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RESEARCH ARTICLE

THE VALUATION OF SALTED LOWLAND FOR RICE PRODUCTION IN THE SAHEL CONDITIONS

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ABSTRACT

The aim of this work wasto conduct varietaltests targeting to determine the best adapted varieties. These tests were carried out in the lowlands of Boli and KeurAliou Gaye, Senegal. During those seven years, the number of rainy consecutive days does not exceed five which show of the arid climate. In 2003, in KeurAliouGueye, varieties "WAS 63-22-1-1-3-3" (5.4 t/ha) and "WAS 164-B-5-2" (5.7 t/ha) exceeded the control over 2 tons. In 2005, all varieties reached a cycle shorter than 100 days, which shows adaptability in these environments. Four out of the ten varieties that has been tested in Boli, have produced above the average yields of the test: "WAS 57-BB-17-3-3-5" (6400 kg / ha),"WAS 63-22-5-9-10 -1" (5578 kg/ha), "WAS 127-B-5-2" (5230 kg/ha) and "WAS 63-22-1-1-3-3" (4663 kg/ha). Use of this batch of tested varieties is an essential component in the development of an integrated management strategy of rice in the region.

INTRODUCTION

A major rice-importing region at the world level accounting for 20% of rice sold on the market, Sub-Saharan Africa only produces enough rice to cover 60% of its needs despite possessing considerable rice-growing potential and land resources (Africa Rice, 2011).

Agriculture in Sub-Saharan African countries is characterized by low productivity, low and irregular rainfall, the initial poverty of soils, low use of inputs (Africa-Rice, 2012). However, the lowlands are favorable production environments (Rodenburg *et al*, 2012) which unfortunately are not enough exploited. Rice and rice based cropping systems represent opportunities to further enhance the production potential of lowlands. In Senegal, only 20% to 30% of needs are covered by domestic production, making Senegal one of the biggest importers of rice in West Africa with 600,000 tons of imported rice (FAO Stat, 2012; SAED, 2012). Develop strategies to increase local production remains the only alternative for sustainable food security.In the Senegal, attainable rice yields with full water, fertilizer and climate control are in the range of 6-15 t ha^{-1} depending on the agro-ecological zone compare toactual farmer's yield 1-3 t ha^{-1} (AfricaRice, 2011), while world's average rice yield was about 4.3 t ha^{-1}in 2009 (FAOStat, 2011). This gap between current yield andpotential is due mainly to: climate change (Rodenburg *et al*, 2011), poor soil andit's degradation (Bado *et al*, 2010), soil salinity and water availability.

In the region of Sine Saloum, most lowlands are in direct contact with sea water (Camara *et al*, 2007) which results in a degradation of arable land (Mbodj, 2001). Apart from the stress related to the periodic intrusion of saline seawater, these lowlands are a valuable natural resource for rural populations (Kilian *et al*, 1999). The program of construction of anti-salt facilities consists of small dams that temporarily block the intrusion of salt.The dam can store fresh water from rainfallduring the rainy season in order to leach the soil (Bama-Nati *et al*, 2013; 2015) and create a reserve of fresh water above the salt water table (Mbodj, 2007). The objective of this work was to conduct the varietal tests in these lowlands in order to determine the most suitable varieties for the revival of rice cultivation in the region.

MATERIALS AND METHODS

Presentation of the study area

The lowlands of Boli(14^{o} 05' 25'' N and 16^{o} 18' 15'' W) and KeurAliou Gaye are located in the region of Fatick (Sine

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Saloun) in Senegal. The area is experiencing an exacerbation of the process of salinization of soil and water, subsequent to the combined effects of drought, declining groundwater, deforestation and sea intrusion. Indeed, in Boli Valley, the salt concentration is so high that during the months of April, May and June, the women collect the salt directly within the backwater (Mbodj, 2001). The river system is made by the course of Saloum and the course of Bagal. The water table is shallow and salty. Thus, surface waters, as well as groundwater, are quantitatively and qualitatively inauspicious for the development of agricultural, pastoral and forestry activities. This agro ecological zone has one rainy season per year, starting from May-June and ending in October. The rainy season is marked by high air humidity (More than 70%), the mean yearly rainfall is 588 mm and air temperatures between 24°C and 39°C (Bama Nati*et al*, 2015). Evaporation is very important, about 2950 mm/year. These soils are generally sandy, sandy-loam, clay-loam, acids or weakly acidic (Camara*et al*, 2008).

