

Influence of skidding in two mechanized tillage systems for quinoa cultivation

Influencia del patinaje en dos sistemas de labranza mecanizada para el cultivo de quinua

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Abstract: The mechanized tillage systems of agricultural soils for the cultivation of quinoa in the central Ecuadorian highlands are influenced by several factors, among them: the skidding that occurs in soil tillage, with different implements used both in conventional tillage and in minimum or reduced tillage, in plowing, harrowing, furrowing, which are executed for the cultivation of quinoa, without considering the slope, humidity, soil compaction and the increase in cost and time. The objective of the study was to determine the percentage of skidding in sandy textured soils for quinoa cultivation, with slope ranges from 5 to 12% with moisture contents from 13 to 18% under conventional and minimum or reduced tillage systems in plowing, harrowing, furrowing, using disk plow, chisel plow, disk harrow, furrower coupled to an agricultural tractor of 95 KW of power with assisted traction.

Keywords: skidding, ploughing, compacting

Resumen: En los sistemas de labranza mecanizada de suelos agrícolas para el cultivo de quinua en la sierra central ecuatoriana influyen varios factores entre ellos: el patinaje que se produce en el laboreo del suelo, con diferentes aperos utilizados tanto en labranza convencional como en labranza mínima o reducida, en labores de arada, rastrillada, surcada, que se ejecuta para el cultivo de quinua, sin considerar la pendiente, humedad, compactación del suelo y el incremento de costo y tiempo. El objetivo del estudio fue determinar el porcentaje de patinaje en suelos de textura arenosa para cultivo de quinua, con rangos de pendiente de 5 a 12% con contenidos de humedad de 13 al 18% bajo sistemas de labranza convencional y mínima o reducida en labores de arada, rastrillada, surcada, utilizando arado de discos, arado cincel, rastra de discos, surcador acoplados a un tractor agrícola de 95 KW de potencia con tracción asistida.

Palabras clave: patinaje, labranza, compactación

Introduction

In the central highlands of Ecuador, soil preparation for quinoa cultivation is carried out by applying conventional and minimum tillage systems, using different implements that cause soil compaction for agricultural crops, with machinery traffic having the greatest impact. The influence of agricultural machinery on compaction is expressed through the action of: pressure on the soil, weight on the rolling systems, number of passes, travel speed and slip; which act on the prevailing conditions on the ground the state of compactness of the plow layer; the slip should be between 5 and 15%, and when it exceeds 15% damage occurs on the soil surface, increases fuel consumption.

The available power is considerably reduced when wheel slip is below the recommended minimum. The ideal slip percentage varies from 8 to 15 % depending on the type of tractor traction (Gómez-Calderón V.-M. S.-Q., 2016).

When a volume of soil is subjected to the stresses caused by the traffic of agricultural machinery and these exceed the internal resistance of the soil, compaction occurs, which has a cumulative character. It extends from the surface to the subsoil. Surface compaction originates up to a depth of 0.3 m, in the arable layer, and subsoil or subsurface compaction occurs at depths greater than the arable layer (Alakukku et al., 2003) cited by (Omar González Cueto, 2010).

The effect of skidding on compaction is manifested through the increase in the length of the contact area and by the shear stress on the soil. Tractor skidding compacts only a thin layer of surface soil up to 0.05 m, its greatest effect is seen from 20 to 30% of skidding, decreasing the pressure on the soil of the vehicle. With skidding higher than 30% the volume density decreases because the wheel digs the soil and throws back the soil, they recommend a maximum skidding of 10%, to avoid damage to the surface layer and the subsoil due to the shear stress of the tire (Omar González Cueto C. E., 2009).

It has been proven that surface compaction is produced by the pressure in the wheel-soil contact zone, but subsurface compaction is produced by the entire weight of the equipment (V. Gasso, 2013); therefore if the weight of an axle does not exceed 49 kN, it will only compact the first 30 cm of the soil profile. (A. M. Terminiello, 2000) This is how the

traffic of the wheels of the equipment used under the RTF system impacts soil compaction. This system consists of passing machinery over the crop field, often intensively, where the decision of the sequence and frequency of operations is made by the producer, causing soil destructuring and reducing its effective porosity.

It has been indicated that in order to conserve the soil efficiently, the number of passes of agricultural machinery over the field should be reduced (B. P. Cadena, 2012). Hence the importance of an adequate selection of equipment (in terms of topography, soil, crop and machinery performance) to avoid repetitive passes of equipment over the same work area with machinery unsuitable for the operating conditions (M. Kroulík, 2011).

Under normal operating conditions of agricultural machinery, when four-wheel drive is used, the power transmission at the rear wheel is more efficient than at the front wheel, but the amount of power developed by the rear axle is less than that at the front due to load differences at the rear and front axles (J. M. Serrano, 2009).

Compaction affects crop development and production; the bulk density of a sandy loam soil is between 1.5 to 1.7 g/cm³ USDA (2000).

