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Correlation Analysis of Rice (*Oryza sativa* L.) Growth, Yield and its Yield Attributes in an Intercrop with Cassava and Melon

Christopher J. Okonji[1,2*] • Emmanuel O. Ajayi[3] • Kehinde A. Okeleye[1] • Akeem A. Oyekanmi[1] • Suleiman O. Sakariyawo[1]

[1] Department of Plant Physiology and Crop Production, College of Plant Science and Crop Production. University of Agriculture, Abeokuta, P.M.B 2240 Abeokuta, Nigeria
[2] Department of Biological Sciences, College of Natural Sciences. Crescent University, Abeokuta, P.M.B 2104, Sapon, Abeokuta, Ogun State, Nigeria
[3] National Horticultural Research Institute, P.M.B 5432 Idi – Ishin, Jerico, Ibadan, Nigeria

Corresponding author: * **xokonji@gmail.com**

ABSTRACT

A two-year study was conducted on three rice varieties (ITA 321, ITA 150 and WAB 189-B-B-HB), (*Oryza sativa* L.) in a rice/cassava (*Manihot esculenta*) intercrop of two cassava varieties (TMS 30572 and TME 1) and a rice/melon (*Citrullus lanatus*) intercrop at the Teaching and Research Farm of the University of Agriculture, Alabata, Abeokuta, during two consecutive growing seasons. The objective of the trial was to investigate the correlation between agronomic parameters and grain yield of rice in an intercrop using cassava varieties (non–branching (TME 1) and branching types (TMS 30572)) and melon. Positive and significant correlations were found for leaf area index at vegetative stage and panicle weight with grain yield of rice in the rice/melon intercrop (r = 0.66 and 0.78). Also, a negative correlation was found for plant height at the three stages of growth with grain yield (plant height at vegetative stage r = -0.42, at flowering stage r = -0.49 and maturity r = -0.43), as number of panicles per hill (r = -0.28), panicle length (r = -0.41) and harvest index (r = -0.5) contributed negatively to grain yield of rice in the rice/melon intercrop. For rice in the rice/cassava intercrop, a positive and highly significant correlation was found for tiller number (r = 0.85), leaf area index (r = 0.68), days to 50% flowering (r = 0.85) and number of panicles per hill (r = 0.81) with grain yield in both years. Plant height was negatively correlated with grain yield (r = -0.59) in both years.

Keywords: agronomic character, correlation coefficient, grain yield of rice, rice/melon intercrop, rice/cassava intercrop

INTRODUCTION

Intercropping is a very common cropping system in Africa and it is practiced by the majority of the farmers mainly due to declining land size and food security needs. In Africa, the bulk of cowpea production is by small-scale farmers using the traditional system of mixed intercropping with maize, sorghum, millet, rice, yam, cassava, pepper and other vegetable crops (CABI 2000). Mixed cropping or intercropping is an important practice in tropical developing countries because of its several advantages (Isoken 2000). Ahmad *et al.* (2007) reported an overall increase in the total rice grain yield equivalent of intercropping treatments of rice + maize over sole treatments. Also, an increase in total rice grain yield was possible as a result of intercropping (Joshi 2002). Upland rice is commonly intercropped with pigeon pea (*Cajanus cajan*) (Mahaptra and Satpathy 1988), cowpea (*Vigna unguiculata*) and lablab (*Lablab purpureus*) (Aggarwal and Garrity 1987), yam (*Dioscorea* spp.) and cassava (*Manihot esculenta*) (Ugwu 1996). In Africa, a farmer usually operates a small, diversified agricultural enterprise, and according to Okigbo (1978), the cropping mixtures of peasant farmers' farms often involve major staples, vegetables, and condiments in multiple (multiple cropping is the production of two or more crops on a field in a year. This is practiced where land is limited because of population density), double (double cropping is a sustainable practice in which more than one crop is grown and harvested at the same time, on the same ground), and relay (is a system in which a second crop is planted into an existing crop when it has flowered (reproductive stage) but before harvesting. There is thus a minimum temporal overlap of two or more crops, intercropping patterns of annuals, perennials or both. Plant breeders are interested in developing cultivars with improved yield and other desirable agronomic and phonological characters. In order to achieve this goal, breeders have the option of selecting desirable genotypes in early generations or delaying intense selection until advanced generations (Puri *et al.* 1982). The selection criteria may be yield, or one or more of the yield component characters. However, breeding for high yield crops require information on the nature and magnitude of variation in the available materials, relationship of yield with other agronomic characters. Selection on the basis of grain yield characters alone is usually not very effective and efficient. However, selection based on its component characters could be more efficient and reliable (Muhammad *et al.* 2003). Knowledge of the association between yield and its component traits in an intercrop and among the component parameters in the intercrop can improve the efficiency of selection in plant breeding.

