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# INFLUENCE OF TILLAGE ON SOME PROPERTIES HYDROPHYSIC OF SOIL AND NUTRIENT EXTRACTION BY WHEAT (*Triticum durum* L.)

## Influencia del laboreo en algunas propiedades hidrofísicas del suelo y en la extracción de nutrientes por el trigo (*Triticum durum* L.)

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**ABSTRACT**. The intensive use of agricultural machinery has been one of the reasons that caused degradation soil, that's why this investigation was conducted in order to evaluate the responses caused by different tillage systems on some hydro soil properties and in the extraction of nutrients for growing wheat (*Triticum durum* L.) in experimental plots of the Institute of Natural Resources and Agrobiology fromSeville, Spain. For the study, a sample design was used. The treatments were: conventional tillage (CT) and conservation (LC) in experimental plots and long-term no-till (NT) and new traditional tillage (NTT) in short duration, on plots of 240 $m^2$ and 140 m2, respectively, in Fluvisol soil. The pilot phase bulk density and water content in the soil were evaluated. Besides the extraction of nutrients by the crop foliage, grain and yield were determined. The results showed significant differences among treatments in the extraction of N, P and K in different parts of plant assessed, highlighting the CT with higher extraction of nutrients for growing and higher performance, the most appropriate, considering the environmental benefits of the same.

*Key words*: tillage, yield, density, soil moisture, nutrition

**RESUMEN.** El uso intensivo de la maquinaria agrícola ha sido una de las causas que ha provocado la degradación de los suelos, es por ello que se realizó esta investigación con el objetivo de evaluar las respuestas provocadas por diferentes sistemas de laboreo en algunas propiedades hidrofísicas del suelo y en la extracción de nutrientes por el cultivo del trigo (*Triticum durum* L.), en parcelas experimentales del Instituto de Recursos Naturales y Agrobiología de Sevilla, España. Para el estudio se utilizó un diseño muestral. Los tratamientos consistieron en: laboreo tradicional (LT) y de conservación (LC), en parcelas experimentales de larga duración y no laboreo (NL) y laboreo tradicional nuevo (LTN) en corta duración, en parcelas de 240 $m^2$ y de 140 $m^2$, respectivamente, en un suelo Fluvisol. En la fase experimental se evaluaron la densidad aparente y el contenido de agua en el suelo. Además se determinó la extracción de nutrientes por el cultivo en follaje, granos y el rendimiento. Los resultados mostraron diferencias significativas entre los tratamientos en la extracción de N, P y K en las diferentes partes de planta evaluada, destacándose el LC con una mayor extracción de nutrientes por el cultivo y mayor rendimiento, siendo el más adecuado, si se consideran los beneficios medio-ambientales que aporta el mismo.

*Palabras clave*: labranza, rendimiento, densidad, humedad del suelo, nutrición

## INTRODUCTION

Soil degradation is one of the most important global environmental problems and the main threat to the sustainability and maintenance of productive capacity of soils. In agricultural soils, conventional tillage can promote the destruction of the structure, loss of organic matter, compaction and $CO_2$ emissions into the atmosphere. Furthermore, conservation agriculture is the combination of the use of agronomic, biological and mechanical

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measures that improve soil quality through three crucial technical principles: not disturbing the soil mechanically (planted or sown directly) ; permanent soil cover, especially with the use of crop residues and cover crops; Judicious selection for crop rotations. These systems show that when soil quality improvement, increase agricultural production and reduce soil erosion (1).

Wheat (*Triticum durum* L.) is one of the three most cereals produced worldwide, with corn (*Zea mays* L.) and rice (*Oryza sativa* L.) and it is an essential component of the human diet, providing about a fifth of the calories consumed (2) and it is the staple food of more than 96,4 % of the world population (3). This work was conducted to evaluate the influence of different tillage systems in some hydrophysical soil properties and nutrient extraction and crop yield of wheat under dry conditions.

