RICE PRODUCTION SYSTEM AND MAJOR NUTRIENT BALANCE ASSESSMENT IN RICE GROWING IN THE IRRIGATED PERIMETER OF THE ZIO VALLEY
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ABSTRACT

The knowledge of cropping systems and farming practices are essential towards improving crop yields. This study aims to characterize rice production systems, analyse fertilization practices, and assess the impact of irrigated rice on the balance of major nutrients in Zio valley. The characterization of production systems and fertilization practices were carried out through a survey of a sample of 192 randomly selected producers, i.e. 34% of the total number of farmers in the four (4) villages of the irrigated perimeter of the Zio valley: 83 in Kovié, 59 in Mission Tové, 26 in Assomé and 24 in Ziowonou. The simplified approach for estimating the partial nutrient balance was used for the mineral nutrient balance, involving only as "input" the contribution of nutrients by the mineral fertilizers used and as "output", the exports of the paddy and rice straw. For nutrient balance assessment, three farmers was selected in each village. These farmers were monitored during two crops cycles to collect necessary data for the calculation of the partial balance (fertilizers inputs and exports of biomass). An analysis of the composition of paddy rice and straw samples was carried out to measure N, P, and K content. Results showed that 80% of farmers are between 20 and 50 years old, the farm size average is 1.2 ha and the average yield is low at 3.3 t/ha. The practice of fertilization essentially consists of adding chemical fertilizers (NPK15-15-15 and Urea 46%N). On average, the quantities of fertilizers applied are 220 kg/ha of NPK and 222 kg/ha of urea, i.e., excess of 20 kg/ha for NPK and 122 kg/ha for urea compared to the recommended formulas. The partial balance is positive for N (+51.38 kg/ha) and deficient for P and K with respectively -8.93 and -15.01 kg/ha. Physico-chemical characterization of soils as well as an adaptation of fertilization formulas are necessary to improve fertilizer use efficiency and increase crop yields.

Keywords: Production systems, fertilization practices, irrigated rice, nutrient balance.

INTRODUCTION

Declining soil fertility is a major cause of low agricultural yields in sub-Saharan Africa. This phenomenon is due to the gradual disappearance of traditional shifting cultivation due to land pressure due to increasing population and competing demands for land use (Sogbedji et al., 2006). In Togo, the decline of soil fertility, becomes one of the main constraints of the agricultural sector, particularly in irrigated rice production where the soil is used each year without fallowing (Sanou & Soule, 2017). According to Wopereis et al. (1999), increasing the doses of fertilizers, especially nitrogenous fertilizers, would improve yields. However, there is a growing need to assess not only the profitability and financial risks of fertilizer use, but also cropping systems that limit sustainable management practices in irrigated rice production (Donovan et al., 1999). In fact, poor fertilization practices can limit fertilizer's efficacity and contribute to a drop in the profitability of farms. Kintche (2011), mentions inappropriate

traditional practices, population growth, export of crop residues through burning, common grazing, and the low mineral return to the soil to explain the decline in the fertility of soils in Africa.

In the Zio Valley, rice production has been practiced continuously since 1964 without fallowing. Indeed, with irrigation, the traditional long-term fallow system no longer exists. This leads to land depletion and induces a decrease in yields, a drop in agricultural income and an increase in food insecurity (Sanou & Soule, 2017). Under these conditions, despite the heavy investments made both by the State and by the farmers, the yields observed are still low (about 3.5 t/ha), compared to the potentials of most of the varieties used on the irrigated site of the Zio valley between 6 and 8 t/ha. It is therefore necessary to assess cropping practices and their impact on soil fertility. The objectives of this study are to characterize production systems, analyze fertilization practices and assess nutrient balance in the irrigated perimeter of the Zio valley.

MATERIALS AND METHODS

Analysis of production systems and fertilization practices

The study was carried out in the irrigated perimeter of the Zio valley. A survey was conducted between September and October 2021 among 192 farmers including 35 women and 157 men chosen at random, i.e., 34% of the total number of farmers in the four (4) villages of the irrigated perimeter of the Zio valley: 83 Kovie, 59 at Mission Tove, 26 at Assome and 24 at Ziowonou. The choice of rice farmers was made by random draw based on the list of rice farmers. The information collected relates to the socio-demographic characteristics of producers (age, level of education, household size), the production system (size of farms, yields, periods of activity and fertilization practices).

Evaluation of the partial balance of nutrients N, P and K

The simplified partial nutrient balance estimation approach was used. For this, twelve (12) farms were monitored and data on the inputs of mineral fertilizers, organic matter as well as grain production and the export of crop residues were collected. Samples of paddy and straw were also taken to evaluate the exports of Nitrogen, phosphorus, and potassium from the farms to the “Soil-Water- Vegetals-Fertilizers” laboratory of the Togolese Institute for Agronomic Research (ITRA). The N, P and K concentrations were measured by using the micro-Kjeldahl procedure, vanadate molybdate-yellow colorimeter and flame spectrophotometer, respectively (Jiang et al., 2017).