In agricultural research, a correlation coefficient measures the mutual association between a pair of variables independent of other variables considered. The results of correlation are of great value in the evaluation of the most effective procedures for selection of superior genotypes. When there is a positive association of major yield characters, component breeding would be very effective but when these characters are negatively associated it would be difficult to exercise simultaneous selection for them in developing a variety (Nemati *et al.* 2009). Determining the relationship between rice grain yield and its components is essential for successful rice cultivation. The objectives of this research, therefore, were to determine the association between rice grain yield, its components, and other agronomic characters in rice intercropped with cassava and melon and also to identify characters whose selection could be used to improve grain yield of rice in rice (*Oryza sativa* L.) intercropped with cassava (*Manihot esculenta*) and melon (*Citrullus lanatus*).

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Table 1 Simple linear correlation coefficient of leaf area index, yield components and grain yield of rice grown in intercrop with melon in early and late season of 2003.

	LAIV	LAIF	LAIM	NTV	NTF	NTM	PHV	PHF	PHM	NP/L	PL	PW	NS/P	HI	TSW	GY
LAIV	1.00															
LAIF	0.55	1.00														
LAIM	0.54	0.98**	1.00													
NTV	0.75**	0.51	0.41	1.00												
NTF	0.55	0.87**	0.80**	0.69*	1.00											
NTM	0.66*	0.84**	0.76**	0.71**	0.96**	1.00										
PHV	-0.13	0.48	0.47	0.17	0.55	0.36	1.00									
PHF	-0.25	0.37	0.35	0.02	0.44	0.30	0.85**	1.00								
PHM	-0.20	0.37	0.33	0.05	0.49	0.36	0.84**	0.98**	1.00							
NP/L	0.14	0.79**	0.78*	0.17	0.71**	0.56	0.78**	0.67*	0.67*	1.00						
PL	-0.23	0.37	0.36	0.19	0.41	0.26	0.85**	0.85**	0.81**	0.58*	1.00					
PW	0.73**	0.17	0.16	0.29	0.06	0.27	-0.7**	-0.68*	-0.64*	-0.34	-0.69*	1.00				
NS/P	-0.01	0.25	0.22	0.36	0.43	0.42	0.46	0.24	0.24	0.22	0.47	-0.21	1.00			
HI	-0.04	-0.01	-0.02	-0.05	-0.07	-0.10	0.39	0.55	0.53	0.21	0.48	-0.27	-0.03	1.00		
TSW	0.52	0.17	0.20	0.02	-0.11	-0.03	-0.25	-0.33	-0.32	0.03	-0.40	0.57	-0.24	0.23	1.00	
GY	0.66*	0.28	0.24	0.54	0.36	0.54	-0.42	-0.49	-0.43	-0.28	-0.41	0.78**	0.21	-0.50	0.10	1.00

