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Full Length Research Paper

The dynamic properties of vertisols as affected by different types of plough under dry farming conditions

Akram A. Khalaf, Nahla M. Salem, *Ahmed S. Khalaf

Faculty of Agriculture and Forestry Duhok University, Iraqi Kurdistan Region

*Corresponding author`s e-mail: asbabawat@yahoo.com; Tel.: +964 750 4996708

Abstract

The effect of stubble mulch and mulch tillage (post harvest tillage with mulcher), and different plough types; no tillage (NT) as control moldboard (MB), chisel plough (CP), vertical disk (VD) and mulcher (MU) at two soil depths (0-15 and 15-30 cm), was investigated on some soil dynamic traits, liquidity index (LI), plasticity index (PI), shrinkage (%) and soil penetration resistance (PR) against tillage equipments. The results revealed that mulch tillage have a significance adverse impact on liquidity index (LI), it was raised from (1.09)for stubble mulch to (1.30) for mulch tillage in other words it disturbed soil consistency for preparing good tilth, moreover mulch tillage also increased (PI) but not to a significant level . Apart from this the mulch tillage enhanced significantly soil texture in terms of (PR) in favor of crop growth, it reduced from (1.5)Kg/cm^2 for stubble mulch to (1.34) Kg/cm^{2}for mulch tillage. All plough types increased liquidity index(LI), but (MB) plough gave the highest value, the reverse for penetration resistance(PR) as all plough reduced, meantime plough types have no significant impact on soil plasticity index(PI) and shrinkage(%).The results displayed that the soil depth affected positively to significant level on the (LI) and (PI), whereas it has no effect on the shrinkage %. Soil liquidity (LI) and plasticity (PI) indexes were declined with soil depth, while shrinkage percentage did not affected by depth. The interaction of plough types with mulch plough also significantly influenced soil liquidity index (LI), the combination of (MB) and (VD) with mulch tillage gave the highest value of soil (LI) and (PI), meantime all plough types with mulch tillage or without mulch tillage reduced soil penetration resistance. Soil shrinkage %, did not influenced significantly by this interaction. Moldboard and (VD) plough at depth (0-15cm) recorded highest value for liquidity and plasticity indexes and shrinkage %. Whereas mulch tillage at (0-15cm) depth recorded the highest value for soil (LI) and (PI) and shrinkage percentage. The second order interaction was also significant, similarly (MB) and (VD) plough with mulch tillage at (0-15cm) resulted in higher values for liquidity and plasticity indexes, but not significant for shrinkage %.

Keywords: Soil liquidity index, plasticity index, soil shrinkage (%), soil penetration resistance, plough, mulcher.

INTRODUCTION

The dynamic properties of soil including liquidity index (LI), plasticity index (PI), soil shrinkage (%) and penetration resistance (R) possess great impact on soil resistance to the agricultural machinery and equipments at seasonal farming and finally influence on the seed germination and crop rhizosphere.

Soil liquidity index (LI) and plasticity index (PI) state soil condition which are considered as a functions of soil consistency and suitability for tillage operation, farming and preparation of good tilth (Al-Aani, 1984).

Penetration resistance of soil as a function of tillage and planting system illustrated an enhancement trend with soil depth (Altuntas et al., 2005; Strudely et al., 2008). Shallow tillage has a positive effect on soil health (Vakali et al., 2011; Riley et al., 2008).

Soil volumes are affected by mechanical stress (tillage process) and also affects on the ability of soil to shrink (McNabb et al., 2001), it was well known that soils are able to shrink and swell (Peng et al., 2006). Altuntas et al. (2005) reported that soil bulk density and penetration

resistance (PR) values in conservational tillage system with mold board and disc harrow were higher than conventional tillage system having chisel and toothed harrow, also Materohera and Mloza-Banda(1997) concluded that bulk density and penetration resistance(PR) on ridges were lower under conventional tillage system than minimum tillage.

The traditional practice in Iraqi Kurdistan region (Northern Iraq) is to gather barley and wheat straw after harvest which was normally at June, to be chopped later and reserved for livestock during winter as there is a shortage in animal feed at this time of the year. The remainder stubble (15-25 cm height) was either left stand or utilized as summer pastures to be grazed by animals; but rarely it ploughed or corporate in the soil immediately after harvest.

Other objectives of mulch tillage immediately after harvest is to restore the soil structure and removing off stiff stubbles by turning and incorporating the trashes and weeds, thus making the soil ready to store rain water. Summer tillage also check soil erosion, it affects on soil aggregates, soil organic matter (Chandrasekaran et al., 2010).

