

Review Article

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Effects of Subsoiler on Farm Fields – A Review

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ABSTRACT

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The constraint of labour shortage resulted in modern heavy machineries which form a hard pan on agricultural field. A subsoiler plough is famous for breaking hardpan and working at higher depths. On overview of effects of subsoiler on field is studied. The subsoiler has better performance on improving soil properties such as bulk density, porosity, strength and infiltration rates. The subsoiling also has its effects on root system of plants positively. The crop yields were seen positive or no correlation on subsoiling. Among the various methods of ploughing, annual ploughing with modified tynes, winged subsoilers are performing efficiently than the conventional one. On an economic point of view, fully irrigated lands and those lands without any hardpan, subsoiling is not recommended. Many crops produced positive outcomes on subsoiling.

Introduction

Subsoiler plough is mainly used as special primary tillage equipment all over the world. Subsoiling is the process of breaking the hard pan of soil layer just beneath the top soil working depth. Due to heavy machineries working on field the soil is compacted which in turn affects the infiltration of water from the surface to subsoil. Heavy machineries and tractors are a part of a reason for soil compaction. Transplanted crop fields, no till seeding fields are prone to soil compaction. Soil compaction, a form of soil degradation, is the phenomenon which occurs when the macro pores are closed and increased bulk density, soil resistance. The other name of the subsoiling are aerating, chiselling and ripping.

It had different effects on modified designs, different crops and several other varying parameters. Subsoiling has the major advantages of decreasing the bulk density and increased water storage capacity. Modern studies progresses for reduced draft and energy requirements of the subsoiler with more soil disturbances.

Application of vibratory (oscillatory) and rotary subsoilers are preferred for lower overall demand on engine power (Simon *et al.*, 2018). Repeated traditional tillage causes excessive pulverization, increased rate of mineralization, reduced soil organic matter content and aggregate stability, and also damages the soil structure (Mwendera *et al.*, 1997; Melesse *et al.*, 2009). In India the cost

of operation in Chattisgarh plains found to be Rs.427 per ha (Ashish Kumar Kerketta *et al.*, 2018), whereas other regions of India may have slight deviations.

Effect on soil properties

When the soil compaction occurs, it affects the soil properties such as soil cone index, total porosity and dry density (Adawi *et al.*, 1996). There exists a significant negative correlation between soil compaction and water content (Ahmadi *et al.*, 2015).

Subsoiling increases soil macro porosity, air permeability and unsaturated hydraulic conductivity. And there will be a reduction in soil bulk density, penetration resistance and critical degree-of-compactness. (João Carlos Medeiros *et al.*, 2013). Also subsoiling has a significant increase on the infiltration of water (Heidari Soltanabadi *et al.*, 2008). Subsoiling increases the water and nutrients uptake (Unger *et al.*, 1981; Bennie & Botha 1986; Harrison *et al.*, 1994; Burgess *et al.*, 1998). The soil resistance on one pass and two pass subsoiling decreased by 13.3 and 26.2% respectively in the first year of study on a cotton field (Ibrahim Akinci *et al.*). Also subsoiling can prevent surface soil erosion (Wang Jinlian *et al.*, 2013).

If depth of subsoiling increases, there will be increase in resistance to upward soil movement. At and below a critical depth, soil easily moves laterally around the point, compressing the soil at the sides and the lower section of the leg.

Subsoiling can result in soil geometry of V or U, and in some cases of clay or much hardened soils, pattern may be irregular due to heavy clods. Some cases the hard pan may not break on subsoiling as a compacted layer may have weaker non compacted layers beneath.

Methods of subsoiling

Autumn season subsoiling gives better outcomes as per the earlier researches. A Danish study says subsoiling in autumn has an increased yield in seven out of nine years (Jensen *et al.*, 1971). An English study says, under the conditions of high level of fertilizer application, subsoiling in autumn has increased yield on clays and loams significantly (Russell, 1956).

