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Combined Tillage Tools: A Review

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ABSTRACT

The costliness of energy, forces the farmers to choose another cost efficient tillage methods. The cost as well as time of operation plays a critical role in choosing another tools for tillage. Combined tillage is the way in which two or more different tillage implements operates at the same time in order to manipulate the soil and reduce the number and time of field operations. It was envisaged that such an implement would affect considerable saving of time, fuel and energy. This would also reduce the cost of operation. There was an efficient and potential reduction in the soil compaction, labour and fuel cost, saving in time and reduction of multiple tillage operation in single pass. The conventional tillage practices are becoming increasingly expensive in terms of time, fuel and equipment costs and are also causing more soil damage and compaction due to higher number of passes required for the conventional implements during seedbed preparation. As the land sizes in India are small, the scope for increasing the speed or width of existing implements is less feasible. Hence, reducing the number of passes by combining two or more field operations with the use of combination tillage implements may provide better solution. In a single run the combined tillage tool performs primary as well as secondary tillage operations.

Keywords: "Combination tillage", "MMD", "Performance", "Draft", "Soil manipulation".

INTRODUCTION

Combined tillage is the way in which two or more different tillage implements operates at the same time in order to manipulate the soil and reduce the number and time of field operations[1]**.** Combined machines are more complex than passive tilling implements or rotary machines, but these machines can unite the advantages of active and passive machines and they can create lower resistance than the passive machines and, at the same time, they can ensure lower specific work than the active, rotary machines[2]. In a single run the combined tillage implements performs more than one tillage operations, which result in the reduction of number of trips in the field in comparison to preadapted tillage practices which results in saving of time and reduction in fuel and labor cost. Combined tillage is the operation which simultaneously using two or more dissimilar tillage tools or implements at the same time to reduce or control the number of field operations[3]. By using combined tillage implement the existing tractor power can be better utilized in the field. Due to simultaneous operations of primary and secon-dary tillage. The energy required for the preparation of the seed bed will be reduced by using combination tillage tool[4]. Tillage equipment should be capable to prepare a suitable land with minimum expense[5]. Tillage is the physical manipulation of soil with tools and implements to bring the soil in

a good physical condition in order to prepare good seed bed for seed germination and development for our consumption. Tillage also aerate the soil after breaking it and also available the soil nutrients for the growth of crops[6]. These active tools are used to till more volume of soil than required for various field crop unit and so requires efficient power for unit width. Active tillage machines contributes power in return to the drawbar of tractor drawbar after pushing it. Due to repeated use of primary, secondary and active tillage implements soil layers become compacted. An average compaction related reduction to be 15 percent of potential yields[7]. Hence idea is formulated to develop combination tillage tool which is developed by combining two or more tillage operations in single pass to save time, money, fuel in land preparation. The combination selection is based on the completion of task in less time with minimum energy and cost[8]. Combined machines are complex than passive tilling implements or rotary machines but these machines can unite the advantages of active and passive machine and they can create lower resistance than the passive machines and at the same time they can ensure lower specific work[9].

Design and development

Various combined tillage tools or implements consists of passive as well as active elements were developed and it was found that it is more efficient than a tool which uses only combination of passive tillage implements when it was tested in the real field conditions and also noticed that the primary tillage tool which is driven by PTO is 50 per cent energy efficient than a mold board which is operating at a same depth of operation[10]. A combination tillage implement was designed and developed comprising cultivator (9 × 0.35 m) and a single-acting disk harrow (8 × 0.6 m) in sequence (C-DH) with a total cutting width of 2.1m for 31 kW power range of tractor. While evaluating the performance of this implement in sandy clay loam soil with a 31 kW 2WD found to be higher tillage performance index (TPI) for combination tillage implement as compared to that of individual tillage implements indicating better efficiency of the tractor-implement combinations[11]. A powered rotary chisel was designed and tested using the single rotor and compared the requirement of power when using a rigid chisel and which give the result as 15 per cent power efficient. 49 per cent power transmission efficiency was assumed for the operations involving drawbar and noticed that the 45 per cent less engine power is required by combination implements[12]. Combination tillage tool reduced bigger size clods in the soil and improves aeration and moisture holding capacity and medium uniformity of soil and finer pulverization modulus obtained by using combination tillage. And also added that maximum loosening of the soil was obtained by the combination tool as reflected by the low soil bulk density range of 1.15±0.05 g/cm^3 as against the normal 1.4±0.20 g/cm^3 encountered in the conventional implements operated field. Savings of 44 to 55 per cent in cost and 50 to 55 per cent in time are possible by the use of combination tillage tool for seed bed preparation[13]. A combined implement was designed with a main mounted frame and 2 gangs of tools arranged in an oblique position with regard to the travel direction. The first gang has 5 shanks with lateral flaps and the second one has 5 hydraulically driven bladed discs with the same rotation as the tractor wheels. The combined implement performance was determined: with a 103 kW 4 WD tractor, the best results were achieved at a travel speed of about 3 km/h and disc rotary speed of about 80 rev/min [14]. A combine machine was developed consisting of disk harrow and Cambridge roller in order to uniform and sufficient breaking of clods as well as gain the uniform soil bed in a single run and least time. The results showed that some physical properties of soil was also improved by the combined tillage tool which was important in breaking of clods, uniformity of soil surface and also noticed that there was no noticeable difference noted between combined machines and operation of disk harrow two times in the various parameters[15]. The draft affecting the tool was reduced by (18%) at a plowing depth of 12 cm and coulter depth equal to 83.33% of the plowing depth while the coulter was positioned 10 cm in front of the tool. Offset distance of 12 cm between coulters and plowing tool on both sides of the tool resulted in a 10.61% decrease in the draft affecting the tool. The study also concluded that theoretically if the weight of every added coulter was less than 4.78 kg, overall draft of the combined machine may be decreased [16]. A combined tillage implement was developed in Bulgaria (a plough body having a spiral-screw soil-fragmenter), the effect of several variable factors on the work of the implement was investigated. With the aid of these it is possible to specify a working regime