Therefore the goals of the current study, firstly to investigate the ability of shifting from traditional practices toward mulch tillage and secondly to determine the effects of different types of plough on the soil dynamic properties of Sumail vertisols at Faculty of Agriculture and Forestry in terms of soil liquidity index(LI), plasticity index(PI),soil shrinkage % and penetration resistance (PR) at two soil depths.

MATERIALS AND METHODS

The experiment was accomplished during June of 2011 on half hectare of barley field after harvest at the farm of Faculty of Agriculture and Forestry, University of Dohuk, Sumail site, which located at 15 km west of Dohuk city (latitude 36˚.84"N, longitude 43˚.01"E) and altitude 583 masl. The average annual rainfall was 535 mm which is usually received during October and extends up to May. The field was divided after barley harvest into two strips, one was left as stubble mulch and the other was incorporated in to the soil by mulcher (mulch tillage immediately after harvest) on 5-6-2010, these were considered as a main plots, each strip was then subdivided into five subplots, and tilled with one of the following plough: moldboard, chisel, vertical disc plough, mulcher (mulch tillage) and control (no tillage) on 21-12-2010.

Mulcher work in shallow depth as a combination between cultivator, harrow and roller, Moldboard plough inverts the soil to one side and cut deeply up to 30 cm. resulting in better pulverization. While Chisel plough breaks the hardpan that exists in the soil. It makes a simple vertical cut to a depth of 45cm and facilitates the downward movement of water and subsoil drainage.

The inclined concave steel disk plough which set at an angle to the direction of travel, as discs rotate, scoop out furrows, invert furrows slice and pulverize thoroughly.

After the first effective rainfall (of an amount 50mm), soil samples were drawn randomly from various sites at two depths (0-15 and 15-30cm) and designated as sub sub plots, and preserved in polyethylene bags to study some soil dynamic traits comprising liquidity, plasticity, indexes shrinkage (%)and penetration resistance.

The experiment was designed as a randomized complete block design in split-split block arrangement with three replications. The mulch tillage designated as the main plots while plough types allocated in the sub plots and the soil depths in sub-sub plots.

The liquidity index, plasticity index shrinkage percentage and penetration resistance were measured in accordance to ASTM, D 423, 1986, ASTM, D424, 1986 and Black, 1965, respectively. The collected data was subjected to analysis of variance utilizing SAS, version 9 (2001), treatments mean were verified by Duncan's MRT (1955).

The physical and chemical properties as mentioned in table (1) were determined by using standard methods as outlined by (Hesse, 1971; Klute, 1986; Black and Hartage, 1986 and Loeppert and Saurez,1996)

The overall routine analysis of the farm soil is display in table 1.

RESULTS AND DISCUSSION

The results in Figure 1 revealed that mulcher tillage enhanced soil plasticity index, shrinkage percentage although it was not significant, whereas soil liquidity index was increases significantly in comparison to stubble mulch, the reverse was evident in soil penetration resistance as it was inferior in mulcher tillage. The explanation of these results is the fact that according to the Atterber Limits for soil consistency and classification of soil consistency respect to liquidity index (LI) the increasing of (LI) value from (1.09) for stubble mulch to (1.30) for mulch tillage in other words it means altering of soil condition from good consistency (very soft) for preparing good tilth for seedlings and plant growth to plastic consistency and later obtaining of bad tilth, but at same time the decreasing of penetration resistance (PR) value from (1.5) $Kgcm^{-2}$ to(1.34)$Kgcm^{-2}$ for stubble mulch and mulch tillage respectively facilitate the penetration of plant roots and seedlings and insurance favor conditions for plant growth (AL-Aani,1984; Altuntas et al., 2005).

Concerning plough types, results in Figure 2 revealed that the plough types has no significant influence on soil plasticity index (PI) and shrinkage percentage, while soil liquidity index (LI) was raised by all types of plough and the highest value was recorded due to vertical disc plough (1.41), followed by moldboard plough (1.39), chisel plough (1.21) and mulcher (1.01) in comparison with no tillage (0.98). Excluding mulch tillage within the range of very soft soil consistency which considered as goods soil tilth and this effect follow this order:

VD> MB> CP> MU (AL-Aani, 1984; Altuntas et al., 2005).

Table 1. Some physical and chemical characteristics of the farm soil.