Alternate zone subsoiling (AS) method is more beneficial on maize, than other methods of tillage. In China, rotary tillage in spring compared among four subsoiling methods such as bulk subsoiling in autumn (BS), annual furrow subsoiling in early summer, annual ridge subsoiling in autumn, and interannual alternate zone subsoiling method (AS). As per the results the soil bulk density was alternately changed by AS, though it had limited effect on the average water storage in the soil. Observing overall, high water-holding capacity is maintained by BS and AS. The method under varying rainfall across different years can stabilize the maize yield. Under AS subsoiling method maize had a higher water-use efficiency and relatively higher production capacity comparing those other three types of subsoiling methods.

When soil disturbance is minimal, then the effects of subsoiling are less persistent (Sporr *et al.*, 1978). The effects of subsoiling will be lasting for 2 to 2.5 years on soil properties except the top soil which may compact soon (Drewry *et al.*, 2010)

Studying the field traffic effect on the physical conditions of the soil, among other tillage systems into wheat residue stubble, best soil condition resulted is conservation tillage practice of in-row subsoiling and planting, as the practice produced the deepest hardpan depth and the lowest cone index

(Raper *et al.*, 1998). In a sandy loam soil of Georgia, effect of in row subsoiling is found to increase grain yields significantly (10% increase) whereas irrigation effect was more in yield (56%) (Box and Langdale, 1984). Also subsoiling is not suitable on wet soil, which increases the wheel slip more than 25%. (Ashish Kumar Kerketta *et al.*, 2018).

Annual subsoiling resulted in reduced bulk density and lower cone index compared to biennial subsoiling, triennial subsoiling, or no subsoiling (Raper *et al.*, 2005).

Depth of ploughing holds a major role on deciding soil property changes. Soil bulk density and porosity of the some soils, differed due to depth of tillage. Experimentally, subsoiling at 35 cm depth was the optimum method to increase maize yield of maize and modulate physical properties of the soil in the North China Plain (Shaobo Wang *et al.*, 2019). Subsoiling with modified tynes produces the highest depth, soil volume disturbances and also higher tractive efficiency than conventional tynes (Hussain Th. Tahir *et al.*, 2018). However in other cases, the depth of tillage required disrupting compacted soil profiles, measurements such as multiple cone-index were needed. In dry land conditions, subsoiling at 45° is superior to other methods of tillage (Michael P. Pop *et al.*, 2001).

With *fanya juus* in Ethiopia, higher tillage depths, infiltration rate, cumulative infiltration, better moisture retention and low soil evaporation were observed by winged subsoiler over traditional tillage but slightly higher dry bulk density observed in the traditional tillage (Desale Kidane Asmamaw *et al.*, 2012).

In addition, winged subsoilers had been found to reduce surface runoff volume that involves repeated passes (Mickelson *et al.*,

2001). Subsoilers with a combination of rotary tillers in a single unit are found satisfactory, (Zhao Wei *et al.*, 2013). Vibrating subsoilers are also worked out and recommended (YunXia Wang *et al.*, 2019).

Effects on roots

There was an improved root parameters such as density, depth, and length on subsoiling. Using Paraplow (type of subsoiler with slanted legs on 45 degree), the root density of spring barley was increased significantly within the horizon (Hippis *et al.*, 1987). Subsoiling increases the depth of roots and in turn helps to withstand conditions of short term droughts. (Meredith *et al.*, 1961; Cooper *et al.*, 1969; Campbell *et al.*, 1974; Raper *et al.*, 1998). Length of the roots may increase by 13% on effect of subsoiling (Xiaomin Feng *et al.*, 2018).

Soil compactness has no direct effects on root development. But there exists an indirect effect on soil physical properties which includes porosity, volumetric water content, gaseous diffusion and hydraulic conductivity of the soil. Even the root development altered by changes in soil compactness exists, the growth of plants above the ground may be normal under the conditions of sufficient water and nutrients available to plants (Taylor *et al.*, 1991). Under artificial soil compaction studies on laboratory, the root penetration decreased (Meredith *et al.*, 1961).

Studies found that productive moisture accumulated in the soil loosened deeply is higher; especially in the subsoil. But the bulk density of subsoil decreased only when grown crops are long-rooted after subsoiling (Velykis, 2000). During a dry summer period following subsoiling, pasture dry matter production was reduced significantly. This was due to the root disturbances and moisture stress (Drewry *et al.*, 2010).

