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Full Length Research Paper

Effect of different methods of seedbed preparation on irrigated canola yield after corn in North West Iran

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One of the major problems that farmers in the Northwest of Iran contend with after the corn harvest for mechanized cultivation of canola is lack of time and soil moisture over prepared seedbed. Consequently, the effects of five different seedbed preparation methods were analyzed, namely; T1: moldboard plows (conventional tillage), T2: stalk shredder followed by chisel and disk, T3: stalk shredder followed by double-disc, T4: chisel followed by disk and T5: two heavy disk tillage using a randomized complete block design (RCBD) with four replications. Results showed that the soil bulk density in the 0 to 10 cm layer had no significant effect, but the 10 to 20 cm depth was significantly higher than the conventional tillage. However, penetration resistance in 10 to 30 cm under T5 was significantly higher than others. Thus, comparison of the soil bulk density, penetration resistance, and plant establishment showed that reduced tillage in canola seedbed preparation was effective. Besides, the surveys indicated that there was significant difference between mean weight diameter (MWD) after primary and secondary tillage and the MWD's under T2, T3 and T5 were 1.18, 1.01 and 1.22, respectively lower than T1 with 2.06. Maximum plant height and grain yield were obtained under T2, 117.12 cm and 2941.50 kg ha^{-1}, respectively. Therefore, T2 was recommended as the time limitation on rapeseed bed preparation after corn, due to higher speed of operation and lower cost.

Key words: Corn residues, cone index, reduce tillage and yield of canola.

INTRODUCTION

Conventional tillage systems have several disadvantages. These include time and cost of depreciation of machinery loss of soil moisture and increased soil erosion and soil conversely. Conservation tillage maintains farm residues, is associated with reduced or absence of wide tillage (Moore et al., 2000).

The depth of tillage is soil and crop specific. Extensive research in Ontario and throughout western Canada for rain-fed canola production has failed to show any improvements in water storage or yield for tillage depths beyond 10 to 15 cm in most soils. Deep cultivation may bring up large-sized clods which is problematic for seedbed preparation. It also brings dormant weed seeds to the soil surface where they germinate and grow (Thomas, 1984). Minimum tillage due to its minimum soil disturbance, lower cost and less fuel consumption should be considered as long as there is no general compaction in the topsoil to be removed. In this case, the principle of tilling the soil from the top down should be adopted to produce fine seedbed. In the first place, a shallow cultivation is performed, then, in the second pass, the working depth of the tillage implement is increased. This is expected to significantly reduce the size of clods and also produce a firmer seedbed when compared whit plowing since the shallow depth of tilled soil react well to consolidation (Ward et al., 1985).

Besides the surveys, Hemmat (2009) reported the

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Table 1. Soil physical and chemical properties at the agricultural research center of Ardabil province (Moghan) in Northwest of Iran.

Depth (cm)	pH	Organic content (%)	Clay (%)	Silt (%)	Sandy (%)	Texture
0-27	7.4	0.98	0.61	0.29	0.10	Clay
27-70	8.2	0.37	0.63	0.27	0.10	Clay

impact of depth and intensity of tillage on soil physical properties, crop establishment and yield of irrigated winter canola in a loam soil near Isfahan in central Iran that the grain yield is not sensitive to reduction in the depth of primary tillage or intensity of secondary tillage. Bonari et al. (1995) compared conventional tillage (25 cm deep plowing) and minimum (10 to 15 cm deep disc harrowing) tillage for winter oilseed rape production on a very sandy soil and concluded that rapeseed grain and biomass yields under both systems never differed significantly. Crop establishment largely depends on the methods of seedbed preparation and sowing (Hakansson et al., 2002).

A study was conducted to investigate the effect of using the stalk shredder, conservation tillage machines and seeding techniques on soil physical characteristics, seedling emergence, crop establishment and grain yield after harvesting corn in Dezfoul, Khouzestan province. Also soil moisture content, bulk density, cone index, soil mean weight diameter and sowing depth uniformity were recorded. Treatments comprised one pass, twice and no stalk shredder (disk) and tillage treatments included combination tillage and disk in main plots followed by flat and raised bed planting in subplots. Twice stalk shredding leaving 5740.3 kg/ha corn residue, increased soil moisture content after planting it was also revealed lower clod weight diameter (1.526 cm). The best sowing depth uniformity (44.84%) had the most effect on the stalk shredder treatments. Seedling emergence (89.2%) and yield (2.02%) were increased where combination tillage was applied. Therefore, combination tillage followed by two actions of stalk shredding and raised bed planting were the most beneficial treatments for wheat production under conservation tillage (Abbasi et al., 2010).