which will ensure the desired quality of tillage[17]. A tool was developed, built on a standard plough body, that crumbles the soil using power-driven helical crusher was developed, and is regarded as a progressive and promising solution. Conditions were derived for the breaking of the soil, including prevailing tensile stresses, by the crusher. The forces were determined depending on the geometrical and kinematic parameters of the tool and on the soil strength. The moment of resistance and the power required to drive the crusher were defined[18]. An implement was developed and tested 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 for using good seed bed preparation in short time. 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. 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[19]. A combo plow was developed with combination of disk plow and rotary blades which is used for soil bed preparation for crop growth. Three types of blades were used which are straight (S), curved (c) and L-shaped) and having three different speeds of rotary blades of 130,147 and 165 rpm. It showed that there was a significant decrement in the mean weight diameter (wet basis and dry basis) and index of instability with the increment in rotational speed from 130 to 165 rpm[20]. A disk plough was designed, fabricated and tested the combo plough for seedbed preparation. Layers of soil was cut and inverted by the concave disk in order to bury the surface matters. There is no significant differences were noticed between the types of blades. There were some effects on selected parameters by the speed of rotation[21]. The dependence of the drawbar power and PTO power on the forward speed of such combined machines was investigated and linear relationships were found to describe the power demand of the implements as a function of forward speed in the speed range used for the investigations. The influence of the distance between the wing tine and the rotor was investigated and the effects on power consumption were found to be small. After reduction in the distance between the straw rotor and the wing tines there could be the reduction in straw blockage[22]. A disc plough was designed, fabricated and tested (Combo plow) for preparation of seedbed. There was the reduction in the mean weight diameter by 0.34mm after increasing the speed of rotation of rotary blades from 130 to 165 rpm. The blade which is in L- shape showed that there were increase in the percentage bulk density on dry basis by increasing the rotor speed[23]. A tractor drawn cultivator was designed and developed with suitable arrangements for mounting the spiked clod crusher behind a spring tyne cultivator. Total fuel consumed for the final seedbed preparation, the cultivator-spiked clod crusher saved 18.5%, 23.47% and 15.60% in soybean field, hand harvested paddy and combine harvested paddy fields respectively The total tractor hours saved with cultivator-clod crusher as compared to cultivator planker combination was about 1.43, 4.25 and 4.80 h/ha which amounts to a saving of about 179, 531.25 and 600 Rs/ha at assumed tractor hiring cost of Rs. 125/h for complete seedbed preparation in soybean field (loam type light soil), hand harvested paddy and combine harvested paddy fields (silty-clay-loam type heavy soil) respectively[24]. The combination tillage tool was tested in two types of soils, namely; black cotton and red soil having moisture content of 11 and 6.5 per cent moisture respectively. It showed that selective use of combi-nation tillage tool after mould board or disc ploughs in black cot-ton or red soils promoted better moisture status in the sub-soil due to the formation of smaller size clods and their arrangements in the profile. Combination tillage tool resulted in a savings of about 44 to 55 per cent in cost and 50 to 55 per cent in time when compared with different combination of other till-age implements[25]. A combined implement was developed for simultaneous loos-ening and levelling of soil surface. It is established that for achievement of the best quality of processing of soil before sowing with minimum costs of energy, the most acceptable working body con-sist of levelling and condensing soil surfaces. This has the condensing surface located under angle to the horizon 16° to 20°, and the level-ling surface is located under angle 130° to 140° to a condensing sur-face. Thus the height of a working body must be within the limits of 150-200 mm and length of a con-

