International Journal of Research and Review
Vol.7; Issue: 4; April 2020
Website: www.ijrrjournal.com
Research Paper *E-ISSN: 2349-9788; P-ISSN: 2454-2237*

Effect of Spacing on the Productivity of Four Varieties of Rice (*Oryza sativa*) in the Locality of Yamoussoukro (Côte d'Ivoire)

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ABSTRACT

In Côte d'Ivoire, the yield of different sorts of rice (*Oryza sativa*) remains below to their own potential productions. Insufficient production of rice recorded by farmers could be attributed to the no respect of cultural practice and inappropriate choice of different sorts of rice. To resolve this problem, the current study was undertaken with a main purpose to improve rice production. Thus, four varieties of rice including WITA 9 (V1) (control), 6444 GOLD (V2), TEJ GOLD (V3) and CY-2 (V4) were tested in four sowing spacing: 20 cm x 20 cm (S1), 20 cm x 25 cm (S2), 25 cm x 25 cm (S3) (control) and 25 cm x 30 cm (S4). Experimental design use in this study was constituted with three random blocks. From planting to harvest of rice seven parameters were collected and analyze statistically. Results of those analysis shown that the better value of yield and its components was recorded with variety CY-2 in the plots with sowing spacing (25 cm x 30 cm). Based on this result, some recommendations have been done to rice producers.

Keywords: *Oryza sativa*, variety, spacing, yield, food security

1. INTRODUCTION

A population growth coupled with urbanization growth in developing nation forced often population to change their dietary (Delisle, 1991 ; FAO, 1997). Populations turn towards cereal crops mainly the rice. In this context, the rice plays a key role to population dietary. It is a basic foodstuff, a job and earned income of half population of the world. But a production dynamic does not match to rice request in African countries. Thus, to supply population in short time, leaders turn towards a mass importation of rice (Mendez & Bauer, 2013). In order to reverse this political, Côte d'Ivoire leaders through a national program of rice production encourage farmers to increase their fields area (SNDR, 2012). For that purpose, some subsidies and easy access to rice production tool are granted to rice farmers. In spite of, strategics support, political, involvement of rice farmers and great area under cultivation intented for this speculation, national production barely satisfies the half of population request (Bouet & Tahouo, 2015). In other words, the yield of different sorts of rice in farms remain under their production capacities. It the case of Nerica which produce 1700 Kg per hectare against 2930 Kg per hectare (Anyang, 2015). Insufficience production of rice recorded by farmers could be attributed to the no respect of cultural practice and an inappropriate choice of different sorts of rice. Spacing of sowing plays a cardinal role in determining of crops farm yield (Noorka *et al.*, 2011). Indeed, when the sowing density is above or below of the optimal density, that leads to a intra-specific competition between crops for the sharing nutrient resources in the environment (Ngala *et al.*, 2013). So it will result to the decreasing of crop production. In this condition, determining of optimal

spacing for each rice variety becomes vital. A current study carried out in this context aims to improve rice production and household incomes for farmers in rural areas. Specifically, it will be first to determine the most productive variety of rice and secondly the optimal spacing in order to maintain or increase the production of this variety.

2. MATERIALS AND METHODS

2.1. Study site

This study was carried on the experimental site of PRORIL (Projet de Promotion de Riz Local en République de Côte d'Ivoire) localized in Yamoussoukro (Latitude 06° 72' and 06° 92' of North and Longitude 05°36' and 05°21' of West. This town is situated from 248 Km to Abidjan with, two growing seasons: dry and rainy seasons. The first season extend from middle of November to middle of march. The second, he is stretched from middle march to middle September. The mean temperature of this town is estimated 26 °C.

2.2. Biology material

The biology material is constituted of 1140 plants. Those plants come from the seeds of four varieties: WITA 9 (control), CY-2, 6444 GOLD and TEJ GOLD.

2.3. Methods

2.3.1. Experimental design and treatment

Field experiences took place on an area measured 34 m x 45 m. After weeding, the plots were divided into three random blocks separated with 1 m. Each block was divided into four plots measured 10 m x 10 m separated each other of 1m. Each of them was subdivided into four elementary plots of 5 m x 5 m. Thus, a total of 48 elementary plots was take place during this trial. Inside of this experimental design, four varieties of rice were sown (WITA 9 :V1 (control), 6444 GOLD : V2, TEJ GOLD : V3 and CY-2 : V4) according to four sowing spacing (20 cm x 20 cm : S1, 20 cm x 25 cm : S2, 25 cm x 25 cm : S3 (control) and 25 cm x 30 cm : S4).

2.3.2. Data collected

From sowing to harvest seven parameters have been collected on the different plants. It's about the number of tillers (NT), the plant length (PL), the number of panicles per tuft (NPT), the number of seeds per panicles, the percentage of full seeds (PFS), the weight of 1000 seeds (W-1000-S) and the Yield (YD).

