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Impact of the cereal-legume cultural association on maize production in the same plot: maize-cowpea example

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Abstract

Zea mays L. is a highly developed cereal in the world. In Africa, particularly in Senegal, maize production has been low. To help improve its production, a study with the overall objective of food and nutritional security was conducted, particularly in the municipalities of Keur Mandongo and Keur Madiabel. A specific objective consisting in evaluating the impact of the maize-cowpea association on maize was necessary in this study. For its implementation, a good methodology has been adopted. This first consisted of sowing cowpea on maize rows ten days after sowing. Then, yield squares (eight per hectare) with sides of five meters were installed at plot level. Finally, the average weight of the ears (five to ten) of the squares of each plot made it possible to determine the yield by a formula which was used. In total, the results of the associated plots were acceptable, especially for the 2019-2020 campaign, i.e. a yield of 932.5 kg per hectare. The average yield of the controls was 1184.530 kg. On the other hand, for that 2020-2021, the results were nil, i.e. a yield of 0.00 kg per hectare. At the end of this study, the maize-cowpea association was recommended in order to safeguard food and nutritional security in maize in the study area, in Senegal and everywhere else in the world.

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Introduction

Maize (*Zea mays* L.) is one of the most developed crops in the world and the first cereal produced, ahead of wheat (*Triticum aestivum* L. subsp. *aestivum*) (FAOSTAT, 2016). This crop occupies more than 33 million hectares each year (FAOSTAT, 2015). In 2002, 73 countries, including 53 developing countries and 20 industrialized countries, each harvested more than 100,000 hectares of maize (FAOSTATS 2002). Also, it has been considered the best way to meet the challenge of food security in Africa (Byerlee and Eicher, 1997). However, in Senegal, maize consumption comes largely from imports. And the high level of maize imports for both livestock and human feed justified the low level of production. Better, the surfaces of the culture of the corn are less and the majority of the poor soils. In order to improve maize production, trials were carried out on the maize-cowpea crop association. This technique consisted of sowing maize in a 2,500 m2 plot and installing the cowpea manually 10 days later, on the maize seeding lines. The spacing adopted is 50 centimeters. A control consisting of pure maize was also installed. To better assess maize production in the associated plot and the control plot in Keur Mandongo (Kmo) and Keur Madiabel (Kme), calculations of maize yields were made from yield squares at the level of all plots. during two successive agricultural campaigns (Cge) (2019-2020 and 2020-2021). In addition, the general objective of this study would be to guarantee food and nutritional security in Senegal, particularly in the study area. It would also make it possible to actively participate in the fight against climate change through adaptation and mitigation phenomena.

Materials and methods

Part of this study was conducted in Kmo located in the district of Wack Ngouna and covers an area of 68 km2. It is bordered to the north by the communes of Ndiédieng and Keur Socé, to the east by the commune of Keur Madiabel, to the south by the commune of Wack Ngouna and to the west by the commune of Ndramé Escale (Fig.1).