## MATERIALS AND METHODS

The work was carried out in experimental plots of different duration, established in the experimental farm "La Hampa" in the Department of Water-Soil-Plant, from the Institute of Natural Resources and Agrobiology of Seville (IRNAS), Spain.

Experimental plots of 240 $m^2$ were established in long-term experiments (18), where the traditional tillage (TT) were compared using moldboard plow and dump soil and conservation tillage (CT) with pass grower and coverage soil with plant residues from the previous crop. and 140 $m^2$ in experiments of short duration (6 years), where the new traditional tillage (NTT) were compared with use of moldboard and turned soil with no tillage (NT). A sample design with two replicates per treatment was used in both cases. The soil was classified as a Xerofluvent (4), which corresponds by the Cuban ranking with a Fluvisol (5), which has a frank clayey texture with low levels of total organic carbon and nitrogen and high in phosphorus and potassium (Table I).

**Table I. Main soil characteristics of the study area (0-10 cm depth)**

| Parameter | Values |
|---|---|
| pH (extract soil: water 1/2,5) | 8,2 |
| EC (extract soil: water 1/5) | 153 µS $cm^{-1}$ |
| COT (Walkley and Black, 1934) | 1,54 % |
| $CaCO_3$ (calcimeter Barnad) | 26,5 % |
| N (extraction $H_2SO_4$ conc.) | 0,095 % |
| $P_{Olsen}$(extraction $HCO_3Na$) | 26 mg $kg^{-1}$ |
| K ($NH_4CH_3COO$ extraction) | 1,2 cmol $kg^{-1}$ |
| Fine sand | 12,2 % |
| Coarse sand | 29,6 % |
| Lime | 24,8 % |
| Clay | 33,4 % |

Wheat planting was performed with a seeder online (space between lines of 16 cm) and to drilling. The variety used was "Euroduro" of medium-long cycle, planting density was 240 kg $ha^{-1}$ approximately. During the development of any crop fertilization was not done. In Table II the work done for each system are summarized.

During the development of experimental phase, bulk density ($\rho_a$) or volume weight of soil (24 samples throughout the experimental area) at different depths (6-10 cm and 2-6 cm 12-16 cm) was determined tracking and moisture profiles evolution of water, the method Frequency Domain Reflectrometry (FDR) was employed. Samples were taken at 21 days before planting, at the time of this and 35 (das).

In growing performance and nutrient content in leaves and beans was evaluated. For extraction of nutrients the content of N, P, K, Ca, Mg and S, expressed in kg $ha^{-1}$[A] was determined. Removal of N, P and K in the aboveground biomass was calculated from the yield of dry matter (DM) of the aerial part and its corresponding concentration of each element (% N, P or K), by the following formula:

Extraction of N, P and K (kg $ha^{-1}$) = [DM (t $ha^{-1}$)
the aerial part x concentration (%)
DM element in the aerial part] x 10

To evaluate the differences among treatments, two to two, LC vs TT on one side and NTT vs NL, the Student t test was used at a level of $\alpha = 0,05$.

