EFFECTS OF LOW LAND RICE-UPLAND RICE-VEGETABLES/COWPEA SEQUENCE ON VEGETABLE AND COWPEA RAINFED INLAND VALLEY

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Abstract

The inland valleys have the potential of growing three crops in sequence within a year without supplemental irrigation. The effects of preceding lowland rice (Oryza sativa L.) and upland rice on the performance of vegetables and cowpea (Vigna unguiculata L.) Walp grown in lowland rice-upland rice-vegetables/cowpea sequences was investigated. Field experiments were conducted at the University of Agriculture Abeokuta, Nigeria in 2000-2003; to determine the agronomic and economic performance of vegetables and cowpea in lowland rice-upland rice-amaranth (Amaranthus cruentus) lowland rice-upland rice-okra (Abelmoschus esculentus L.) sequences. The first, second and third crops in all the cropping cycles were planted in May, September and January, respectively. The yields of cowpea and okra in the inland valley were comparable to those of upland ecology. Amaranth appeared to be a better utilize of residual fertilizer of the preceding upland rice than cowpea and okra. The depth of groundwater table ranges between 45 and 72 cm. Thus, preceding lowland and upland rice influenced leafy vegetable.

Key words: amaranth, cowpea, inland valley, okra, rice, sequence

INTRODUCTION

Inland valley in West Africa shows considerable potential for intensification and sustainable land use (Izac et al., 1991; Windmeijer and Andriesse, 1993). In most areas, the valley bottoms offer the only possibility for dry-season cropping of dry land crops (Carsky and Ajayi, 1992). Increased sustainable cultivation of IVs, which generally have more fertile soils than adjacent uplands soils, promises to relieve the pressure on over-exploited upland soils while adding significantly to food production in the developing nations, particularly in Africa (IITA, 1990).

Under traditional farming in the inland valley, one crop of rice is grown per year because swamps are not developed and water flow is not controlled (WARDA, 1993). In Nigeria, most farmers practice double cropping in the IVs. That is, lowland rice is planted in the main cropping season between April and May when the rains have become steady and is harvested in August and September depending on the length of maturity of the variety. The IVs are then allowed to drain until such a time when the land is no longer saturated and will support upland crop, such as vegetables or maize (*Zea mays* L.) during the dry season (lowland rice-fallow-vegetable sequence).

Considerable opportunity exists for growing the second crop between the main crop (lowland rice) and the dry season cropping. This niche is not usually cropped because it is too short to accommodate another lowland rice crop and the available moisture may not be sufficient to support a lowland rice crop. Hence, early maturing upland rice was evaluated in the niche. The use of the existing niche in IV calls for investigation of the effects of the lowland rice and upland rice crops on the performance vegetables and cowpea. There is dearth of information on the performance of vegetables and cowpea cropped after two crops of rice in rainfed inland valley. Therefore, this study focuses on the effect of lowland rice and upland rice varieties on the performance of vegetables and cowpea.

MATERIALS AND METHODS

The experiments were conducted in three years (2000/2001, 2001/2002, and 2002/2003 cropping seasons) at the bottom of the inland valley of the University of Agriculture, Alabata, Abeokuta (7°20'N, 3° 23'E), Nigeria. The top 1–20 cm soil layer had pH (1 : 2 soil : water) of 6.64, 17.4 mg/kg K measured using Flame photometry 45.50 g/kg organic matter (Walkley-Black method), 2.40 g/kg total N (Macro-Kjedahl method) and 16.09 mg/kg Bray extractable P. The textural class of the soil was loamy soil (784 g/kg sand, 164 g/kg silt, and 52 g/kg clay). The soil series of the experimental site was Ikire (Aiboni, 2001). This is equivalent of Aquic Ustifluvents according to Aiboni (2001). The available long-term climatic data include rainfall and mean temperature. The average annual rainfall is 1 148 mm and average daily temperature is 28°C for period of 21 years.