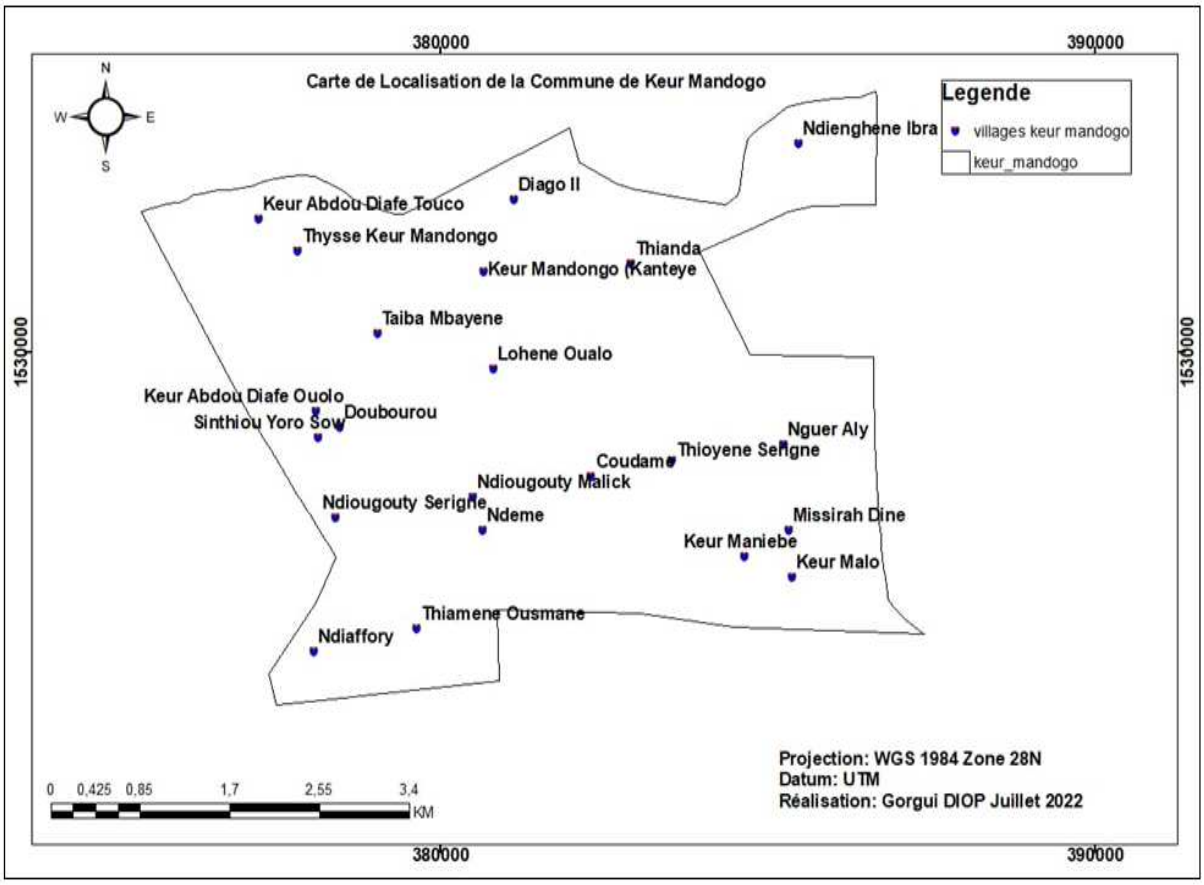

Fig. 1. Geographical position of the municipality of Keur Mandongo.

While the other part of the study was made at the level of the Cme de Kme located in the department of Nioro. It is 33 km from Kaolack, 220 km from Dakar and 27 km from the border with Gambia. It is also bordered to the south by the former rural community of Wack Ngouna, to the north and west by the former rural community of Keur Mandongo and to the east by the former rural community of Gainte Kaye (Fig. 2). In addition, a methodology has been put in place to obtain reliable results relating to plot yield. This first consisted in delimiting yield squares. The square is obtained by the 3, 4, 5 method leading to the right triangle with sides 3m and 4m and hypotenuse 5m. Once this triangle has been obtained, we will use the chalk line as a compass and the tape measure to materialize the 4 stakes of the 5m square.

