Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 177 (2023) 56786 - 56790

ISSN: 2229-712X

Effects of Soil Preparation Methods on Yam Production (*Dioscorea cayenensis* Lam,1792) in Kisangani, Democratic Republic of Congo

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ARTICLE INFO

Article history:

Received: 6 March 2022;

Received in revised form: 5 April 2023;

Accepted: 14 April 2023;

Keywords

Dioscorea Cayenensis,
Mound,
Ridge,
Tubers,
Growth,
Yield.

ABSTRACT

Yam cultivation requires loose soil, and tillage is essential for better production. The objective of this study was to evaluate the effects of soil preparation on the number and yield of yam tuber (Dioscorea cayenensis). A randomized full-block system with three treatments (mound, ridge and no tillage) and repeated three was implemented. Vegetative parameters and performance components were measured.

The results obtained showed that:

- The method of soil preparation had definite effects on the growth and number of tubers;
- An increase in the number of tubers was observed for mounded plots compared to those with ridges and no tillage ;
- The mound increased tuber yield compared to the ridge and control.

Introduction

World food yam production, estimated at 36 million tonnes, ranks second only to cassava for tuberous root and tuber plants (FAO, 2004). Yam cultivation contributes to the food security of 300 million people in tropical countries and its nutritional value varies by variety (F.A.O, 1999). It is a food plant of primary importance in Asia, South America, and Africa

Wherever yam is grown, it remains extensive and consumes little or no input. However, it is considered demanding in terms of soil fertility, and is primarily at the head of the rotation after a long fallow, forcing the producer to always travel further to look for areas suitable for its cultivation (Cornet, 2015). The yam occupies a prominent place in food security, especially in Africa through its food, medicinal and household income improvement role. However, cultivation practices in yam-based cropping systems remain inefficient and generally harmful to the environment. The yields obtained under such conditions are low, well below the production potential of the crop, and highly variable (Pouya 2018)

Also, several studies attest that the method of soil preparation, especially mound and ridge, contributes enormously to the increase in yam production. For example, Godet (1993) attests that good soil preparation affects the rooting and development of yam tubers and is essential for successful yam cultivation. In addition, other studies (FAO and IFA, 2000) have shown that the growth of yam tuber requires loose soil with little resistance to penetration. Yams are therefore grown in mounds or ridges. The work of Ennin et al. (2003) and Fasinimirin and Reichert (2011) on yams and potatoes has shown that ridges provide better control of grass cover and better conservation of soil water through better soil cover compared to mounds.

Given the research already carried out in this field, our study proposes to evaluate the effects of soil preparation methods (mound ridge and no-till) on the number of tubers and yam yield (D. cayenensis Lam) in Kisangani.

Equipment and Methods

Study Website

The experimental field was installed in Kisangani in the DRC in the Bofaka concession at Pk7. The geographical coordinates of the experimental site taken with Garmin GPS mark map 62 are: 00° 33' 39.5" north latitude is 025° 12'43.5" east longitude, its average altitude is 393 m. The climate of Kisangani belongs to type Af according to the Köppen classification. It is a humid tropical climate characterized by temperatures hovering around 25°C on average. According to Van wambeke and Libens (1957), rainfall is abundant (1800 mm per year on average) and is distributed throughout the year according to two seasons: one very rainy long from September to November and the other less humid, relatively short which extends from the end of March to June. Relative humidity ranges from 80 to 90% (Borek, 1987). The vegetation is a rainforest but the terrain on which our test was carried out It was a grassy fallow of a few months predominated by the following species:

Panicum maximum, *Cynodon dactylon*, *Pueraria javanica*, *Digitaria occidentalis*, *Comelllinas diffusa and Ailaes guiness*. The previous crop of the experimental site was cassava and maize.

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Materials

The biological material used in our study was the yam species *D. cayenensis*, the most popular and marketed in the city of Kisangani. This species has a crop cycle of seven to twelve months and its potential yield is of the order of 50 t/ ha-1 (Diby *et al*., 2012). The non-biological material consisted of a decameter, pen, string, machete, precision scale, empty bag, stake, spade, cow dung and pig droppings.

Methodology

The device adopted for this trial was that of randomized complete blocks, having three treatments (mound, ridge and no tillage), repeated three times. The experimental field had a total area of 530 m^2 and a total density of 486 plants. The spacings applied were 1m x 1m.

The plot made available to us had been left fallow for a year beforehand. It was demarcated, cleared manually and finally incinerated. Plowing took place two weeks before the implementation of the trial in order to ensure better decomposition of plant debris (organic matter) over the entire thickness of the topsoil and promote good soil fragmentation, control weeds and regrowth, bury crop residues, loosen surface layers and improve the drying of wetlands or drained lands. The mounds were 30 cm high and 1m in diameter; This technique, like that of raised boards, is widespread in tropical Africa more mainly for the cultivation of root and tuber plants such as sweet potato, yam and cassava (Boissière, 2003). It allows to have a layer of loose and thicker soil, which is very interesting for thin soils, while bringing a maximum of soil around the plants to allow a good development of the plant (Cdq, 2007).