Soil	Particle size distribution g kg^{-1}			Textural class	Bulk density Mg m^{-3}	Ec $ds.m^{-1}$	pH	$CaCO_3$ g kg^{-1}	Gypsum g kg^{-1}
Sumail vertisol	Sand	Silt	Clay	Silty clay	1.36	0.55	7.9	89.70	14.20
	38.5	513.3	448.2						

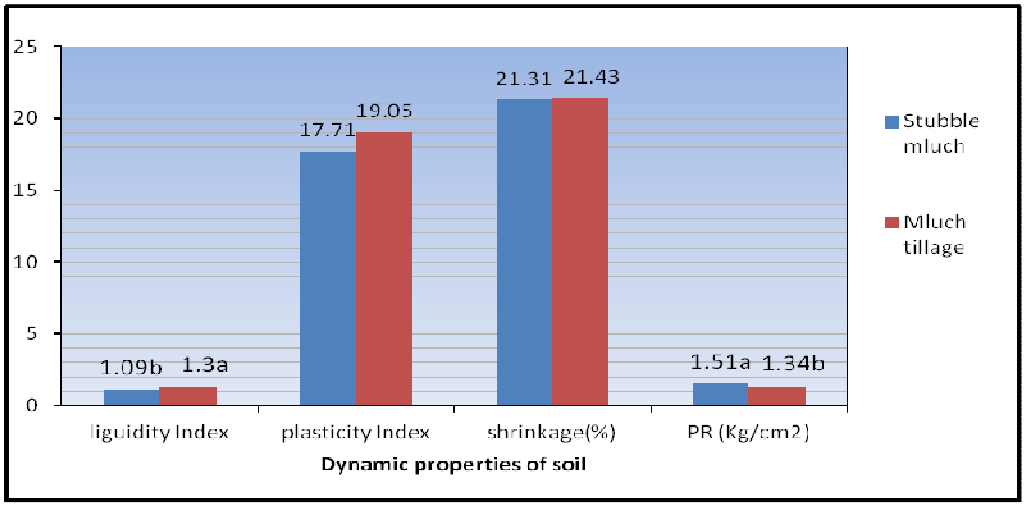

Figure 1. Effect of stubble mulch and mulch tillage (mulcher after harvest) on soil dynamic characteristics of Sumail vertisol.

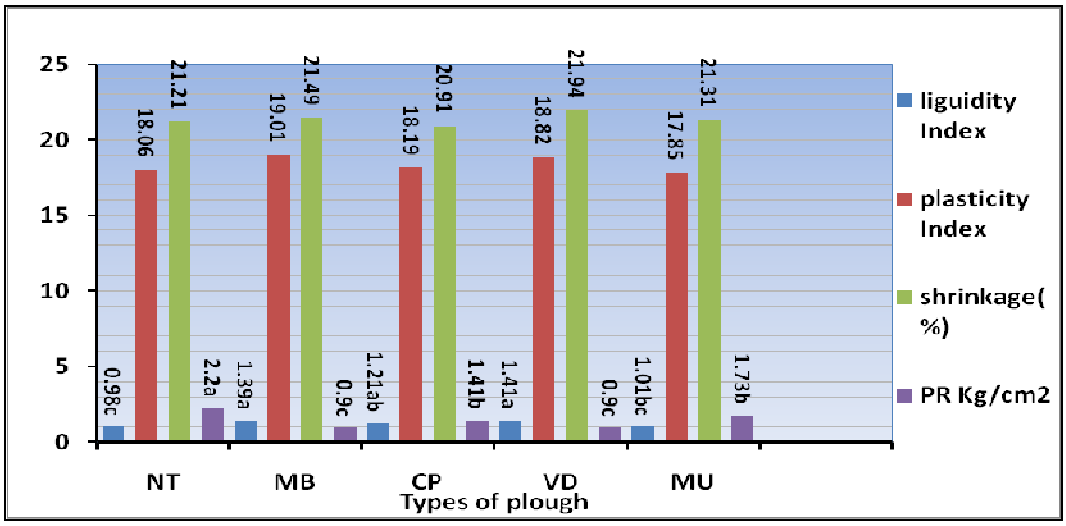

Figure 2. Effect of plough types on soil dynamic characteristics of Sumail vertisol.

