APPROPRIATE TECHNOLOGY FOR RELAY INTERCROPPING: COWPEA INTERPLANTED AS RELAY INTO MAIZE

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ABSTRACT

The risk of crop failure due to low, delayed or abrupt cessation of rainfall is a major constraint in both the uni and bi-modal rainfed cultures characteristic of West African agriculture. Relay intercropping offers a possible solution to the total crop failures encountered, particularly by maize farmers. This study was undertaken to develop appropriate technologies for relay intercropping of cowpea into maize so that land use, resource management and input utilisation could be optimised. Residual moisture-use is of particular importance in this cropping situation. Four main factors each at two levels were evaluated for their effect on cowpea pod weight and grain yield. These were: maize variety component of relay (early and full season); bending-over of maize stalk below ear before interplanting cowpea (non-bending and bending over); time of interplanting cowpea into maize stand (at black layer and two weeks after black layer of maize grain) and method of weed control before relay cowpea is planted (hand weeding and chemical control). All the main factors except bending-over, significantly influenced cowpea yield. The results showed that light interception and residual moisture-use were critical to the yield of the relay cowpea. The results also indicated that though light was critical, the amount of light intercepted by interplanted cowpea did not change with bending-over. This labour demanding task can thus be avoided without any significant reduction in cowpea yield.

Keywords: Cowpea, maize, residual moisture, light interception, bending-over, relay intercropping, pod weight, grain yield.

INTRODUCTION

Water is a limiting resource for crop growth in West Africa not only because rainfall distribution is variable but also soils have low water holding capacity because of their low organic matter content. In certain instances, the rains cease abruptly. Lack of moisture for crop growth is therefore a major cause of both the low yield and lack of yield stability.

To minimise the risk of crop failures due to drought, early planting [1], and use of early maturing varieties [2],]3] and [4], are some of the management interventions suggested. These management practices allow greater flexibility and more intensive cropping. This is especially true in the second season of the bimodal rainfall areas where the rainfall is not only low but also ceases abruptly.

To further minimise the risk, sometimes of complete crop failure, maize farmers in particular could multiple-crop to maximise resource and input utilisation. Cowpea as an early, drought-tolerant leguminous crop, is ideally suited, as a relay intercrop, to take advantage of the residual moisture conditions prevalent in the season.

Relay intercropping is a crop production intensification technique that involves growing two or more crops simultaneously, the second crop is usually planted when the first has reached its reproductive stage of growth but before it is ready for harvest [4].

In the simultaneous interplanting of two or more crops in relay, light interception into the undersown crop, residual moisture-use by the undersown crop, and seed bed preparation for sowing the second crop are primary areas focus. Light interception will be influenced by the size, leafiness, architecture and density of the first crop. The strategy here is to influence productivity of the system by decreasing the magnitude of the yield reduction anticipated of the second crop since its lower canopy vegetation will receive less total solar radiation. Radiation interception is therefore critical to yield in intercrops and should receive particular attention [5].

Residual moisture-use by the second crop, crop in relation to maturity of both crops. Evapotranspiration is expected to be less for this will be influenced by the planting time of the second lower canopy crop in intercrops [5] and therefore moisture requirement by the undersown crop might partially be met. Residual moisture could also be conserved by utilising weed residue as mulch after seed bed preparation to sow the second crop.

Growing the early - maturing cowpea types under residual moisture in both the southern and northern Guinea savannah zones of West Africa has therefore been recommended [6]. Cowpea, a C_3 plant, will likely succeed than C_4 cereals as a lower canopy crop. Cowpea also has an added benefit of increasing yield of subsequent non-legume crop [7]; [8]. This study was therefore conducted to develop appropriate technologies for a maize-cowpea relay intercropping in West Africa.

Materials and Methods

Field experiments were conducted in 1988 and 1989 at two research stations of the Crops Research Institute both near Kumasi, a central forest belt area with a bimodal rainfall regime. The first season (major season) rains normally begin in March and end in July. There is a short dry spell in August and then the second season (minor season) rains begin in September and end in about November. Table 1 gives the rainfall figures recorded in 1988 and 1989.

The 1988 experiment was conducted at Kwadaso, a suburb of Kumasi. This site had previously been continuously cropped to maize and cassava for 5 years. The soil is classified as Kumasi series (FAO, UNESCO: Ferric Acrisol; USDA: Oxic paleustult) with a pH of 6.9.

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The site used in 1989 was at Fumesua, another suburb of Kumasi. The site had previously been continuously cropped to maize and cassava for three years. The soil is classified as Asuansi series (FAO - UNESCO: Ferric Acilsol; USDA: Typic Paleustult) with a pH of 5.9.