Experimental protocol

Variety trials have been conducted on several lowlands, during two periods.

The first trials have been conducted, during the wet season 2003, in KeurAliou Gaye, and in three reference lowlands. Six salt-tolerant varieties from Africa-Rice and local control variety were tested. The applied fertilizer dosage is 50 kg/ha of diammoniumphosphate (DAP) and 100 kg/ha of urea. Direct broadcast seeding were conducted during the month of July. The mixture (propanil / Weedone) was used for the first weed control. Following the first chemical control of weeds, manual weeding has been performed where required. Phosphorus in the form of 18-46 has been used as background fertilization. Urea has been used to supplement (150 kg/ha) in two applications: at the early tillering (50% of the dose) and at initiation of the panicles (50% of the dose). No insecticide treatment has been performed.

For the second trials, during wet seasons in 2005 and 2006 in Boli, ten varieties issued from Africa-Rice plants breeding, and local variety as control, have been used. The pattern used there, was a homogeneous block without repeating. The basic plot had an area of 5m^2. The varieties have been sown by broadcasting in fields already plowed. The applied fertilizer dose is 50Kg of DAP and 30 kg of Nitrogen (N) in the form of urea. Phosphorus (P) in the form of (DAP) has been used as the background. The Nitrogen (N) in the form of urea has been applied at the beginning of tillering. Weed control have been performed by manual weeding, depending on demand. At the harvest, yield squares have been collected to estimate the yield. The data of yield have been analyzed with SAS.

Meteorological data and analyse

A national weather station located in Fatick recorded air temperature, relative air humidity, Pich evaporation, radiation, rain and wind speed. On each lowland we installed a rain gauge. Using the climate data, monthly ETo were computed with the FAO Penman-Monteith equation by the ETo Calculator version 3.1; 2009.

RESULTS AND DISCUSSION

Climate data

The rainfall has been very different from one year to another (Fig 1 and 2): the rainfall of the 2005 year far exceeds during the seven years considered in the study (Fig 1) : An annual total of 830 mm versus 720 mm (in 2003) and 830 mm versus 555 mm (in 2004) (Fig 1). We find that the pic of the rainfall is reached during the month of August or September depending on the year (Fig 3). During those seven years, the number of rainy consecutive days does not exceed 5, which show of the arid climate (Fig 1). Furthermore, the number of rainy days varies from year to year, (Bama-Nati*et al*, 2013) led to the same conclusion.

The water supply in paddy fields under rainfed conditions is determined primarily by rainfall, and frequent rainfall events can retain standing water in the field until flowering, thereby reducing exposure to drought. This variability of rain during year in these rainfed lowland's conditions have affected yield (Tsubo *et al*, 2006) because the lowland rice production is limited by the availability of rainwater.

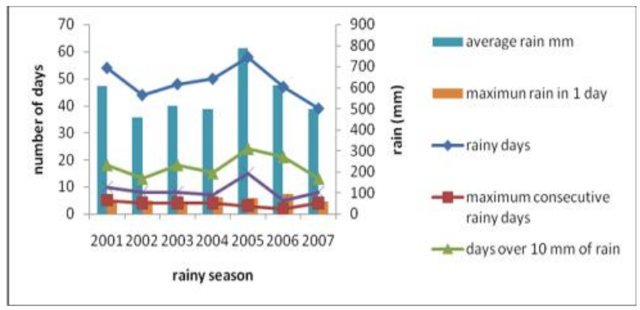

Figure 1 Climate index in the study area

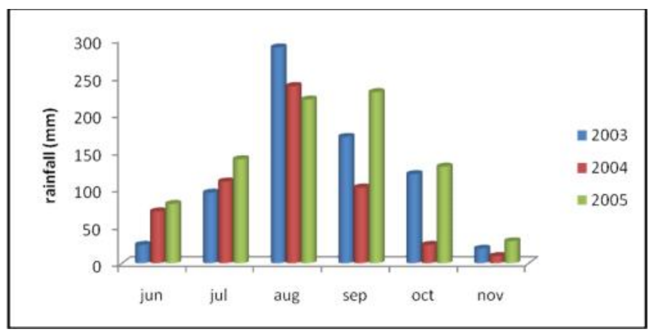

Figure 2 Cumulative monthly precipitations during wet season

The water deficit compared to the ETo is 7.4% (Fig 3) during the wet season 2005.