Effects on crops yield

Subsoiling may increase nitrogen availability thereby a positive effect on crop growth (Christian Bugge Henriksen *et al.*, 2004).

In short duration drought period, subsoiling can increase corn yield (Robertson *et al.*, 1957). Later say was depending on water supply, positive results have been demonstrated in corn (Reeves *et al.*, 1986; Beck *et al.*, 1992; Gameda *et al.*, 1994; Adawi *et al.*, 1996). Comparing rotary tillage, subsoiling tillage has increased maize yield (6.3%) (Xiaomin Feng *et al.*, 2018).

In an old established citrus orchard, subsoiling between the plant lines alters the soil physical and hydric properties. These effects of soil physical and hydric properties were related to increased fruit number and yield of the citrus orchard. There found a 31 % increase in fruit mass.

In coastal regions, subsoiling cotton fields are necessary (D. Wayne Reeves 1995). Other research says, in a cotton farm, in-row subsoiling had 22% increased yield under sandy loam soil (Mullins *et al.*, 1997). But applying one pass and two pass subsoiling, in a fully irrigated condition of a cotton (*Gossypium hirsutum L.*) field, the crop yield increased slightly which is insignificant statistically (Ibrahim Akinci *et al.*). Later it was found there was no improvement in cotton yield due to subsoiling (Busscher *et al.*, 2003; Raper *et al.*, 2005).

In Iran, irrigated sunflower field on subsoiling has no effect on yield of sunflower (Heidari Soltanabadi *et al.*, 2008).

German study says that subsoiling in autumn had increased potato yield up to 14 pct (Häge 1996). On growing seasons, inter-row subsoiling in potatoes has found to slightly

decrease yield previously (Friessleben, 1981). Later studies shown that subsoiling significantly reduced the percentage of malformed potatoes on an average. (Christian Bugge Henriksen *et al.*, 2004). Subsoiling with straw mulch is superior to other tillage methods for potato (Xianqing Hou *et al.*, 2018).

Subsoiling favoured the scattered sowing of wheat under other some conditions. (Kestutis Romaneckas *et al.*, 2016). With or without surface tillage, subsoiling is beneficial in wheat (Hunt *et al.*, 2004).

Sugarcane grown with cross subsoiling at 1.0 in distance recorded higher cane and CCS yield significantly, which was 24.86 and 31.72 % higher comparing no subsoiling treatment (Chaudhari *et al.*, 2018)

Pea yield has been increased up to 34% by subsoiling, under irrigated condition, and by 18-43% in dryland conditions (Greenwood *et al.*, 1990).

Studying the compaction and subsoiling effects on soybean yields, subsoiling the compacted plots, compaction effect was removed, and there is an substantial improvement on crop yield (Adawi *et al.*, 1996).

Subsoiling delays leaf senescence after anthesis, also maintains greater green leaf area and capacity of photosynthesis, which helps promoting post-anthesis DMA and grain filling (Xuefang Sun *et al.*, 2017). Some studies reveals that rainfall has effect on crop yield, but subsoiling has no effect in crops such as corn, cotton, tobacco (Vepraskas *et al.*, 1992).

In conclusion from the scientific works carried on subsoiler and its effects following points may be concluded. Subsoiler holds

good at breaking the hard pan and improves soil properties, under the conditions of dry and compacted soils. Root characteristics are altered positively as a result of improved soil properties. Most of the crops gives positive yield on subsoiling except the few crops, under full irrigation which has shown no correlation with subsoiling. In wet soils and soil with no compaction, subsoiling is not recommended in economical point of view. Also there may be a failure of subsoiling operation occurs on certain soil conditions and geometry. Winged and modified tynes shows superior performance compared with conventional tynes. Autumn season subsoiling, in row method of subsoiling, alternate zone subsoiling are the yield promising way of subsoiling. Increased water infiltration rate, reduced runoff and soil erosion are the advantages on the environmental point of view.

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