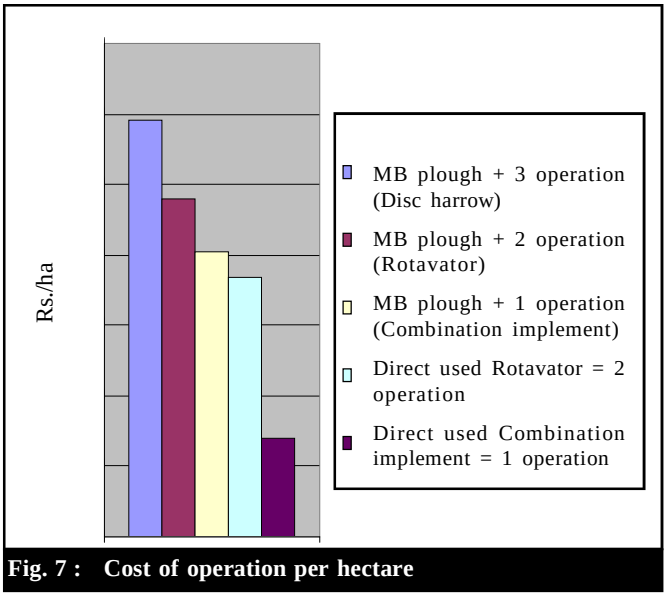

Fig. 7 : Cost of operation per hectare

done by MB plough.

And after ploughing the rotary tiller or disc harrow was used for harrowing and leveling.

Field performance :

Table 1 indicate the comparative field data for the prototype and the others implements. In medium black soil the field capacity was compared with first three same treatments where MB plough + disc harrow, MB plough + rotary tiller and MB plough + Prototype (combination implement) were 0.16 ha/h, 0.19 ha/h and 0.25 ha/h, respectively. The combination tillage implement had of an advantage than other two implements 0.09 ha/h advantage than Disc harrow and comparison between Rotary tiller and prototype (combination implement) the advantage of 0.06 ha/h than rotary tiller. In case of other two remaining treatments where primary and secondary tillage operation covered by direct rotary tiller and direct combination implement. The field capacity was observed 0.34 ha/h for rotary tiller and 0.78 ha/h for combination implement, respectively. here also an advantage for combination implement was 0.44 ha/h. In terms of the

time taken per unit area, the MB plough + Disc harrow required 6.16 hrs to cover a hectare , the MB plough + rotary tiller required 5.01 hrs and MB plough + Prototype (combination implement) required 3.88 hrs to cover a hectare. Hence, the prototype saved 1.13 hrs than rotary tiller and 2.28 hrs than disc harrow for each hectare covered. In case of other two remaining Treatments where primary and secondary tillage operations covered by direct rotary tiller and direct combination implement. Here direct used rotary tiller required 2.9 hrs and direct used prototype requires 1.28 hrs which gives the advantage 1.62 hrs per hectare.

In terms of fuel consumption, depth of cut and soil inversion first three treatments *i.e.* MB plough + Disc harrow, MB plough + rotary tiller and MB plough + Prototype (combination implement) required 48 l/ha, 44 l/ha and 35.22 l/ha, respectively. Also depths were 15 cm, 16 cm and 18 cm, respectively. Soil inversions were 86.37 %, 95 % and 98 %. Hence comparison for those three treatments the MB plough + Prototype (combination implement) was better than other two treatments. In case of other two remaining treatments where primary and secondary tillage operation covered by direct rotary tiller and direct combination implement, the fuel consumption, depth and soil inversion for direct used rotary tiller were 29 l/ha, 8cm and 75 % and compared with direct used prototype (combination implement) were 15 l/ha, 14.5 cm and 88.75 % as such prototype implement was better than the rotary tiller.

In Fig. 3 shows the cost of operation in comparison between (MB plough + disc Harrow), (MB plough + rotary tiller) and (MB plough + Prototype) the prototype implement saved the 434.52 Rs/ha between disc harrow and prototype and 298.52 Rs/ha than rotary tiller. Also direct used rotary tiller and combination implement the combination implement saved 476 Rs/ha than rotary tiller.

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 5 mm, for good seed soil contact.

In case of fuel consumed M.B. plough + Disc harrow (3 operation), M.B. plough + Rotary tiller(2 operation) and M.B. plough + Prototype (combination implement) required 48 lit/ha, 44 lit/ha, 35 lit/ha. In case of other two remaining treatments where primary and secondary tillage operations covered by direct rotary tiller and direct combination implement were required 29 lit/ha and 15 lit/ha. The first three treatments, comparative implement saved 13 lit/ha over M.B.plough + Disc harrow (3 operation) and 9 lit /ha over M.B. plough + Rotary tiller (2 operation) and remaining treatments saved 14 lit/ha over Rotavator (2 opertions).

The time required for treatments, like M.B. plough + Disc harrow (3 operation) was 6.16 h/ha, M.B. plough + Rotary tiller(2 operations) 5.01 h/ha and M.B.Plough + Prototype (combination implement) 3.88 h/ha. In case of other remaining treatments where primary and secondary tillage operations covered by direct rotary tiller (2 operations) was 2.9 h /ha and combination implement was 1.28 h/ha.

As far as cost of operation is concerned the comparison between (M.B. plough + Disc harrow), (M.B. plough + Rotary tiller) and (M.B.Plough + Prototype), the prototype implement saved the Rs. 434.52/ha between disc harrow and prototype and Rs. 298.52 /ha compare to rotary tiller. For direct use rotary tiller and combination implement, the combination implement saved Rs. 476 / ha compared to rotary tiller in medium black soil.

The comparative field performance clearly indicates that the prototypes machine system offers an advantage over a conventional system in terms of field capacity, time of operation, fuel consumed, energy required and cost of operation.

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