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Effect of nutrients and the N/K ratio on the yield index of a lowland histosol rice crop in the commune of Songon, southern Côte d'Ivoire

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Abstract

The aim of this study was to determine the effect of the main nutrients N, P, K and the N/K ratio on the rice yield index. To this end, four treatments and a blank control were used in a randomised complete block design with three replications to carry out this study in a lowland area with a histosol character in the commune of Songon in the south of Côte d'Ivoire. In this design, the blocks were separated by 1 m and, within each block, the microplots of 15 m^2 containing the treatments were separated by 0.5 m. The principle of the experiment is a response curve to increasing doses of N and K combined with a constant dose of P set at 14 kg P ha-1. The rice variety AR051H, a hybrid variety from Senegal evaluated by the GIPS expert group, was transplanted after a 21-day nursery period, with one seedling per poquet at 20 × 20 cm within the microplots. Fertiliser was applied in three doses at transplanting, tillering and bolting. A minimum of 5 cm of water was applied to the microplots 10 days after transplanting and maintained until the rice reached maturity. A selective systemic foliar herbicide (Weedkill 720 SL) was used for weed control and a systemic insecticide (Decis 50 EC) for insect control. The results showed a very significant effect of the treatments on the harvest index, which was 43% with the optimum doses of 105 kg N ha^{-1} and 75 kg K ha^{-1}.

Keywords: Nitrogen; Dose; Histosol; Harvest Index; Response Curve; Potassium

1. Introduction

Demand for rice in West and Central Africa is growing at 6% per year [1] (WARDA, 2008). This growth is higher than anywhere else in the world. As a result, local rice production in the various African countries does not meet consumption needs for this commodity [2] (Norman and Otoo, 2003). In Côte d'Ivoire, rice has become the staple food for the majority of the population. With rapid urbanisation, an annual population growth rate of 3.3% [3] (Avit *et al.,* 2014) and relatively high demographic growth estimated at 2.8% [4] (DSRP, 2009), rice consumption has increased from 140,000 tonnes in 1961 to around 1.3 million tonnes in 2008 [5] (USDA, 2009). However, national rice production is unable to meet the needs of the population, leading to imports costing several billion CFA francs [6] [7] [8] (Aliou, 2005; Amancho *et al.,* 2009; Kouablé, 2010). There are many reasons for this rice deficit. These include the depletion of the soil of the main nutrients required for rice production in the different agro-ecologies, and standardised, inappropriate and inaccurate fertilisation [9] [10] (Doberman, 2007; Konan, 2013) in the current context of climate change. Indeed, fertilisation in such a context leads to fertiliser applications that do not match the nutrient needs of the crop, resulting in wasted nutrients, money and, above all, environmental pollution [11] (Wang et al., 2001). It is therefore important to assess the nutrient capacity of the soil so that mineral fertiliser applications can be better

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matched to crop needs. To this end, mineral fertiliser application must take into account the current nutrient reserves of the soil and the appropriate dose. With this in mind, this study was carried out on a floodplain in the commune of Songon in the south of Côte d'Ivoire to determine the appropriate doses of N and K and their interaction for better rice production by assessing their harvest indices and related yield.

2. Materials and methods

2.1. Study site

The experimental site is located in Songon with the following geographical coordinates 5018'53''N and 4015'29''W. Songon is a commune in the south of Côte d'Ivoire, west of Abidjan, the economic capital of the country. Bordered to the north by the commune of Yopougon, to the east by the commune of Anyama, and to the south by the departments of Jacqueville and Dabou, it has an area of 536 km² [12] (MCLU-JICA, 2015). The experimental site is a floodable lowland (figure 1).