The ridges were about 20 to 30 cm high and 6 m long after incineration and ploughing in order to promote soil conservation by reducing erosion losses (water and wind), to facilitate mechanical weed control and soil conservation (Cdq, 2007).

Study soil composition

Table 2. Chemical characteristics of cow dung and pig manure

Type of organic matter	C/N	N	P	K
Cow dung	2	2	1.5	2
Pig faeces	11.4	1.6	1.5	4

Lab IFA/Yangambi

Seed preparation

Healthy tubers of the species *D. cayenensis* were used for the establishment of the trial. These tubers were cut into mini-fragments of about 200 g. The latter were treated against insects and fungi, by soaking for 10 minutes in a solution of ash. These reated fragments were then wiped in a cool place 24 hours before planting.

Maintenance

The maintenance of the crops consisted of staking, weeding and watering operations. The stakes were placed in the first two months after planting. Plot weeding was performed as required. Thus, four weedings were done manually in the field to eliminate weeds.

Harvest

The tubers were harvested manually. This operation took place 10 months after planting for all treatments. A full harvest of tubers was carried out on each plot.

Parameters studied

Fragment recovery rate : $\frac{Total\ number\ of\ fragments\ taken\ up}{Total\ number\ of\ plant\ fragments} X100$

The diameter of the rod was measured with a digital caliper;

Average number of tubers per foot : $\frac{Total\ number\ of\ tubers}{Total\ number\ of\ plants\ harvested}$

Tuber length: Measured with a lath ;

Tuber diameter: measured with a caliper ;

Production in Kg: $\frac{Total\ weight\ of\ tubers\ harvested}{Total\ number\ of\ tubers}$

Yield in t/ha: *Poids* total of *tubercules* x10000 / Number of harvested plants X 1000

Statistical analysis

A single-factor analysis of variance after validity checking was performed and the Bonferroni post hoc test was applied to detect means that were different with Prism5 GraphPad software at the 5% significance level.

Results

1. Mini-fragment recovery rate

Table 3. Number of fragments per treatment

Soil modes	Number of plants
Billon	15,66
mound	15,44
No tillage	15,44
Meaning (p)	0,9868

The average number of fragments taken varied according to the treatments and numerically higher for the ridges, followed by mounds that were in equality with the unploughed plots. Statistical analysis showed no significant difference between treatments (P = 0.9868).

2. Rod diameter

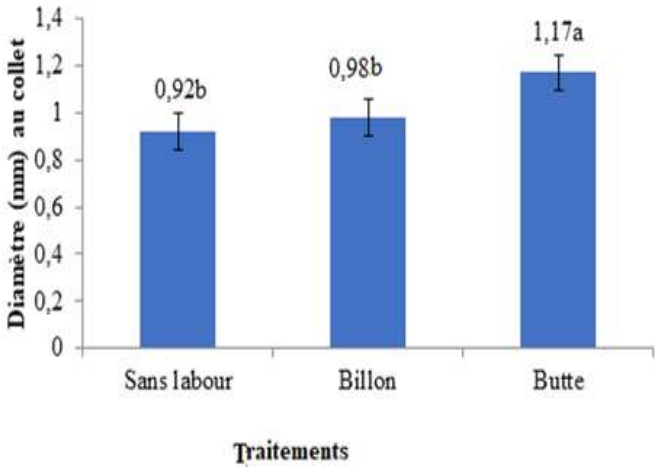

Figure 1. Collar diameter per treatment

The methods of soil preparation significantly influenced the diameter at the crown of the stem. The mounds come first with a high average collar diameter, followed by ridges and unploughed plots close the march. Statistical analysis a very significant difference between mounds compared to ridges and plots not plowed (P = 0.00521).

Table 1. Physico-chemical characteristics of the 0-20 cm horizon

Characteristics physico-chemical	N (%)	P_2O_5 (%)	K_2O (%)	pH	MO	A g/kg	L g/kg	S g/kg
Values	0,32	0,0009	4,07	4,07	32	37	10	53

Legend. N = total nitrogen; P2O5 = total phosphorus; K2O = total potassium; Ph hydrogen potential; OM = organic matter; A = clay; L = silt; S = sand.

3. Average number of tubers per foot

Table 4. Average number of tubers per plant per treatment

Soil modes	Number of tubers
Billon	1,70[b]
mound	1,74[a]
No tillage	1,45[c]
Meaning (p)	0,0070[**]

Legend: Means with common letters, no significant differences for p> 0.05 according to Bartlett's test; P: probability and **: Highly significant differences.

