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Original Article

# Impact of Plowing on Some Soil Physical Properties under Hybrid Seed Corn Production

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**Abstract**

Corn hybrids were first commercially grown in the early 1930s and by 1945, appreciatively 90% of the corn in the U.S. represented hybrids meanwhile in Romania the first hybrids has been cultivated since 1957. One of the biggest problems in seed production technology is the large ruts that are left by detasseling machines used in muddy conditions. Successful corn seed production requires a much higher level of management skill and is far more labor and time consuming than corn grain production. This report summarizes just a single separate trial, with the main objective to investigate under field conditions the soil physical properties impact of 30 cm deep ploughing and three years continuous corn seed production technology, in Bivolari area, somewhere in the north-eastern part of Romania, 47$^{o}$29.191' N latitude and 27$^{o}$25.033' E longitude, on Prut river basin. Once at every three or four years subsoiling (deep ripping) was carried out to a depth of 50 cm. The field was laid out at 144 m elevation, on a clay-loamy textured cambic chernozem, with 3.12 % humus content and 36% clay, under a precision irrigation system from Valley. The majority of data in this study was collected between 2011 and 2012 and makes references to soil physics parameters. The field has been established on a fertile land with well drained soils and favorable conditions of temperature and moisture, to reduce stress and maximize yield potential and grain quality, most proper conditions for seed production.

***Keywords:*** compaction, tillage, corn hybrids.

## 1. Introduction

Corn (*Zea mays* L.) in Romania is one of the main agricultural crops with a great economical importance and it's the world's most widely grown cereal. Corn production has been increasing for 500 years since Columbus. The human selection was very important in forming new varieties.Corn hybrids were first commercially grown in the early 1930s and by 1945, appreciatively 90% of the corn in the U.S. represented hybrids meanwhile in Romania the first hybrids has been cultivated since 1957. Seed corn companies have grown larger, better, and fewer over time.

One of the biggest problems in seed production technology is the large ruts that are left by detasseling machines used in muddy conditions. These ruts destroy soil structure, increase tillage requirements, increase erosion, result in major yield reduction in the corn crop and possibly in the crop the following year as well, and result in damage to harvesting and tillage machinery [3, 5, 10, 11, 14].

Hybrid corn generates high yields, increased value and reduced production costs with bigger plants, more vigorous and stronger, increased resistance to diseases and enhanced agronomic characteristics compared with the parental lines [2].

Successful corn seed production requires a much higher level of management skill and is far more labor and time consuming than corn grain production. The "best" management practices recommended for use in normal crop production become especially important in seed production [13].

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Controlling weeds, insect pests, and diseases has become an integral part of seed production [8]. Since inbreds are less competitive than hybrid maize with broad leaf weeds and grasses, seed growers rely heavily on herbicide applications to minimize weed pressure. Above and belowground insecticide applications (seed, pre-, and post-application) are regarded as a necessity by many producers.

This paper seeks to review the current knowledge on soil management practices under conventional tillage in hybrids corn seed production.

This report summarizes just a single separate trial, with the main objective to investigate under field conditions the soil physical properties impact of 30 cm deep ploughing and three years continuous corn seed production technology, in Bivolari area, somewhere in the north-eastern part of Romania, 47°29.191' N latitude and 27°25.033' E longitude, on Prut river basin. Once at every three or four years subsoiling (deep ripping) was carried out to a depth of 50 cm. The field was laid out at 144 m elevation, on a clay-loamy textured cambic chernozem, with 3.12 % humus content and 36% clay, under a precision irrigation system from Valley. The majority of data in this study was collected between 2011 and 2012.

The field has been established on a fertile land with well drained soils and favorable conditions of temperature and moisture, to reduce stress and maximize yield potential and grain quality, most proper conditions for seed production

The climate is of temperate-continental type, long-term amount of precipitation at this site reaches 517.8 mm at an average air temperature of 9.4°C, but significant deviations from the long term average and temperature have been observed in recent years. Average air temperature and amount of precipitations were recorded at Iasi meteorological station. Total precipitation varied considerable in the experimental years, as follows: 444.4 mm in 2010/2011 and 498.0 mm in 2011/2012, 19 mm below the normal values. The annual average temperature fluctuated less, with 10.8°C in the first year was and 10.6 °C in the second year.

Corn remains on the same plot for three years, in continuous cropping system. In each year, after corn was harvested all residues were incorporated into the soil by moldboard plowing in the fall.

Common planting pattern for Dekalb - Monsanto hybrids include "narrow rows" 6:2, in alternating strips of six rows of female parent at 60 cm and to two rows of male parent at 40 cm between rows, planting of the female and male parents on different dates to optimize the synchronization of pollen shed and silking of the two seed parents, following the same wheel tracks as closely as possible. From this pattern resulted 100000 – 105000 female plants/ha and 30000 male plants/ha. Sometimes, the proper timing of planting parents with different flowering dates can cause problems. The interval between planting dates may be 1 or 2 weeks in this situation problems in tillage may arise. At corn planting, starter fertilizer was applied each year

Control of weeds by chemicals in such instances was also used.

