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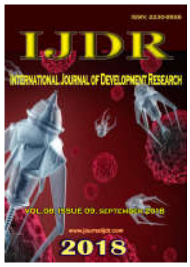

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

USE OF NEEM (AZADIRACHTA INDICA) SEED CAKE TO IMPROVE LOWLAND RICE PRODUCTION

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ABSTRACT

Objective: Soils in Burkina Faso are mostly characterized by their poverty in organic matter and nutrients. Several sources of organic matter were studied in Burkina Faso, but few scientific results are available on the use of neem (*Azadirachtaindica*). The current study was initiated to evaluate the effect of neemseed cake (NSC) on lowland rice productivity. The experimental design was a randomized blocks design established in Manzourin 2017. Treatments were: T0: control; T1: Recommendation/200 kg.ha-1 NPK + 100 kg / ha urea; T2:5 t.ha-1 NSC + 200 kg / ha NPK; T3:5 t.ha-1 NSC +100 kg / ha urea; T4: (5 t.ha-1 NSC + 200 kg / ha NPK + 100 kg / ha urea). The results showed ahighestnumber of tillers (22 tillers) and paddy yields (7.45 t.ha-1) for T4 treatment (5 t.ha-1 NSC + 200 kg / ha NPK + 100 kg / ha urea) compared to other treatments. TreatmentsT1 and T3 recorded comparable paddy yields (respectively 5.91 and 5.77 t. ha-1). The NSC combined with mineral fertilizers (NPK and / or urea) can significantly increase rice productivity inthe lowlands.

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INTRODUCTION

In Burkina Faso the original poverty of soils and the low use of organic and inorganic fertilizers are major constraints to land productivity (Bationo *et al*., 2011). In this country, rice is ranked 4thcereal (after sorghum, millet and maize) in terms of surface and production. Despite lot of efforts provided by thelocal government, projects and NGOs to increase rice production in the country, the local production can hardly cover 40% of the country needs leading to currency losses from the country (FAO, 2014). The paddy yields are low (around 2.5 t.ha^{-1}) compared to the potential of varieties proposed to the farmers (4 t) (Bazié *et al*., 2014, Guissou and Ilboudo, 2012).The low productivity of the varieties can be explained by unsuitable farming practices characterized by an exclusively use of mineral fertilizers, (Segda *et al.,* 2014a). The consequence is a decreasing crops yields over the years as a result of a declining soil fertility conditions (Abdo, 2014). Segda *et al.* (2014b) indicated that the most sustainable way to keep the lowland productivity is the combination of organic and inorganic soil amendments.

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Furthermore, Traoré *et al.* (2017) showed positive impact of the combination use of organic and mineral fertilizers on rice production in Burkina. Many sources of organic matter were studied in Burkina Faso (farmyard manure, compost, cover crops, domestic wastes, etc.) and recommendations done to increase to use these organic manure sources. But the results obtained are far below the expectations. One of the most important constraint identified is availability and accessibility to these sources of organic matter. The Neem (*Azadirachtaindica*) plantation has increased in the Sahel over the past 20 years to cope with erratic climatic conditions and to fight against land degradation. In Burkina Faso, the total area covered by Neem trees. The leaves and seeds of Neem are used as insecticide or in cosmetics products. The residues from neem extracts are in most cases thrown away as trash when several studies (Radwanksi and Wickens, 1981) showed that Neem cake contains nitrogen (2-5%), phosphorus (0.5-1.0%), potassium (1-2%), calcium (0.5-3%) and magnesium (0.3-1%) that can improve soil properties and adequately feed the crops. The Neemcake is therefore an excellent source of nutrients able to providing essential macronutrients for crop growth (Garba and Oyinlola 2014, Oyinlola *et al.,* 2014).

Table 1. Chemical properties of NSC

	Nutrients content					
	C %	O.M (%)	N (%)	C/N	Total_P (%)	Total_K (%)
NSC	54,59	94,11	2,65	21	0,27	1,91

O.M: Organic Matter; N: Nitrogen; C: Carbone; P: Phosphorus; K: Potassium

Table 2. Chemical properties of the study soil

pHwater	C_org (%)	O.M (%)	N (%)	C/N	Total_P (mg.kg^{-1} soil)	Available_P (mg.kg^{-1} soil)	Total_K (mg.kg^{-1} soil)	Available_K (mg.kg^{-1} soil)
6,93	0,72	1,23	0,04	16,13	109,14	1,49	1 863,69	42,20

O.M : Organic Matter ; N : Nitrogen ; C : Carbone ; P : Phosphorus ; K : Potassium ;