2.3.3. Statistical analysis

Statistical analysis consists in testing effect of variety, sowing spacing and their interaction on rice growth and production parameters. For each one of variables which have been significantly affected by production factor multiples comparison are done by realizing *ppds* test ($P \leq 0,05$). This test allows to identify parameters which differ significantly to others. All analysis has been made with STATISTICA software version 7.1.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Effect of variety on yield and its components parameters

Statistical analysis showed that seven parameters have been affected the factor variety on nine parameters tested. Thus the best value of NT, NPT, W-1000-S and YD have been recorded with the variety V4. Also similar better value of PL and NSP have been obtained with varieties V4 and V2.

Table 1. Effect of variety on yield and its components parameters

Parameters	Varieties				Statistical	
	V1	V2	V3	V4	*F*	*P*
NT	13,42±4,41^{c}	13,73±3,96^{b}	12,76± 4,71^{d}	14,35±4,22^{a}	5,62	0,00
PL (cm)	75,76±11,9^{b}	91,12±10,43^{a}	76,69±10,95^{b}	90,7±13,6^{a}	4,5	0,00
NPT	11,01±3,82^{b}	11,48±3,81^{b}	11,28±4,52^{b}	12,44±4,30^{a}	9,65	0,00
NSP	108,45±25,09^{b}	140,95±13,23^{a}	120,66±29,37^{b}	120,08±27,26^{b}	7,25	0,00
PFS	80,87±5,9^{a}	82,67±5,56^{a}	82,69±3,48^{a}	84,55±5,1^{a}	2,09	0,1
W-1000 S (g)	28,31±3,73^{b}	27,3±2,1^{b}	27,41±1,4^{b}	33,73±3,69^{a}	26,44	0,00
YD (t/ha)	4,4±1,2^{c}	5,74±0,82^{b}	4,65±0,86^{c}	6,5±1,16^{a}	21,68	0,00

NT : number of tillers, PL : plant length, NPT : number of panicles per tuft,, NSP : number of seeds per panicles PFS: percentage of full seeds, W-1000-S :weight of 1000 seeds, YD (T/ha) : Yield, V1 : WITA 9, V2 : 6444 GOLD, V3 : TEJ GOLD, V4 : CY-2 *F* : F-statistical of Fischer et *P* : probability associated to the test. For each parameter, values bearing a same letter are statistically similar. ($P \geq 0{,}05$).

3.1.2. Effect of spacing on yield and its components parameters

Except w-1000-S, the six other parameters have been affected by the sowing spacing. Thus, the best value of NT, PL, NPT, NSP and YD have been recorded on plot with spacing S4. Also, similar better value of PFS have been obtained with spacing S3 and S4.

Table 2. Effect of spacing on yield and its components parameters

Parameters	Spacings				Statistical	
	S1	S2	S3	S4	*F*	*P*
NT	10,97±2,84^{d}	11,87±3,39^{c}	14,14±3,77^{b}	17,29±4,33^{a}	4,53	0,00
PL (cm)	83,38±12,96^{b}	82,26±15,03^{b}	82,25±14,69^{b}	86,38±12,53^{a}	4,78	0,00
NPT	9,24±2,96^{d}	10,98±3,43^{c}	12,66±3,42^{b}	15,85±4,45^{a}	2,4	0,00
NSP	111,62±24,34^{c}	106,25±20,54^{c}	127,58±26,86^{b}	144,7±17,47^{a}	14,12	0,00
PFS	79,53±6,35^{b}	80,82±3,11^{b}	84,36±3,69^{a}	83,28±5,69^{a}	4,79	0,00
W-1000S (g)	28,6±3,6^{a}	28,74±3,64^{a}	28,98±4,5^{a}	30,44±3,81^{a}	1,12	0,34
YD (t/ha)	4,92±1,52^{c}	4,86±1,09^{c}	5,62±1,33^{b}	6,03±1,08^{a}	3,68	0,00

NT : number of tillers, PL : plant length, NPT : number of panicles per tuft,, NSP : number of seeds per panicles PFS: percentage of full seeds, W-1000-S :weight of 1000 seeds, YD (T/ha) : Yield, S1 : spacing 1 20 cm × 20 cm, S2 : spacing 2 20 cm × 25 cm, S3 : spacing 25 cm × 25 cm, S4 : spacing 25 cm × 30 cm, *F* : F-statistical of Fischer et *P* : probability associated to the test. For each parameter, values bearing a same letter are statistically similar. ($P \geq 0{,}05$).

3.1.3. Effect of interaction between variety and spacing on growth parameters

Interaction between variety and sowing spacing indicated that two growth parameters have been affected. Th best value of the two parameters recorded their better value on the plots space S4 with the variety V4.