The experiment was laid out in a split-split plot design with three replicates. Two lowland rice varieties namely, BW 311-9 and FAROX 317-1-1-1 were planted in May. These constituted the main plot treatment and were assigned to plots 437 m^2 (19 m × 23 m) in size. The two varieties of early-maturing upland rice namely, ITA 257 and ITA 150 planted in October were the subplot treatments (19 m × 7 m), and a fallow check (19 m × 3 m). Three upland crops (okra/amaranth/cowpea planted in January after harvesting the upland rice and the

fallow check were assigned to the sub-sub-plots (4 m × 3 m).
The agricultural calendar year, which began in May and ended in April of the following year constituted a cycle. This experiment was conducted in three agricultural calendar years of 2000/2001, 2001/2002, and 2002/2003 cycles. Each cycle consisted of four sequences that ran concurrently with each other. The sequences included the following: (1) lowland rice-upland rice-okra (2) lowland rice-upland rice-amaranth (3) lowland rice-upland rice-IT90K-76 (4) lowland rice-upland rice-IT90K-277-2. Each sequence commenced in May with the planting of lowland rice as the first and the main crop. Two early maturing upland rice cultivars were planted in September and harvested in December. Two vegetables (okra and amaranth) and cowpea planted in January and harvested in March.

Cultivation of lowland and upland rice

The land was cleared manually. Raised beds of 4 m × 3 m sub-sub plots were also manually constructed early in May before the soil got saturated. The upland rice was planted on the flat 2000/2001cropping season whereas those of 2001/2002 and 2002/2003 planted on raised bed to increase the depth of water table. The two lowland rice varieties were sown May 2000, 2001, and 2002. This was harvested in September 2000, 2001 and 2002. The two upland rice varieties were planted in late September and harvested in December. The two types rice were spaced at 20 cm × 20 cm on a 4-m row plot giving a total stand population of 250 000 plant stands per hectare. The first and sixteenth row, were considered as the border rows while the second, third, fourteenth, and fifteenth rows were considered as sample rows. The net plot was made up of the fourth to the thirteenth rows.
The partially decomposed upland rice straw that was used for mulching in cowpea/vegetables crop was incorporated during land preparation for lowland rice whereas the residues of the preceding vegetables/cowpea were used for mulching in lowland rice plots. Lowland rice straws in lowland rice-upland rice-fallow, lowland rice-upland rice-okra, lowland rice-upland rice-amaranth, and lowland rice-upland rice-cowpea sequences were always removed because of the difficulty in handling bulky lowland rice straw during the construction of bed for upland rice and the fact that there was little or no decomposition in flooded soil. The basal fertilizer was applied at the rates of 30 kg N/ha, 7 kg P/ha, and 13 kg K/ha in the form of N : P : K (20 : 10 : 10) at 14 day after planting (DAP) while the top dressing was 30 kg N/ha in the form of urea for all treatments at 70 DAP.

Cultivation of vegetables/cowpea

The crops grown during the dry season were okra (NHAe-47-4), amaranth and cowpea (IT90K-76 and IT90K-277-2). These crops were established on the residual soil moisture at the spacing of 80 cm × 20 cm for cowpea and 80 cm × 50 cm for okra while the tho-roughhly mixed amaranth seed (1.28 kg) and 20 kg of fine soil was drilled in at 40 cm between rows.
Rice straw of the preceding upland plants were usually used as mulching. No fertilizer was applied to cowpea plot but 60 kg N/ha, 13 kg P/ha; 26 kg K/ha in the form of 20 : 10 : 10 NPK compound fertilizer was applied to okra and amaranths 20 days after planting (DAP). The first and the sixth rows, second and fifth rows, third and fourth rows were considered as border rows, sample rows and net rows for cowpea and okra, respectively. For amaranth, the fourth, fifth, sixth and seventh rows were considered as net rows.