Table 1: Monthly total rainfall (mm) for Kwadaso, and Fumesua, 1988 & 1989

Month	Kwadaso		Fumesua*	
	1988	1989	1988	1989
JANUARY	26.9	51.6	0	53.7
FEBRUARY	10.4	0	10	2.3
MARCH	218.7	165.9	309.5	112.0
APRIL	183.4	94.7	135.7	77.2
MAY	142.5	124.2	110.7	126.2
JUNE	376.7	397.0	341.7	310.4
JULY	109.9	50.0	138.8	89.3
AUGUST	22.8	143.0	15.0	177.0
SEPTEMBER	227.8	227.1	185.5	281.2
OCTOBER	139.7	201.0	136.4	186.3
NOVEMBER	18.0	61.5	38.6	39.5
DECEMBER	56.9	2.5	78.9	8.2

*Values for Fumesua are the values obtained for Kumasi airport area by Meteorological Services. This area is close to the Fumesua location. Actual values were not available.

The experimental design used in both locations was randomised complete block with 4 replications in a 2^4 factorial arrangement. Plots were 6 rows x 5m long. Maize was planted 80cm between rows and 50cm between hills at 2 plants per hill. Cowpea was planted 80cm between alternating maize rows. Cowpea hills were spaced 20cm within rows, with 2 plant/hill. Factors under study were: 1) Maize variety component of relay (early and full season maturity); (2) Bending-over of maize stalk below ear before interplanting cowpea (non-bending and bending-over). (3) Relay cowpea-interplanting time into maize stand (at black layer and two weeks after black layer of maize grain) and (4) Method of weed control before relay cowpea is planted (hand weeding and chemical scorching of weeds).

The commercial maize varieties used were Aburotia, a medium maturing 105-days white dent ope pollinated variety with erect leaves developed at Crops Research Institute (CRI), Kumasi. The variety silks at 51 DAP and grows to a height of about 150cm at maturity yielding an average of about 4.6 ton/ha. Dobidi an open-pollinated full season maturing 120-days white dent was also released by CRI. The variety silks at 60 DAP and grows to a height of about 120cm at maturity yielding an average of about 5.5 ton/ha. The Cowpea variety component of the relay was Asontem, a semi-erect 60-65 day extra early maturing light-red seeded variety also released in Ghana by CRI. It yields an average 1.7 ton/ha.

Fertiliser (compound and ammonium sulphate) applied was equivalent to 90:38:38 of N-P_2O_5-K_2O and ammonium sulphate, were applied to maize at 2 and 6 weeks after maize planting respectively. Primagram 500 (250g/l metolachlor + 235g/l atrazine + 10g/l atrazine related compounds), a pre-emergent herbicide was applied at the rate of 2kg/ai/ha to control weeds after planting the maize in the first rainfall season.

One half the number of plots was planted to cowpea at the black layer stage of maize grain (on 12th August in 1988 and 8th August in 1989) and the other half at 2 weeks after black layer formation of maize grain. Similarly, the maize stand in one half of the plots was bent over below the ear before cowpea was interplanted and plots were either hand weeded or weeds were sprayed with gramozone (276g paraquat dichloride/1) at the rate of 2 kg ai/ha. Weed regrowth was not controlled again after the weed control treatment. The harvest was made from two middle rows of each plot that measured $4.2m^1$.

RESULTS AND DISCUSSION

In both years, cowpea yield was significantly affected by maize variety, relay planting time and method of weed control (Table 2). This indicates the importance of maize plant size and leafiness, residual moisture and density of weed residue in influencing yield of relay cowpea. Bending-over did not influence cowpea yield significantly in both years (Table 2). Bending-over was expected to facilitate better light penetration into maize canopy to benefit the undersown cowpea. This lack of response suggested that bending-over did not change the pattern of light penetration into the canopy enough to influence yield. This labour demanding and therefore an expensive operation may therefore not be beneficial to the farmer and the task may be avoided.

Table 2: Effect of maize variety, relay planting time, bending-over and weed control on pod weight and grain yield of cowpea

Factor Level	1988		1989	
	Pod Weight	Grain Yield Kg/ha	Pod Weight	Grain Yield Kg/ha
MAIZE VARIETY				
Aburotia	1863**	1323**	888*	610**
Dobidi	1269	884	761	492
RELAY PLANTING TIME				
At black-layer	2709*	1225*	920**	627**
Two weeks later	1450	982	730	475
BENDING-OVER				
Non-bending	1560^{NS}	1078^{NS}	808^{NS}	539^{NS}
Bending-over	1600	1129	842	563
WEED CONTROL				
Hand weeding	1409**	987**	639**	427**
Paraquat scorching	1751	1220	1010	675
CV (%)	16.9	18.3	20.8	21.5
S.E.D.	94.3	71.5	60.6	42.0