Table 3. Impact of fertilization options on rice tillering

Treatments	Tillers number		
	21 DAT	38 DAT	55 DAT
T0 (Control)	1,92 c	4,86 e	8,39 d
T1 (200 kg.ha^{-1} NPK+100 kg.ha^{-1} urea)	5,89 a	12,12 b	20,16 b
T2 (5 t.ha^{-1} TDN+200 kg.ha^{-1} NPK)	6,11 a	10,34 d	14,57c
T3 (5 t.ha^{-1} TDN +100 kg.ha^{-1} urea)	4,37 b	11,18 c	19,69 b
T4 (5 t.ha^{-1} TDN +200 kg.ha^{-1} NPK+100 kg.ha^{-1} urea)	6,15 a	13,80 a	22,50 a
Probability	<0,0001	<0,0001	<0,0001
Signification	*HS*	*HS*	*HS*

The averages followed by the same letter in the same column do not differ significantly at the 5% threshold according to the Newman and Keuls Test. HS: highly significant; DAT: Days after transplantin.

The current study was initiated to evaluate the capacity of Neem seed cake (NSC) to support lowland rice productivity in Burkina Faso.
The specific objectives are:

- Evaluate the impact of different fertilization options including the NSC on low land rice productivity
- Propose the best fertilization options including the NSC for sustainable lowland rice productivity
- We hypothesize that combining NSC with limited quantities of mineral fertilizers can significantly improve the productivity of low land rice.

MATERIAL AND METHODS

The trial site: The study was carried out in Manzourlowlandin Southwest region of Burkina Faso during the rainy season of 2017. The geographic coordinatesof the site are: 11 ° 13'11 " N and 3 ° 24'28 " W. The soils of the site are hydromorphic to pseudo-Gley. The climate of the site is South-Sudanian characterized by two seasons: a rainfall season lasting 5 months (from mid-May to mid-October) and a dry season of 7 months (from mid-October to mid-May) (Yili, 2006). The average annual rainfall of the site (2007 - 2016) is estimated to 861.27 mm (DPAAH / Ioba, 2017) and 1008 mm of rainfall were recorded in 50 days during our study period in 2017.

MATERIAL: Rice variety used is FKR 64 with growing cycle (planting-maturity) of 120-days and potentialyield of 6.5 to7 t.ha^{-1}

Mineral fertilizers used in the trial: The mineral fertilizer used are: NPK (14-23-14) and urea 46% N.

Organic manure: The organic manure used was Neemseed cake (NSC). The NSC is obtained after oil extraction from the seeds. Table 1 summarizes the chemical properties of the NSC used.

METHODS

Experimental design: The experimental design was a complete randomized blocks with five treatments in 3 replications. The following treatments were compared: T0 (no fertilizer, control); T1 (200 kg.ha^{-1} NPK + 100 kg.ha^{-1} urea or recommended mineral fertilization`); T2 (5 t.ha^{-1} NSC + 200 kg.ha^{-1} NPK); T3 (5 t.ha^{-1} NSC + 100 kg.ha^{-1} urea); T4 (5 t.ha^{-1} NSC + 200 kg.ha^{-1} NPK + 100 kg.ha^{-1} urea. The size of experimental, plot was 32 m² (8 m x 4 m).

Rice planting and fertilizers application: After 30 days in the nursery, the rice plants were transplanted in the plots at density 25 x 25 cm with 1 plant/hole. The NSC and NPK were applied as starter fertilizer in a single application just before rice transplantation. Urea was applied, 1/3 at 30 days after transplanting (DAT) and 2/3 at 45 DAT after drainage of the plots.

Laboratory analyses: Soil pH Water was measured from a soil solution obtained at a mass / volume ratio of 1 g.2.5 ml^{-1} (BUNASOLS, 1986). Total Phosphorus was measured using digestion and mineralization (Anderson and Ingram 1989). The available phosphorus, Total nitrogen, Organic carbon were determined using respectively BRAY 1 (Dickman*et al*., 1940). Kjeldahl (Hillebrand *et al*., 1953). Walkley-Black (1934) methods. Soil organic matter content was estimated using the carbon content according to the formula = Carbon content * 1.724 (Walkley-Black (1934). Total potassium was measured by spectrophotometry.

Data analysis: Statistical analyzes were performed using the XLSTAT 2007.5 software. The averages were separated by the Newman-Keuls method at the 95% confidence level.

RESULTS

Soil chemical properties: The results of the chemical properties of the soil before the trials were planted are shown in Table 2.

