

Is using combined tillage implements the solution?

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Abstract

The fuel consumption, the energy requirement, the time of prepare seedbed, the tractor wheel slippage and the number of passes in the field, all of this factors make farmers choose more efficient methods of plowing. Compound tillage is the solve and the method means that two, three or more different plowing tools are work at one time for plowing soil, pulverization, seeding and fertilize, the aid of this way, reduce the drudgery, number and saving time of field operations. The primary (conventional) and secondary tillage implements are becoming expensive time, fuel and costs, additional, needs several passes to prepare seedbed, which increase compaction and damage of the soil and leads to formation the hard pan in the soil due to tractor and machines movement. The farmers size of field holdings in Iraq is middle or usually small, the way of increase the width of tools or speed is less useful and effective, therefore, reduce and shorten the number of traffic or passes by use a combination tillage implements consider better solution. Compound tillage saving cost of 44 - 55 %, time of 50 - 55 % and enables the farmers to reduce the number of trips over the field, also, shortage of farm labor. Carrying out the tillage process by compound tillage with two or more equipment to reduce time, fuel consumption and power requirement for prepare the best seedbed. In this review, various paper researches on combination tillage implements will be discussion.

Keywords: *Tillage, Plow, Soil.*

I. INTRODUCTION

Tillage can be defined as any mechanical manipulation of soil, tillage system divided to primary and secondary tillage. Primary tillage is always deeper compared to the rest of the operations in the system, it is a deep tillage operation stirring the soil, disintegrating and breaking the soil to reduce the resistance of the soil,

burying the residues and mixing them with the soil for analysis and increasing soil fertility, exposing the lower soil layers to the sun by turning them over by implements such as chisel, moldboard, disk, subsoiler and heavy rotary plows, these tools usually operate at least 15 cm deep and produce a rougher soil surface than secondary tillage tools. Secondary tillage is used to break up the large clods which result after conducted primary tillage, weeds killing, cut and bury plant remains (residues), mixing fertilizers with the soil, prepare a suitable bed for seeds by agricultural tolls such as disks, cultivator, rotary hoes, harrows, rotary tiller, roller, ridge or bed forming implements. Primary tillage means cutting and smoothing the soil with a plowing depth ranging from 15 to 90 cm (Mckyes 1985). The moldboard plow is the most important plow among the primary tillage plows in the world, and can plowing types of soil, as it turns over the soil and the residue (remains of plants) and weeds (Bernacki et al 1972; Mckyes 1985; Hakansson et al 1998). The moldboard plow is the most widely used and widespread plow due to its early introduction in to Iraq (Alsabbagh 1990). Iraqi farmers still using primary and secondary tillage (Abdul-Munaim 2013; Abdul-Munaim *et al* 2020; Hamid and Alsabaag, 2023), addition, most researchers used plows such as moldboard, disc and chisel, then used harrows tools to prepare lands for agricultural verity crops (Al-Badri and Al-Hadithy 2011; Jasim and Alhashimy 2015; Himoud 2018; Nafawaah and Mageed 2019; Jebur *et al* 2020; Jebur and Al-Halfi 2022; Alwash and Al-Aani 2023). Compound machine is a group of different machines linked together in one structure and performs several purposes at the same time, such as plowing, smoothing, opening the rows, seeding, and fertilizing. The concept of compound tillage and design and development were began since decades (Shafee 1995), but this technology is not common or expended enough in many countries of the world, including Iraq, so it need to shed more light on it. Loghavi and Hosseinpoor

(2002) noted when used moldboard plow and roller as one machine that clod diameter significantly decreased and the soil surface was uniform more than using moldboard plow alone.