Shading is detrimental to cowpea yield [9] especially the erect types because these cowpea types, like other crops, need abundant light penetration into the canopy for high yield though creeping types might be adapted to shade. The later maturing maize is therefore less suitable in relay intercropping with cowpea because of shading of cowpea due to its size and leafiness. Results obtained confirm this view. It was better to interplant cowpea into Aburotia at the two times of relay planting (Table 3) in 1988. The yield difference between cowpea interplanted into Aburotia and into Dobidi ranged between 23-36% for pod weight. It has been suggested that

Table 3: Effect of maize variety and relay planting time on cowpea pod weight and grain yield at Kwadaso in 1988

Maize variety	Pod weight		Grain Yield	
	At Black Layer Kg/ha	Two Weeks Later	At Black Layer Kg/ha	Two Weeks Later
Aburotia	2091	1635	1519	1126
Dobidi	1328	1265	930	838
CV (%)	16.9	16.9	18.3	18.3
SED	133.3	133.3	101	101

the degree of success of polycultures may depend in part on the spatial and/or temporal display of phytoelements, which minimises competition for photosynthetic active radiation [5]. The corresponding value ranges between 26% - 39% for grain yield (Table 3).

In 1989, it was again better to interplant cowpea into Aburotia when planting was done two weeks after black layer than into Dobidi (Table 4). Shading by Dobidi and late planting combined to severely depress cowpea yield. Yield reduction was 43% and 47% for pod weight and grain yield respectively. At black layer stage, no differences in cowpea yield were established, however, when cowpea was planted into either of the maize varieties (Table 4) in 1989.

Table 4: Effect of maize variety and relay planting time on cowpea pod weight and grain yield at Fumesua in 1988

Maize variety	Pod weight		Grain Yield	
	At Black Layer Kg/ha	Two Weeks Later	At Black Layer Kg/ha	Two Weeks Later
Aburotia	849	928	598	621
Dobidi	991	531	656	328
CV (%)	20.8	20.8	21.5	21.5
SED	85.7	85.7	59.3	59.3

Table 5: Effect of maize variety and relay planting time on cowpea pod weight and grain yield at Fumesua in 1988

Maize variety	Pod weight		Grain Yield	
	At Black Layer Kg/ha	Two Weeks Later	At Black Layer Kg/ha	Two Weeks Later
Aburotia	571	1205	388	831
Dobidi	707	815	466	518
CV (%)	20.8	20.8	21.5	21.5
SED	85.7	85.7	59.3	59.3

Cowpea yield under chemical weed control was better than yield under hand weeding in both environments (Table 2). It is probable that there was regrowth of weed under hand weeding leading to yield loss. It is also probable that the mulch under paraquat scorching might have smouldered new weed regrowth. Yield of cowpea under chemical weed control in Aburotia was however higher than that in Dobidi (Table 5). This could be due to more residual moisture under Aburotia than under Dobidi. Prior to application of the weed control treatments, there was likely to be more weeds under Aburotia than under Dobidi because of the expected better light penetration into the canopy of Aburotia and consequently, more weed growth. After application of paraquat, the scorched weeds might have served as mulch and preserved the residual soil moisture for higher cowpea yield under Aburotia. Chemical weed control was also more effective than the manual treatment at the two times of planting relay cowpea.

These results are in agreement with suggestions by [10] for cereal - cowpea relay intercropping in both the savannahs and humid areas of Africa. The results also suggest the following feasible and appropriate technology for a maize-cowpea relay intercropping system:

(a) A short season, early-maturing and short-statured maize variety to allow ample light penetration into interplanted cowpea canopy.

(b) Early interplanting of an early maturing cowpea to take advantage of residual soil moisture. Planting should be at the black layer state of maize grain.

(c) Chemical scorching of weeds in which the residual is preserved to serve as mulch in seed bed preparation before relay is sown. This conserves moisture, reduces evapotranspiration and smoulders weed regrowth.

(d) The practice of bending-over maize stalks before relay interplanting cowpea did not improve yield and may be avoided.

Since cowpea, probably the most important legume in Africa, is grown in association with other crops [11] this technology can be easily adapted especially in areas where maize is the main crop and the cowpea crop is additional and regarded as a bonus crop. This will be relevant in both the uni and bi-modal rainfall areas in West Africa. In Ghana, cowpea has also proved to be a valuable crop not only for nitrogen fixation but for the soil improvement qualities of its roots on continuously cropped land [7]. A maize farmer can therefore grow an additional crop efficiently within his normal cropping calendar in the savannah or forest zones of West Africa. For these farmers, the availability of cowpea as an early drought tolerant leguminous crop with soil improvement qualities that can be interplanted into maize early to take advantage of the residual moisture conditions in the soil is a bonus that cannot be over emphasised.

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