

## Performance comparison of three tillage systems in wheat farms

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### Abstract

The performance of three tillage systems in a wheat farm were considered consisting of conventional farming as the method with maximum soil manipulation, cultivating using a multi-task machine with minimum amount of soil practice and last, the cultivating using a direct sowing machine as No-till. Results from analysis of variance for field performance of the three tillage systems showed that obtained dry mass was highest in reduced tillage (19.7 tons/ha) compared to conventional (19.3 tons/ha) and No-Till (15.1 tons/ha) systems. The yield performance of wheat in conventional tillage was 8.06 tons per hectare where as for reduced tillage and No-tillage were 7.9 and in No-till 6.3 tons respectively. The mass of thousand seeds followed the same trend as yield performance for three systems. As a result, a good replacement for conventional tillage is the No-till system with disk furrow openers in dry land fields and fields which are rain irrigated. Also, reduced tillage practice may be used for different conditions of fields due to less traffic which reduces the cost and compaction with more profits.

**Key words:** Field performance, Maximum tillage, Multi-task machine, No-till, Reduced tillage, Soil compaction.

### Introduction

Tillage operation and cultivation in a farming season consist of plowing, preparing the seed bed, leveling, cultivating, covering the seed, making the irrigation furrow, and sometimes application of fertilizer. Machines used for these types of operation are consisted of different kinds of plowshare, disk, harrow, cultivator, leveler, planter and furrow opener. Each of these equipments has to be attached to tractor and used in farm to accomplish the operations.

One of the most effective ways of reducing field operations, and also the cost of production is to use combined machines. Also, in No-till method, a machine makes a furrow (without mixing the layers of soil), then puts the seed under the ground, and finally covers it up. This machine is named direct sowing machine. That is usually without the section of creating irrigating furrow, and especially is used for dry lands or the lands which use classic type of irrigation (However we are able to make furrows simultaneously by attaching furrow openers).

Now it is more than five decades that developed countries are trying to minimize traffic and field operations (tillage, preparing bed for seed, and cultivating) in their farms. Each and every year it becomes more popular in European and American farms to utilize combined equipments. Studies show the process of improvement of these equipments; in regards to doing more operation during a step of working in the farm. The results of using combined machines resulted in reducing energy consumption and cost of field operations, increasing the production in unit area and minimizing soil compaction.

Agriculture, which is the most important sector in the production of food in Iran, is also a big consumer of energy in this country (Farahmandpour et al., 2008). Kosutic et al. (2005) studied the energy consumption in different tillage systems and the corresponding crop yield in Slovenia. Tillage systems and implements used were: conventional tillage (CT) using plow and disc-harrow and combined implement; conservation tillage (RT) using the drill plow and multi-tiller; and no-tillage system (NT). Energy requirements of the different tillage systems and their effects on yield were compared. Results indicated that the CT system was the greatest consumer of energy with 1.8 GJha<sup>-1</sup>. The RT system with chisel plow and multi-tiller consumed 1.1 GJha<sup>-1</sup>, or 37.5% less than the CT system, while the NT system required 0.27 GJha<sup>-1</sup>, which is about 85.1% less energy than the CT system. Tabatabaee et al. (2008) compared five tillage treatment systems for wheat production. The tillage treatments were: moldboard plow + roller + drill (T1); chisel + roller + drill (T2); cyclo-tiller + roller + drill (T3); sweep + roller + drill (T4); and no-till (T5). Their results showed that the energy consumption in tillage using T1 (maximum tillage) and T5 (no tillage case) systems was 32.5% and 19% of the total consumed energy, respectively. Asadi et al. (1998) conducted a research on the effect of different tillage methods on an irrigated wheat farm. Experiments were conducted according to the factors of machine and product performance and physical properties of soil for four years to find a suitable tillage method. Four-year of experiments illustrated that producing irrigated wheat farming in Isfahan would face with a significant reduction of performance by utilizing No-till plant method. As an alternative, a reduced



**Fig 1.** Multi-task machine during reduced tillage operation

tillage method was a suitable substitute of conventional tillage (plowing with chisel to a depth of 15 cm).

Solhju and Niazi (2001) during a year, had studied on the effect of two working depth levels of 30-35 and 40-45 cm of subsoiler without utilizing moldboard plow compared to conventional method in yield performance and the physical properties of soil. The results were ; (1) subsoiling in 30-35 and 40-45 cm had a significant effect at 5 % level on reduction of bulk density in comparison with observation, (2) all of the tillage treatments cause increase in penetration rate of soil basis (in comparison with no operation of tillage) and (3) the results of analysis of variance of yield related to wheat efficiency of all treatments did not showed any different among treatments.

Taki (2007) had studied on an oat planter by attaching an active, serrate furrow opener, which is powered by from PTO. This furrow opener had sliced the soil which was not plowed and created a furrow to place the seed and fertilizer beneath the soil. Results illustrated that the cutting units based on rotation of cutting plate were able to open furrows with a height of 5.5 cm and the width of 1.5 cm and move the soil in two directions of forward and upward while cutting plates were rotated at 580 to 700 rpm opposed to the direction of rotating wheels. Craciun et al (2004) reported that in comparison with the technology with two passes on land, the fuel consumption is reduced up to 60%.