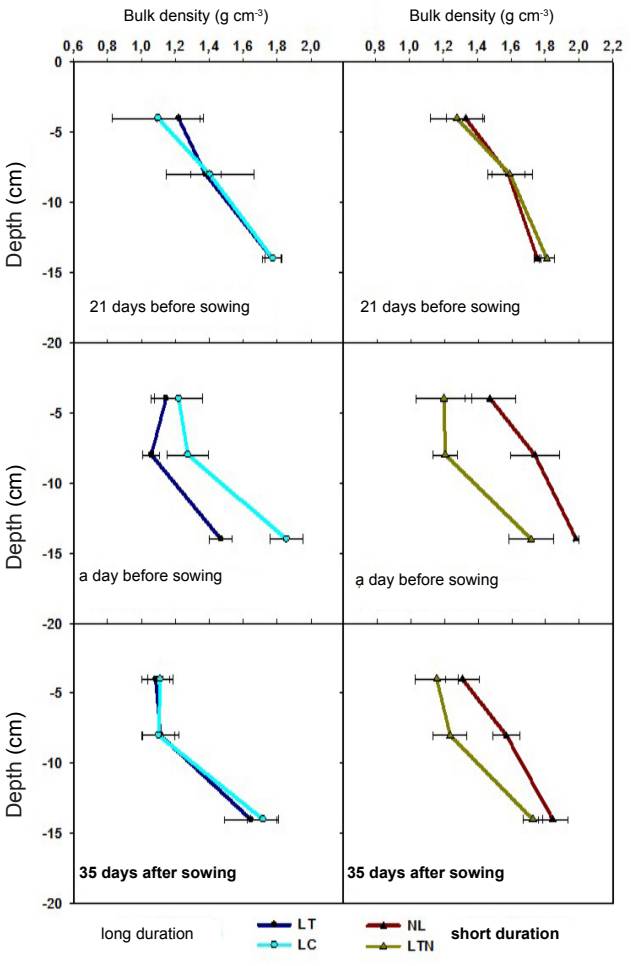
[A] Martin, R. *Sistemas de labranza: su efecto en algunas propiedades hidrofísicas del suelo y en la extracción de nutrientes por el cultivo (Triticum durum L.)*. Tesis de Maestría, Instituto Nacional de Ciencias Agrícolas, 2015, Mayabeque, Cuba, 95 p.

**Table II. Work and agronomic operations performed**

| Treatments | | | |
|---|---|---|---|
| TT | CT | NT | NTT |
| Moldboard | Herbicide | Herbicide | Moldboard |
| Cultivator | Cultivator | - | Cultivatorr |
| Disc harrow | Disc harrow | - | Disc harrow |
| Sowing and Harvesting | Sowing and Harvesting | Sowing and Harvesting | Sowing and Harvesting |

## RESULTS AND DISCUSSION

The bulk density (ρa) and the water content in the soil are hydrophysical properties are modified by the type of tillage. These properties are essential for understanding the behavior and evolution of the physical state of the soil (Figure 1).




(TT) traditional tillage (CT) conservation tillage
(NT) no tillage (NTT) Traditional tilling
New bars mean the confidence interval for the mean (α = 0.05)

**Figure 1. Influence of the type of tillage on bulk density (ρa) of Fluvisol soil at different depths, in experiments of long and short duration**

In the plots of long-term experiment no significant differences in samples taken 21 days before planting and 35 days later were found, which could be related to the water content in the soil at the time, a variable that will discussed below.

However, when analyzing the sampling at the time of planting significant differences for depths greater than 5 cm were found, which is a response to precipitations[A] occurred during this period and prior to the time of sampling.

This behavior was very similar to that in the short-term experiment in which the traditional new tillage compared to no-till, where even the differences were greater among treatments at planting time and 35 das not going well in the long-term experiment.

One benefit of cultivating soil is to reduce $\rho_a$ to (increased porosity), however, the effect of tillage on the $\rho_a$ is temporary since after completion of the work, the soil quickly reestablishing, recovering from this way its $\rho_a$. It is noteworthy that the tillage system used also has a significant effect on the behavior of bulk density, especially in the upper layers.

In this regard (6) state that used tillage systems showed no effect on the physical properties of the soil or to their detriment, or improvement, due to soil stability and short-term work.

Similarly, when evaluating the apparent density on two tillage systems (conventional and no-till) in the cultivation of maize and sorghum for a year (7) found no significant differences among treatments, however, they show that there is a clear trend to find higher values in treatments with conventional tillage, unlike the treatments without pre-planting (tillage) work.