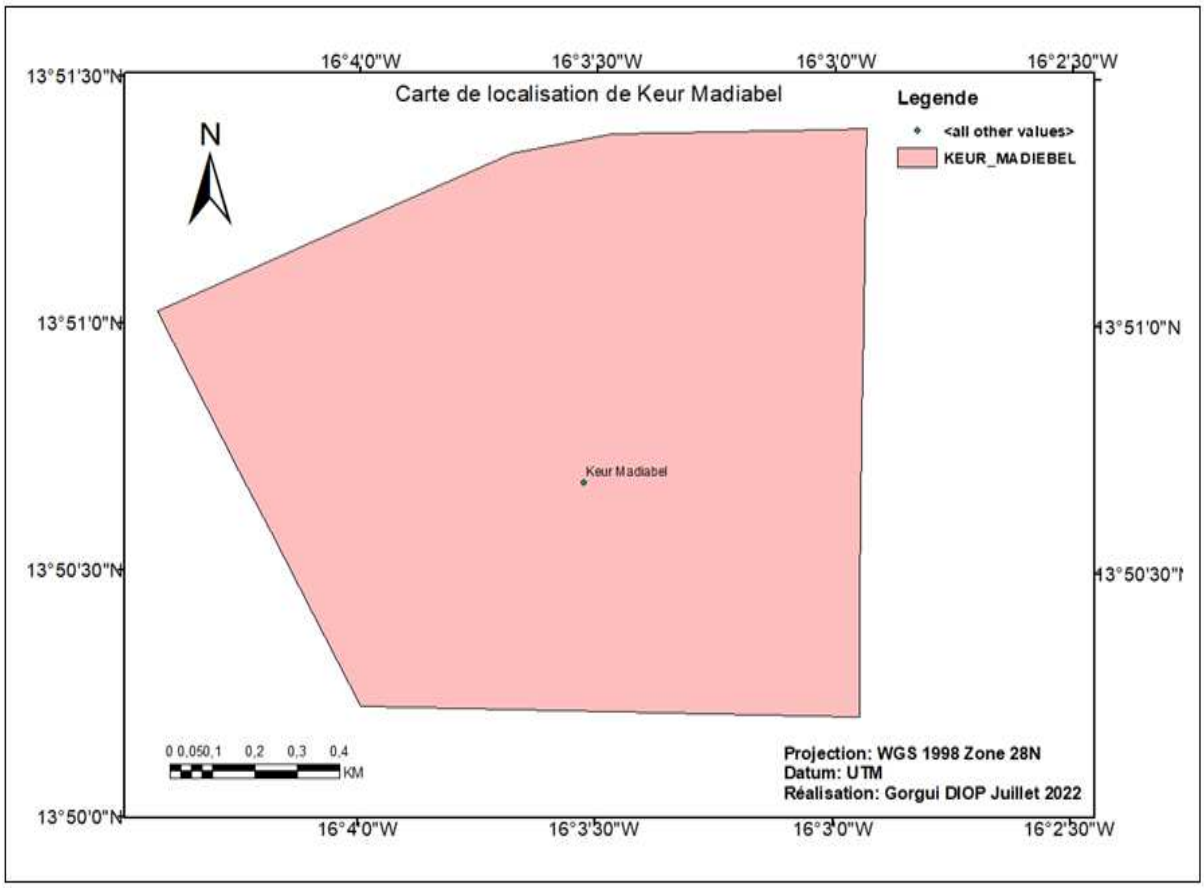

Fig. 2. Geographical position of the municipality of Keur Madiabel.

The number of squares per hectare is eight. Then, 5 to 10 ears were harvested per yield square before calculating the average of these ears and the sum of the averages of the squares of the whole plot. The sum of the means of the squares per plot finally made it possible to determine their mean. It is therefore the final average per plot that made it possible to determine the plot yield using the following formula:

Ptotal ears×400×0.28

400 is the conversion coefficient of the square yield per hectare 0.28 that of converting the rachis into seeds.

The yield unit is the kilogram per hectare (Kg/ha)

To implement this methodology, it is essential to make an appropriate choice of equipment consisting of cutters whose role is to cut the stakes to materialize the yield squares. The function of the tape is to measure the sides when delimiting the yield squares. The chalk line played the function of a compass by tracing arcs. And the knife was used to harvest the ears. As for the other elements, they kept the ears (bags), allowed the filling of the bags (basins) and the weighing of the ears (scale). Finally, the pen was used to record information (number of ears per square, average weight of ears per square and per plot) in a

notebook. In addition, the implementation of this methodology led to obtaining results that have been discussed.

Results

The evaluation of the level of maize production occupies a primordial place in the activities of our study. Indeed, it shows the various information relating to the yields of the crop plots. At the end of this activity, the average yields of the plots in association including those of the plots of pure maize (control) during the two agricultural campaigns were determined. Thus, during the 2019-2020 agricultural campaign, the plots of associated maize have an average production (kilogram per hectare) of 932.5 and those of pure maize of 1184.530 (see table 1).

This difference in yield could be explained by a better suitability of the soils of the plots of pure maize (control) for maize production. In other words, the soils were decks and were previously well fertilized with organic matter. On the other hand, the soils of the plots in association are sandy and have not previously been fertilized with organic matter.

Table 1. Presentation of plot yields by producer per hectare (Results 2019-2020).

(Cge)	(Cme)	(Kack)	Yield/Pcl (Kg/ha)	
			Pcl(M-N)	Pcl(MP)=Tm
2019-2020	Kmo	$Kack_1$	542.64	677.6
		$Kack_2$	873.4	1881.6
		$Kack_3$	1254.4	1646.4
		$Kack_4$	1344	1407.504
		$Kack_5$	756	582.4
	Kme	$Kack_6$	770. 56	911.68
	Mean		**932.5**	**1184.530**

In addition, the abundant rains of this campaign could also have a negative impact on the plots in association. Indeed, the soils were confronted with problems of retention of the little organic matter present. But cowpea, although the soils are poor, could contribute to the improvement of maize production. Hence the obtaining of an average yield close to one tonne (average yield of plots in association). For the last campaign (2020-2021), yields were nil, 0.00 kg per hectare (see table 2). The reasons for these data were, among others: very late sowing, incomplete corn cycle, premature cessation of the rains, etc.

