Effect Of A Modified And Common Disc Openers On Soil Failure And Forces Using For Direct Planting

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ABSTRACT

Agricultural conservation systems are growing fastly in the world as well as Iran. Success of using and extending conservation tillage systems in particular, is depended on the performance of direct drilling machines. The suitable machine has to place seed in a proper depth at different field conditions including not plowing, high residue contents and sticky soil. Moreover the performance of such machine in those conditions is affected by its furrow openers. In this research different furrow openers including common double disc types and a modified one by adding two horizontal mini discs were investigated with the goal of increasing performance of planting machines in the conservation systems. The treatments were: 1. Double disc type both with angles; 2. Double disc type one vertical and one with angle; 3. Modified furrow opener with horizontal narrow furrows. The experiments conducted in a soilbin with 2500 cm length, 180 cm width and 100 cm depth with sandy loam soil texture. The treatments were evaluated using factorial design based on completely randomized statistical design, the parameters of soil failure and pattern, moisture content, evaporation rate and soil penetration resistance in the furrows were measured and determined. The results indicated that soil disturbance in the seed zone made by both discs arrangements was almost similar with slight difference on furrow width. But the modified one indicated different pattern with greater width and failure. Moreover the evaporation rate was less compared to common double disc types. In terms of force it was noted that vertical force was negative for double discs openers which needed additional force for penetration. But it was positive for modified opener which can solve the challenge of penetration by double discs. However the depth of furrow slightly increased compared to disc types which can affect seed germination. The modified furrow opener also showed less penetration resistance at seed zone which can resulted proper contact between seed and soil.

Key words: Conservation tillage, Furrow opener, Direct drilling, Double discs, Opener arrangements.

Introduction

There are two methods in order to evaluate furrow openers. The first method is to evaluate its performance regarding seed germination and yield and has to be conducted in the field. The second is to investigate specification which can be done both at field and lab. There have been many experiments that investigated design factor mostly focus on optimum rake angle (Dransfield et al., 1964; Simense et al., 1965; Abernathy & Porterfield, 1969; Gebersenbet & Johnson, 1992; Mathure & Panthy, 1992; Damora & Panthy, 1995). The summary of all above research indicated that the vertical and horizontal forces can be increased, by increasing rake angle and the minimum pulling resistance occurred at 25°.

Baker (1976) investigated the performances of furrow openers including disc, chisel and hoe types in the lab. It was noted that germination was significantly higher by chisel (77%) than hoe (26%) and disc (27%) that was mainly due to remaining moisture in the furrows.

Wilkins et al., (1983) evaluated six different furrow openers of single disc, double discs, hoe types and deep opener. The result indicated that moisture content was higher under hoe and deep openers. However the double disc opener pushed seed and dry surface soil was also in to the furrow.

Freebairn et al., (1986) conducted a comprehensive study on 64 different opener types in Queensland of Australia, in heavy soil texture. They concluded that considering cost and yield a planter by a disc with 550 mm diameter as coulter and spear point opener with a rubber press wheel was the most promising arrangement.

Baker and Afzal (1986) developed a winged opener with possibility of placing seed and fertilizer. Later they developed two winged opener enabled to separate seed and fertilizer and called in Bioblade.

Chaudhary et al., (1988) introduced an inverted T-opener which was successful in terms of germination rate compared to common methods. Srivastavaa and Panuwar (1986) proved that soil returning in to the furrow for blades with 40 mm width is significantly greater than 50 mm width.
Bahri and Bansal (1993) investigated openers in different soil textures. They concluded that double disc type was suitable in loose and relatively moist soils although hoe type worked better in dry and harder soil. Chadhurary (2001) found that there was a furrow wall between seed and unplowed soil in no-till method. This wall can affect the germination rate at later stage despite proper germination at the early stage.

Asodar (2004) evaluated different point type openers at south of Iran. The results showed that down to 50 mm below seed placement, the penetration resistance was less by narrow-winged point which increased root length and weight in beans and wheat.

Vamerali et al., (1996) noted that hair pinning is a limiting factor for germination which is low by invented-T opener compared to double disk particularly at heavy moist soil or dense residues.

However the review of research proved that there have always been many experiments to improve performance of furrow openers. But nowadays particularly with extending the new cultivation method with the goal of less soil disturbance and necessity to keep moisture, it is still very important to work on modification of openers for different soil conditions, residue and crops.

**Material and Methods**

The experiments conducted in a soil bin with 25 m length, 1.8 m width and 1 m depth located in Agricultural Engineering Research Institute (AERI) in Karaj city 25 km west of Tehran, Iran.

The soil bin was one of the largest in the region and soil was prepared by different equipment. The soil texture was loamy clay with 80% sand, 10% clay and 10% silt. A MF-399 tractor with 100 hp was used to move the tools equipped by two load cells as well as speed and slippage measurement facility. (See Figure 1)

![Soil bin and the equipped tractor](image.png)

**Fig. 1:** Soil bin and the equipped tractor
2.1. Treatments:

In this experiment 3 different furrow openers were investigated as follows.