And the effect of plough types on (PR) illustrate that all types of plough decreased (PR) significantly and decreased influence could arrange as the following order:

MB> VD>CP>MU

The effect of soil depth was displayed in Figure 3 indicated to declination in soil liquidity index(LI) by soil depth as it was dropped from (1.33) to (1.06)for the depth (0-15) and (15-30) cm respectively, similar trend was evident for soil plasticity index(PI) as it as it was reduced from (18.84)to (17.93) for(0-15)cm and (15-30) cm respectably. Whereas Soil shrinkage percentage was not affected by soil depth. The indexes values of liquidity and

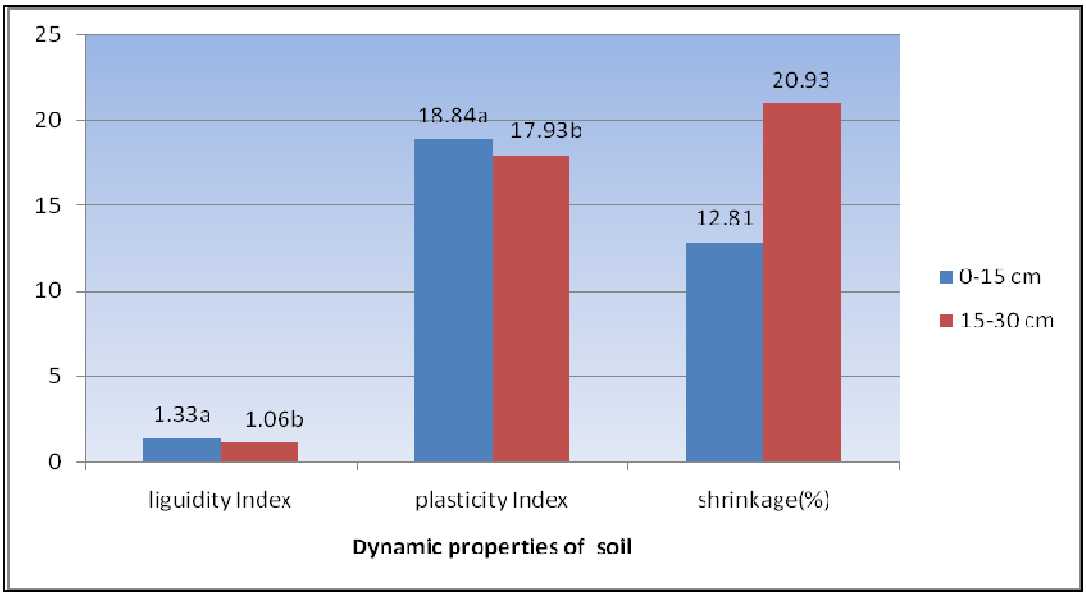

Figure 3. Effect of sample depth on soil dynamic characteristics of Sumail vertisol.

plasticity were significant reduced but it considered a desirable result and positive for soil consistency enhancement in preparing good tilth for tillage process and seedbeds preparation for (15 to 30) cm depth of soil.

The most outstanding conclusion that can be drawn from this figure is the undesirable influence of different types of plough on soil dynamic properties (LI, PI and (%) shrinkage governed just the surface layer ranged between (0-15) cm . Apart from this it can be notice a positive and desirable effect for the layer ranged between (15-30)cm, one possible illustration for acceptable effect at soil depth (15-30) cm on some dynamic properties of (LI and PI) can be explained on the basis of the fact that tillage process comprising (cutting, turning ,mixing , loosening and finally redistribution of soil particles) focused the surface layer of Sumail vertisol possessed texture of silty clay soil.

Soil liquidity index (LI), plasticity index (PI) and penetration resistance (PR) were influenced significantly by mulcher and plough types interaction. Vertical disc (VD) plough and moldboard (MB) plough with mulch tillage enhanced soil liquidity index (LI) significantly and recorded highest value (1.60 and 1.55, respectively); but mulcher worked on stubble mulch gave the least value (0.78). Similar trend was noticed for soil plasticity index (PI). The reverse was evident in soil penetration resistance (PR) as all plough with stubble mulch or mulch tillage reduced this trait in comparison to no tillage treatment. But soil shrinkage percentage was not affected by this interaction (Figure 4).

The effect of soil sample depth and plough types interaction was shown in Figure 5, all plough types gave higher value than no tillage at (0-15)cm soil depth, vertical disc plough and moldboard plough at (0-15) cm depth recorded the highest liquidity index value (1.80), meanwhile mulcher and moldboard at (15-30) cm gave the least liquidity index value (0.95 and 0.97, respectively).