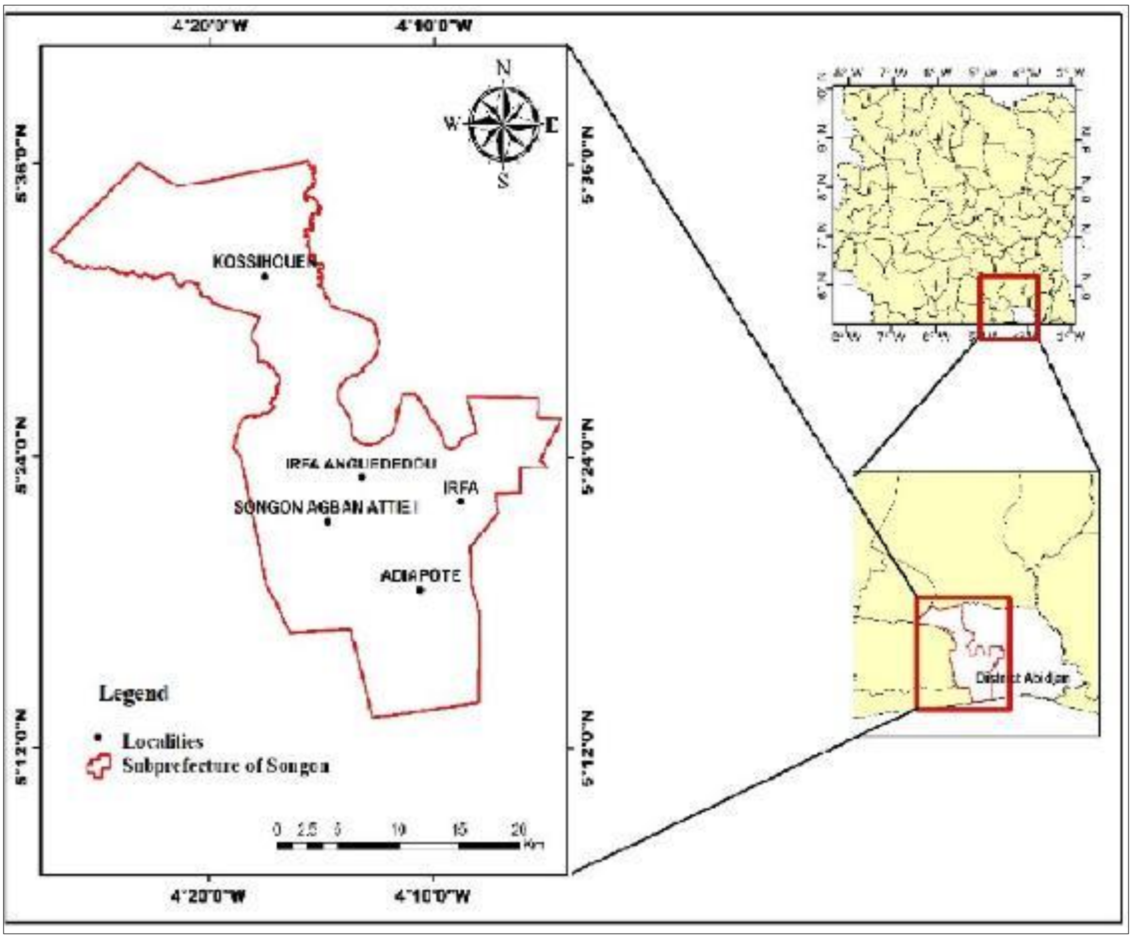

Figure 1 Location of study area

2.2. Inputs

2.2.1. Plant material

The rice variety used is F5- AR051H, developed by AfricaRice since 2016. It is a variety recommended for flooded lowlands. The yield potential is between 12-15 t ha^{-1} [13] (El-namaky, 2015) (figure 2).

Figure 2 F5- AR051H rice seed

2.3. Mineral fertilisers

The mineral fertilisers used in this study are essentially fertilisers containing the mineral elements necessary for rice development. These are urea ($CO(NH_2)_2$: 46% N), triple superphosphate ($Ca(H_2PO_4)_2$-H_2O: 18-22% P) and potassium chloride (KCl: 50% K), which contain nitrogen-N, phosphorus-P and potassium-K respectively.

2.4. Morpho-pedological characterisation and soil sampling

For soil characterisation and sampling, a 100 × 80 × 120 m soil pit was opened in the lowland where the trial was located and described according to the criteria defined by Baize and Jabiol (2011) [14] and Boulet et al. (1982) [15]. The soils were classified according to the CPCS classification (1967) [16], coupled with that of the World Soil Resources base (WRB, 2014) [17]. After the morpho-pedological characterisation of the study site, soil samples were taken with an auger to a depth of 0-20 cm at each corner and in the centre of the microplots. These samples were dried, crushed and mixed, and 1 kg was taken as a composite sample, which was analysed in the laboratory to determine pH, content of granulometric fractions, organic carbon (C-org), azotal-N-total, total phosphorus, potassium-K, calcium-Ca, magnesium-Mg, zinc-Zn, iron-Fe and aluminium-Al, using the analytical methods commonly used in soil science. Soil granulometric fractions were determined using the Robinson pipette method (Gee and Bauder, 1986) [18]. Soil carbon-C was determined by the Wakley and Black method (Nelson and Sommers, 1982) [19], total nitrogen-N by the Kjeldahl method according to Bremner and Mulvaney (1982) [20], K, Na, Ca and Mg, Fe, Zn and Al by electrothermal atomic absorption spectrometry. The pH of the water was determined using an electronic pH meter on a 1/2.5 water/soil suspension.