The recommended schedule of irrigation was: 13-15 days, 30-35 days, 45-55 days and 65-80 days after planting.

For preparing the seed-bed, cutting the weeds, breaking the soil clods and leveling the field, a cultivator has been used, with a day before plating the female form.

As the reason of plants differ in time of tasseling, the time in which the field was detasseled varied from 4 to 7 days. To remove the tassel of the seed parent to prevent self-pollination was used mechanically machines and labor, resulting in major plant injury with accompanying lower seed yields. The workers must patrol each row four to seven times during the season. Yield reduction due to detasseling has been estimated to range from 1.5% to 13.5% for hand detasseling and 2%-45% for mechanical detasseling [16].

Harvesting has begun at 35 to 38-percent moisture, reducing the risk that part of the seeds may be damaged in germination from severe early freezes. The pickers (harvesting machines) was an six rows **OXBO**, which removes ear from stalk and places ear with attached kernels in a dump. The weight of the picker is 14 tones without header and empty dump.

Soil penetration resistance was measured in vegetation and right after harvesting, when soils were near field capacity. Because soil PR depends on soil moisture, we measured soil moisture gravimetrically from 6 locations in same depth increments. Soils were weighed wet then dried for 10 hr at 105°C and weighed again.

Undisturbed and disturbed soil samples were collected form vegetation period (*veg.*) and harvesting (*harv.*) to determine physical properties; three soil samples were taken from the crop inter-row, from the layers 0-10, 10-20 and 20-30 cm.

## 3. Results and Discussions

Crops used in rotation with corn vary regionally, but there has been an increase in the number of fields that have a corn-to-corn rotation, as opposed to rotation to another crop [4]. In some areas, the corn-to-corn rotation requires increased levels of fertilizer inputs [12]. Insect pests may also increase in corn-to-corn rotations as this system may provide a continual host environment for some insects and diseases.

It is well known that the "parents" are less vigorous than hybrids, than we took grater care at the seed-bed preparation, to provide optimum germinating conditions for the seeds. This usually means that the soil is **tilled more frequently**, possibly resulting in more carbon loss and exposing the soil to the possibility of increased erosion, higher traficabillity with all the negative consequences, increasing bulk density, increasing PR, soil structure alteration.

The soil structure is one of very important soil properties and depends on the capability of soil particles to aggregate or disaggregate and create structural aggregates. Kemper W.D [9] indicated that suitable values of water-stable aggregates (WSA) Ø > 0.25 mm (with the diameter between 1-2 mm) at 2-4% organic mater and 30-40% clay content are between 74-78%. Analyzing each layer we observed lower values WSA at soil surface indicating the degradation of soils. In 2011 on 0-10 cm depth the WSA was 71.21% and in 2012 was 69.87%. This is a problem caused by the high number of passes of heavy machinery on the soil surface and detasseling operation, absolutely necessary, but at an unsuitable soil moisture condition. This can deteriorate the soil quality and the productive capacity. Under 10 cm depth we can conclude that the indicator value is at an optimal level (table 1). Bulk density (BD) is an indicator of soil compaction. In most of the cases under humid conditions compaction decreases yields, and sometimes is beneficial under arid conditions, restricting water movement through the soil profile. The highest values of BD were reached on 20-30 cm layer at harvesting, 1.50 g/cm$^3$ in 2011 an 1.52 g/cm$^3$ in 2012. For the clay-loamy soil de optimum values are under 1.4 g/cm$^3$ and valued that may affect root growth are >1.6 g/cm$^3$; the reference bulk density is highly correlated to the clay content. Also an increasing from vegetation to harvesting has been observed, form 1.25 to 1.32 g/cm$^3$ on soil surface and from 1.37 to 1.43 g/cm$^3$ on 10-20 cm layer in 2011. In the production of seed corn, when detasseling is required, severe damage to the soil structure can occur from the use of detasseler carriers and mechanical detasselers under wet soil conditions, resulting in poor water drainage, increased root damage and ineffective nutrient uptake resulting in lower seed yields [3,10].