With respect to soil plasticity index, all treatment combinations of plough types and soil sample depth were statistically similar excluding vertical disc plough and mulcher at 15-30cm depth which gave least values (17.77 and 17.49, respectively). While the highest values were recorded for moldboard and vertical disc plough at 0-15cm soil depth (19.99 and 19.86, respectively).

Plough types with soil sample depth interaction was also influenced soil shrinkage trait significantly, the highest value was recorded with vertical disc plough at 0-15cm (22.82), and the least with chisel plough and moldboard plough (20.46 and 20.51, respectively), meantime all the rest combinations were statistically similar.

The effect of mulch and soil sample depth was displayed in Figure 6, mulch tillage at soil depth (0-15)cm enhanced significantly soil liquidity and plasticity indexes, but the highest values were recorded for both traits at mulch tillage with 0-15cm (1.42 and 19.50, respectively). Whereas the soil shrinkage percentage was not significant, stubble mulch at the depth 15-30cm resulted in least soil liquidity and plasticity indexes. Soil shrinkage percentage was not affected by this interaction.

The second order interaction of mulch tillage, plough types and soil depth were shown in table 2 revealed that in general all treatment combinations were higher than no tillage, stubble mulch and (0-15)cm soil depth as it record the least value of liquidity index (0.60), however the moldboard plough with mulch tillage at (0-15) cm gave the highest value for soil liquidity index (1.91). Soil plasticity index recorded highest value with the combination

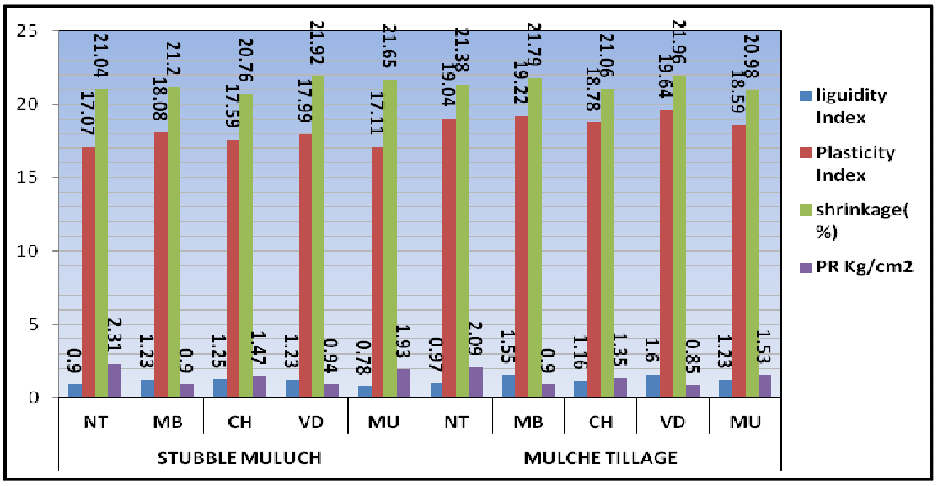

Figure 4. Effect of stubble mulch, mulch tillage and types of plough interaction on soil dynamic properties of Sumail vertisol.

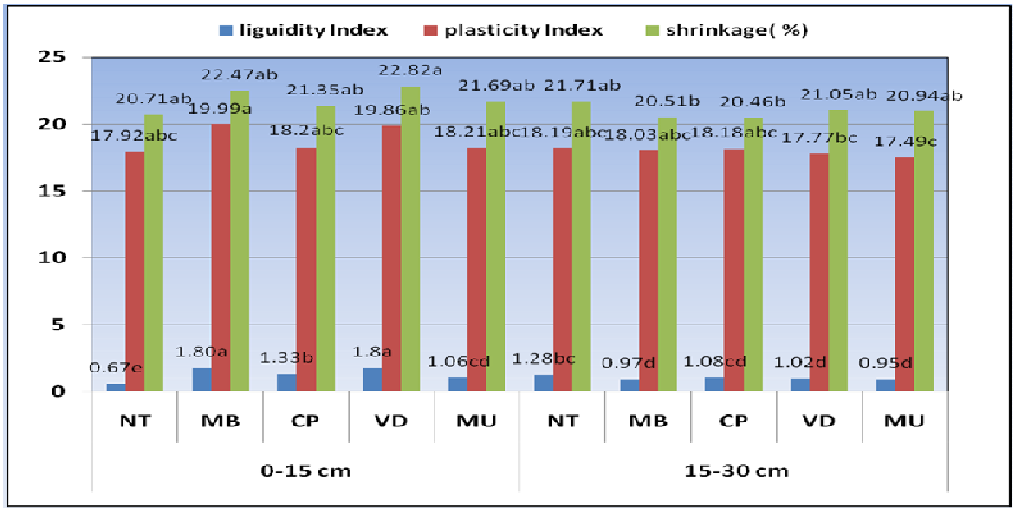

Figure 5. Effect of soil sample depth and plough types interaction on soil characteristics.