A compound tillage tools was consist of cultivator and disk harrow with operation width of 2.1 m and tractor horsepower 41.5 hp for evaluating the performance in sandy clay loam soil founded to achieve better performance and efficiency for compound tillage tools as compared with tillage equipment alone (Raheman and Roul 2013). The combined plowing tools can be save and utilize the power of tractor in the fields and reduce the energy requirement for prepare the bed of seed with in minimum cost (Kumar 1986). Due to repeated primary and secondary tillage by using the plows and harrowing machines soil layers become hard and compacted, so the rate compaction reducing 15 % from possibility of the yield (Onwualu and Watts 1998). Combined plowing or tillage is the process which at the same time using two or more different plowing implements or tools to control or reduce the filed process (Suhu et al 2006). The combination choosing is according to the complete of operation in minimum time, power, labor and money. The costs, energy requirement and the time of agricultural process force the researchers and the farmers to find alternative implements or tools for conducting the tillage (Bayhan 2006 and Prem et al 2016), The most effective methods is use combined machine (Akbarnia 2010). Jasim and Alrawshdie (2014) recommended to use a combined implement for tillage and subsurface irrigation tubes instillation, because save time, fuel consumption, obtain acceptable ratios and higher working efficiency. Jasim et al (2018) making five agricultural operation in one field passing when used compound machine consist of five parts performed primary and secondary tillage, opining rows, seeding and fertilizer, they concluded higher efficiency, save time and fuel consumption, good productivity, higher rate growth and insure quality of Yield of Corn (*Zea mays L.*). Prasrtkan and Usaborisut (2018) concluded when used subsoiler and rotevator as a combined tillage the slippage reduce 34.00-50.66 % in all experiment condition compared with subsoiler alone, addition, the energy requirement for prepare seedbed reducing. Compound tillage implements reduced the size of large clods in the soil, improve aeration soil, good pulverization and uniformity of soil, also added a higher soil loosening which lead to obtained best bulk density rate 1.15 g.cm⁻³ as compared the normal 1.4 g.cm⁻³ in the primary tools (Kailappan et al 2001). Saving the cost and time of operation of 44-55 % and 50-55 %, respectively, and obtained a higher tillage performance index are make- possible by use the compound tillage tools for prepared seed bed (Javadi et al 2006; Asgill 2008; and Manjeet et al 2016). Alkhafaji et al (2018) found when using moldboard plow and ripper as compound machine that the fuel consumption saved 7.67 L.ha⁻¹ compared with worked moldboard separately, and included reduced the numbers of passing and save time process. Using combined tillage unit for sowing melon allow to reduce up 25 % and 50 % as the labor and energy costs, respectively, addition, reducing time of the work and compaction of the soil by reducing the field passes (Aldoshin et al 2020).

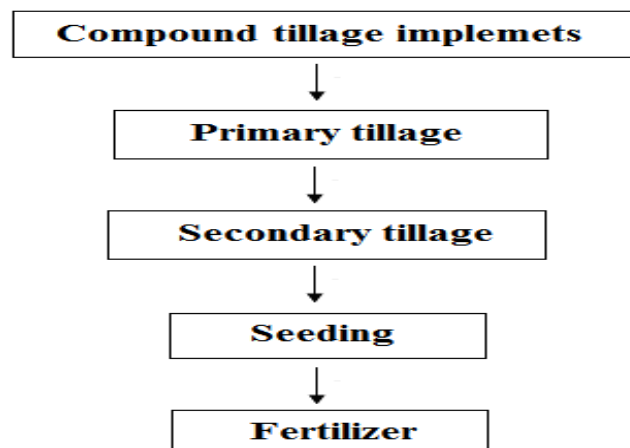


Fig. 1. The most important agricultural operations which conducted by compound tillage tools.
 Table 1. Summary of the results of some compound tillage implements.

Reference	Compound implement	Investigation	Soil type + water contain	Major findings
Chamen et al 1979	Rotary and chisel	Field study rotary and chisel as one unit	Clay 20.8%	Rotary energy required 50% lesser compared conventional plowing, also the efficiency was higher.
Watts and Patterson 1984	Cultivator and disc harrow	Evaluate performance combined unit	Clay loam + sandyclay	Lower requirement energy, addition, higher productivity.
Wilkes and Addai 1988	Subsoiler and moldboard plow	Compare combined tillage with moldboard operation alone	Clay	The combined resulted in less slip than moldboard plow, required more draft, specific energy requirement,.
Weise 1993	Cultivator (wing share and tine) + roller	Test traction and requirement powers for a compound tillage (wing in front and followed tines)	Siltyloam + silty clay loam 26%	Increasing the loosening of the soil. Increased the rotor rpm was not aid to reducing the size of clods.
Javadi and Hajiahmad 2006	Disc harrow and roller	Compared compound tillage tools with disc harrow alone	Loam 39 %	Compound tillage recorded higher uniformity of soil, better bulk density, lowest penetration rate.
Jasim and Husian 2012	Moldboard+ tank injecting herbicides	Performance to injecting herbicides below the soil surface	Silt clay loam 18 %	Higher production and efficiency, reduce slippage tire tractor and weed control.
Raheman and Roul 2013	Cultivator + Disc harrow	Compared combined tolls with separately work of cultivator and disc harrow	Sandy loam 10.8-12.5%	Combined tillage gave a higher volume soil leads to better performance of tillage index, good pulverization of soil.
Alrawshdie and Jasim 2015	Chisel, roller and subsurface irrigation tubes installation	Calculate economic and technical of combined tillage	Silty clay loam	Save costs, time, Fuel consumption, pulverization soil and install irrigation tubes in one pass, and fast working
Parmar and Gupta 2016	Cultivator + Pulverizing roller	Evaluate the performance combined tillage and PTO operate pulverizing roller	Black (medium) 13 %	Combined tillage tools was recorded less fuel consumption and cost operation, better field performance
Jasim et al 2018	Subsoiler, harrow opener rows, seeder and fertilizer	Evaluation of mechanic unit indicators	Loam clay 16-18 %	Slippage within the permissible limits, less than 15%. Higher efficiency and productivity. Saving time and fuel consumption
Alkhafaji et al 2018	Moldboard plow and ripper	Compare combined tillage with moldboard	Clay 18%	Reduce 50% from soil clods <10 cm in m ² and soil roughens, reduce field passes and time operation
Mankhi and Jebur 2022	Moldboard and Disc harrow	Performance of the locally manufactured compound Tillage	Silty clay loam 17-18%	Maintain productivity with one pass. Reducing soil clods larger than 5 cm and good tillage appearance. Accept- able penetration and bulk density
Nassir et al 2023	Chisel Plow and disk harrow	Effects manufacturer combined tillage on some traits under two speed 1.5 and 3 km.h ⁻¹ .	Silty loam soil	Reducing the draft 40 and 34 %, save fuel consumption 19.88 and 25.89, increasing the efficiency 13.64 and 5.63%, reduce power losses due to slippage 54 and 37%