In addition, to reduce and simplify the tables, abbreviations have been used. These can be summarized as follows : Kack : producer ; Pcl : parcel ; M-N : maize-cowpea ; MP : pure maize ; Cge : campaign ; Tm : control ; Cme : municipality ; Kmo : Keur Mandongo ; Kme : Keur Madiabel ; Yield : yield ; ha : hectare ; kg : kilogram ; kg/ha : kilogram per hectare. Example, the table below illustrates these abbreviations.

Discussion

This study consisted in determining the impact of maize-cowpea crop associations on the level of maize production in the different plots (Pcl) of producers (Kack) during the two campaigns (2019-2020 and 2020-2021). For this, the yield of maize associated with cowpea was determined as well as that of the control, i.e. pure maize. Average yields by crop type were calculated. Thus, after observing Table 1, it was noted that the plots containing cowpea for the most part recorded acceptable yields. Indeed, this result could be explained by the improvement of soil fertility thanks to the legume, cowpea (*Vigna unguiculata* L. Walp.) even if these soils are sandy and not very weak. Nitrogen was able to promote the development of maize plants, having a positive impact on yield. In addition, weeds likely to compete with maize have been slowed down. This could increase performance. This result is close to that of Garba (2007) who showed that the association of two crops (cereal and

legume) produces advantages in terms of weed control, soil cover and soil protection against weeds. This could contribute to improving the yield of the plots. This result corroborates the work of Bousseau (2009) who claimed that one of the advantages of the association was the better yield of the associated crops compared to the average of the two species grown individually. Better still, the results of Juste *et al.* (2009) revealed that the total yield of the combination (wheat + pea) is greater than or equal to that of pure wheat (or pure pea). Thus, it is very likely that the association is most often more productive than the pure cultures. Other authors have also proven the advantages of the association compared to pure cultures of the associated species. These are (Zougmoré and *al.*, 2000; Juste and *al.*, 2009; Akédrin and *al.*, 2010) who indicated that in general the association of crops gives a totally better yield than that of the components of the association grown in pure. And the first results have been obtained since the 1980s. These systems have many agronomic and economic interests. This result could be explained by the fact that these plots were well fertilized beforehand with organic matter. Better, their soils are decks and therefore favorable to the production of corn. The densities of these plots were good, unlike those containing cowpea, which were low. The rains of this campaign were also very abundant. This therefore contributed to the increase in yields at the control level.

Table 2. Presentation of plot yields by producer per hectare (Results 2020-2021).

Cge	Cme	Kack	Yield/Pcl (Kg/ha)	
			Pcl(M-N)	Pcl(MP)=Tm
2020-2021	Kmo	$Kack_1$	0.00	0.00
	Kme	$Kack_2$	0. 00	0.00
	Mean		0.00	0.00

In addition, the yields of the 2020-2021 campaign for all plots combined were nil compared to those of the 2019-2020 campaign. Because, sowing was late and started in mid-August. To this was added the premature end of the rains at the end of the cycle for maize. Better, the corn could not complete its complete cycle. This result, due to the poor physiognomy of the rainy season, led to a negative impact of the maize-cowpea association on maize production. However, the cycle and water are essential for production.

Conclusion

Maize cultivation is an important value chain in general. In Senegal, particularly in the Cme of Kmo and Kme, the maize-cowpea association has been implemented to improve its production. At the end of this study, the maize yields in the different plots including the controls were determined. And this, for two campaigns (2019-2020 and 2020-2021).

All in all, maize production in associated crops (i.e. an average yield of 932.5 kg per hectare) was acceptable, especially during the 2019-2020 campaign. The low seed density and sandy soils had a slight negative impact on maize yields. For the witnesses, the good production (i.e. 1184.530 kg per hectare) is due to the decked soils of their plots. In addition, these soils have been amended with organic matter before.

On the other hand, for the 2020-2020 campaign, the yields were nil. This result is largely due to the delay in the rainy season and the premature cessation of the rains. In addition, the cereal-legume association, in particular that of maize-cowpea, should be recommended in order to ensure food and nutritional security in maize in the Cme of Kmo and Kme, in Senegal and in the world.

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