Jory (2002) suggested that for combined tillage systems in sustainable agriculture one can use disc, cultivator and/or chisel shank as tillage tools. Sojka *et al* (1997) approved the effects of shallow plowing and deep plowing on the physical properties of soil and performance of production. In their research, the effects of different methods of tillage including: primary tillage (PT), deep plowing (DP), shallow plowing (SP), reduced tillage (RT), plowing in the depth of 15 cm by rotary tiller and roller (RT) and No-till (NT) on production of oat were compared. Experiments showed that by plowing soil porosity, hydraulic conductivity of water and air penetration were improved. Also field crop efficiency was increased. By plowing, the soil condition was improved where as produced oat yield was highest too.

Guerif *et al* (2001) agreed that chisel plows due to lower drawbar power and less time of operation in unit area, uses less energy consumption although conservation tillage reduces time of operation with the same field performance.

The period of studies which were done during 1997 to 2009 illustrated that conventional farming is considered as the most common method. To compare this method with reduced tillage, one step of conventional tillage was omitted and also two tillage tools were combined together. An operation which is named minimum tillage too. While tractor

with other attached equipments goes into the farm for more than one pass even in minimum tillage method which is suggested by experts. Also Taki in 2007 introduced a new mechanism for operating No-till method by utilizing active, serrate furrow opener attached to the planter.

Since most of the farms in Iran are dry-land farms and the soil texture and climatic conditions are differed, imported machines must be adapted to these conditions in order to be applicable. The purpose of this research was to study the effect of three methods of tillage included conventional tillage as maximum tillage, field operation with developed multi-task machine as minimum tillage and cultivating using a direct sowing machine as the reduced tillage on wheat performance.

## Materials and methods

In this research the effect of three different methods were studied on wheat cultivation performance. These three methods were: (1) Conventional tillage as maximum practice, (2) Reduced tillage as a minimum practice and (3) No-till. To accomplish this purpose the required equipments were:

- A. Steps taken and equipments used in conventional tillage (Max-T): Moldboard plowing, 2. First and second pass disk at least two times, 3. Tabulation (leveler), 4. Application of fertilizer (since planter does not have fertilizing equipments), 5. The third disk (covering fertilizer with soil), 6. Cultivator (planter) and 7. Furrow opener (for conventional irrigation).
- B. Steps taken and equipments used in reduced tillage (Red-T): Multi-task equipment was used in this step. The mentioned machine did the plowing (in the depth of 20 cm), preparing the seed bed, cultivating, covering and stabilizing seed and making the irrigation furrow (if needed) in one pass of operation.
- C. Steps and equipments used in No-Till (No-T): A direct sowing machine (OZDOKEH Model 2007, Turkey) was used in furrows needed for cultivating by chisel shanks in front toolbar, and seeds were covered and stabilized by roller in the back of the machine.

Selected field for the operation was in Shahriar province (Baghestan region), and every year was cultivated twice (the first cultivation was wheat or oat and the second was forage). In all kinds of tillage practices (conventional, reduced and No-tillage), John Deere 3140 tractor was the source of power. Depth of tillage was 30 cm in conventional and 20 cm in reduced tillage and No-Till. Soil of the fields was loamy with moisture of contents 10-14 during the operation. Method of irrigation was classic (rain irrigation by using rotating sprinkler guns) and cultivated wheat was Pishtaz brand. The condition of the operation was the same for all three methods

**Table 1.** The mean of dry mass, field performance and mass of thousand seeds of wheat for three different tillage systems

Method of cultivation	Mass of thousand seed	Field performance (weight of seed)		Mean of dry mass (included stem and cluster)	
	(Gr)	(ton/ha)	(kg/ m <sup>2</sup> )	(ton/ha)	(kg/ m <sup>2</sup> )
Conventional method	38.03	8.06	0.806	19.3	1.93
Reduced tillage	37.7	7.9	0.79	19.7	1.97
No-Till system	31.1	6.3	0.63	15.1	1.51

**Table 2.** Analysis of variance of the wheat performance in three tillage methods

Sources	Degree of freedom	F	Sum of squares	Mean of squares
Treatments	2	9.6 *	5.48	2.74
Block	2	0.035 ns	0.02	0.01
Error	4	---	1.14	0.285
Total	8	---	6.64	---

\* Significant at 5% level, ns- No significant, C.V= 7.18

(Reduced tillage machine is illustrated in Fig.1 and No-Till is illustrated in Fig. 2).

## Results

Experiments' data were analyzed in a completely randomized block design for three treatment included; conventional tillage (Max-T), reduced tillage (Red-T), and No-Till (No-T) with three replication. Yield from field tests for three systems were measured to determine the performance of these tillage methods.