2.5. Experimental design

A randomised complete block design was established on an area of 375 m^2 with microplots of 15 m^2 with 5 treatments in 3 replicates. The principle of the experiment was to evaluate the effect of increasing doses of N and K for a constant dose of P set at 14 kg ha^{-1}. For this purpose, five treatments were carried out: N1PK1 (control), N2PK1 (T1), N3PK1 (T2), N1PK2 (T3) and N1PK3 (T4). In these treatments, nutrients were applied at rates of 80 kg N ha^{-1}, 100 kg N ha^{-1} and 120 kg N ha^{-1} for N1, N2 and N3 respectively, and 50 kg K ha^{-1}, 100 kg K ha^{-1} and 150 kg K ha^{-1} for K1, K2 and K3 respectively. These nutrients were applied in the form of urea (CO(NH2)2; 46% N), triple super phosphate ($Ca(H_2PO_4)_2$-H_2O; 18-22% P) and potassium chloride (KCl; 50% K). The rice variety F5- AR051H was then transplanted after 21 days of nursery, with one plant per pot and 20 × 20 cm spacing within the microploùùts. Potassium and nitrogen were applied in threes. Phosphorus was applied as a single dose at transplanting. Urea and potassium were applied 1/3 at transplanting, 1/3 at tillering and 1/3 at bolting. A minimum of 5 cm of water was applied and maintained for 10 days after transplanting until the rice reached maturity. Weeding was carried out chemically and manually as necessary. Birds were hunted from the time of milk collection until the day of harvest.

2.6. Collection of rice agro-morphological data

At 21 days after transplanting (DAT) and at 45 DAT, the number of rice tillers was counted per plot for each treatment in a 1 m^2 grid. Then, at maturity, the height of the plant and the number of rice panicles were determined under the same conditions. Harvesting was carried out manually over an area of 8 m^2 in each microplot, leaving two border lines to avoid border effects. After threshing and drying, the weight of the straw and that of the rice grains were determined to estimate the grain yield (GY) and straw yield (SY). The moisture content of the rice grains was determined after oven drying at 70°C for 24 h and the grain yield was calculated for a standard moisture content of 14%. Straw and grain yield, total dry matter (TDM) and harvest index-HI were calculated using the following formulae:

$$GY\ (tha-1)\ =\ (Grain\ dry\ weight\ (kg)/\ 8\ (m2))\ x\ (10000/1000)\ x\ ((100-H)/\ 86) \quad [1]$$

$$SY\ (tha-1)\ =\ (Straw\ weight\ (kg)/8(m2))\ x\ (10000/1000) \quad [2]$$

$$TDM\ (tha-1)\ =\ GY\ +\ SY \quad [3]$$

$$HI\ (\%)\ =\ (GY/TDM)\ x\ 100 \quad [4]$$

The moisture content was determined using the following formula:

$$H\ (\%)\ =\ ((Fresh\ weight\ -\ dry\ weight)/Fresh\ weight)\ x\ 100 \quad [5]$$

2.7. Statistical analysis of data

The data obtained were entered into Excel for statistical analysis. Data on height, number of tillers, grain yield, straw yield, total dry matter and harvest index were subjected to analysis of variance (ANOVA) and response curves were constructed to determine the optimum doses of N and K that gave the best yields. SAS version 10 software was used to analyse the data and means were compared using ppds at $\alpha = 0.05$ and 0.1 thresholds.

3. Results and discussion

3.1. Morpho-pedological characteristics of the soil

In the hydromorphic zone, two horizons with irregular boundaries were observed and described in the profile of the soil pit (Figure 3) studied. A surface horizon A1 0 - 20 cm deep, dark in colour (2.5Y 2.5/1), sandy with the presence of organic matter and containing a few subhorizontally oriented roots was observed. An Ag horizon 20 - 30 cm deep, essentially sandy and greyish in colour (5YR 3/1) was also observed. This horizon has a loose particulate structure. The perched water table appears from a depth of 30 cm. The type of soil described in the hydromorphic zone is a Stagnic Arenosol. In the lowland zone itself, the soil core (Figure 4) shows three distinct horizons. An O horizon, 0 - 13 cm deep, has a high organic matter content, high moisture content and a silty clay texture. The general colour of this horizon is dark brown (7.5 YR 3/2). The second horizon is a histic horizon 13 - 34 cm deep and blackish in colour (7.5 YR 4/6). This horizon contains decomposed and undifferentiated organic matter. Horizon three is a blackish peaty horizon (7.5 YR 3/3) and is essentially organic. The abundant organic matter is decomposed and differentiated. The lowland soil itself is a histosol vertic.

Figure 3 Arenosol Stagnic

Figure 4 Histosol Vertic

3.2. Physico-chemical characteristics of the soil in the 0-20 cm horizon

Table 1 The physico-chemical characteristics of the soil in the 0-20 cm horizon at the experimental site.

Physical characteristics	
Clay (%)	--
Silt (%)	--
Sand (%)	--
Chemical properties	
pH (water)	4.72
C (gkg^{-1})	45.39
OM (gkg^{-1})	78.25
N (gkg^{-1})	2.18
C/N	20.79
Zn (ppm)	0.35
Fe (ppm)	0.71
K^+ ($cmolkg^{-1}$)	0.42
Ca^{2+} ($cmolkg^{-1}$)	0.03
Mg^{2+} ($cmolkg^{-1}$)	1.47
Al ($cmolkg^{-1}$)	0.06
Redox potential (mV)	133.9
P (ppm)	0.65

---: not available; OM: Organic mater

Table 1 shows that the soil does not contain clay, silt or sand. Observation shows that it consists entirely of organic matter. The soil has a very high content of organic matter (78%) and organic carbon (45.39%) and a relatively low cation exchange capacity (CEC) (3.42 cmol kg-1). The results of the chemical analysis also show that this soil is very low in nitrogen, as indicated by the N content (2.18%). The C/N ratio (20.79%) and the redox potential (133.9 mV) are high. Iron, potassium, zinc, calcium, aluminium and phosphorus are low.