RESULTS AND DISCUSSION

Farms characteristics and fertilization practices

Irrigated rice producers in the Zio valley are mostly young. It appears that nearly 80% of producers are between 20 and 50 years old with an average age of 42.23±9.26 years. The average farm size is 1.2±0,6 ha per producer and the average yield is 3.3±0.8 t/ha, i.e., 55% of the potential of the IR841 variety grown by 94% of producers. For chemical fertilization, producers declare using an average of 220 kg/ha of NPK (15-15-15) and 222 kg/ha of urea (46%), i.e., a respective excess of 20 kg/ha and 122 kg/ha of NPK (15-15-15) and urea recommended. For NPK (15-15-15), only 42% of farmers use the recommended 200 kg/ha dose and for urea, barely 8% still use the recommended 100 kg/ha. These increases are made by growers to compensate for the continued decline in soil fertility that results in low yields.

Table 1. Sociodemographic characteristics of rice producers in the Zio Valley irrigated perimeter.

Parameters	Modality	Frequency	Percentage
Age	below 20	0	-
	20 to 35 years old	54	34,4
	36 to 50 years old	72	45,9
	51 to 75 years old	29	18,5
	75 and over	2	100
Exploited areas (ha)	less than 1	75	39
	From 1 to 5	115	60
	More than 5	2	1
Yields obtained (t/ha)	$x \leq 2$	23	12
	$2< x \leq 4$	107	12
	$4< x \leq 5$	49	56
	More than 5	13	26
Quantity of NPK (15-15-15)	$X \leq 200$kg	43	22,4
	200kg	81	42,2
	$200\text{kg}< X \leq 300\text{kg}$	55	28,6
	More than de 300kg	13	6,8
Urée (46%)	$x \leq 100$kg	1	0,5
	100kg	15	7,8
	$100\text{kg}< x \leq 200\text{kg}$	103	53,6
	$200\text{kg}< x \leq 300\text{kg}$	54	28,1
	More than 300kg	19	9,9

Assessment of farm nutrient balance

Estimates of N, P, and K budget inputs and outputs are shown in Table 2. For the study period, N input from fertilizer in each village exceeded rice N uptake. For P and K, fertilizer input did not exceed crop uptake. This result indicates that the amount of nitrogen provided by the mineral fertilizers used by farmers is greater than the export needs of rice plants for current yields. As this result does not consider the other factors of nutrient loss such as leaching and gaseous losses, it is not possible to conclude on the effectiveness of nitrogen inputs. Thus, to know more about the sustainability of the system, a complete nutrient balance would be necessary. However, for P and K, mineral fertilizer inputs from producers are lower than export needs. Current yields are therefore due to a contribution of these nutrients by the soil.

Thus, the rice monoculture system and the practice of unsuitable fertilization contribute to a continuous depletion of the soil nutrient and to a potential pollution of water in nitrogen. These results confirm those of Drabo (2009) who observed soil depletion due to cereal monoculture combined with unsuitable mineral fertilization.

Table 2. Nutrient balances.

Villages	Balance sheet items	N (kg/ha)	P(kg/ha)	K(kg/ha)
Ziowonou	Input NPK	17.50	7.64	14.58
	Input Urea	61.33	0.00	0.00
	Grain export	23.02	10.18	5.56
	Straw export	18.93	5.03	24.95
	Balance	**+ 36.88**	**-7.57**	**-15.92**
Mission Tove	Input NPK	32.50	14.19	27.08
	Input Urea	84.33	0.00	0.00
	Grain export	42.33	18.72	10.21
	Straw export	26.02	6.92	34.30
	Balance	**+48.48**	**-11.44**	**-17.43**
Kovie	Input NPK	35.00	15.28	29.17
	Input Urea	84.33	0.00	0.00
	Grain export	35.32	15.62	8.52
	Straw export	22.91	6.09	30.19
	Balance	**+61.11**	**-6.42**	**-9.55**
Assome	Input NPK	30.50	13.32	25.42
	Input Urea	92.00	0.00	0.00
	Grain export	38.12	16.86	9.20
	Straw export	25.31	6.73	33.36
	Balance	**+59.07**	**-10.26**	**-17.14**
Mean	Input NPK	28.88	12.61	24.06
	Input Urea	80.50	0.00	0.00
	Grain export	34.70	15.34	8.37
	Straw export	23.29	6.19	30.70
	Balance	**+51.38**	**-8.93**	**-15.01**

CONCLUSION

This study has made it possible to update cultural practices in irrigated rice cultivation in the Zio valley, particularly in terms of fertilization. Rice yields are still low despite the permanent availability of water. Although other factors such as the quality of the seeds used and the control of pests can be used to explain these low yields, the study notes that the unsuitability of the fertilization formulas at the site is a factor in the depletion of soil nutrients and a source of nitrate pollution. To improve the efficiency of fertilizers and increase yields, an evaluation of the physico-chemical state of the soil and an adaptation of the fertilization formulas is important. In addition, it will be necessary to support farmers in identifying the best strategies for preserving the nutritional quality of soils adapted to the conditions of irrigated rice cultivation.

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