The same trend was respected, it is still the mounds that come first with an average number of tubers per foot has been high, followed by the ridges and the no-till mode occupies the last position. These numerical differences between treatments were confirmed by statistical analysis (P = 0.0070).

4. Tuber length

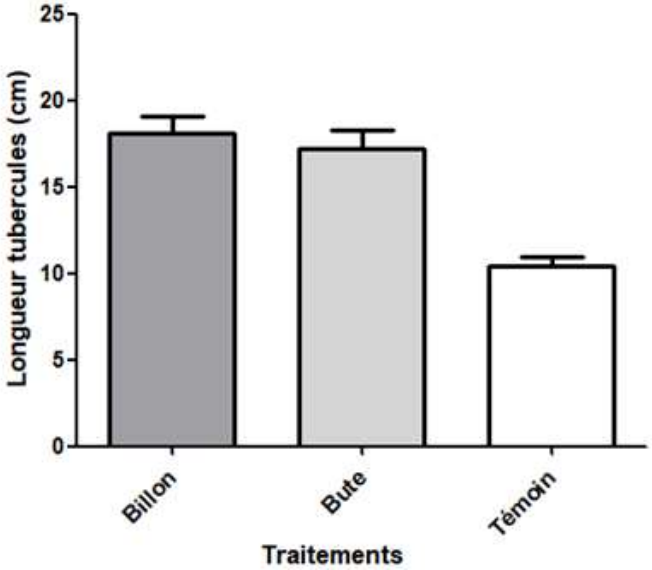

Figure 2. Tuber length

The ridges gave the tubers with an average length of 60.33 ± 2.65 cm and the mounds produced tubers with an average length of 51.63 ± 3.54 cm `; while the untilled plots produced the tubers with an average length of 19.50 ± 1.9 cm. Statistical analysis showed a highly significant difference between ridges and mounds compared to untilled plots (P0.0001), and between ridges and mounds the difference was significant (P=0.04).

5. Average tuber diameter

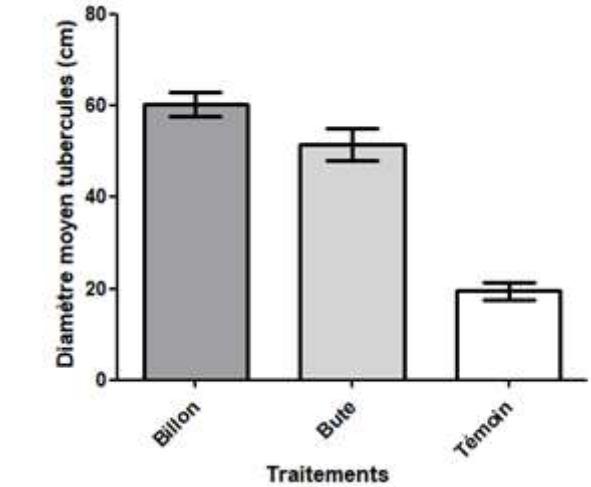

Figure 3. Average tuber diameter

The ridges produced tubers with an average diameter of 18.10 ± 0.97 cm, followed by mounds with an average tuber diameter of 17.24 ± 1.1 cm and the unploughed plots yielded tubers with an average diameter of 10.44 ± 0.5 cm. Statistical analysis showed a highly significant difference between the ridges, mounds compared to the control plots (P=0.0001). However, no significant differences were found between ridges and mounds (P>0.05).

6. Average tuber weight

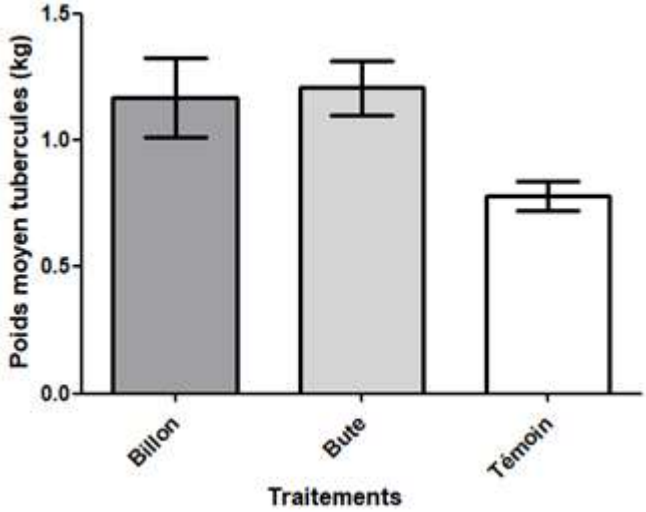

Figure 4. Average tuber weight in cm

The mounds came first with tubers with an average weight of 1.21 ± 0.1 cm, followed by ridges with tubers with an average diameter of 1,170 ± 0.15 cm and the unploughed plots gave tubers with an average weight of 0.78 ± 0.06 cm. Statistical analysis showed a very significant difference between the mounds and the control plots (P=0.001), and a significant difference between the ridges and the control plots. (P=0.001), and a significant difference between ridges and control plots (P=0.02); however, between mounds and ridges there was no significant difference (P>0.05).