3.3. Morpho-pedological and chemical characteristics of the lowlands.

The morpho-pedological characterisation of the lowland reveals a peaty histosol. Histosols are soils composed of organic matter and large quantities of water, leading to the formation of peat bogs, which represent the organic matter accumulation layer. Physico-chemical analyses show a high organic matter content, estimated at 78.25%. Organic matter is one of the key factors in improving soil fertility and crop yields by acting as a cohesive layer and storing water (Hubert and Schaub, 2011) [21]. The organic carbon content is also high (45.39%), with a C/N ratio of 21.11. A C/N ratio greater than 12 indicates slow decomposition of organic matter. This low activity of mineralisation of organic matter could be related to the acidity of the soil, pH = 4.73. This acid soil is also deficient in calcium, magnesium and potassium in relation to normative values. According to the work of Sahrawat et al (1995) [22], acid soils are often deficient in calcium and magnesium. According to Konan (2013) [10], in lowland rice fields, the mineralisation of organic matter is reduced at a slower rate than its accumulation. Despite the high organic matter content, there is a low rate of cation exchange capacity CEC<10 cmolkg-1. This low CEC content would explain the low content of exchangeable bases observed in the lowland soil. This may be due to the strong relationship between organic carbon and CEC (Brady and Weil, 2002) [23]. According to Vidal et al (1996) [24], the accumulation of high C/N organic matter is a sign of more or less complete blockage of biological life, often resulting in low mineral content in lowland soils. Thus, the low level of CEC in lowland soils is not without consequences for the mineral nutrition of irrigated rice, which could experience toxicity problems, especially iron toxicity, which according to Zro-bi et al. (2012) [25] is very characteristic of hydromorphic soils and lowlands in humid tropical regions.

3.4. Characterisation of treatments on agromorphological parameters

3.4.1. Effect of treatments on average height and average number of tillers

Table 2 The average height and average number of tillers according to the treatments

Treatments	Average height (cm)	Number of tillers (m^{-2})
T1	118,85a	11.12a
T2	122,13a	11.42a
T3	122,12a	15.30a
T4	112,71a	17.55a
Indicator	107,98a	10.29a
CV (%)	21,40	44.12
GM	116,75	13.14
P> F	0,67	0.04

GM: general mean CV: Coefficient of variation P: Probability. Means in a column followed by the same letter are not statistically different using the Newmann-Keuls test at the 5% threshold.

Analysis of Table 2 shows that the treatments did not have a significant effect on the average height of the rice, but they did have a very significant effect on the number of tillers. The highest average number of tillers was observed in treatments T4 and T3. The lowest number of tillers was observed in the control, T1 and T2 treatments.

3.5. Effect of treatments on average rice height according to cropping cycles

Table 3 The effect of treatments on the average height of rice according to cropping cycles

Growing cycle	Rice height (cm)							
	T1	T2	T3	T4	Indicator	CV%	GM	P> F
Cycle 1	93.84a	98.73a	97.10 a	87.12 a	84.70 a	12.11	92.30	0.49
Cycle 2	117.39a	120.82a	127.80a	103.45a	107.78a	8.49	115.45	0.07
Cycle 3	145.31a	146.84a	141.45a	147.56a	131.44a	12.28	142.52	0.78

GM: general mean CV: Coefficient of variation P: Probability. Means in a column followed by the same letter are not statistically different using the Newmann-Keuls test at the 5% threshold.

Analysis of Table 3 shows that the treatments had no significant effect on the height of the rice, regardless of the crop cycle. However, the highest overall average heights were observed with treatments T2 and T3 for cycles 1 and 2; T4, T2 and T1 respectively in the third cycle. In general, rice height increased from the first to the third cycle.

3.6. Effect of treatments on the number of rice tillers in different cropping cycles

Table 4 The total number of rice tillers by crop cycle

Number of tillers								
Growing cycle	**T1**	**T2**	**T3**	**T4**	**Indicator**	**CV (%)**	**GM**	**P> F**
Cycle 1	12.35a	10.09a	14.91a	13.75a	7.71a	32.17	11.76	0.21
Cycle 2	8.86a	11.41a	15.83a	17.38a	12.50a	42.73	13.19	0.40
Cycle 3	12.16a	12.77a	15.17a	21.52a	10.66a	58.79	14.46	0.57

GM: general mean CV: Coefficient of variation P: Probability. Means in a column followed by the same letter are not statistically different using the Newmann-Keuls test at the 5% threshold.