Data collection

Cowpea Leaf area at 6 WAP: The total number of middle leaf was counted and then multiplied by a constant; i.e. Leaf area/plant = No of terminal (middle) leaflet × 2.7 × 1/0.37 (Nangju and Wanki, 1980).
Other data on cowpea includes: Number of pods/ped-uncle, number of peduncles/plant, biomass at harvest 10 WAP and grain yield,
Okra Leaf area at 6 WAP: The sum of the length of the mid rib of a plant divided by number of leaves multiplied by 115 minus 1 050. That is $Y = 115x - 1\,050$ (Asif, 1977). Where Y is leaf area; x is the sum of all the length of midrib of a plant divided by the number of leaves.
Other data collected okra were No of branches at 10 WAP, plant height at 10 WAP, fresh pod from the net rows (4.8 m^2), biomass at maturity 10 WAP oven dried to a constant weight at 70°C.
Amaranth: data was collected from the net plot (6 m^2) on plant height and Fresh plant weight 5 WAP

Data on disease incidence

The disease incidence for *Choanephora* spp (lamb's tail pod rot) was scored from the first four plants of every second row of the cowpea plot. This was done by counting the number of infected pod divided by the number of healthy pods.

Data analysis

The data generated from the vegetables and cowpea was subjected to analysis of variance (ANOVA) using split plot that of cowpea was split-split plot.

RESULTS

The cropping cycles of 2000/2001 and 2001/2002 had no rainfall between November and February (Fig. 1) whereas 2002/2003 cropping cycle had rains during the dry season cropping. The leaf area of okra was significantly higher in the 2002/2003 cropping cycle than the 2000/2001 (Table 1). The reverse was the case for fresh pod weight. Plant height and fresh leaf weight of amaranth were similar. However, the fresh leaf weight of amaranth was higher in 2002/2003 than 2000/2001 cropping cycle. The performance of the two vegetables in the preceding plots of lowland and upland rice varieties were similar suggesting that any combination of the two types of rice was adequate.

The number of pods/peduncles in 2000/2001 was significantly higher than those of 2002/2003 cropping seasons. There was disease infection induced by the rainfall which reduces the grain yield in 2003/2003 cropping season (Table 2). There were significant different between the preceding of lowland and upland rice crops. The leaf area and biomass of IT90K-277-2 was significantly higher the IT90K-76. In contrast, IT90k-76 produced more peduncles per plant than IT90k-277-2. The percentage of disease incidence was higher in IT90k-76 than IT90k-277-2. The depth of groundwater table ranged between 45 and 72 cm (Table not presented). Similarly all the data generated on vegetables and cowpea from preceding plots of the two varieties of both lowland rice and upland rice were also similar.

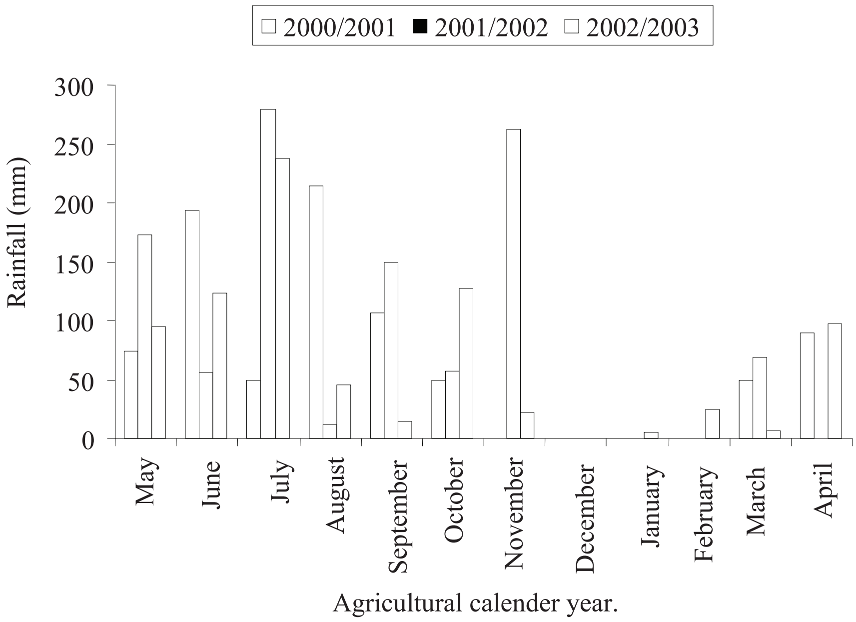

Figure 1: Rainfall data in Abeokuta during the study period (2000/2001, 2001/2002 and 2002/2003 cropping cycles)