**Table 1**. The influence of ploughing on soil physical characteristics in corn seed production

| Year | Depth (cm) | Bulk density (g/cm$^3$) | | Total porosity (% v/v) | | Compaction degree (% v/v) | | Water stable aggregates | |
|---|---|---|---|---|---|---|---|---|---|
| | | Veg. | Harv. | Veg. | Harv. | Veg. | Harv. | Veg. | Harv. |
| 2011 | 0-10 | 1.26 | 1.32 | 52.45 | 50.19 | -3.12 | 1.34 | 71.21 | 72.36 |
| | 10-20 | 1.37 | 1.43 | 48.30 | 46.04 | 5.04 | 9.50 | 75.00 | 77.02 |
| | 20-30 | 1.40 | 1.50 | 47.17 | 43.40 | 7.27 | 14.69 | 76.12 | 78.06 |
| | Mean | 1.34 | 1.42 | 49.31 | 46.54 | 3.07 | 8.51 | 74.11 | 75.81 |
| 2012 | 0-10 | 1.28 | 1.35 | 51.70 | 49.06 | -1.63 | 3.56 | 69.87 | 70.04 |
| | 10-20 | 1.37 | 1.42 | 48.30 | 46.42 | 5.04 | 8.75 | 74.60 | 76.31 |
| | 20-30 | 1.43 | 1.52 | 46.04 | 42.64 | 9.50 | 16.17 | 77.00 | 77.40 |
| | Mean | 1.36 | 1.43 | 48.68 | 46.04 | 4.30 | 9.50 | 73.82 | 74.58 |

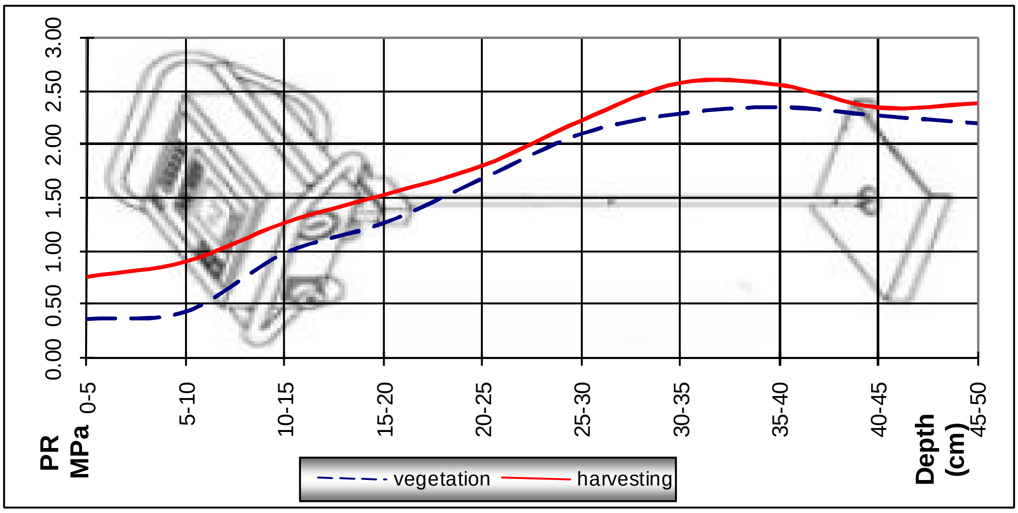


**Figure 1**. Soil Penetration Resistance on corn seed production (mean values on vegetation and harvesting on 2011 and 2012)

Soil compaction is a complex function of soil texture, moisture, grazing intensity, vegetation composition and climate [15]. Penetration resistance is widely measured because it provides an easy and rapid method of assessing soil strength. Soil penetration resistance at different depths in response to tillage, on vegetation and right after the harvesting, when the soil water content was nearly at field capacity, is shown in figure 1. PR increased with depth and from vegetation to harvesting. Analyzing the growing period we observed high values under 30 cm depth, indicating the existence of hardpan. Crops roots growth can be depressed when soil bulk density reaches 1.5 g/cm$^3$ [7] and PR overpasses a threshold of 2.5–3.0 MPa [6]. In our field these limits were easily exceeded in.Indirect effects of detasseling, such as soil compaction, could also impact the subsurface soil environment. The corn root system is closely associated with several microbial groups such as bacteria, fungi, protozoa, and mites [1] and probably modifies the ecology because of these associations.One of the biggest problems in seed production technology is the large ruts that are left by detasseling machines used in muddy conditions. These ruts destroy soil structure, increase tillage requirements, increase erosion, result in major yield reduction in the corn crop and possibly in the crop the following year as well, and result in damage to harvesting and tillage machinery [3, 5, 10, 11, 14].

## 4. Conclusions

Soil compaction is best measured using both PR and BD, correlated with soil moisture measured simultaneously. Specific climatic conditions of each year influenced the soil properties.

The results of this study suggest that after three years of continuous corn crop the soil physical properties is negatively modifying but not alarming.

A slowly increase in bulk density values is not necessarily bad to crop growth, because at certain limits this increase can contribute to soil water storage With higher soil tillage intensity and detasseling machines used in muddy conditions the stability of soil aggregates get lower.

The high tonnage of the harvesting machine has varying effects on the intensity, layer, and thickness of soil compacted, depending on soil texture and soil humidity at the time of harvest.

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