Study conducted to investigated the effect of tillage and planting date on yield, soil physical and biological properties of rapeseed showed the tillage treatment and planting date were significantly affected in grain yield and soil physical properties. (Torabi et al. 2008) Few field operations are more closely related to success or failure in canola production than in seedbed preparation. For canola, the seedbed should be reasonably leveled, uniformed, well packed, weed-free, warm, slightly lumpy on the surface and moist throughout its whole depth. A firm, well-packed seedbed provides excellent soil moisture and oxygen supply to seeds (Thomas, 1984). In recent years, more than 90% of the vegetable oil consumed in Iran has been imported from foreign countries. In 2005, Iran imported 850,000 metric tons of vegetable oil (Fars News Agency, 2005). In a cold semi-arid climate, Arshad et al. (1995) found that spring canola under reduced tillage (soil tilled with a cultivator to a depth of 8-10 cm once in the spring just prior to seeding) tended to be higher than either conventional tillage (soil tilled with a cultivator to a depth of 8-10 cm once in the preceding fall and twice prior to seeding in the spring) or no-tillage, although the mean differences were usually non significant. The Iranian government is planning to achieve self sufficiency in vegetable oil production in the long term. Canola with its high oil content has been introduced as a new oilseed crop to farmers. Canola cropping in Northwest of Iran raised questions about many basic production practices including optimum cultivation depth, and seedbed preparation methods. This study was conducted to determine effect of different methods of seedbed preparation on irrigated Canola yield after corn in Northwest of Iran.

MATERIALS AND METHODS

The study was performed in 2009-2011 at the agricultural research center of Ardabil Province (Moghan) (39°39´N; 48°88´E; 78 m.a.s.l.) in the Northwestern part of Iran. The mean annual precipitation and temperature at the station are 332 mm and 21.5°C, respectively. The values of some physical and chemical properties of the soil are given in Table 1.

The experimental design was a randomized complete block design (RCBD) with four replications to effects of five different seedbed preparation methods namely; T1: moldboard plow (conventional tillage), T2: stalk shredder followed by chisel and disk harrow, T3: stalk shredder followed by double-disc harrow, T4: chisel followed by disk harrow and T5: two heavy disk harrow (offset tillage). The description of the tillage and planting implements are given in Table 2.

In the month of September, after harvesting the corn, Plots Experiments consisted of 20 plots (with dimension of 20 m in length and 5 m in width each) were selected. Prior to tillage practices the crop received 100 kg N ha^{-1} as urea, 200 kg P ha^{-1} as ammonium phosphate , 50 kg K ha^{-1} as potassium sulphate and 3 L terfelan ha^{-1} as herbicide across the field for all treatments followed by disking were accomplished. Full applications of P and K and a one-third application of N were broadcast before secondary tillage operation. The remaining N was applied in all treatments in two split applications at stem elongation stage (March) and at the beginning of flowering stage (April). The field was irrigated 5 times from seeding to harvest time. Before applying treatments, the amount of residue remaining on the soil surface and after secondary tillage amount of residue and mean weight diameter (MWD) (15 cm) were taken from each plot with the aid of an A 1 × 1 m frame. Thereafter, all the soil aggregate samples were dried prior to sieving. Each soil sample was passed through the set of sieves, and the soil retained on each was weighed, as well as the soil that assessed through the sieve with the smallest aperture. The aggregate mean weight

Table 2. Tillage implements and drill specifications.

Equipment	Weight (kg)	Width (m)	Description
Moldboard plow	425	1.2	Mounted, general purpose, 4-bottom, 30 cm bottom spacing
Chisel plow	480	1.8	Mounted, 5 straight rigid shanks, fixed on a 2-row, 40 cm stem spacing
Stalk shredder	1014	3	Mounted,1 horizontal rotor, with 32 L-shaped blades arranged on 7 flanges of its rotor
Disk harrow (offset)	2500	3.2	Wheel draft,14 disks in each gang, diameter of front gang notched disk 53 cm,18 cm disk spacing.
Disk harrow (tandem)	630	2.5	Wheel draft, 7 disks in each gang, diameter of front gang notched disk 46 cm, 18 cm disk spacing.
Drill (agromaster)	1200	4	Mounted, 35 sowing rows with 13 cm spacing, Shoo opener, without covering device (agromaster brand)

diameter of the individual sample was calculated by the following equation (Adam and Erbach, 1992):

$$MWD = \sum \frac{x_i w_i}{W_i} \quad (1)$$

where MWD is the aggregate mean weight diameter, mm; xi is the average aggregate diameter in a particular sieve in mm, wi the weight of aggregates in the size range i, and W is the total weight of aggregates, as a function of total dry weight of sample analyzed. One week after the first irrigation, the soil bulk density (BD) for the 0 to 10 and 10 to 20 cm layers in each plot was estimated using the core method. Intact soil cores with a 5.4 cm diameter by 4 cm length were obtained using a core sampler (Blake and Hartage, 1986).