Regardless of the criteria reported in the literature, the results of this work demonstrates that in the condition of not tilling increases the apparent density largely caused by soil compaction, which reduces the pore spaces does not take place any work on the same, but these effects do not reach

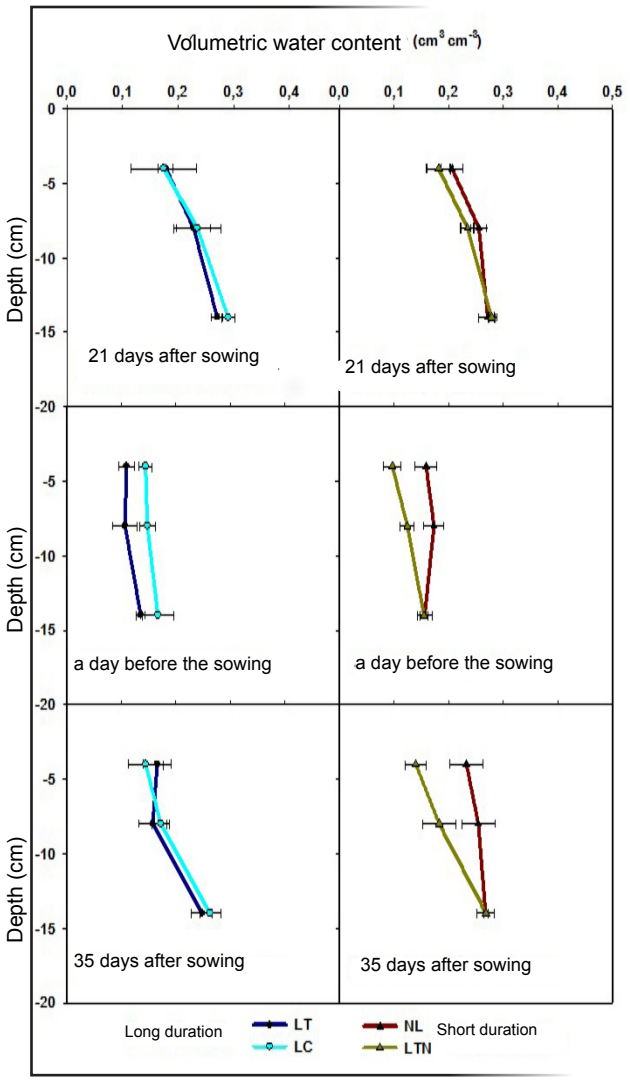
levels agronomically risk. Moreover, structural stability and infiltration increase significantly under direct seeding, allowing greater water storage in soil. These changes result in poor aeration and inadequate oxygen supply to the plant development. Likewise, degradation of soil structure by compaction causes a slowdown or stoppage of root development, to increase the mechanical strength.

Moreover, it is shown that the physical properties of the soil are taken into account important in areas with low rainfall (8), affecting grain yield and water use efficiency in wheat cultivation.

According to the volumetric water content in the soil (Figure 2) evaluated at three different times, shown in general a tendency to show higher water contents treatments LC and NL in both experimental conditions from the time of planting, with respect to the other treatments, which is in full correspondence with the low intensity of tasks performed in both systems, which allows the soil to hold less altered its structure and retain a greater number of capillaries It allows the rise of water from the deeper layers and thus have a higher water content than when several tasks are performed, especially in soils with high water holding capacity and in the years of lower rainfall. It is noteworthy that in both experimental conditions the volumetric water content in the first sampling showed similar values among treatments, which is in correspondence to this sampling was performed immediately after the occurrence of the precipitations[A].

In all cases the higher moisture levels were found in the deep layers, due to the action of recent work that favored the infiltration of rainwater, regardless of tillage system used, because the water recharge of the profile is only possible under these conditions, if any precipitation. In this regard, one aspect to consider is the depth of the soil in the determination of moisture (9), when what it is concerned is to evaluate the potential wheat yield.