*,** indicate significance at P = 0.05 and 0.01 level of probability, respectively.
LAIV = leaf area index at vegetative, LAIF = leaf area index at flowering, LAIM = leaf area index at maturity, LAI = leaf area index, NT/H = number of tillers per hill, NTV = number of tillers/hill at vegetative, NTF = number of tillers/hill at flowering, NTM = number of tillers/hill at maturity, PH = plant height, PHV = plant height at vegetative, PHF = plant height at flowering, PHM = plant height at maturity, NP/H = number of panicles/hill, D50F = days to 50% flowering, PL = panicle length (cm), PW= panicle weight (g), NS/P = number of seeds/panicle, HI = harvest index, TSW = 1000-seed weight (g), GY = grain yield (kg)

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm of the University of Agriculture, Alabata, Abeokuta (7° 15′ N lat. and 3° 25′ E long.) in the forest-savanna transition zone of South-west Nigeria during the 2002 and 2003 growing seasons. Three rice varieties were used (ITA 321, ITA 150 and WAB 189-B-B-HB), two cassava varieties (TMS 30572 and TME 1) and melon.

Rice intercropped with melon and cassava

The rice/melon experiment was a split–split plot in a randomized complete block design in three replications. The main plot was season (early and late), while rice varieties was the sub–plot and sowing dates was as sub–sub–plot which included; melon planted the same day with rice (0WAP), melon planted two weeks after planting rice (2WAP) and melon planted four weeks after planting rice (4WAP). The experiment contained eleven treatments giving a total number of 33 plots. The rice varieties tested were WAB–B–B–B–6–HB and ITA 150 planted by the dibbling method alone and in an intercrop of 30 cm. The plot size was 6 m × 10 m, each plot was separated by a part way of 0.5m as the rice was planted at a spacing of 25 cm × 25 cm. Each plot had 41 rows of rice in sole and in intercrop had 35 rows of rice per plot in intercrop. Melon had a spacing of 2 m × 1 m giving a melon population of 6 rows per plot in sole and intercrop. The second experiment was rice intercropped with cassava and the trial consisted of eleven treatments arranged in a randomized complete block design replicated three times. The treatments consisted of three rice varieties (ITA 321, ITA 150 and WAB–B–B–B–6–HB). The plot size was 9 m × 6.4 m, each plot was separated by a part way of 0.5m as the rice was planted at a spacing of 30 cm × 30 cm. Each plot consisted of 31 rows of rice in sole. In mixed stands, a constant arrangement of one row of cassava bordering two rows of rice with rows 30 cm apart were used. Cassava was planted at 0.9 m × 0.9 m giving a cassava population of 85 plants per plot for sole.

Land preparation, planting and other cultural practices

The field was disc ploughed and disc harrowed fourteen days later. The missing hills of rice were supplied in order to ensure a targeted planting population per unit area. A basal fertilizer application of 30 Kg N ha^{-1}, 30 Kg P ha^{-1} and 30 kg K ha^{-1} was done two weeks before planting rice by the broadcasting method. A basal fertilizer was used because of the intercrop with cassava and melon. Weeding was performed manually three times before harvesting.

Data analysis

Correlation analysis (Dewey and Lu 1959) was based on 10 hills of rice selected randomly from a plot and was carried out to find out the association between rice grain yield and its component characters (LAIV = leaf area index at vegetative, LAIF = leaf area index at flowering, LAIM = leaf area index at maturity, Leaf area index = LAI, NTV = number of tillers/hill at vegetative, NTF = number of tillers/hill at flowering, NTM = number of tillers/hill at maturity, PHV = plant height at vegetative, PHF = plant height at flowering, PHM = plant height at maturity, NP/H = number of panicles/hill, PL = panicle length (cm), PW= panicle weight (g), NS/P = number of seed/panicle, HI = harvest index, TSW = 1000-seed weight (g), GY = grain yield (kg)) in the intercrop with melon and cassava using Pearson's correlation at P = 0.05 using MSTACTC.