Tab. 1: Residual effects of sequential cropping on growth, pod yield of the okra and fresh leaf of amaranth (Abeokuta, Nigeria)

Treatments	Okra					Amaranth	
	Leaf area (cm^2)	Plant height (cm)	Branch No.	Biomass (g/plant)	Fresh pod wt. (t/ha)	Plant height (cm)	Fresh leaf weight (t/ha)
Cropping cycle (CC)							
2000/2001	402.6	53.8	3	77.76	5.57	41.73	4.86
2002/2003	724.2	56.9	2	65.22	3.90	40.08	11.85
SE (CC)	4.51	0.84	0.18	8.02	0.11	2.14	0.18
F-Test (P < 0.05)	0.0126	ns	ns	ns	0.0347	ns	0.0184
Lowland rice (LR)							
BW 311-9	558.2	58.2	3	76.26	5.64	40.99	7.14
FAROX 317-1-1-1	568.6	52.4	3	66.72	3.82	40.81	7.57
SE (LR)	15.02	0.77	0.13	7.27	0.57	1.71	0.63
F-Test (P < 0.05)	ns	ns	ns	ns	ns	ns	ns
Upland rice (UR)							
ITA 257	578.7	55.0	3	74.78	5.27	40.89	7.35
ITA 150	548.1	55.6	3	68.20	4.20	40.91	7.36
SE (UR)	28.05	2.08	0.13	7.85	0.53	1.82	0.40
F-Test (P < 0.05)	ns	ns	ns	Ns	ns	ns	ns

Interactions were not significant; Ns = not significant

Tab. 2: Residual effects of sequential cropping on leaf area, biomass, grain yield and some yield components of cowpea varieties IT90k-76 and IT90k-277-2 in a three-crop sequence (Abeokuta, Nigeria)

Treatments	Leaf area (cm^2)	No of pods/peduncle	No of peduncles/ plant	Biomass g/plant	Grain yield (t/ha)	Disease incidence (%)
Cropping Cycle (CC)						
2000/2001	258.0	2.7	16.8	57.4	1.56	–
2002/2003	288.9	2.1	16.6	55.1	0.99	25.57
SE (CC)	13.16	0.06	1.01	4.94	0.086	
F-Test (P < 0.05)	ns	0.011	ns	ns	ns	
Lowland rice (LR)						
BW 311-9	268.1	2.4	16.0	55.3	1.31	28.26
FAROX 317-1-1-1	278.9	2.3	17.4	57.1	1.24	22.87
SE (LR)	13.16	0.06	1.01	4.94	86.75	1.85
F-Test (P < 0.05)	ns	ns	ns	ns	ns	ns
Upland rice (UR)						
ITA 257	284.4	2.4	16.7	57.8	1.30	24.97
ITA 150	262.5	2.4	16.5	54.6	1.45	25.91
SE (UR)	13.16	0.06	1.01	4.94	86.75	4.46
F-Test (P < 0.05)	ns	ns	ns	ns	ns	ns
Cowpea (VU))						
IT90k-76	223.2	2.4	19.3	44.3	1.33	40.79
IT90k277-2	323.7	2.4	14.2	68.2	1.21	10.10
SE (VU)	13.16	0.06	1.02	4.94	86.75	5.06
F-Test (P < 0.05)	0.001	ns	0.029	0.038	ns	0.030

Interactions were not significant; ns = significant

DISCUSSION

The rainfall pattern during the dry season played a significant role in disease and pest development as well in the soil chemistry of inland valley ecology. The rainfall pattern accounted for the difference in yield of vegetables and cowpea between 2000/2001 and 2002/2003 cropping cycles. The reduction in fresh pod weight of okra (30% reduction) in the 2002/2003 cropping cycle compared to 2000/2001 cropping cycle could be attributed to the negative residual effects of the fertilizer carried over from the preceding upland rice. Mohanty et al. (1989) gave a similar report of negative residual effect of fertilizer on the green gram. The fresh pod in this study was comparable to the report of Olasantan (1998) who experimented on upland ecology.