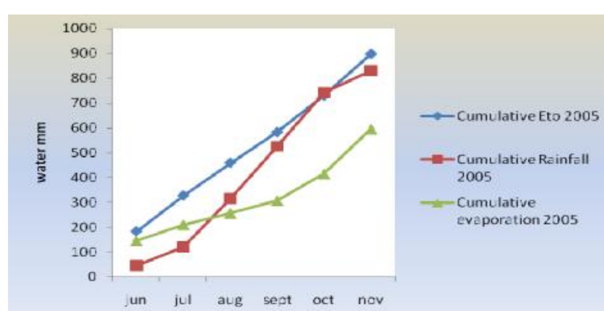

Figure 3 Comparison between monthly cumulative ETo (Penman-Monteith), Rainfall, Pich evaporation in the study area during 2005 wet season

The lowland of KeurAliou Gaye compared to controls lowlands

In 2003, the test average yields varied between 2 and 4.4 t/ha (Table 1).The site KeurAliouGueye gave the best returns with an average of 4.4 t/ha. In this site the five varieties tested yielded much higher returns compared to the control. Two of them: WAS 63-22-1-1-3-3 (5.4 t/ha) and WAS 164-B-5-2 (5.7 t/ha) exceeded the control by more than 2 tons. AtDjilor yields varied between 2.7 and 4.1 t/ha with an average of 3.2 tons/ha.Four varieties: WAS-47 BB-194-4-2 (4.1 t/ha), WAS 63-22-1-1-3-3 (3.7 t/ha), WAS 63-22-5-9-10- 1 (3.2 t/ha) and WAS 127-B-5-2 (3.1 t/ha) had higher returns compared to the control that produced 2.7 t/ha. Among these four, two varieties have far exceeded the indicator by at least one ton.AtDasilaméSerere, only the results of four varieties are available. The control intended to be used there could not get into maturity and variety WAS 63-22-1-1-3-3 has been grazed by animals.Two varieties WAS 22-63-5-9-10-1 and variety WAS 47-BB-194-4-2 have pretty well behaved with returns of 3 and 2.7 t/ha. NdourNdour is the site where yields were weaker with average 2 t/ha for the control, only the variety WAS 47-BB-194-4-2 (2.7 t/ha) exceeded the (2.3 t/ha) by 400 kg.Other varieties have produced less than the local control.

Several factors explain the low yields: flooding of fields after sowing, draught and salinity. The importance of water sheet during the entire rice cycle limiting tillering of varieties and leading to very small tillers. The response of rice to salinity varies with growth stage (Linghe *et al*, 2004) and reduced tillering is one of the main phenotypes observed under salinity stress during the vegetative stage that affects final yield.

Table1 Yield of each variety in KeurAliouGaye compared to control lowlands in 2003

Varieties	NdourNdour	Djilor	KeuraliouGueye	Dassilamé	Average
WAS 47-BB-194-4-2	2.7	4.1	3.8	2.7	3.3
WAS 63-22-5-9-10-1	2.0	3.2	4.8	3.0	3.2
WAS 63-22-1-1-3-3	2.2	3.7	5.4	-	3.7
WAS 164-B-5-2	1.2	2.7	5.7	2.4	3.05
WAS 127-B-5-2	1.8	3.1	3.9	2.3	2.8
local control	2.3	2.7	3.1	-	2.7
Average	2.0	3.2	4.4	2.6	3.1
Standard Deviation	0.4	0.5	1.0	0.3	
CV (%)	23	16	22	11	

Table 2 Cycles, heights, yields and percentage of sterility of varieties,in the lowland of Boli in 2005