RESULTS

Rice intercropped with melon

Simple correlation coefficients of the characters were studied for rice in intercrop with melon (**Table 1**). A highly significant correlation was observed between LAIV (40 – 45 DAP) and NTV (40 – 45 DAP) stage (r = 0.75), NTM (80 – 90 DAP) (r = 0.6), PW (r = 0.7) and GY (Kg) of rice (r = 0.66). The correlation analysis of LAIM of rice in intercrop was also observed to be highly significantly correlated with NTF (45 – 55 DAP) (r = 0.86), NTM (80 – 90 DAP) (r = 0.76) and NP/H (r = 0.78). The NTV stage (40 – 45 DAP) was also observed to have significant correlation with NTF (r = 0.69) and maturity (r = 0.71) (**Table 1**).

The result further shows a significant correlation between PHV and PHF (r = 0.85) and PHM (r = 0.84). Also significant correlation was observed between PHV stage and NP/H (r = 0.78) and PL of rice (r = 0.85).The correlation coefficient of rice PHM in intercrop with melon was also observed to have significant influence on NP/H (r = 0.67) and highly significant influence on PL of rice (r = 0.81) in intercrop. A significantly negative correlation was observed to have existed between rice PHM and PW of rice (r = -0.64) in intercrop with melon (**Table 1**). However, there was a negative correlation between PHM and TSW (r = -0.32) and GY of rice (r = -0.43). Among the yield components of rice in intercrop a significant correlation was observed between NP/H and PL of rice (r = 0.58) while negative correlation was observed between NP/H and PW (r = -0.34) and GY of rice (r = -0.28).

A significantly negative correlation was observed between PL and PW of rice (r = -0.69) as negative correla-

Table 2 Correlation coefficient of plant height and yield components and yield of rice grown in intercrop with cassava in 2002 and 2003.

	PH	NT/H	LAI	HI	D50F	NP/H	NS/P	TGW	GY
2002									
PH	1.000								
NT/H	-0.207	1.000							
LAI	-0.051	0.890**	1.000						
HI	0.858**	0.236	0.141	1.000					
D50F	-0.448	0.776*	0.679*	0.539	1.000				
NP/H	-0.292	0.930**	0.817**	0.340	0.812**	1.000			
NG/P	-0.148	0.822**	0.710**	0.061	0.802**	0.859**	1.000		
TGW	0.350	-0.767*	-0.692**	-0.355	-0.937**	-0.819**	-0.899**	1.000	
GY	-0.441	0.826**	0.672**	0.539	0.706*	0.913**	0.623	-0.599	1.000
2003									
PH	1.000								
NT/H	-0.220	1.000							
LAI	-0.655	0.836**	1.000						
HI	-0.343	0.387	0.212	1.000					
D50F	-0.681*	0.721*	0.710**	0.205	1.000				
NP/H	-0.439	0.909**	0.782**	0.201	0.876**	1.000			
NG/P	-.0550	0.393	0.298	0.601	0.537	0.304	1.000		
TGW	-0.437	0.212	0.201	-0.144	0.403	0.233	0.329	1.000	
GY	-0.594	0.846**	0.689**	0.440	0.846**	0.805**	0.670*	0.581	1.000

,* indicate significance at P = 0.05 and 0.01 level of probability respectively.
LAI = leaf area index, NT/H = number of tillers per hill, PH = plant height, NP/H = number of panicles/hill, D50F = days to 50% flowering, PL = panicle length (cm), PW = panicle weight (g), NG/P = number of grains/panicle, HI = harvest index, TSW = 1000-grain weight (g), GY = grain yield (kg)

tion was also observed between PL and HI (r = -0.40) and GY of rice (r = -0.41). The PW of rice in intercrop with melon was observed to have negative correlation on NS/P (r = -0.21) and HI of rice (r = -0.27) (**Table 1**). Nevertheless it had a highly significant positive correlation with the GY of rice (r = 0.78). The negative correlation was also observed at NS/P as there was negative correlation between NS/P and HI (r = -0-03) and TSW of rice (r = -0.24) in intercrop. A negative correlation was also observed between HI and GY of rice (r = -0.50) in intercrop (**Table 1**).