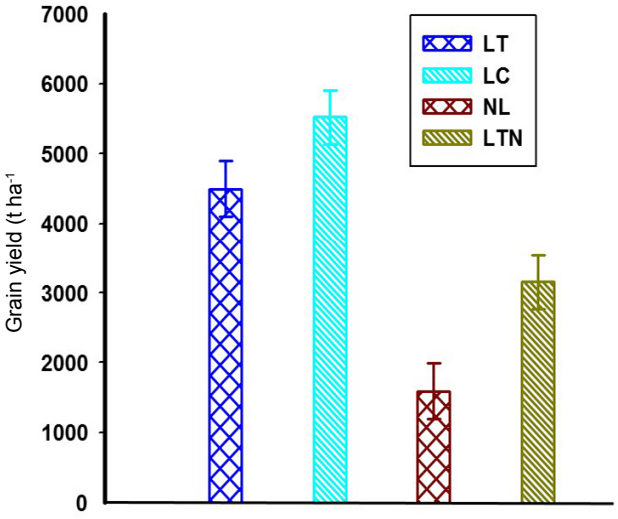
It has been established that the availability of water in the soil is a determining factor in agricultural production (10) and it is not only associated with climatic conditions, land use and properties of this, but also with fluctuating groundwater during the growth period. Moreover, the water deficit affects wheat yields and grain quality (11).




(TT) traditional tillage (CT) conservation tillage
(NT) no tillage (NTT) Traditional tilling
New bars mean the confidence interval for the mean ($\alpha$ = 0.05)

**Figure 2. Influence of the tillage type in the volumetric water content of soil at different depths Fluvisol in experiments of long and short duration**

As for performance analysis (Figure 3) it can be seen that there are significant differences among treatments in the two experimental conditions. It should be noted that the yields obtained were low the NT in the short-term experiment, which could be influenced by lower exports of dry mass of foliage to the grain due to lower plant growth given the unfavorable conditions that this led the NT.

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New bars mean the confidence interval for the mean ($\alpha$ = 0.05)

**Figure 3. Behavior grain yield (kg ha$^{-1}$) in experiments of long and short duration**

It has been established that wheat production is limited by the mechanical strength of the soil (12), a factor that is part of the radical environment and thus the proper functioning of the roots, which translates into lower yields unable to meet needs water and nutrients required at all times of the cycle.

However, in the long-term experiment conservation tillage, given the positive effects that this system gives the hydrophysical properties of soil, allowed the plants reached the highest performance, not being so, in plots in which he used conventional tillage because in the same work intensity was higher.

The yield of the wheat crop in a given region is the result of the interaction between ecological factors as proper plant solar radiation, temperature, availability of water and nutrients, technological and tilling the soil and eventually genetic, whose final result is the product of interactions between the processes of growth and development that occur throughout the crop cycle (13).

The potential of the wheat crop differs between the different producing regions of maize, mainly due to climatic factors. However, in many cases potential crop yields are not achieved, where nutrition and management through fertilization, are one of the main resources that limit production of wheat (9, 14).

Tentatively could be attributed differences in production[B] to increased resistance to soil penetration by the roots exist in the treatment of non-tillage, which does not allow the root system will offer the cultivation all conditions to express its maximum production potential, besides the fact sow in any of the conditions set tilling (TT, CT and NTT), it led to favorable conditions for growth and development plants.

An important element of wheat production constitutes the work done on the ground in preparing it for planting, which can affect soil fertility. In Figure 4 the extraction of macronutrients is presented in the foliage, in experiments of long and short, as it can see the behavior is similar in both types of experiments, even though the treatments used in either condition were those that caused more or less extraction.