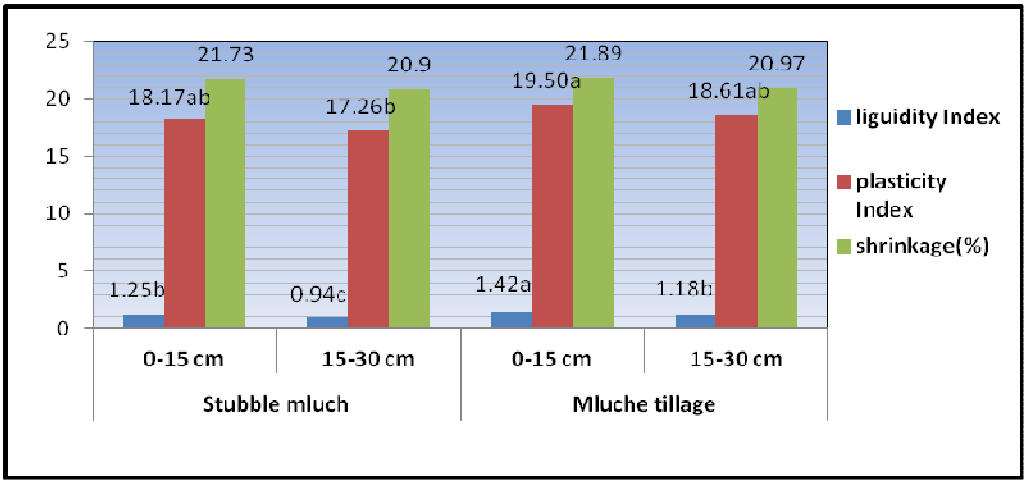

Figure 6. Effect of mulch and soil sample depth on soil dynamic characteristics of Sumail vertisol.

Table 2. Effect mulch tillage, plough types and sample depth on soil dynamic characteristics.

Characters			Liquidity index	Plasticity index	Shrinkage %
	plough	depth			
Stubble mulch	No tillage	0-15	0.60e	17.08abcd	20.58
		15-30	1.37b	17.06abcd	21.51
	Moldboard	0-15	1.70a	19.60abcd	22.10
		15-30	0.76de	18.00abcd	20.29
	Chisel plough	0-15	1.35bc	16.93bcd	21.09
		15-30	1.15bc	18.26abcd	20.43
	Vertical. disc	0-15	1.77a	19.68abc	22.86
		15-30	0.69de	16.30d	20.97
	Mulcher	0-15	0.81de	17.55abcd	22.03
		15-30	0.75de	16.67cd	21.28
Mulch tillage	No tillage	0-15	0.74de	18.77abcd	20.85
		15-30	1.20bc	19.32abcd	21.90
	Moldboard	0-15	1.91a	20.37a	22.85
		15-30	1.18bc	18.07abcd	20.73
	Chisel plough	0-15	1.32bc	19.46abcd	21.61
		15-30	1.01cd	18.11abcd	20.50
	Vertical. disc	0-15	1.83a	20.04ab	22.78
		15-30	1.36bc	19.25abcd	21.14
	Mulcher	0-15	1.30bc	18.87abcd	21.36
		15-30	1.16bc	18.31abcd	20.60

*Within each column figures shared similar letters are not different significantly at α 5%.

of mulch tillage with moldboard at 0-15cm depth (20.37), while the least value was belong to stubble mulch with vertical disc plough at 15-30cm depth (16.67). Soil shrinkage percentage was not influenced by the second order interaction.

The following conclusion can be drawn from the results that the ploughs types and mulch tillage (immediately after harvest) have a significant enhancement on soil penetration resistance in comparison with no tillage and stubble mulch in term of preparing a good soil tilth. Whereas the effect of plough types and mulch tillage recorded a contradict on characteristics values of (LI) and (PI) restrict or include just the soil depth of surface layer ranged between (0-15 cm) and under saturation conditions (After irrigations and rainfalls).

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