Rice intercropped with cassava

Plant height of rice in intercrop with cassava had a negative correlation with NT (r = -0.20 and r = -0.22), LAI (r = -0.05 and r = -0.65), NP/H (r = -0.14 and r = -0.43), NS/P (r = -0.14 and r = -0.55) and GY of rice (r = -0.44 and -0.59) in 2002 and 2003 (**Table 2**). Nevertheless, PH of rice had significantly and highly positive correlation with HI (r = 0.85) in 2002 while in 2003 it had a negative correlation. Also PH of rice in intercrop had a negative correlation with D50F in 2002 but in 2003 it had a significant but negative correlation (r = -0.68). The NT of rice in intercrop was also observed to have had significantly high positive correlation with LAI (r = 0.89 and r = 0.83), NP/H (r = 0.93 and r = 0.90) and GY of rice (r = 0.82 and r = 0.86) in 2002 and 2003 (**Table 2**). Also in 2002 and 2003 the NT of rice in intercrop had significant correlation with D50F (r = 0.77 and r = 0.72). In 2002 the NT of rice in intercrop was observed to have had significant but negative correlation with TSW of rice (**Table 2**).

LAI of rice in intercropping with cassava was observed to have had significant correlation with D50F (r = 0.67) in 2002 and highly significant correlation in 2003 (r = 0.71), while a highly significant correlation was observed with NP/H (r = 0.81 and r = 0.78) in 2002 and 2003 in intercrop with cassava (**Table 2**). The LAI of rice was also observed to have had highly significant correlation with NS/P (r = 0.71) in 2002, while its correlation with TSW was a highly significant but negative correlation (r = -0.69). In 2002 and 2003 LAI had a highly positive significant correlation with the GY of rice in intercrop (r = 0.67 and r = 0.68).

Among the yield components of rice in intercrop with cassava, HI had a negative correlation with TSW of rice (r = -0.35 and r = -0.14) in 2002 and 2003 (**Table 2**). D50F of rice in intercrop with cassava had a highly significant correlation with NP/H (r = 0.81 and r = 0.87) in 2002 and 2003. Also in 2002 the HI of rice in intercrop had a highly significant correlation with NS/P (r = 0.80) in 2002, and also had a negative and highly significant correlation on TSW of rice in the same year (**Table 2**). D50F in 2002 had significant correlation with GY (r = 0.70), while in 2003 it had a highly significant correlation with grain yield of rice in intercrop (r = 0.84).

The NP/H was also observed to have highly significant positive correlation with the GY of rice in intercrop (r = 0.91 and r = 0.80) in both years, as in 2002 it had also highly significant correlation with NS/P (r = 0.85). TSW of rice in intercrop with cassava was also highly negatively significant as the NP/H in 2002 had highly negative significant correlation (r = -0.81) with TSW of rice in intercrop with cassava (**Table 2**). NS/P of rice in intercrop was observed to have had highly negative significant correlation with TSW of rice in 2002 while in 2003 it had significant correlation with GY of rice in intercrop with cassava (r = 0.67).