Tillers in any crop cycle. However, the number of tillers was higher in the second and third cycles in treatments T4 and T3. The trend increased from the first to the third cycle.

3.7. Effect of treatments on rice grain and straw yields

Table 5 The effect of treatments on rice grain and straw yields

Traitments	RGY (tha^{-1})	RSY (tha^{-1})
T1	1.23ab	4.34a
T2	1.30a	4.22a
T3	0.93b	4.51a
T4	1.08ab	4.99a
Indicator	1.04ab	4.30a
CV (%)	28.53	18.73
GM	1.11	4.47
P>F	0.13	0.99

GM: general mean CV: Coefficient of variation P: Probability. Means in a column followed by the same letter are not statistically different using the Newmann-Keuls test at the 10% threshold

Analysis of Table 5 shows that the treatments had not significant effect on grain yield at the 10% threshold, in contrast to straw yield. The highest grain yield that was statistically different from the others was 1.30 t/ha, which occurred with treatment T2. This yield was followed by the yields of treatments T1, T4 and the control, which were not statistically different from each other.

3.8. Effect of treatments on harvest indices and total rice dry matter

Table 6 The effect of the treatments on the harvest index and the total dry matter of the rice

Traitments	HI (%)	TDM (t/ha)
T1	22.38ab	5.58a
T2	24.31a	5.52a
T3	17.46b	5.45a
T4	18.84b	6.07a
Indicator	20.16ab	5.34a
CV (%)	26.86	15.91
GM	20.63	5.59
P>F	0.08	0.47

GM: general mean CV: Coefficient of variation P: Probability. Means in a column followed by the same letter are not statistically different using the Newmann-Keuls test at the 10% threshold.

Analysis of the effect of treatments on harvest index and total dry matter shows that there was a very significant difference between treatments on harvest index. However, no effect was observed on total dry matter. The best harvest indices were obtained with treatments T2 and T1 respectively and are statistically different. Treatment T4 gave a total dry matter higher than the overall average.

3.9. Effect of treatments on rice harvest index according to cropping cycles

Table 7 The effect of treatments on rice harvest index (HI) by crop cycle

Indice de récolte (%)								
Crop cycles	T1	T2	T3	T4	Indicator	CV (%)	GM	P> F
Cycle 1	28.77a	24.02a	20.61a	23.47a	21.25a	33.57	23.62	0.74
Cycle 2	19.80b	29.06a	17.74b	20.86b	23.69ab	17.80	22.23	0.04
Cycle 3	18.57a	19.85a	14.03a	12.20a	15.54a	26.27	16.04	0.22

GM: general mean CV: Coefficient of variation P: Probability. Means in a column followed by the same letter are not statistically different using the Newmann-Keuls test at the 5% threshold.

Analysis of the table shows that the treatments had a significant effect in cycle 2, in contrast to cycles 1 and 3. The best harvest indices were obtained with treatments T2 in cycle 2 and T1 and T2 in cycle 1. Overall, the best harvest indices were obtained in the first two crop cycles. Treatments T1 and T2 gave a harvest index higher than the overall average for cycles 1 and 3. For cycle 2, treatments T2 and control gave an average above the overall average.

4. Analysis of N, P and K doses on rice grain yield

4.1. Interactive effects of N and K doses on rice grain yield

The figure 5 shows that there is an increasing effect of potassium dose between 80 and 150 kg ha-1, with almost no effect for doses below 80 kg N ha-1 when the nitrogen dose is below 80 kg/ha. On the other hand, grain yield increased with the interactive effect of N and K up to 105 kg N/ha, which corresponds to the optimum nitrogen dose for rice grain yield, irrespective of potassium doses above 80 kg K ha^{-1}. The optimum yield is about 3.10 t ha^{-1} for the dose of 105 kg N/ha and 75 kg K