Varieties	Cycle (days)	Height (cm)	yield (kg / ha)	Grain per panicle	Sterility (%)
WAS 127-B-5-2	81	88	5230	93	20
WAS 57-BB-17-3-3-5	89	92	6400	73	15
WAS 63-22-1-1-3-3	85	92	4663	82	16
WAS 63-22-5-9-10-1	85	80	5578	67	17
WAS 164-B-5-2	83	92	2770	51	10
WAS 63-22-5-9-10	92	101	3860	68	16
WAS 73-BB-128-1	85	83	3878		
WAS 21-BB-20-4-3-3	95	80	4431	83	9
WAS 57-BB-17-3-3-5	90	83	4366	94	7
WAS 127-B-5-1	83	110	3867		
Average	89	90	4504	76	14
Standard deviation	4.7	9.68	1030	15	5
Minimum	81	80	2770	51	7
Maximum	95	110	6400	94	20

Table 3 Performance of varieties in Boli in 2006

Varieties	cycle	Height	returns Kg / ha	spikelets per panicle	Sterility (%)
WAS 127-B-5-2	100	82	birds	-	-
WAS 57-BB-17-3-3-5	108	92	3000	81	36
WAS 63-22-1-1-3-3	100	102	3500	86	23
WAS 63-22-5-9-10-1	100	87	5000	87	29
WAS 127-B-5-1	100	90	2000	112	19
WAS 63-22-5-9-10	100	98	4000	73	20
WAS 73-BB-128-1	100	96	-	-	-
WAS 21-BB-20-4-3-3	100	96	3000	89	27
WAS 57-BB-17-3-3-5	100	89	3500	73	31

The different behavior of varieties in sites indicates a site effect. The most favorable site is the deep valley of KeurAliouGueye with a correct sheet of water throughout the cycle of the varieties leading to the best returns as illustrated by the average yields of 4.4 t/ha (Table 1).

The level of average yields for each variety (2.7 to 3 t/ha) are very encouraging for this type of rice, where yields typically range between 1 ton and 2 tons/ha (Asch *et al*, 2001). The use of this lot of varieties tested is an essential component in the development of integrated management strategy for rice production in the region.

Performance of varieties in Boli in 2005 and 2006

In 2005, all varieties have got a cycle shorter than 100 days (Table 2).Varieties have not suffered any lack of water.These mentioned cycle durationclearly show that there is good adaptability in these environments with a rainy season that lasts only three months. Varieties have got yields ranging from 2770 kg/ha to 6400 kg/ha with an average of 4504 kg/ha.Four varieties have produced above the average returns of the test:These are WAS-57 BB-17-3-3-5 (6400 kg/ha), WAS 63-22-5-9-10 1 (5578 kg/ha), WAS 127-B-5-2 (5230 kg/ha) and WAS 63-22-1-1-3-3 (4663 kg/ha).

In 2006, the varieties have suffered from a lack of water due to rains stop after lifting, causing deathof many plants.The panicle sterility ratio (empty grain/grain total) is quite high (Table 3).

CONCLUSION

In 2003, the average yields of trials ranged between 2 to 4.4 t/ha. The site KeurAliouGueye have given the best returns with an average yield of 4.4 t/ha. In this site, two varieties: WAS 63-22-1-1-3-3 (5.4 t/ha) and WAS 164-B-5-2 (5.7 t/ha) exceeded the control by more than 2 tons. This level of performance is very encouraging for this type of rice farming. The use of this lot of varieties tested is an essential component in the development of integrated management strategy for rice production in the region. In 2005, all varieties have got a cycle shorter than 100 days. These observed cycles duration clearly show that there is a good adaptability in these environments with a rainy season that lasts only three months. The 10 varieties tested have got an average yield of 4504 kg/ha. Four varieties have produced above average returns of the trial: These are WAS-57 BB-17-3-3-5 (6400 kg/ha), WAS 63-22-5-9-10 1 (5578 kg/ha), WAS 127-B-5-2 (5230 kg/ha) and WAS 63-22-1-1-3-3 (4663 kg/ha). In 2006, the varieties have suffered from a lack of water due to rains stop after lifting causing death to many plants.

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