DISCUSSION

Intercropping is a very common cropping system in Africa and it is practiced by majority of the farmers mainly due to declining land sizes and food security needs. There has been grower interest in intercropping possibly because it could reduce management inputs that result in sustainable systems that more efficiently use and even potentially replenish natural resources used during crop production for long term management of farm land. Intercropping is been practiced in developing countries of Central America, Asia and Africa (Altier and Liebman 1994) and its advantages are: risk minimization, effective use of available resources, efficient use of labour, increased crop productivity, erosion control, food security (Andrew and Kassam 1976) and pest control (Wein and Smithson 1979). The intercrop of rice with groundnut was reported to have significantly reduced stem borer (*Chilo zacconius*) incidence to 7.4 and 13.2%, respectively for wet and dry season cultivation compared with the control (12.0 and 18.0%) (Epidi *et al* 2008). It has also been reported by Epidi *et al.* (2008) that the yield of rice was significantly higher when planted sole than when intercropped with cowpea, groundnut or egusi (melon) except for groundnut during the wet season. Of interest is the fact that many African farmers practice intercropping (Okeleye *et al.* 2001). Also of more significance however is the right crop combination as well as optimum plant population of the component crops. In Thailand, Japan, Brazil and Cote d'Ivore, rice has been successfully grown as cover crop with young coffee, cocoa, citrus and rubber trees (CTA 1993). Riaz *et al.* (2007) reported that the maximum reduction in PH of rice intercropped with sesbania was due to luxuriant growth of sesbania which over shaded the associated rice crop and thereby retarding its growth. Also reduction in PH of rice as a result of intercropping different forage legumes has also been reported by Saeed *et al.* (1999). Intercropping treatments was also observed to by Riaz *et al.* (2007) reduced the grain weight/panicle to a significant level compared to sole rice crop. Also suppressive effects of intercropping on grain weight/panicle of rice were also reported by Banik and Bagchi (1994) and Saeed *et al.* (1999). As Abdul *et al.* (2005) concluded that intercropping systems utilizes agronomic resources more effectively and efficiently towards increased production. Intercropping has been reported to be an important practice in tropical developing countries because of its several advantages (Fujita and Offosu-Budu 1996; Isoken 2000). Correlation analysis carried out in this study establishes the extent and causes of association between rice GY and its attributes in intercrop with melon and cassava. As in this study simple correlation coefficient analysis of rice characters in intercrop were studied to find the extent and causes of association between the GY of rice and its attributes in intercrop between rice/melon and rice/cassava. There has been little or no information on correlation analysis on intercrop of crops, nevertheless, Bello *et al.* (2010) reported the significant and positive correlation of GY/ha with D50F tassel and PH of maize. In this study a negative correlation was rather observed between PH of rice and other stages of growth inclusive of the GY of rice in rice/melon intercrop and rice/cassava intercrop. The findings of this study, however, is in agreement with the findings of Bello *et al.* (2010) who reported that D50F had a positive and significant correlation with the GY of rice in intercrop (rph = 0.56*). High correlation of GY of rice in intercrop with PH is also reported by other researchers (Annapurna *et al.* 1998; Gautam *et al.* 1999). Trayer and Larkin (1985) observed that PH was positively correlated with D50F but this was not the same in rice cassava intercrop as PH had negative correlation with D50F in 2002, while in 2003 it had a significantly negative correlation with D50F. This also implies that the increase in this attributes could invariably decrease D50F. Khatun *et al.* (1999) reported that the GY of rice was positively and significantly correlated with 1000-SW of maize but in this trial of rice in intercrop with melon and cassava, however, TSW of rice in intercrop had no significant correlation with the GY of rice, while in rice/cassava intercrop, 1000-SW of rice had a negative correlation with the GY of rice. Orlyan *et al.* (1999) and Gautam *et al.* (1999) suggested that among most important characters in improving maize GY is PH. Also Halil and Necmi (2003) reported a significant correlation of GY of rice with HI but HI in this study never had any contribution to the GY of rice in intercrop rather it contributed negatively the GY of rice in rice melon intercrop. Although D50F was reported by Halil and Necmi (2003) to have had negative and significant correlation with GY, in this study it had a significantly and positive correlation with the GY of rice in intercrop with cassava.

The results obtained in this trial were observed not to be in agreement with the findings of Javed *et al.* (2010) for the NT/H with the GY of rice (r = 0.29) as it did not significantly influence rice GY. Halil and Necmi (2003) and Surek *et al.* (1998) reported that D50F had a negative effect on the GY of rice (r = -0.44) but this contradicted the findings of this trial as it has positive and significant effects on the GY of rice in intercrop with cassava. Thus, selection for the improvement of GY of rice in intercrop can be efficient if it is based on traits like LAI, PW, NT, NP/H and NS/P.

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