Quinoa is an Andean crop of high nutritional value that is in high demand in the domestic and international markets. The technology used in cultivation varies from traditional to highly technical, with an emphasis on soil conservation (Emilio Pinedo Taco, Alberto Marcial Julca Otiniano, 2020).

The chisel plow is an equipment of massive use in agriculture, which has come to satisfy the need to break and remove the soil, without inverting it, at depths between 20 to 35 cm, the minimum or reduced tillage system seeks to reduce soil loss, reduce compaction, conserve moisture, reducing the number of passes, using vertical working equipment such as the chisel plow, the chisel plow works at a speed of 4 to 6 km / hour (Jorge Riquelme S.).

The disc plow used in conventional tillage performs a horizontal cutting and turning action of the soil and can work at a speed range of 5 to 8 km/hour; the disc harrow is a secondary work implement that allows breaking up the soil and chopping stubble, it works at a speed of 5 to 10 km/hour depending on its type; the furrower has the purpose of tracing

furrows and its working speed is 4 to 6 km/hour (JAIME ORTIZ-CAÑAVATE PUIGMAURI, 2012).

Conventional or traditional tillage involves the intensive use of disc implements such as harrows, rakes and polishers that seek to remove the soil surface. The number of passes ranges from 4 to 8, which can cause annual soil losses of 10 t/ha, compaction and soil degradation (Colombiano, 2021).

Materials and methods

The research was carried out in the field in the community of Tunshi in the canton of Riobamba, province of Chimborazo, Ecuador, located at the following coordinates: latitude 1o 45'20"N, longitude 78o 38'20", altitude 2829m.a.s.l. (Figure 1). m (figure 1) with an average annual temperature of 15oC, average rainfall of 650 mm, relative humidity of 68%, the soil belongs to the Inceptisol order with slightly undulating topography, slope of 5 to 12%, sandy loam texture, humidity of 5 to 18%, the previous crops were corn, peas, barley, potato. A 10000m² lot was used in DBCA design with 3 replications in which conventional tillage systems were applied with disc plow, disc harrow and furrower and in minimum tillage with chisel plow and furrower coupled to an agricultural tractor of 95 Hp power assisted traction (figure 2). The travel time, the travel distance in 10 turns of the driving wheel, the percentage of skidding was calculated for the two tillage systems with each implement. In addition, the resistance to cutting was determined with the penetrometer and the infiltration velocity using the double ring meter infiltrator.

The following formula was used to determine the slip:

$\% \text{ Skid} = (D_{sc} - D_{cc})/D_{sc} \times 100$ (1) where : D_{sc} = unloaded displacement in (m);

D_{cc} = displacement with load (m)

The displacement is considered as 10 turns of the driving wheel.

Figure 1. Map of Tunshi community

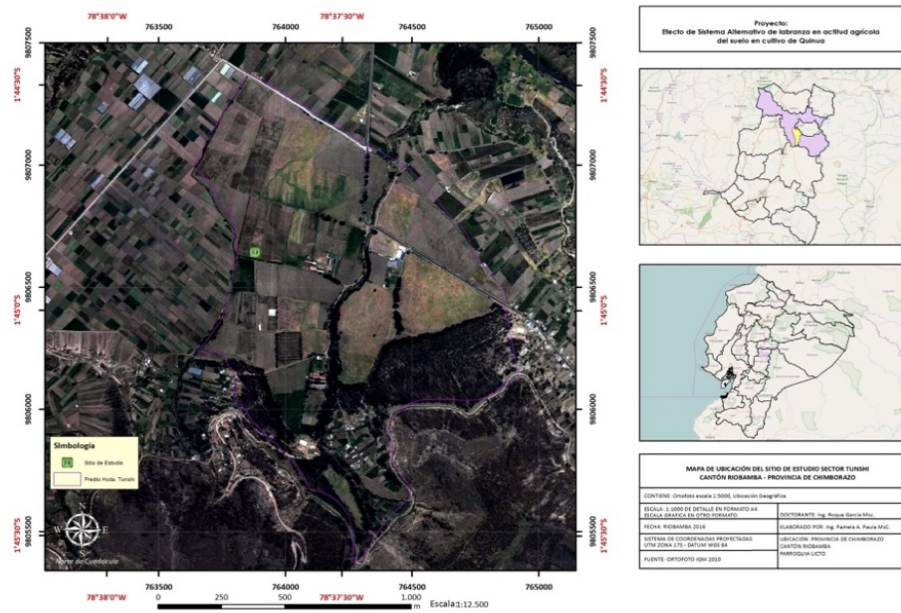


Figure 2. Equipment and implements used in the investigation





3. Result

In mechanized soil preparation for quinoa cultivation in the central highlands of Ecuador, conventional tillage and minimum tillage systems are used with different types of implements and number of passes in the same plot in each case, as shown in Table 1, and Table 2 shows the percentage of skidding that occurs in the drive wheels and in the steered wheels during the 10 turns of the same in each plot.

