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USING RESIDUAL MOISTURE TO SUPPORT A SECOND CROP IN A RICE-BASED CROPPING SYSTEM IN TWO DIFFERENT AGRO-ECOLOGICAL ZONES IN GHANA

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ABSTRACT

The common practice of most rice farmers in Ghana is to leave the land fallow after harvesting the rice. However, the possibility of using the residual moisture to produce some kind of vegetable may enhance the income of the rice farmer to improve his or her livelihood. The main objective of the study was therefore to grow rice under two different cropping systems, (i.e. flooded-puddled conditions and semi-flooded no-till conditions), and to investigate the potential of these two cropping systems to produce okro (okra) after harvesting the rice using the residual moisture after rice. The study was conducted using farmers' fields. The study showed clearly that it is more profitable to produce rice under flooded-puddled condition. Growing rice under rain-fed condition in the semi-deciduous forest zone is risky. Further more, it is unprofitable to grow vegetables like okro after rice in the two agro-ecological zones. Again, under no-till condition, the loss incurred in growing okro after rice was far lower than that under flooded-puddled condition.

Keywords: residual moisture, rice, cropping system, puddled, agro-ecological.

1. INTRODUCTION

Irrigated rice-based cropping systems are among the major water users globally and account for around half of all diverted freshwater in Asia. Rice is usually irrigated with 2 to 3 times more water than other irrigated cereals (Tuong *et al.*, 2005). The increasing scarcity of water and competing claims on water by other sectors (CA, 2007; FAO, 2003) require that agriculture uses water resources more efficiently than in the past. Therefore, growing more than one crop of rice per season or year has become a subject of great importance because of the relatively higher crop water requirements of rice as compared to "dry foot" crops.

The common practice of most rice farmers in Ghana is to leave the land fallow after harvesting the rice. Perhaps this could be due to the fact that the soil after growing rice becomes consolidated, making it unfavorable for growing any other crop. Furthermore, it is common practice of farmers to burn the rice straw after harvesting. There is the suggestion that when rice is produced under flooded-puddled conditions the residual moisture after harvesting could at least, support one crop of vegetable production. But the poor soil structure resulting from flooding and puddling is often a limitation to farmers to grow any other crop. However, the possibility of using the residual moisture to produce some kind of vegetable may enhance the income of the rice farmer to improve his or her livelihood.

The main objective of the study was therefore to grow rice under two different cropping systems, (i.e. flooded-puddled conditions and semi-flooded no-till conditions), and to investigate the potential of these two cropping systems to produce okro (or okra) after harvesting the rice using the residual moisture. This study was conducted using farmer's fields.

2. METHODOLOGY

2.1 Selection of sites and farmers

The two sites selected were Assin Akonfudi and Kobina Anokrom in the semi-deciduous forest and coastal savanna zones, respectively. In the semi-deciduous forest zone (Assin Akonfudi), rice is either produced in the low-lying areas or in the valley bottoms. Such areas are marshy with stands of raffia palm. The farmers normally grow rice under semi-upland condition that is, using water collected under wetland condition without dikes or bunds. At Kobina Anokrom, the farmers have been growing rice under flooded-puddled condition over decades.

The two farmers were selected with the help of the local agricultural extension staff. The farmers agreed to grow okro and cowpea as succeeding crops after rice. But it was realized during the first year that cowpea was sensitive to the high initial soil moisture content. Therefore, it was decided to grow only okro as the succeeding crop after rice.

2.2 Assin Akonfudi site

2.2.1 Okro production

The field was located at Assin Akonfudi on the Assin Fosu-Kumasi highway. In 2002, the farmer had already harvested the rice when the site was selected. Therefore we began with okro as the succeeding crop. Three plots of size 12m x 10m each were demarcated and diked with 2m between the plots. The plots were sprayed with Round-Up (glyphosate) at the rate of 300ml of Round-Up in 15 litres clean water in a knapsack (or 3 litres of Round-Up per hectare).

The okro variety 'asontem' was planted at a spacing of 50 cm by 20 cm using three seeds per hole and

later thinned to one plant per stand. Compound fertilizer 15:15:15 was applied at a rate of 2.5 kg per plot using the banding method of application. Weed control was done two times using the hoe. Harvesting of okro was done weekly.