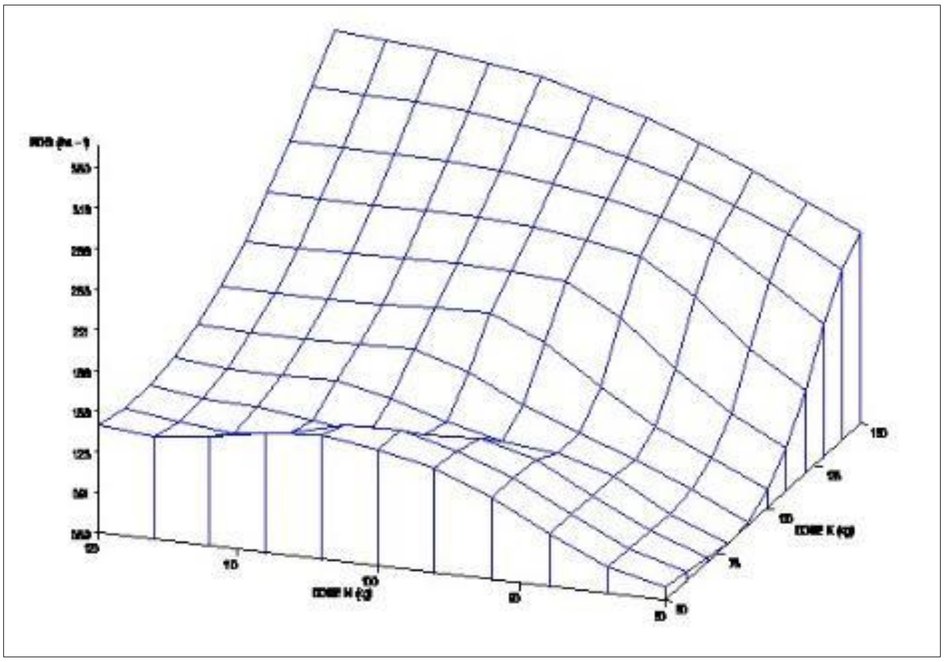

Figure 5 Rice grain yield response curve to nitrogen (N) and potassium (K) doses for the three cycles combined

4.2. Interactive effects of N and K doses on rice grain yield

Figure 6 shows the interactive effects of N and K doses on rice grain yield for all three cropping cycles. There was also an increasing effect of potassium dose between 80 and 150 kg ha^{-1}, with almost no effect for doses below 80 kg K ha^{-1} when the nitrogen dose was below 80 kg ha^{-1}. On the other hand, the harvest index increases with the interactive effect of N and K up to 105 kg N ha^{-1}, which corresponds to the optimum nitrogen dose for the rice harvest index, irrespective of the potassium doses above 80 kg K ha^{-1}. The optimum harvest index is around 43 for a dose of 105 kg N ha^{-1} and 75 kg K ha^{-1}.

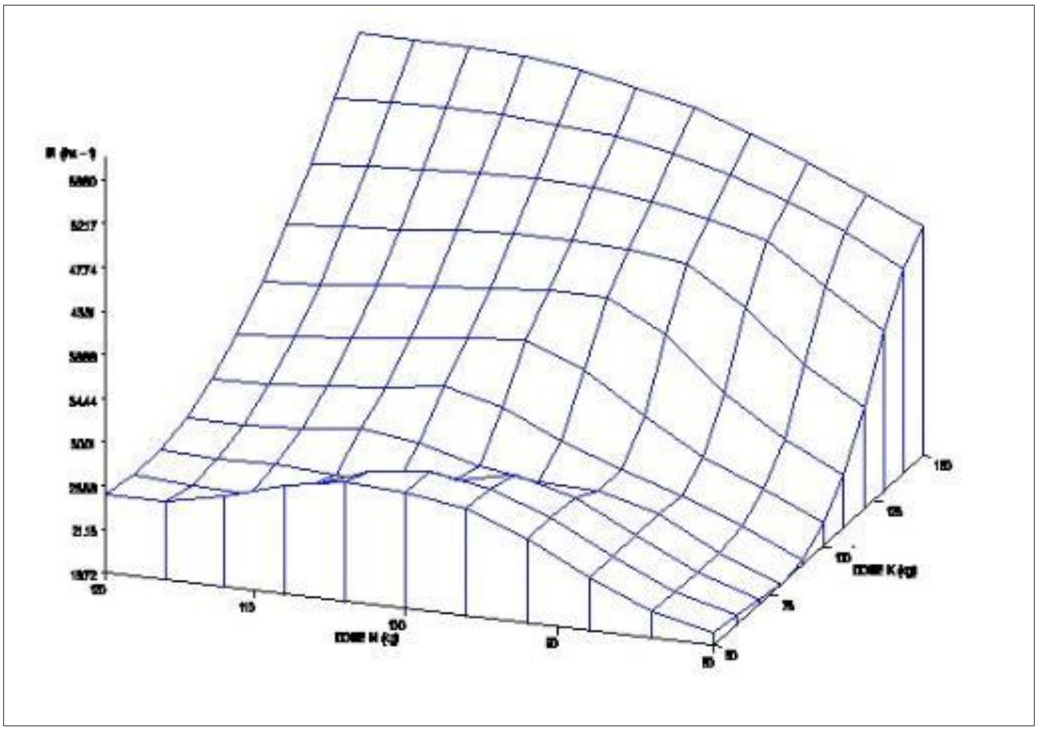

Figure 6 Response curve for rice yield index as a function of nitrogen (N) and potassium (K) for the three cycles combined