The superior fresh leaf weight of amaranth in the 2002/2003 cropping cycle compared to that of 2000/2001 was due to the rainfall in 2002/2003. This rainfall could have dissolved the residual fertilizer left by the preceding upland rice crop in soil solution which could be available to the vegetable in 2002/2003 cropping season and consequently increased the leaf yield of amaranth. Amaranth, being a leafy crop, responded positively to the residual fertilizer carryover from the preceding upland rice suggesting that it is a better utilizer of N fertilizer than either cowpea or okra. This confirms the finding of Mohanty et al. (1989) who reported that rice, as a succeeding crop appeared to be a better utilizer of residual fertilizer N.

The superiority of IT90k-277-2 to IT90k-76 in fodder yield confirms the report of Okeleye and Ariyo (2000). Cowpea grain yield in inland valley was comparable to the report of Okeleye and Ariyo (2000) who experimented in an upland ecology. Although the grain yield 2000/2001 and 2002/2003 cropping cycles were similar. However, the difference in cowpea grain yield between the two cropping cycles was substantial (37%**).** This difference in cowpea grain yield could be attributed to the rainfall in 2002/2003 cropping cycle with the associated lamb's tail pod rot disease caused by *Choamephora* spp. Furthermore, the shallow groundwater table is an indication that water requirement of the vegetables and cowpea could be met by capillarity.

Generally, the similarity in all the agronomic parameters of vegetables and cowpea in the preceding plots of lowland rice and upland rice varieties simply implies that any of the varieties of lowland rice and upland rice could be combined with any of the vegetable species or cowpea varieties. The similarity in soil chemical properties prior to planting of vegetable/cowpea also confirms the fact that any combination of the lowland rice and upland rice varieties will suffice. Based on this study, preceding upland rice reduced the yield of okra fresh pod but favoured fresh leaf weight of amaranth. Hence any combination of lowland rice variety and upland rice variety with leafy vegetable appeared to be best sequence.

REFERENCES

ASIF M.I. (1977): Estimation of leaf area in okra Abelmoschus esculentus (L) moench. Tropical Agriculture (Trinidal), 54: 192.

CARSKY R.J., AJAYI E.O. (1992): Fitting soil-improving legumes into inland valley rice-based cropping systems in West Africa. In: Mulongoy K., Gueye M., Spencer D.S.C. (eds.): Biological fixation and sustainability of tropical agriculture, pp. 395–404.Wiley-Sayce Co-publication.

IITA (International Institute of Tropical Agriculture) (1990): IITA Annual Report 1989/1990. Ibadan, Nigeria, pp. 82–43.

IZAC A.M., SWIFT M.J., ANDRIESSE W. (1991): A strategy for inland valley agroecosystems research in West and Central Africa. RCMD Research Monograph No. 5. Research and Crop Management Program, International Institute of Agriculture, Ibadan, Nigeria.

KLUTE A. (1986) (ed.): Methods of soil analysis. Part 1 Physical and mineralogical methods. (2nd ed.) American Society of Agronomy, Soil Science Society of America. Madison. Wisconsin. USA.

MOHANTY S.K., PANDA M.M., MOSIC A.R., MAHAPATRA P., REDDY M.D. (1998): ^{15}N balance studies in a rice-green gram-rice cropping system. Journal of Indian Society of Soil Science, 46 (2): 232–238.

NANGJU D., WANKI S.B.C. (1980): Estimating leaf area of cowpea and soybean using dry weight terminal leaf. Experimental Agriculture, 16: 149–159.

OKELEYE K.A., ARIYO O.J. (2000): Effects strip intercropping and insecticide spray on the performance of cowpea (Vigna unguiculata) L WALP in a cowpea/ Maize intercropping. Niger. Agric. J., 31: 23–32.

OLASANTAN F.O. (1998): Effect of preceding maize and cowpea in sole cropping and intercropping on growth, yield and nitrogen requirement of okra. Journal of Agric.Sci. Cambrigde, pp.1–6.

TOLER R.W., DUKES P.D. (1965): Chaonephora pod rot of cowpeas. Plant Dis. Reptr., 49 (4): 347–350.

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