2.2.2 Semi-flooded rice under no-tillage

The rice variety used was 'Sika Rice'. Three plots were used, each measuring 12 m x 10 m. The plots were sprayed with Glyphosate (Round-Up) at concentration of 3.0 litres per hectare. The rice was nursed and transplanted at a spacing of 50 cm x 20 cm. Weeds were manually controlled twice. The first weed control was between three (3) and five (5) weeks after transplanting and the second one between seven (7) and nine (9) weeks after transplanting. NPK compound fertilizer was applied three weeks after transplanting at a rate of 2.5 kg per plot and sulphate of ammonia was applied seven weeks after transplanting at a rate of 2.5 kg per plot. Duration of the trial was five months for every year (2003/2004 and 2004/2005).

2.3 Kobina Anokrom site

2.3.1 Okro production

At Kobina Anokrom, it was possible to begin with the farmer right from field preparation for rice cultivation to harvesting the rice and followed by growing okro with the residual moisture. The size of the okro plot measured 19 x 13 m (0.025 ha). The plot was manually weeded after harvesting the rice. The soil was not further tilled using the hoe, but was mulched with rice straw before planting the okro (Figure-1). While the growth of okro was progressing, the plot was manually weeded once while water was manually applied twice from a well at the site using the watering can when the crops showed signs of water stress. Harvesting of okro was done weekly.

Figure-1. Planting under rice straw mulch at Kobina Anokrom.

2.3.2 Flooded-puddled rice trial

At Kobina Anokrom, land preparation for paddy rice production was done using the rotary tiller under flooded conditions. The same variety of rice 'Sika Rice' was transplanted at a spacing of 50 cm by 20 cm. Weed control was done two times manually. The first one between three (3) and five (5) weeks, and the second one between seven (7) and nine (9) weeks, depending on the severity of weed infestation. Compound fertilizer 15:15:15 was applied at a rate of 100 kg/ha seven weeks after transplanting. Duration of the work was five months for each of the years (2003/2004 and 2004/2005). Four plots were used each measuring 20 m by 20 m.

3. RESULTS AND DISCUSSIONS

3.1 Some soil properties of the two sites

Some soil properties measured at the sites are presented in Table-1. The soil at Kobina Anokrom was sandy clay while it was sandy loam at Assin Akonfundi. Even though the soil at Kobina Anokrom was puddled, it gave a lower bulk density than that of Assin Akonfudi, probably due to texture variation. The Nitrogen and Phosphorus contents of the soil at Assin Akonfudi were about 12.6 times and 8 times, respectively those at Kobina Anokrom. This confirms work by Lian (1986). His experiments demonstrated that growing corn in plots previously flooded and puddle had lower phosphorus and nitrogen available as compared to corn planted on plots which had been allowed to drain and fallow. Lower yields were the results. In reality, the soil at Assin Akonfudi was richer in chemical composition than that at Kobina Anokrom. The pH indicated that the soil at Kobina Anokrom, was more acidic than the soil at Assin Akonfudi

Table-1. Some soil properties of the two sites.

Soil property	Kobina Anokrom	Assin Akonfudi
Bulk density (g/cm^3)	1.14	1.40
Total nitrogen content (%)	0.09	1.13
Organic carbon (%)	1.37	1.83
Phosphorus (Mg/g)	2.13	16.49
Potassium (C mol / kg)	0.15	0.08
pH	3.44	4.97
Soil texture	sandy clay	sandy loam

3.2 Okro yields

The yields of okro and the number of fruits harvested for the two sites are given in Table-2. In all the three years, the yield of okro at Assin Akonfudi was higher than that at Kobina Anokrom. The average yield of okro at Assin Akonfudi was more than three times that obtained at Kobina Anokrom.

Table-2. Yield of okro at the two sites.

Site	2002		2003		2004		Mean	
	No. of fruits/ha	yield kg/ha	No. of fruits/ha	yield kg/ha	No. of fruits/ha	yield kg/ha	No. of fruits/ha	yield kg/ha
Assin Akonfudi	56,722	1191.2	16.300	342.3	19,050	399.1	24,026	640.8
Kobina Anokrom	7.040	147.8	8,800	184.9	13,300	279.3	7,285	200.4

3.3 Paddy yields

The yields of paddy from the two treatments at the two different locations are presented in Table-3. In 2002, the farmer at Assin Akonfudi had already harvested his rice when the field was selected, so no yield data were available for that site. In all the years, with the exception of 2003, the yield of paddy was remarkably higher at Kobina Anokrom than at Assin Akonfudi. The overall mean yield of paddy at Kobina Anokrom was more than double that of Assin Akonfudi.