Cone penetration resistance (PR) was measured using a digital cone penetrometer (Eijkelkamp model ST S-100kg-G2, holland with an apex angle of 30°). Estimates of PR to a depth of 30 cm in 1 cm measurements were made One week after the firth irrigation on November and 3 insertions per plot were made. Soil samples at a 0-20 cm depth were collected for gravimetric water content determination.

At the time of PR measurement, the mean gravimetric moisture content at the 0-30 cm depth was 19%.

For amount of residue remaining, samples taken by sampling (A 1 × 1 m) frame in three replicates from each plot before and after operation was calculated by the following equation:

$$RS = \frac{Wa - Wb}{Wa} \times 100 \quad (2)$$

where RS is the percent residue being returned, Wa is the dry weight of weeds and plant debris prior to the operation (kg) and Wb the dry weight of weeds and plant debris after the operation (kg).

The number of plants at full emergence was determined in November by observational estimates in rows per plot. Emergence for each plot was also subjectively assessed as a percentage of the plot area with canola plants. Following the winter, plant stand was estimated in March. Seedling establishment for each plot was expressed as a percentage of the plot area with canola plants. Canopy ground cover was estimated at the end of April. Prior to harvesting, 10 plants from each of the considered rows were randomly selected and plant height was determined.

In order to measure the grain yield of (A 1 × 1 m frame) at three points on each plot and harvest based on moisture content was 8%. All data were subjected to analysis of variance using SAS Proc GLM of (SAS Institute, 1990). When the analysis of variance was significant at P< 0.05 probability level, treatment means were separated by Least Significant Difference ($LSD0_{.05}$) test.

RESULTS AND DISCUSSION

Aggregate mean weight diameter

Aggregate mean weight diameters mean (MWD) by moisture content 12.7% was significantly higher under T1 (2.06) than T2, T3 and T5 which were 11.8, 10.1 and 12.2, respectively (Table 3). However, stalk shredder plus chisel plow plus 2disk (T2) or stalk shredder plus 2disk (T3) of the tined implement was as effective as moldboard plowing (T1) in soil fragmentation. It is reported that a good seedbed is obtained when 50% of the aggregates by weight are in the range of 0.5 to 6.0 mm. This corresponds to an MWD of 12 mm (Berntsen and Berre, 2000). Russell (1973) also indicated that it is generally accepted that soil particle sizes in the range of 1 to 5 mm are required for seedbeds. Table 3 shows that stalk shredder plus chisel plow or stalk shredder plus 2disk were as efficient as Moldboard plow.

Amount of residue return

The results of the percentage of amount residue returned analysis showed that in application of Moldboard plow plus 2disk (T1) tillage method the highest returned whit

Table 3. Effect of primary and secondary tillage on mean weight diameter (MWD) of the aggregates and the percentage of amount residue returned *a*.

Treatment	MWD (mm)	Amount of residue returned (%)
Moldboard plow + 2disk (T1)	20.6[a]	88.00[a]
Stalk shredder + chisel plow +2disk(T2)	11.8[c]	67.00[b]
Stalk shredder + 2disk (T3)	10.1[c]	58.20[bc]
Chisel plow+2disk (T4)	16.0[b]	61.50[bc]
Two heavy disk (offset)(T5)	12.2[c]	56.80[c]

[a] Mean values followed by the same letter or with no letters in each column within treatment category are not significantly different at the 5% level of probability by LSD.

Table 4. Effect of primary and secondary tillage on soil bulk density and penetration resistance[a].

Treatment	Bulk density (g cm^{-3})		Penetration resistance (kPa)		
	0-10 cm	10-20 cm	0-10 cm	10-20 cm	20-30 cm
Moldboard plow + 2disk (T1)	1.15	1.23[ab]	531.75	590.00[b]	811.25[b]
Stalk shredder + chisel plow+2disk(T2)	1.18	1.20[a]	526.25	630.00[b]	931.25[b]
Stalk shredder, + 2disk (T3)	1.16	1.24[ab]	470.75	537.25[b]	819.50[b]
Chisel plow+2disk (T4)	1.18	1.23[ab]	464.50	552.50[b]	939.50[b]
Two heavy disk (offset)(T5)	1.17	1.30[a]	504.00	946.25[a]	1674.50[a]

[a] Mean values followed by the same letter or with no letters in each column within treatment category are not significantly different at the 5% level of probability by LSD.

Table 5. Effect of primary and secondary tillage on percentage of seedlings at full emergence, stand establishment after winter and canopy cover measured in spring[a].

Treatment	Observation emergence (%)	Plant establishment after winter (%)	Canopy ground cover (%)
Moldboard plow + 2disk (T1)	0.80[b]	0.83[b]	0.87
Stalk shredder + chisel plow + 2disk(T2)	0.89[a]	0.88[a]	0.91
Stalk shredder + 2disk (T3)	0.83[b]	0.84[ab]	0.89
Chisel plow + 2disk (T4)	0.87[b]	0.81[b]	0.88
Two heavy disk (offset)(T5)	0.82[b]	0.86[ab]	0.88

[a] Mean values followed by the same letter or with no letters in each column within treatment category are not significantly different at the 5% level of probability by LSD.