Double angled disc, both with same tilt angles opposite each other (See Figure 2-a).

This type is almost common and used on common wheat planters in Iran. This type can create V type furrow with minimum soil disturbance and rolling of the disc as advantage for penetration and residue passes (Murray et al., 2006). However compaction of side and bottom of this furrow can be disadvantage for this arrangement (Iqbal et al., 1998).

Double disc, one vertically without angle and one angles disc.

In this arrangement, the second disc had angle. In both vertical and horizontal directions and only cut the soil without movement, on the other hand in may reduce moisture lost due to less soil disturbance (See Figure 2-b).

Modified opener with double angled disc and horizontal sluts. It is expected that the horizontal sluts besides V shape furrow seed trap and keep the moisture in the soil (See Figure 2-c).

![Fig. 2: a) Double angle discs; b) Double discs one vertical; c) Modified opener](image)

2.2. Parameters:

The parameter of moisture content was measured in the furrow with interval time of 48 hours at the depth of 0-5 and 5-10 cm depth.

The penetration resistance was determined using 30° cone petrologger before and after operations. The soil profile and failure pattern was also determined at bottom and side of furrow in all arrangements.

2.3. The modified opener:

The new modified opener was consists of two offset discs with 390 mm diameter and one disc 32 mm ahead of the second one. The disc placed with 10° between them to allow seed and fertilizer placement. The side distance was 60 mm between two discs. Two little discs with 100 mm diameter were attached to create horizontal sluts. The rake angle of the discs were considered to be 30° to minimize pulling resistance (Damura and Pandi, 1995)

The size and diameter of discs was determined using the equation introduced by Desbiolle (2009).
The main goal was minimum soil disturbance in the direct drill or no-till systems. Therefore the disc angle and tilt angle was considered to be minimum in the disc type openers.

Results and Discussions

3.1. Furrow moisture:

The results indicated there was no signification difference for remaining moisture after 24 and 48 hours in the furrow at the 0-4 cm depth. However a significant difference was observed after 6 days (144 hours) at same depth level. The reduction of moisture was 11.07% for double disc opener compared to 8.6% for the modified one (see table 1).

However Figure 3 shows that moisture was kept slightly more at deeper layer 4-8 cm depth measured after 48 hours.

Table 1: Mean moisture content in the furrow

<table>
<thead>
<tr>
<th>Arrangements</th>
<th>Moisture loss after 6 days (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double angled discs</td>
<td>11.07</td>
</tr>
<tr>
<td>Double discs one vertical</td>
<td>8.07</td>
</tr>
<tr>
<td>Modified opener</td>
<td>8.6</td>
</tr>
</tbody>
</table>

Fig. 3: Moisture content at different depth levels

It can be due to moisture blocking in the furrow made by modified opener. In double disc type with rake angle greater than 90° the soil is pushed in to the furrow therefore soil disturbance was minimum, (Tessier et al., 1991) but this angle is 25° for the modified one.

The horizontal side furrow was another reason for trapping moisture. It could be due to closing the horizontal furrow by weight of top soil or pressing wheels which kept the moisture in the furrow. But in the V type discs the moisture was more exposed to the out side air. This was also proved by Chaldoury, 2001.

3.2. Soil disturbance profile:

The experiment was performed all in similar and constant speed of 8 km/h in order to reveal the difference between types. The photos were taken by a digital camera as used by Vamerally et al., 2006. The results shown in figure 4.
Fig. 4: The disturbance profile of different openers

The furrow pattern was noted to be almost-symmetrical for double V type disc opener with 8 cm width, 4 cm depth at right hand side and 4 cm at left hand side.

The furrow pattern was almost similar for double discs, one vertical with 6.5 cm width and same depth (See Figure 5).

However the results for modified opener indicated non-symmetrical disturbance with 9 cm width, 10.5 cm depth, 7 cm height at right and side and 5 cm at left hand side (See Figure 6).

Fig. 5: Soil disturbance of double disc arrangements

Fig. 6: Soil disturbance of modified opener
This can increase depth of planting by working deeper of middle larger disc as well as hilling up the soil at two sides. This may cause seed germination delay.

3.3. Penetration resistance:

Although reducing soil compaction at depth has always been a challenge it should be compromised at soil surface and seed zone in particular. In the proper situation soil has to be slightly compacted under seed zone in order to allow moisture exchange. On the other hand less compaction on top of the seed zone would provide better germination condition.

Figure 7 shows penetration resistance and related pressure for two arrangements of double disc and modified one. The vertical line indicates seed depth in the figure. This shows that the resistance above seed depth was slightly greater for both double discs opener. Moreover the results noted that depth for modified one continued down to 10 cm and after that both presented similar resistance. The less compaction at 6-10 cm depth would provide proper condition for micro-roots and crop establishment of plant.

Fig. 7: Cone index in the furrow, (●) double disc; (▲) modified one

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