Table 4. Impact of fertilization options on rice panicle number

Treatments	Number of panicles per plant
T0 (Control)	7,98 e
T1 (200 kg.ha-1 NPK+100 kg.ha-1 urea)	16,80 b
T2 (5 t.ha-1NSC+200 kg.ha-1 NPK)	12,48 d
T3 (5 t.ha-1NSC +100 kg.ha-1 urea)	15,84 c
T4 (5 t.ha-1NSC +200 kg.ha-1 NPK+100 kg.ha-1 urea)	18,99 a
Probability	<0,0001
Signification	HS

The averages followed by the same letter in the same column do not differ significantly at the 5% threshold according to the Newman and Keuls Test. HS: highly significant; DAT: Days after transplanting

Table 5. Effects of treatments on paddy yield of lowland rice

Treatments	Rice paddy yield (kg.ha-1)
T0 (Control)	1,88 d
T1 (200 kg.ha-1 NPK+100 kg.ha-1 urea)	5,91 b
T2 (5 t.ha-1 TDN+200 kg.ha-1 NPK)	4,11 c
T3 (5 t.ha-1 TDN +100 kg.ha-1 urea)	5,77 b
T4 (5 t.ha-1 TDN +200 kg.ha-1 NPK+100 kg.ha-1 urea)	7,45 a
Probability	<0,0001
Signification	HS

The averages followed by the same letter in the same column do not differ significantly at the 5% threshold according to the Newman and Keuls Test. HS: highly significant; DAT: Days after transplanting

The results show a soil pH closed to neutral. Soil available P and available K are very low compared to the level of soil total contain of these nutrients. The results show also low N contain and high C/N ratio.

Impact of fertilization options on the number of rice tillers and panicles: Table 3 shows the number of tillers based on fertilization options and the number of days after transplanting (DAT). The number of tillers increased between 21and 55DAT. The results show highly significant difference between treatments and this is independent of observation dates (21 DAT, 38 DAT and 55 DAT). At 21 DAT, the highest number of tillers was recorded for treatment T2 containing NPK-combined with NSC. At 38 and 55 DAT the highest number of tillers is obtained with T4 treatment «NSC + NPK + urea" followed by the recommended mineral fertilizer. For all the three observation dates the lowest number of tillers was recorded on the control treatment without fertilizer application.

Effects of fertilization options on number of panicles: Table 4 shows the number of panicles per plant according to different treatments. The results show highly significant difference between treatments for panicles numbers. The highest panicles number per plant was recorded for treatment T4 "NSC + NPK + urea" followed by T1 treatment ("NPK + urea»). The lowest number of panicles was recorded with T0 treatment "control treatment.

Effects of fertilization options on rice paddy yield: The paddy yields per treatment are reported in Table 5. The results show highly significant difference in paddy yields between treatments (P <0.0001). The highest paddy yield was obtained with treatment T5 (NSC + mineral fertilizer). Paddy yields are comparable for T1 (200 $kg.ha^{-1}$ NPK + 100 $kg.ha^{-1}$ urea) and T3 (NSC +100 $kg.ha^{-1}$ urea) treatments. The lowest paddy yields was obtained with T0 treatment ("without fertilizer").

DISCUSSION

The results show high variability with highly significant difference between treatments for both physiological parameters and paddy yields.

The combination Neem cake and mineral fertilizers generated the highest impacts on all the measured. These results show the capacity of the Neem cake to support the growth of the rice crop. The same results were reported by Shah and Kumar (2014) and Lokanadhan *et al*. (2012) in India. Lokanadhan *et al.* (2012) indicated also an increase in rice yield with application of NSC in the rice fields According to Oyinlola *et al.*(2017) crops performance is due to an increase insoil organic carbon and nitrogen contain. For Ademi (2006) and Azim *et al*. (2011) the success of using NSC would result from an increasing of the level of soil organic matter. Thechemical properties in our case of the NSC showedvery high content of organic carbon (94%) thus having the capacity to increase soil organic matter. Indeed, if mineral fertilizers are easily soluble, their good uptake by plants depends on the good physical, chemical and biological properties of soils (Schoebitz and Vidal, 2016). The combination of NSC with NPK and / or urea has probably improved the absorption of mineral fertilizers leading to the performance obtained. According to Yan and Gong (2010) the high nutrient concentrations of NSC and its positive impact on chemical properties would explain this performance on increasing crop yields while reducing their variability over the yield. According to Lokanadhan *et al*. (2012), using the NSC as soil amendments will increase soil organic matter, which avoid nitrogen loose in the soil profile mainly in the sandy soils. The positive impact of the Neem cake on soil properties makesit asan excellent source of organic matter for soils and nutrients for crops and this is supported by Yusuf *et al.* (2011). The high yields of paddy obtained with treatmentT4 (NSC + NPK + urea) and T3 «NSC + urea" shows that the use of this product as organic amendment would sustainably support the productivity of rice in the lowlands in Burkina Faso. The results obtained showed also that the NSC can be used with limited quantities of mineral fertilizer for rice production in Burkina which is very important for farmers with very low income. This low cost fertilization option can be more accessible to higher number of farmers and this can definitely boost rice production in the country.

Conclusion

From our study we can conclude the following

- The use of NSC has a positive impact on the growth and development of rice,
- The NSCcombined with mineral fertilizer can boost rice productivity in the low lands
- Rice yields are highest and closed to the potential yield of the varieties when the NSC is combined with recommended mineral fertilizers.
- Rice yields are very low when no fertilizer.

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