Table 1 illustrates the mean of dry mass, yield performance and mass of thousand seeds of wheat for three different tillage systems. Results from analysis of variance for field performance of three treatments showed that the obtained dry mass was highest in reduced tillage (19.7 tons/ha) compared to conventional (19.3 tons/ha) and No-Till (15.1 tons/ha) systems. The yield performance of wheat in conventional tillage was 8.06 tons/ha whereas for reduced tillage and No-tillage were 7.9 and 6.3 tons/ha respectively. The mass of thousand seeds were measured as 38.03, 37.70 and 31.10 grams for conventional, reduced and No-till systems respectively which followed the same trend as yield performance for the three systems. According to Table 1, the obtained dry mass was highest in reduced tillage, but the product performance in conventional tillage was slightly higher than the performance of reduced and No-till systems. The mass of thousand seeds for conventional system was highest compared with reduced and No-till systems.

The analysis of variance of wheat performance in three tillage methods as shown in Table 2 revealed that there was a significant difference at 5% level among treatments (F-value=9.6). Table 3 shows the Duncan's multiple range tests for mean comparison of wheat performance for different tillage and cultivation methods at 5% probability level. The difference was between the means of wheat yield between the conventional and No-till systems. The yield performance of wheat in conventional tillage was highest as 8.06 tons/ha whereas for reduced tillage and No-tillage were 7.9 and 6.3 tons/ha respectively. There was no statistical difference among the mean of yield between the conventional and reduced tillage systems. Also there was no difference between the reduced and No-till systems.

## Discussion

As mentioned before, in the selected field of research, corn for forage production was the previous cultivation. So, as tractor, chopper and truck passes the field for harvest and

**Table 3.** Duncan's multiple range tests comparison for different treatments (tons per hectare)

Treatment	Classification at 5% level	
	1	2
Conventional tillage	8.06	-
Reduced tillage	7.9	7.9
No-Till	-	6.3

transportation practice, the soil was compacted severely. Tillage practice has to be in a way to make the soil less compact and leave a smooth surface. Hence, soil and seed would be more in contact, better soil aeration and roots of the plant receives mineral material and water more easily which cause improvement in yield performance.

As it is illustrated in the Table 3, based on this justification, we have higher yield with conventional and reduced rather than No-Till method. Similar results were obtained by other researchers. Khosrovani *et al* (2003) by evaluation and comparison of shallow tillage and conventional tillage and the effects of these two systems on wheat, reached to the fact that the ratio of seed performance in shallow tillage to conventional tillage is 92%. Hemmat and Asadi (1998) in their studies found that No-Till has the least performance in comparison with other systems of tillage. Hemmat and Asadi (1998) proved the effect of direct-cultivation, tillage without molding and conventional tillage on performance of wheat seed which was cultivated in fall under the irrigated condition. Results have shown that conventional tillage and No-Till had the most and the least performance, respectively.

The process of tests which were done in regard to this issue, illustrates that the conventional tillage is the most common method. Utilizing combined machine in field operations is vital to save time, field space, and energy more efficiently and also reduce costs to produce more yields. Use of multi-task machine (reduced system) is one of the best solutions in this case. Also using direct sowing machine (No-till) is the other alternative of reducing the operations of tillage and cultivation. But the No-till system (direct sowing machine) with chisel shanks used in this research opened dip furrows for seed placement without burying the residue. So the residue are collected in front of shanks and resulted in an unsuitable seed bed and uneven cultivation. Also since this machine is used in an unplowed soil for direct planting, so



**Fig 2.** Direct sowing machine during No-Till operation

the soil texture is rough and due to remained compaction, seeds could not have a good contact with soil to absorb water and nutrition by plant roots and therefore lower yield product is obtained as shown in Table 3. As a result, a good replacement for conventional tillage is the No-till system with disk furrow openers in dry land fields and in fields which are rain irrigated. Also, reduced tillage practice may be used for different conditions of fields due to less traffic which reduces the cost and compaction with more profits.

## Conclusion

As a conclusion, conventional tillage and cultivation causes increase in costs of production (consume so much time and energy and tractor's wear-out and etc.) and soil compaction depending on the number of traffic passes of tractor and equipments in the field. The results showed that yield performance between conventional method (maximum tillage) and multi-task machine (reduced tillage) were not significant. Also it showed no significant relationship between yield performance of multi-task machine and direct sowing cultivation. So it was concluded from the above results that, if in direct sowing machine, chisel is used as furrow opener, it causes sweeping and collecting plant residues. Also, cultivating when using direct sowing machine in dry lands with rain irrigation system, causes an uneven depth of planting and make the machine work in an inappropriate condition. The direct sowing machine with disk opener, works more efficient in the fields which is covered by plant residues. Multi-task machine leads to reduce cost of production and an increase in income and also increase in the soil compaction at different physical condition of farms (irrigated or dry lands); since tractor and other equipments pass through the field less than the other alternatives. Finally it is suggested as a suitable substitute for conventional farming.

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