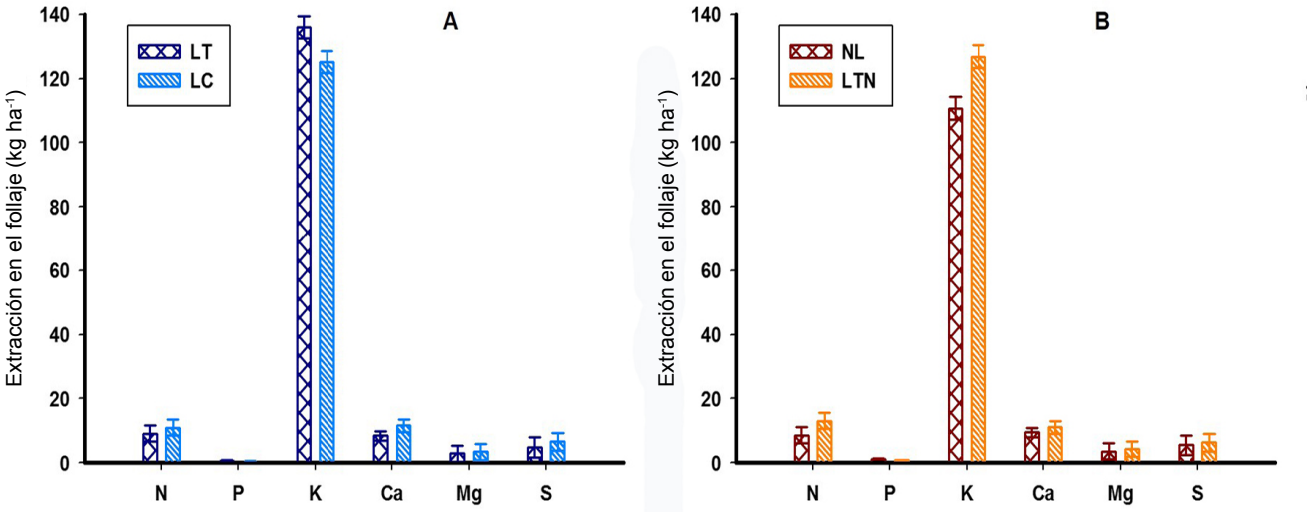
The element in larger quantities was extracted is the K, coinciding both with the treatments in which the traditional tillage and traditional new tilling was done, apparently this condition encourages further exploration of the roots in the ground, achieving greater accumulation in the aerial part depending on the movement of nutrients in the plant. It is also important to note that this nutrient is found in greater concentration according to the results of analysis before planting soil (Table I).

K is the most abundant cation in the vacuole and the cytoplasm therefore plays a key role in osmoregulation occurring processes stomatal closure and opening. Moreover activator is over 50 enzymatic systems, among which stand out oxidoreductases, dehydrogenases, transferases, kinases and synthetases (15).

In addition it plays an important role in their presence foliage, avoiding sensitivity of plants to lodging by the wind, as well as pathogen attack the roots. The biochemical role thereof in nutrition and osmoregulation, is given because it decreases the adverse effects of the presence of high salt concentrations in the soil (16).

It is also known its value within the plant because it reduces the effect of stress (17, 18) and it is primarily responsible for the transfer of photosynthesized sugars, as the plant photosynthesizes, it accumulates sugars in the leaves, these are the ones that plant translocates to the grains at the time of filling them.

[B] Montenegro, J. J. *Efecto de tres sistemas de labranza en la calidad de los suelos y el desarrollo de tres sistemas de cultivo, tercer ciclo de observación*. Tesis de Grado, Universidad Earth, 2006, Costa Rica, 78 p.

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New bars mean the confidence interval for the mean ($\alpha$ = 0.05)

**Figure 4. Extractions of macronutrient on foliage, in experiments long (A) and short (B) duration**

The P was less absorbed element, which is in correspondence with the lowest needs of this element by the plants, in relation to the rest of the macronutrients, low availability of soil P it is one of the major constraints on achieving yields higher in sustainable agriculture (19).

When analyzing the behavior of the macronutrient content of the grain, in experiments long and short duration (Figure 5), it can see that the result is different, because in this case the highest concentrations in this body for the N, deferring significantly between treatments. Such is the case where the CT was plants had a higher accumulation in the grain compared to TT in the long-term experiment.

Studies show that conservation tillage provides effective means to conserve soil fertility (20) and increased nitrogen needs, which implies a higher content of this element in the grain, as evidenced by the results.