Table 1. *Tillage systems and implements used*

Sistemas de labranza	Aperos
Labranza convencional	Arado de discos, rastra de discos , surcador
Labranza mínima	Arado cincel y surcador

Table 2. *Percentage of skidding on drive and steer wheels for each implement, speed and working depth*

Sistema de labranza	Apero	% Patinaje rueda motriz	% patinaje rueda directriz	Velocidad Trabajo Km/h	Profundidad de labor (m)
	Arado de discos (4)	7,44 a 15,9	6,43 a 9,5	6	0,30

Labranza convencional	Rastra de disco de tiro excéntrico (16)	7,63 a 12,89	5,78 a 9,5	8	0,15
	Surcador trisurco	7,44 a 9,89	6,19 a 6,9	5	0,25
Labranza mínima	Arado cincel	5,45 a 7	3,2 a 3,7	5	0,30
	Surcador trisurco	3,1 a 4,3	2,2 a 3,5	5	0,25

The disk plow used in the conventional tillage system presents a slip percentage of 15.9% in the driving wheel, being the primary tillage implement that in the present trial has the highest value compared to the chisel plow used in minimum tillage, which presents 7% slip; the other implements for complementary tillage present lower values as can be seen in Table 2.

Soil compaction occurs when pressure or load is applied to the soil surface, as a result of trampling by animals and people, inadequate use of equipment such as tractors, especially when the soil is wet, depending on the tillage system, the implement applied in each task, which produces different percentages of slippage.

The percentage of skidding of the driving wheel in soils of sandy to sandy loam texture should not exceed 15% when this happens the traction is inefficient, soil moisture and shear strength in Kpa in soils of the Tunshi community, presents statistical differences for tillage systems with an average of 8.93 Kpa and a Coefficient of Variation of 5.78%.

This is explained by the action of the horizontal rototilling implements caused by implements such as the disk plow, disk harrow that influence the first 0.25 m of the soil, used in conventional tillage; while the application of vertical rototilling implements such as the chisel plow, allows a good aeration and loosening of the soil at greater depth, which is achieved with alternative tillage, preserving the agricultural aptitude of the soil, avoiding degradation, which in the end can be manifested in the crop yield.

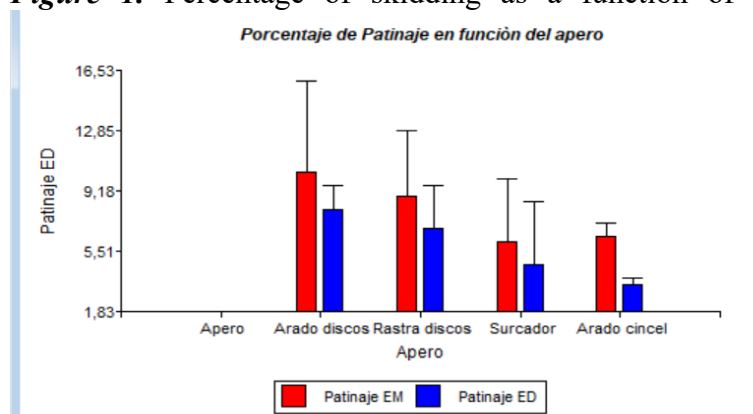
The tillage system influences soil compaction to the extent of the intensity of tillage, this compaction in turn influences the root growth of quinoa, the development of the plant, and finally the yield.

Penetration resistance is a good index to evaluate problems of restriction in the root development of plants, due to the presence of compacted layers and/or low porosity. Soil penetrability is a measure of the ease with which an object can be introduced into the soil, i.e., the mechanical resistance of the soil to lateral expansion and shearing produced by the object.

This resistance is not a particular property of the material, but is the sum of the effects of different characteristics and properties, such as bulk density, moisture content, resistance to penetration and shear, which in turn, are a consequence of the particle size distribution, structure, and mineral and organic composition present in the soil.

Compaction causes changes by altering physical properties such as porosity and bulk density, which in turn reduces the rate of water infiltration and the availability of air for root growth. The resistance of a soil to penetration by a probing instrument is an integrated index of soil compaction, moisture content, texture and clay type. It is an index of soil resistance. It is a determination involving soil consistency and structure. The instrument used to determine it is called penetrometer or penetrometer and measures the force needed to penetrate the soil with a probe.

Figure 1. Percentage of skidding as a function of the aperture



4. Conclusions

The tillage system and the implement used in soil preparation for quinoa cultivation influence the percentage of slippage that occurs, above the limit of 15%, which affects the agricultural suitability and quality of the soil in the Tunshi community, affecting its physical properties; while the application of minimum tillage, with the chisel plow, favors the conservation of the agricultural suitability of the soil.

The use of disc implements in conventional tillage system can change the soil structure after some time, due to the effect of the horizontal cut with inversion of the soil that is produced.

The application of minimum tillage system with the use of chisel plow tends to conserve the physical properties of the soil such as: bulk density, porosity, soil moisture, infiltration rate, temperature, while the use of implements under the conventional system alters the values in the case of this sandy loam soil, moving away from ideal conditions for cultivation with the consequent low yield of quinoa crop.

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