0.88% and two heavy disks (T5) by 56.80 in the lowest (Table 3).

Bulk density and penetration resistance

The dry soil Bulk Density (BD) after the first irrigation in primary and secondary tillage treatments is presented in Table 4. BD was affected by 10 to 20 cm layer in primary and secondary tillage. The average values of the BD at 0 to 10 and 10 to 20 cm were 1.16 and 1.24 g cm^{-3}, respectively. Similar BD for chiseling and moldboard plowing were obtained also by Benjamin and Cruse (1987) and Comia et al. (1994). Cone penetrometer measurements showed no differences in soil strength among primary tillage treatments in the 0 to 10 cm layer while, at the10 to 30 cm depth, T5 had significantly higher soil strength than the other treatments (Table 4). Contrary to the results for BD, this indicated that the moldboard plow was more efficient than a tined implement in soil loosening. Similar results were obtained by Carter (1996) and Arvidsson (1998). No differences in penetration resistance were found between secondary tillage treatments for both depths.

Observational seedling emergence, stand establishment and canopy cover estimates

The canola plant population at full emergence was significantly affected by the primary or secondary tillage operations (Table 5). This was the result of relatively

Table 6. Effect of primary and secondary tillage on height of plant and grain yield[a].

Treatment	Plant height (cm)	Grain yield (kg ha^{-1})
Moldboard plow + 2disk (T1)	109.81[b]	2735.75[b]
stalk shredder + chisel plow+2disk(T2)	117.12[a]	2941.51[a]
Stalk shredder + 2disk (T3)	110.87[b]	2834.00[ab]
Chisel plow+2disk (T4)	109.06[b]	2734.25[b]
Two heavy disk (offset)(T5)	106.81[b]	2856.00[ab]

[a] Mean values followed by the same letter or with no letters in each column within treatment category are not significantly different at the 5% level of probability by LSD.

high emergence resulting from a fine, firm and well-packed seedbed under all treatments (Tables 3 and 4). Rolling before sowing crushed the large aggregates, leveled the soil surface, and facilitated a uniform shallow seeding depth. Rolling immediately after sowing, provided good soil-seed contact for moisture absorption during germination (Hakansson et al., 2002). von Polgar (1984) reported an extensive series of trials with rolling after spring sowing of barley, oats and wheat on soils with clay contents of between 3 and 56%. On average, rolling immediately after sowing increased early crop emergence by 9%, final emergence by 4% and yield by 2% irrespective of crop and harrowing or sowing depths. Seedling losses and uniformity of establishment are especially influenced by seedbed conditions at the time of sowing (Daniels et al., 1986) and during establishment (Taylor and Smith, 1992). Plant establishment after the winter was influenced by tillage treatments. Its trend was similar to the percentage of emergence (Table 5), while, the effect of tillage on canopy ground cover measured in spring was not significant (Table 5).

Seed yield and plant height

The plant height measured in the spring was significantly affected by primary and secondary tillage. The plant height under T2 had the highest (Table 6). A significant difference in grain yield of canola was found in tillage treatment (Table 6). However, the results agree with the findings of Torabi et al. (2008) how reported that the tillage treatment and planting date were significantly affected in grain yield and soil physical properties Hocking et al. (2003) have studied the responses of canola cultivars to tillage (one-pass cultivation and no-tillage) in both high and low rainfall environments and found that tillage had little effect on seed yields. Beside, Arshad et al. (1995) studied the effects of decreasing tillage intensity (conventional to zero tillage) on the growth of canola (*Brassica campestris* L.) on a clay soil under a cold, semi-arid climate of the northern Canadian Prairies. They reported that, in most cases, tillage effects on mean crop yields were non-significant and a reduced tillage system (tilling once just prior to seeding with a cultivator to depth of 8 to 10 cm) was recommended.

The mean of plant height over all tillage treatments was 110 cm. However, the values for plant height obtained in this study were lower than 135 to 153 cm as observed for canola cultivars grown as a second crop after rice in a high rainfall region in the North of Iran (Rabiee et al., 2004).

Conclusions

There were significant differences in the yield of canola after corn were found among tillage treatment. Therefore, this experiment reveals that canola yield did not respond to changes in the depth of tillage provided that a good seedbed (aggregate mean diameter of less than 20 mm) for sufficient plant establishment could be achieved. These results demonstrate that reduced tillage could be suitable. T2 treatment is recommended because it has no negative influence on the plant establishment and with a probability of crop yield improvement for irrigated canola production after corn in the north west of Iran.

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