In the cultivation of wheat, it has been found that the electrical conductivity (EC) and the nitrate concentration (8) were significantly correlated with grain yield.

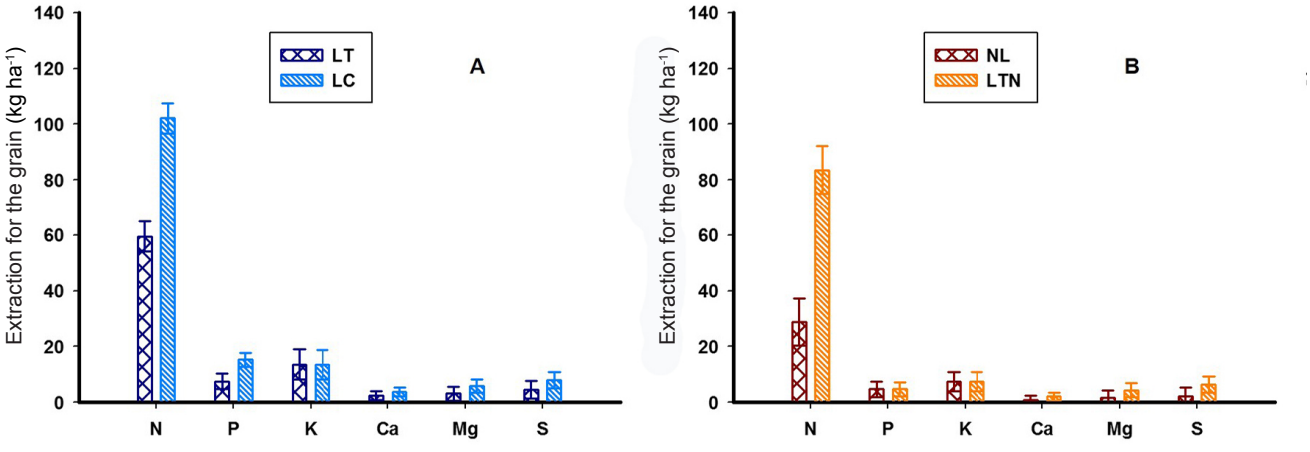
In general, the N when the plant absorbs, it accumulates as nitrate in the leaves and it is responsible for this nitrate motorizes synthesis complex growth hormone, whose primary exponent is indoleacetic acid (IAA). Also, nitrogen is the major component of most amino acids that make up proteins, perhaps for this reason are high levels in grains (21) .In this same experiment the other elements no significant differences between the two treatments evaluated.

In the case of short-term experiment, it must note that in systems no-till the mineralization of organic matter (OM) soil is reduced and no residue incorporation slows mineralization thereof. The magnitude of the retardation in the mineralization of waste will depend on the amount of waste, the type of waste, both in physical form such as size, density and diameter as well as in chemical composition by the C/N, lignin content among others and finally on weather conditions, which explains that in this specific case under that condition tilling, was where a lower extraction (15) was found.

Importantly find greater amounts of nitrogen in the grain, is related to mobilization of assimilates and nutrients from the foliage to the body, taking into account that N is the most important in the development of the plant nutrient, given its abundance in major biomolecules of living matter (22), and forming part of proteins and nucleic acids and amino acids and other compounds.

In Figure 6 the total content of more grain of the main macronutrients in long-term experiments (A) and short (B) is represented foliage.

It is appreciated that in both experiments nitrogen contents differed significantly between treatments, however in the case of P and K show no significant differences.