4.3. Effect of increasing doses of N and K on grain yield and harvest index

The results show that grain yield and harvest index were highly significant depending on the treatment. However, an increase in grain yield (RDG) and harvest index (IR) was observed for treatments T1 and T2. Treatments T1 (100 kgN+14kg P +50 kg K) and T2 (120 kg N+14kg P+ 50 kg K) had the highest RDG and IR. The control had the lowest RDG, while T3 had the lowest IR, even though the potassium dose in the control was the same as in T1. This variability in RDG and IR is thought to be due to the dose of nitrogen fertiliser applied as a supplement. In fact, several studies (Belaid, 1987; Hafsi, 1990; Halilat, 1993 and Aissa and Mhiri, 2001) [26] [27] [28] [29] have shown that there is a synergy between the different nutrients N, P and K. Mineral nutrition of plants requires a balance between nutrients (Halilat, 1993) [28]. Good rice nutrition can only be achieved by balancing the different mineral elements in the soil (Filsch *et al.*, 2007) [30]. Treatments T3 and T4 gave low grain yields despite the high dose of potassium fertiliser applied. This could be due to nutrient leaching. The decrease in RDG observed with the highest doses of mineral fertiliser shows that the grain filling phase is a critical stage in yield development and would have been disrupted (Lacharme, 2001; Akintayo et al., 2008) [31] [32]. The high dose of potassium improves biomass rather than grain yield. In fact, the addition of nitrogen increases the plant's need for K and consequently the level of this element in the plant (Halilat, 1993; Loué, 1970) [28] [33]. The optimum dose is 105 kg N ha^{-1} and 75 kg K ha^{-1}. Fertiliser efficiency varies according to region, country, farmer and soil type (Prudencio, 1993 and Pypers, 2010; Sanginga et Woomer, 2009) [34] [35] [36].

5. Conclusion

The results obtained in this study show that histosols are organic, acidic soils with slow mineralisation of organic matter and high immobilisation of trace elements for plant nutrition. The treatments had no significant effect on the vegetative development of the rice and grain yield, but had a very significant effect on the harvest index at T1 (N2PK1) and T2 (N3PK1). In order to consolidate what has been learnt and to deepen our knowledge of the best fertilisation practices for improving the harvest index of rice, further studies should be considered, such as increasing the harvest index by increasing the dose of K.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

References

[1] WARDA, NERICA. The New Rice for Africa compendium. EA Somado, RG Guei and So Keya (eds). Cotonou, Benin, 2008.

[2] Norman JC, and Otoo E. Rice development strategies for food security in Africa. In Sustainable rice production for food security. Proceedings of the 20th session of the international rice commission. FAO, Rome. (2003) « http : II www. Aatf-africa.org ».

[3] Avit JBLF, Bony YK, Konan FK., Kouassi CN, Traoré S et WA Yté . Paramètres environnementaux du grossissement d'Oreochromis nilotiques (Linne, 1758) (cichlidae, perciformes) en association avec le riz Djoukèmin (Oryza sativa) en étang. Recherche sur l'élevage pour le développement rural 26 (7) 2014. Bulletin du LRRD, 12p.

[4] DSRP. Stratégie de relance du développement et de réduction de la pauvreté. Document de stratégie de réduction de la pauvreté (DSRP). Gouvernement de Côte d'Ivoire(2009), 198 p.

[5] USDA. Rough rice production by country and geographical region, 1960/61-2008/09, IRRI World Rice Statistics, www.irri.org/science/ricestat/index.asp. Addle River, New Jersey (2009). 960 p.

[6] Aliou D. Impact de la libéralisation du commerce sur la filière riz : cas de la Côte d'Ivoire. Atelier régional sur les politiques agricoles et sécurité alimentaire en Afrique sub-saharienne Cotonou, 7-9 Novembre 2005, 21 p.

[7] Amancho AN, Diallo AH, Kouassi KN, Bouet A, N'Guessan KP. Criblage de quelques variétés de riz de Côte d'Ivoire pour la résistance à la panachure jaune du riz : incidence de la maladie sur quelques caractères agronomiques. Sciences and Nature Vol. 6 N°1, (2009) p. 27 – 37.

[8] Kouablé N.. Transmission des fluctuations et calcul des prix de parité du riz et du maïs à l'importation en Côte d'Ivoire. Michigan State University, CILSS, RESIMAO, Syngenta foundation, (2010), 56 p.

[9] Dobermann A. . "Nutrient Use Efficiency: Measurement and Management" (2007). Department of Agronomy and Horticulture: Faculty Publications. 1442, 28p.

[10] Konan KF.. Diagnostic minéral d'un sol de bas-fond secondaire développé sur matériaux granito-gneissiques en région centre de la Côte d'Ivoire : essai comportemental de riziculture irriguée. DEA en Science de la terre, Abidjan : Université Félix Houphouët-Boigny(2013). 70 p.

[11] Wang W, Chris JS, Chalk PM, Chen D. Evaluating Chemical and Physical Indices of Nitrogen Mineralization Capacity with an Unequivocal Reference. Soil Sci. Soc. Am. J., 65(2001): p. 368-376.

[12] MCLAU-JICA . Ministère de la Construction, du Logement, de l'Assainissement et de l'Urbanisme Agence Japonaise de Coopération Internationale. Projet de développement du Schéma Directeur d'Urbanisme du Grand Abidjan (SDUGA), (2) (2015) 508p.

[13] El-Namaky, R. Overview .f hybrid rice in Africa. 8th annual meeting of HRDC, IRRI- 25-27 March 2015. Africa-Rice, 27 p.