densing surface at 175 to 200 mm[26]. An active-passive tillage machine was developed consisting of 16 rotor active elements and four passive elements with ability to change the depth of passive tool with respect to active tool and also rotor speed. The effect of all active tools had significant influence on draft at all levels of forward velocity. The energy, time and cost of operation for the active-passive tillage tool was less by 64.7 to 71.3, 61.7 to 69.9 and 62.2 to 70.3%, respectively, as compared to the different implement combinations to obtain almost the same quality of tilth[27]. By using combination tillage bed furrow former (CTBFF) in black clay loam and red loam soil there is significantly changes in physical properties of soil as the percentage of fine soil particles of less than 3.5 mm was great using the CTBFF; more in the combination 43.5% in black clay loam soil and 52.2% in red loam soil. Bulk density was reduced in the plot tilled with the use of CTBFF from 1.49 g/cc to 1.26 g/cc in black clay loam and from 1.54 g/cc to 1.23 g/cc in red loam soil. The cost of operation was 47.22 per cent less and the energy consumption was 39 per cent less[28]. An experimental tillage tool which is combination of active and passive tillage elements were field tested. Because negative draft showed by the forward rotating active elements, thus, there was reduction in tool's overall requirements of draught requirements. With considering total power similar 87% less draught power shown by the combination of 2 active and 2 passive and 4 passive elements. 57% less wheel slip was recorded for combination of 2 active and 2 passive tillage tool in comparison to 4 passive tillage element. On the basis of efficiency of transmission of power, the efficiency of combined machine was 34 per cent more than same passive tool[29]. Nine geometric combinations was tested as a function of depth in 2 soil types. When 2 tillage tools were placed in front and on either side of a third tool and were sufficiently close to cause interaction between the outside and center tools, total draft force for the system could be reduced. For each configuration there was a depth at which specific draft reached a minimum or plateau. When the 3 tools were spaced close together and side-by-side, an increase in draft force was likely[30].

Soil conditions

The average clod size was used as indirect index for soil tilth. The minimum average clod size was obtained for control 12.1 mm and maximum was 29.3 mm found that when pulverizing roller was combined which resulting into decrease average clod size from 29 to 14 mm[31]. The combination of tillage tool enables the task to be completed in the shortest time with minimum operating cost and energy requirement[32]**.** Among the soil physical properties of a silty loam soil crop yield is inversely proportional to soil bulk density and directly proportional to total porosity[33]. By using cultivator with spiked tooth roller the soil parameters measured in the range of 12 to14 mm, 1.21 to 1.36 g/cc and 0.568 to 1.5 kg/cm^2 in case of clod MMD, dry bulk density, and clod index of soil respectively[34]. For several types of tillage, modelling of manipulation of soil was studied. Using the required tool three soils of a single field were tested and estimated the days for conventional and minimum tillage in which they were in readiness state for 11-year period. For minimum tillage all of the soils for longer period of time were ready than for conventional tillage[35]. Two series of field experiments were conducted in the UK and the Iran. The investigation on the effect on the soil structure by each implement. Final evaluation was carried out by the preparation of seed bed for potato by these implements. Changes in physical properties of soil were calculated after and before cultivation. It was observed when the die new plow was used, there was 40 per cent improvement in output (ha/h) as compared to conventional plow[36].

Draft requirement

The combination of active and passive tillage implement could able to minimize the draft by at least 50 per cent as compared to only combination of passive tillage tools[37]. A methodology was developed to calculate the draft requirements in any operating and soil conditions of combination tillage implements. It was observed that the equation developed was able to predict the draft of both combination tillage implements within a permissible variation[38].

Performance Evaluation

To measure the performance of the tractor and the implements attached with it the system of mobile instrumentation was developed. Three implements included of disk plow, chisel plow and moldboard plow at four forward velocities (1.5, 2.3, 3 and 4 km/h) in 23 cm depth and 1500 rpm engine speed was examined and observed that draft requirement for implements in tests ranged

from 8.2 kN for the disk plow to 13 kN for the chisel plow and fuel consumption ranged from 10.72 l/ha for the chisel plow to 26.5 l/ha for the moldboard plow[39]. Draft, field speed and work performance was measured for plow-combinations of moldboard plow + plow packer, moldboard plow + subsurface packer, and moldboard plow + spring-tooth harrow and a mold-board plow separately on black soil. The results indicate that different combinations have varying effect on soil preparation and workability[40]. A tractor-cul-tivator combination was investi-gated and revealed that the speed and depth of operation have significant effects on the draft[41].

CONCLUSION

Combination tillage tools were more energy efficient as compared to same single passive tillage tool. Higher tillage performance index (TPI) for combination tillage implement is found as compared to that of individual tillage implements indicating better efficiency of the tractor-implement combinations. Savings of 44 to 55 per cent in cost and 50 to 55 per cent in time are possible by the use of combination tillage tool for seed bed preparation. The energy, time and cost of operation for the active-passive tillage tool was less by 64.7 to 71.3, 61.7 to 69.9 and 62.2 to 70.3%, respectively, as compared to the different implement combinations to obtain almost the same quality of tilth. Combination tillage implement reducing the number of passes by combining two or more field operations with the use of combination tillage implements may provide better solution.

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