7. Tuber yield

Table 5. Tuber yield (t/ha).

Methods of soil preparation	Yield (t/ha)
billon	6,96b
mound	9,10a
No tillage	5,50c
Meaning (p)	0,0000***

Means with common letters, no significant differences for p> 0.05 according to Bartlett's test P: probability ***: Very highly significant differences

It appears from this table that the tuber yield varied considerably depending on the treatment, following the same trend as all components of the yield and more particularly the average tuber weight. The highest yield was obtained in the mounds with an average value of 9.10 t/ha and the ridges gave a yield of 6.96 t/ha. However, the control plots had the lowest yield (5.50 t/ha). These numerical differences were confirmed by statistical analysis (P = value 0.000).

Discussions

Influences of soil preparation methods on the number of fragments taken back

The recovery rate obtained was very good and this rate of fragment recovery at the level of the various treatments was favored by the good rainfall observed during the period following planting.The result also shows that the tubers used for propagation were of good quality. The work of Onwueme and Haverkort (1991) and Craufurd *et al.* (2000) shows that yam recovery depends more on the size, nutrient reserve, quality and physiological age of planting material. The same result was observed by Molongo *et al.* (2021) who worked on

the influence of seed material on growth and yam yield (*D. cayenensis*).

Effect of soil preparation methods on stem diameter

The methods of soil preparation strongly influenced the diameter at the collar compared to the no-till mode. The increase in crown diameter for ridges could be explained by the amount of nutrients, conservation and availability of soil water offered by this method of soil preparation. These results corroborate those of Dibi *et al.* (2016). which suggest that the evolution of stem diameter would be proportional to the size of the mini-fragments and the duration of yam culture as well as to variations.

Effect of soil preparation methods on tuber numbers

The number of tubers varied from 1 to 2 for all treatments. The presence of two tubers per foot was more common in plots that had ridges and large tubers were produced by the mounds. These results are similar to those of Pouya (2018) who had worked on the combined effects of tillage type, fertilization options and plant emergence date on yam growth and yield in Burkina Faso. Almost similar averages were obtained in Burkina by Bazie (2018) and in DRC by Molongo *et al.* (2021) ranging from 2 to 3 tubers on feet.

Effect of soil preparation methods on diameter and tuber length.

Soil preparation methods had an influence on the diameter of the tuber. Among the modes used, ridges are the best suited. They were better than the mounds and the unprepared soil mode on almost all the parameters studied. Also, the ridges gave tubers of large diameter, a little shorter than those produced by the mounds and weighing around 1.5 kg. This performance would be due to the ability of the ridges to offer plants a larger operating space and also an ability to save organic matter that is gradually released, also, a capacity to conserve water from the soil, promoting infiltration and limiting runoff. This is similar to Pouya (2018) who conducted research on the combined effects of tillage type on yam growth and yield in Burkina Faso. The seedlings of the plots from ridge gave very considerable tuber length that butte and witness

Effect of soil preparation methods on tuber weight

The results found show that the mounds were able to produce yam tubers with a high average weight. Our results are contrary to those of Ennin *et al.* (2003) and Fasinimirin and Reichert (2011). However, our average is much higher than that of Abdul (2017) in Burkina Faso. with an average wet weight ranging from 0.44 kg to 0.09 kg.

Effect of soil preparation methods on yield

We observed that the mound gave a better result. Our results are consistent with those of Odjugo (2008). Similar results were reported by Van Scholl (1998). Since the root system of yams is shallow (Hgaza *et al.*, 2011), fertilizer application followed by mounds reassembly as recommended in the management options Integrated soil fertilization, promotes their absorption by the roots.

Conclusion

This study was initiated to evaluate the influence of soil preparation methods on the number of tubers and the yield of yam (*D. cayenensis*) in Kisangani. A system in complete blocks comprising three treatments (mound, ridge and no tillage), repeated three times, was put in place. Vegetative parameters and performance components were measured. The results obtained showed that:

- The method of soil preparation has largely contributed to the number and yield of yam tubers. A numerical upward trend in the number of tubers was observed for mounded plots compared to those with ridges;
- The ridges gave tubers of large calibers as the mounds and the no-till mode;
- The longest tubers were obtained with the mounded plots followed by ridge and the lowest average was observed for the no-till mode;
- The treatment based on the mound made it possible to produce yam tubers each with a high average weight followed by ridges and the control gave tubers of a much lower average weight.
- The mound increased tuber yield compared to the ridge and control

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