Lachuga et al 2020	Disc and cultivator	Development of the combined plowing tools	Clay	Reducing fuel consumption up to 15%, increase the service life, improves the water-air balance in the soil and more stability.
Alkhafaji et al 2020	Moldboardp, Harrow and Leveling board	Develop and compare triple combined tillage with other tillage tools	Clay	Reduce index roughness and bulk density, slippage increased from 8 to 17% when used compound tillage
Nassir et al 2023	Subsoiler, chisel disc harrow, and roller	Evaluate combined tools on soil properties and maize grain yield	Silty clay loam	Improved bulk density, mean weight diameter, achieved a grain yield greater than 14.18%

Table 2. A summary of the results of field experiments by some researchers.

Implement	Width mm	Operation conditions		Drawbar power kW	PTO power kW	Total power kW	Reference
		Speed km.h ⁻¹	Depth mm				
Rotor + Chisel	2600	3.2- 7	15-230	6.16-10.20	12.23-31.32	18.39-41.52	Shinners <i>et al.</i> (1990)
Rotary + Chisel	2400	4.8-8	300	5.7 to 33.7	16.9-53.4	-	Shinners <i>et al.</i> (1993)
Cultivator + chisel	1240	1.72-3.28	150-250	1.60-5.66	7.35-8.49	8.96-14.16	Manian & Kathirvel (2001)
Moldboard with disc implement	1200	145-	1.7-4.5 188	1.28-7.62	-	-	Sahu (2005)
Rotvator + Cultivator	1550	2.21-4.35	80-120	-	-	7.2-15	Raheman & Behera (2018)
Subsoiler + harrow + roller	1000	1.79-3.33	200-400	17.15-22.77	11.59-15.12	-	Usaborisut & Prasertkan(2019)
Combined disc harrow	1450	3.46-6.82	120	2.68-9.07	7.34-14.24	12.19-27.81	Upadhyay & Raheman (2020)

Advantage of compound tillage

The benefits of compound tillage are (1) Reducing the operations of seedbed preparing, which leads to save the time and costs (Kepner et al 1972; Rohit and Hifjur 2006). (2) Reducing in the traction force of tillage tools, which leads to less slippage in tractor wheel and improve practical productivity (Shinners et al 1990; Ahmad and Amran 2004). (3) Reducing in the number of passes in the field, which result to reducing soil compaction and tractor operation cost). (4) More efficient power transmitted to the tillage tools through a powertrain mechanism than to tractor tires (Hendrick 1980; Anpat and Raheman 2017). (5) Reducing the soil compaction and hard pan. (6) Summarized some agricultural operation in one field operation.

Conclusion

Compound tillage implements are needs power more than single tillage implement, adding to, saving cost and operation time 44-55% and 50-55%, respectively. Combination tillage tools reducing the passes in the field by compound two or three or more field operation when use the combination tillage tools, which could be provide better solution. Combined tillage enables the farmers to reduce the number of trips over the field, also, shortage of farm labor and large farm sizes have increased the

popularity of combining tillage. Highest plowing performance and efficiency was noticed for compound implements compared to that of single tillage implement or conventional tillage. Further field experiments as a researches are needed to investigation the effect on combined tillage tools with relation soil on the long-term yield of crops.

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