(TT) traditional tillage (CT) conservation tillage
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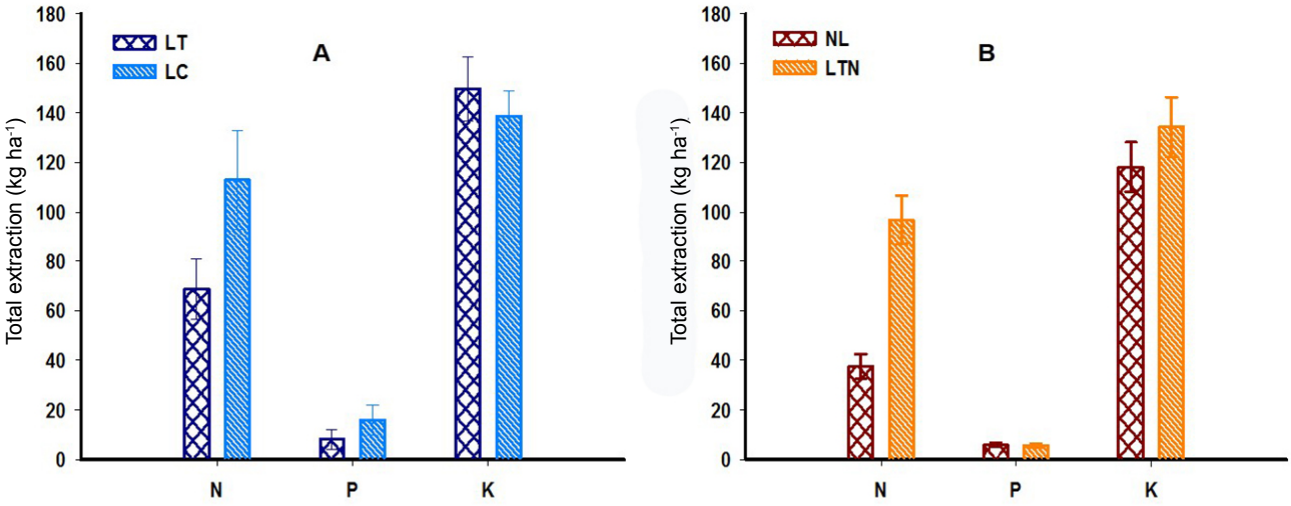
New bars mean the confidence interval for the mean ($\alpha$ = 0.05)

**Figure 5. Extractions of macronutrients by grain, in long (A) and short (B) duration**




((TT) traditional tillage (CT) conservation tillage
(NT) no tillage (NTT) Traditional tilling
New bars mean the confidence interval for the mean (a = 0.05)

**Figure 6. Macronutrients total extraction in aerial part, in long duration experiments (A) and short duration (B)**

When the needs of fertilization of crops are diagnosed (23), it is important to know the amounts of absorbed nutrients to achieve a given performance, in the case of wheat states that to achieve a yield of 5000 kg $ha^{-1}$ is needed to extract 99 kg $ha^{-1}$ N, 19 kg $ha^{-1}$ of P and 16 kg $ha^{-1}$ K.

In this study it was found that the highest yield (5524 kg $ha^{-1}$, CT) plants extracted a total of 113 kg $ha^{-1}$ N, 16 kg $ha^{-1}$ of P and 139 kg $ha^{-1}$ K, so it can ensure that this tillage system led to yields achieved were obtained and extraction levels were around the indicated values, even if they made no contribution of mineral fertilizer, but they were incorporated by tilling waste the previous crop (*Pisumsativum*, L.) cultivar Hardy.

In general, if the foliage is used as ground cover in the experimental plots where no tilling was used, it would incorporate 23 % of N; 18,3 % of P and 93,8 % K with respect to the total extracted, but the foliage is used as fodder for animal feed; so, these elements are exported soil, making it less productive unlike the experimental plots where conservation tillage in which incorporates not the foliage of wheat because it also exported used, but if the field pea, which contributes to improving soil properties.

## CONCLUSIONS

Hydrophysical properties such as bulk density and the volumetric water content in soil respond positively to a lower intensity of work, where the CT plays an important role as it provides greater total extraction of nutrients, which allows greater are reached yields. It is also important to ensure in such studies as long as the areas that are subject to soil preparation to achieve the desired result.

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