Table 3. Effect of interaction between variety and spacing on growth parameters

Interactions		Parameters	
		NT	PL (cm)
S1	V1	10,26±2,12^{h}	77,5±21,56^{g}
	V2	11,3±2,82^{g}	85,7±13,78^{e}
	V3	11,18±0,7^{g}	77,14±0,7^{g}
	V4	11,15±1,41^{g}	93,2±2,82^{a}
S2	V1	10,58±0,7^{h}	71,58±13,43^{i}
	V2	12,13±1,41^{f}	97,61±5,65^{a}
	V3	11,15±3,68^{g}	71,95±4,24^{i}
	V4	13,61±2,82^{e}	87,92±0,7^{d}
S3	V1	15,1±2,12^{c}	73,88±12,02^{h}
	V2	14,03±3,53^{d}	90,64±0,35^{b}
	V3	11,85±5,65^{f}	77,47±11,31^{g}
	V4	15,6±0,7^{b}	87,00±1,41^{d}
S4	V1	17,75±2,82^{a}	80,08±2,82^{f}
	V2	17,48±0,7^{a}	90,54±3,53^{c}
	V3	16,86±10,6^{a}	80,21±19,09^{f}
	V4	17,06±2,82^{a}	94,69±14,84^{a}
Statistical	*F*	5,09	7,71
	P	0,00	0,00

NT : number of tillers, PL : plant length, V1 : WITA 9, V2 : 6444 GOLD, V3 : TEJ GOLD, V4 : CY-2, S1 : spacing 1 20 cm × 20 cm, S2 : spacing 2 20 cm × 25 cm, S3 : spacing 25 cm × 25 cm, S4 : spacing 25 cm × 30 cm, *F* : F-statistical of Fischer et *P* : probability associated to the test. For each parameter, values bearing a same letter are statistically similar. ($P \geq 0{,}05$).

3.1.4. Effect of interaction between variety and spacing on production parameters

All the production parameters have been affected by the interaction between variety and spacing. On the five parameters tested NPT, NSP and YD recorded their better value on the plot S4 with the variety V4. About, PFS and W1000S theirs better values have been obtained on the plot S3 with variety V4.

Table 4. Effect of interaction between variety and spacing on production parameters

Parameters						
Interactions						
		NPT	NSP	PFS	W1000S (g)	YD (t/ha)
S1	V1	9,08±1,41^{k}	84,66±20,5^{j}	72,48±5,23^{k}	28,88±2,54^{f}	3,61±0,88^{k}
	V2	9,46±5,65^{j}	130,5±11,31^{e}	87,29±7,98^{b}	27,13±0,96^{h}	6,66±0,3^{c}
	V3	8,9±6,36^{k}	109,83±23,33^{h}	77,48±1,63^{j}	27,69±1,06^{g}	4,28±1,38^{k}
	V4	9,52±3,53^{j}	121,5±23,33^{f}	80,86±2,14^{h}	30,69±7,92^{e}	6,15±1,84^{d}
S2	V1	9,69±7,77^{j}	96±4,24^{i}	83,11±4,98^{f}	26,97±1,28^{h}	3,72±0,04^{k}
	V2	9,96±4,94^{i}	138,5±2,82^{c}	80,69±3,49^{h}	26,94±2,89^{h}	5,3±0,92^{g}
	V3	11,87±0,7^{g}	95,33±7,77^{i}	85,81±1,6^{c}	26,8±0,17^{h}	4,44±0,007^{i}
	V4	12,42±4,94^{f}	95,16±12,02^{i}	85,66±0,74^{c}	34,25±2,32^{b}	5,98±1,46^{e}
S3	V1	12,64±6,36^{f}	108,66±3,53^{h}	85,44±1,01^{c}	26,05±1,13^{h}	4,3±0,33^{j}
	V2	13,12±5,65^{e}	143,33±24,74^{b}	79,11±2,67^{i}	26,42±0,9^{h}	5,28±0,58^{h}
	V3	10,88±4,94^{h}	145±53,74^{b}	84,8±2,44^{d}	27,21±2,48^{h}	4,57±1,47^{i}
	V4	14,00±6,36^{d}	113,33±13,43^{g}	88,1±1,38^{a}	36,25±0,5^{a}	6,76±1,95^{b}
S4	V1	15,08±13,4^{c}	144,5±17,67^{b}	82,46±2,77^{g}	31,34±8,8^{d}	5,96±2,3^{e}
	V2	16,01±8,48^{b}	150,5±9,19^{a}	83,59±8,46^{e}	28,72±0,41^{f}	5,71±0,28^{f}
	V3	15,8±6,36^{b}	132,5±12,02^{d}	83,47±0,46^{e}	27,95±0,93^{g}	5,32±0,94^{g}
	V4	16,5±9,89^{a}	150,33±35,35^{a}	83,59±12,54^{e}	33,74±2,55^{c}	7,13±0,6^{a}
Statistical	*F*	7,5	3,907	6,98	2,57	2,95
	P	0,00	0,00	0,00	0,01	0,004