[14] Baize D, Jabiol B . Guide for soil description. New edition, France: Quae editions; 2011. World Journal of Advanced Research and Reviews, 2022, 15(02), p. 598–605.

[15] Boulet R, Chauvel A, Humbel FX, Lucas Y. Structural analysis and cartography in pedology: taking into account the two-dimensional organization of the pedological cover: studies of toposequences and their main contributions to knowledge of soils. Cah. ORSTOM, ser. Pedol. 1982; 19(4): p. 309-321.

[16] CPCS. Commission de Pédologie et de Cartographie des sols, classification des sols :Tableaux des classes, sous-classes, groupes et sous-groupes des sols. Service de classification des sols. INRA, France (1967). 96 p.

[17] WRB. (World Reference Base for Soil Resources 2014). International soil classification system for naming soils and creating legends for soil maps. 4th Edition, (2022) 234 p.

[18] Gee GW, Bauder JW. « Analyse granulométrique ». Dans Méthodes d'analyse des sols, partie 1 : Méthodes physiques et minéralogiques, édité par A. Klute, (1986). pp.383-411Wiley. https://doi.org/10.2136/sssabookser5.1.2ed.c15.

[19] Nelson D, et Sommers LE. « Carbone total, carbone organique et matière organique ». Dans Méthodes d'analyse des sols. Partie 2. Propriétés chimiques et microbiologiques, édité par AL Page, 539-579. Soil Science Society of America, American Society of Agronomy (1982).

[20] Bremner JM, Mulvaney CS. Azote total . Dans AL Page (éd.), Méthodes d'analyse des sols, partie 2 (2e éd. , pp. 595-624) .). Société américaine d'agronomie (1982).

[21] Hubert G, Schaub C. La fertilisation des sols. L'importance de la matière organique. Chambre d'Agriculture, Bas-Rhin. Service Environnement-Innovation,2011, 46 p.

[22] Sahrawat KL, JONES et Diatta S. Réponse du riz pluvial au phosphore dans un Ultisol dans la forêt humide d'Afrique de l'Ouest. Recherche sur les engrais 41, 1995, pp. 11-17 .

[23] Brady N C, Weil R R. The Nature and Properties of Soils, 13th Edition. Prentice Hall. Upper S, Agroforestery. Syst 54 (3), 249, 2002.

[24] Vidal L, Boucher L (AFUP), Lavigne D ph. « Les bas-fonds en Afrique tropicale humide : stratégies paysannes, contraintes agronomiques et aménagements » in Pichot et al eds. Fertilité du milieu et stratégies paysannes sous les tropiques humides, actes séminaire international, CIRAD,1996, pp.148-161.

[25] Zro-bi GF, Yao-kouame A, Kouame KF. Evaluation statistique et spatiale de la fertilité rizicole des sols hydromorphes (gleysols) de la région du Bélier (Côte d'Ivoire), tropicultura 30 (4), 2012, pp. 236-242,.

[26] Belaid D. Etude de la fertilisation azotée et phosphatée d'une variété de blé du (Hedba 3) en condition de déficit hydrique. Mémoire de magister. I.N.A 108 p.1987

[27] Hafsi M. Influence de la fertilisation phospho-azotée sur la variété de blé dur « Mohamed benbachir » (Triticum durum) cultivée dans les conditions des hautes plaines sétifiennes. I.N.A. 124p. 1990.

[28] Halilat MT. Etude de la fertilisation azotée et potassique sur blé dur (variété Aldura) en zone saharienne (région de Ouargla). Mémoire de magister. I.N.E.S. Batna. 130p.1993.

[29] Aissa AD, et Mhiri A. Fertilisation phospho-potassique du blé dur en culture intensive en Tunisie. Cahiers Agricultures 11 (6), 2001, pp. 391-397..

[30] Flisch R. Bien respecter la loi du minimum. Revue UFA 12. 3 p. 2007.

[31] Lacharme M. La fertilisation minérale du riz. Mémento Technique de Riziculture. 17 p. 2001.

[32] Akintayo I, Cissé B, Zadji LD. Guide pratique de la culture des NERICA de plateau. ADRAO. 29 p. 2008.

[33] Loué A. Importance de l'interaction azote x potassium dans l'appréciation de la réponse à la potasse. Academie d'agriculture de France.1970. pp. 721-730.

[34] Prudencio CF. Ring management of soils and crops in West African semi-arid tropics: The case of the Mossi farming system in Burkina Faso. Agriculture Ecosystems and Environment 1993. 47: pp. 237-264.

[35] Pypers P. Integrated soil fertility management: The TSBF definitions, seminar at UEA, 11th May 2010. Bukavu, DRC, 73 p.

[36] Sanginga N., Woomer P. Integrated soil fertility management in Africa: principles, practices and process development, TSBFCIAT and FORMAT, Nairobi Kenya, 2009,pp. 23-67.