Table-3. Paddy yields (t/ha).

Assin Akonfud	2002	2003	2004	Mean
	-	2.049	0.611	1.315
Kobina Anokrom	4.600	2.168	2.168	2.978

3.4 Gross income from sales of paddy and okro

The gross incomes from the sales of paddy and okro are indicated in Tables 4 and 5, respectively. The selling price of paddy for 1 bag of 40 kg was $20.25 in 2002, $23.01 in 2003 and $26.68 in 2004. In all the years under study, okro was sold at $0.02 per fruit. The gross income analysis for growing paddy under flooded-puddled condition indicates that the rice farmer working under flooded-puddled conditions is far better off than the farmer working under semi-flooded conditions using no-till conservation tillage.

The total gross income for sale of okro was higher at Assin Akonfudi than Kobina Anokrom, the mean annual value being as high as 5 times that at Kobina Anokrom.

The overall income from okro is low compared to paddy, but at Assin Akonfudi in the semi-deciduous forest, the mean gross income from sale of paddy was not significantly different from the sale of okro. However, at Kobina Anokrom, where the land was flooded and puddled, there was an evidence of soil structural deterioration which is a limitation to the production of okro as a succeeding crop after rice. This is also in agreement with work done by Lian and Hsiang (1989) who reported that systematic puddling of soil completely degraded the soil.

3.5 Net income analysis

3.5.1 Paddy and okro production costs

Tables 6 and 7 show the cost of producing paddy rice under the two cropping systems at the two different locations.

Table-4. Gross income from sale of paddy at the two sites ($).

Site	2002	2003	2004	Mean
Assin Akonfudi	-	42.41	14.67	29.00
Kobina Anokrom	1417.72	759.49	880.49	1019.00

Table-5. Gross income from sale of okro at the two sites ($).

Site	2002	2003	2004	Mean
Assin Akonfudi	51.70	15.01	8.49	25
Kobina Anokrom	4.46	4.05	5.91	5

Table-6. Paddy production cost ($).

Site	2002	2003	2004	Mean
Assin Akonfudi	-	55.24	66.70	61
Kobina Anokrom	113.92	109.09	110.06	111

Table-7. Okro production cost ($).

Site	2002	2003	2004	Mean
Assin Akonfudi	47.22	48.33	46.69	47
Kobina Anokrom	44.30	28.19	34.80	36

3.5.2 Profit/loss analysis

Comparison of Tables 4 and 6 gives the profit/loss analysis of paddy rice production at the two sites as presented in Table-8. The analysis indicates that the farmer producing rice under flooded conditions at Kobina Anokrom could gain a net profit of $941 while the farmer producing rice at Assin Akonfudi under rain-fed semi-flooded condition could lose about $81 (Table-7).

Table-9 gives the net profit/loss from producing okro as a succeeding crop after rice. Apart from the year 2002 when there was a meager profit of $7.39 at Assin Akonfudi, there was a net loss for the succeeding years at the two sites.

Table-8. Profit/loss analysis of paddy production ($).

Site	2002	2003	2004	Mean
Assin Akonfudi	-	-66.74	-95.39	-81
Kobina Anokrom	1303.80	704.26	813.79	941

Table-9. Profit / loss analysis of okro production ($).

Site	2002	2003	2004	Mean/Year
Assin Akonfudi	7.39	-13.19	-26.33	-11
Kobina Anokrom	-42.76	-44.28	-40.78	-43

4. CONCLUSIONS

The study has shown clearly that it is more profitable to produce rice under flooded-puddled condition. Growing rice under rain-fed condition in the semi-deciduous forest zone is risky.

Even under the condition where the field was bunded to harvest more rain to give it semi-flooded condition, there was a net loss in income. Therefore, the situation is likely to be worse in most farmers' fields where the rice seeds are broadcast on the flat without any system of rainwater harvesting.

Further more, this work indicates that it is unprofitable to grow vegetables like okro after rice. With cowpea, there was a total failure. Nevertheless, under no-till condition, the loss in growing okro after rice was not as high as under flooded-puddled condition.

The major pest limiting rice production in the semi-deciduous forest is birds. Even though labour was hired to scare the birds, the birds come too early, so before the bird scarers came, the damage had already been done.

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