NPT : number of panicles per tuft,, NSP : number of seeds per panicles PFS: percentage of full seeds, W-1000-S :weight of 1000 seeds, YD (T/ha) : Yield, V1 : WITA 9, V2 : 6444 GOLD, V3 : TEJ GOLD, V4 : CY-2, S1 : spacing 20 cm × 20 cm, S2 : spacing 20 cm × 25 cm, S3 : spacing 25 cm × 25 cm, S4 : spacing 25 cm × 30 cm, *F* : F-statistical of Fischer et *P* : probability associated to the test. For each parameter, values bearing a same letter are statistically similar. ($P \geq 0,05$).

3.2. DISCUSSION

Determining optimal spacing is an important step in increasing the production of any crop (Olowe & Busari, 2003; Dorval, 2015). It is in this context that this study was undertaken to determine the effect of variety and spacing on rice productivity. For that purpose, the results from statistical analyzes showed that the best values of the yield and of its components were obtained with the variety V4 compared to the three other varieties. Difference in production observed could be explained by the specific characteristics of each variety. Indeed, the varieties V2 and V3 were made to answer more to organoleptic requirements. Thus, they would have potential yields at the origin lower than that of the variety V4, respectively 7.2 t / ha, 6.5 t / ha and 7.9 t / ha (CREVU / UEMOA, 2016). Similar results were recorded by Beka et al (2016) studying on three varieties of rice.

The best value of production obtained with variety V4 could also be explained by the better value of seed weight. Indeed, this parameter is an essential component of the yield. When its value is higher, the yield is also higher. These results differ from those of Kouakou et al (2016) working on four varieties of rice (NERICA 1, NERICA 4, NERICA 8 and NERICA 11). They explained the same seed weight of the four rice varieties by the fact that the climatic conditions which prevailed during the filling of the grains were similar for all the varieties.

Our results also showed a low level of rice production with the control (variety V1 (WITA 9)) compared to its potential yield (10t / ha). The WITA 9 variety is an irrigated variety, which means that it must have water at all times to maintain or increase its production. During our study, the supply of water to plants of this variety was not regular. Consequently, this recorded result could be explained by water stress. Similar explanations were also given by Kambou (2008) working on four varieties of rice. Also, according to Doorenbos & Kassam (1987) and Wopereis et al. (2004), rice needs a lot of water during the entire reproductive phase and the first half of the maturation phase.

to the effect of spacing, the grain yield and its components are better with plants from the widest spacing S4. These results could be explained by the low seeding density which reflects a small population on a given area unit. This would imply an absence of competition or competition for space, water and mineral elements (El Naim et al., 2010). The

availability of sufficient quantities and quality of nutrients for the plants in these plots ensures their physiological function, which has contributed to obtaining such a result. According to Oad et al (2001), the spacing of plants directly affects normal physiological activities through intra-specific competition. These results corroborate those of Shrirame et al (2000) who indicated that the total number of tillers was higher at the wider spacing.

These results also agree with those of Balock et al (2003) who reported that the increased spacing of the plants significantly resulted in vigorous plant growth and provoked a significant increase in the number of panicles per clump, the yield in grain by tufts, the percentage of grains filled by panicle and the weight of 1000 grains. Also according to Ogbodo et al (2010) rice plants transplanted at the spacing 30 cm x 30 cm have a higher grain filling rate and a higher grain yield than rice plants transplanted at the spacings 20 cm x 20 cm and 10 cm x 10 cm.

As regards the effect of interaction spacing and variety, plants from plants of variety V4 on plot with the widest spacing S4 have obtained the best values of grain yield and its components.

This result is due to photosynthesis, which is best achieved by vigorous plants from wider spacing than less vigorous plants with reduced spacing. Indeed, according to Donald & Hamblin (1976), the grain yield is the result of a balance between the carbon gain from CO2 in the air from photosynthesis and the carbon loss by respiration.

4. CONCLUSION

It emerges from this current study that the both production factors sowing spacing and variety have influenced the productivity parameters of rice. Thus, the best value of yield and its components come from plants grown with spacings of 25 cm x 30 cm. Also, it is with the variety CY-2 which recorded a better value of production than the three other varieties. However, to increase the production of this speculation, CY-2 variety must be cultivated with spacing 25 cm x 30 cm. Base on this result and food self-sufficiency context in Côte d'Ivoire with rice, some recommendations have been done to rice producers.

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How to cite this article: Nestor GBB, Anzara KG, Georges YKA et.al. Effect of spacing on the productivity of four varieties of rice (*Oryza sativa*) in the locality of Yamoussoukro (Côte d'Ivoire). International Journal of Research and Review. 2020; 7(4): 140-145.

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