FINAL REPORT OF THE SHORT-TERM PRODUCTION ORIENTED RESEARCH PROGRAMME IN RICE AT THE BRUMDEC PROJECT IN JAMAICA

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APRIL 1981 - APRIL 1982

by

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November 1982

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1. INTRODUCTION

This report is prepared in accordance with Article 6, Section 6.01 of the Agreement between the Black River Upper Morass Development Company Limited (BRUMDEC) and the Inter-American Institute for Co-operation on Agriculture (IICA).

The period covered by this report is April 25, 1981 to April 24, 1982. The Rice Production Specialist arrived in Jamaica on April 25, 1981. The initial report [1] entitled "Rice Research and Production in the BRUMDEC Project: State-of-the-art Review, Identification of Constraints and Interim recommendations and Budget for Establishing 405 hectares (1,000 acres) of rice on the Clay Soils at BRUMDEC" was submitted to the Client in June, 1981. The target area of 405 hectares (1,000 acres) was determined by BRUMDEC.

Later, this target area for a renewed attempt in rice cultivation was reduced by BRUMDEC to 202.5 hectares (500 acres). Several factors predicated this decision, the more important factors being the unavailability of appropriate machinery and implements in the country which could be used for the development and tillage of the clay soils for rice cultivation in the project; and the closing-down of operations at the ADC-owned rice mill at Spanish Town. This development which occurred as from August 1, 1981, affected the extensiveness of proposed rice cultivation at BRUMDEC by removing an outlet for paddy produced in excess of the capacity of the BRUMDEC facilities.

The Rice Production Specialist assisted the BRUMDEC staff who prepared the budget for the cultivation and processing of paddy from 202.5 hectares (500 acres).[2]

In June, 1981 the proposed short-term research programme was submitted to BRUMDEC. With the approval of the research proposals, BRUMDEC was requested to provide all materials, and services required for the implementation of the research programme.

The selection of sites for the research work was done by the counterpart of the Rice Production Specialist who used his knowledge of the area and the Detailed Soil Survey Report (3) in selecting the experimental sites.

Land preparation services were provided for the rice research programme on July 21, 1981. The sites of experiments R1/1/81 and R2/1/81 were prepared and ready for sowing on August 25 and September 4, 1981 respectively. Experiments R3/1/81 and R4/1/81 were sown on September 11 and September 25, 1981 respectively. Experiment R5/1/81 was sown in the Morass Peat area on 9-10 November, 1981. All of these experiments were fertilizer trials.

On March 18, 1982, an observation plot of variety CICA-8 was sown on the Morass Peat. At this time approval was obtained from BRUMDEC for a temporary weir to be constructed in the drainage canal adjacent to the experimental site on the Morass Peat. The objective of constructing the weir was to raise the water level in the drainage canal sufficiently high so as to irrigate the experimental and observation plots by gravity and to enable the area to be adequately flooded. This method of controlling flood level in the rice crop grown on the Morass Peat was successful and is in fact in implementation of the principle of recommendation (xii) contained in the report "Recommendations for land use and irrigation needs in the BRUMDEC project" (4). In this observation plot a fungicide observational trial and a nitrogen x copper, 2x2 factorial in randomized complete block design are to be superimposed later. On April 23, 1982, a variety x fertilizer trial was sown on the Morass Peat utilizing four U.S. rice varieties and one Colombian variety each at three different levels of fertilization. The results of all work started in March and April, 1982 will be presented in a separate report. Previous quarterly reports are attached as Appendices to this report.

2. OBJECTIVES

The long-term objective of the rice research programme is to develop and define economically viable rice crop management systems of rice on the flat, mineral soils and Morass Peat soil within the project area.

In the short-term the research programme has aimed at investigating variety and fertilizer usage under conditions of wet tillage on both groups of soils, chemical weed control utilizing 2.4-D and propanil, Blast disease control utilizing benomyl and Kasumin, Helminthosporium (Cochliobolus) and related Drechslera control utilizing Dithane M-45, grasshopper and stink-bug control utilizing diazinon and carbaryl. Comparisons of dry-tillage-based and wet-tillage based rice crop management systems could not be made due to shortage of facilities to implement such a study.

3. MATERIALS AND METHODS

In all fertilizer studies carried out the Colombian variety CICA-8 was the test variety. This rice variety was chosen because it was identified from earlier studies carried out by the Japanese-Jamaica Government Rice Mission at Elim to be the best variety tested. The U.S. varieties Labelle, Lebonnet, Starbonnet, and Bellevue together with CICA-8 were tested in the variety x fertilizer trial.

For the fertilizer trials two experimental designs were utilized:

(i) 3 x 3 x 3 x 4 (N x P x K x Mixture of Fe, Zn and Mn) factorial set out in randomized complete blocks.

(ii) 3 x 3 x 3 (N x P x K) factorial with partial confounding of the NPK interaction in an incomplete block design.

On the mineral soils area the levels of the fertilizer nutrients tested were:

-- nitrogen at 0,56 and 112 kg/ha (0, 50, and 100 lb/acre) in both types of studies;

-- micronutrient mixture of chelated manganese, chelated iron, and chelated zinc, at 0, 0.125 kg/ha 0.250 kg/ha and 0.375 kg/ha of each micronutrient. (0, 0.111, 0.222, and 0.333 lb/acre of each micronutrient)

On the Morass Peat the levels of fertilizer nutrients tested were:

-- nitrogen at 0, 11.2, and 22.4 kg/ha (0, 10, and 20 lbs/acre)

-- phosphate at 0, 28, and 56 kg/ha (0, 25 and 50 lbs/acre)

-- potash at 0, 30, and 60 kg/ha (0, 26.8, and 53.6 lbs/acre)

-- copper at 0, 2.24, 4.48, and 6.72 kg/ha (0, 2, 4, and 6 lbs/acre)

Details of the splitting and timing of the fertilizer applications are given in the third quarterly report.

4. RESULTS AND DISCUSSION

Experiment R5/1/81

The results of the 3 x 3 x 3 x 4 (N x P x K x Cu) in a randomized complete block experiment on Morass Peat are summarized below. This experiment was severely damaged by Blast disease. Only five treatments listed in Table 1 produced mean yields of at least 2 tonnes/hectare, of the 108 fertilizer treatments tested.

Table 1. Mean yields of the five highest yielding fertilizer treatments in the 3 x 3 x 3 x 4 (N x P x K x Cu) factorial in RCB on Morass Peat.

TREATMENT	TONNES/HA	SHORT TONS/ACRE	GROUPING
$N_2P_1K_0Cu_2$	4.20	1.87	a
$N_2P_2K_2Cu_1$	3.15	1.41	ab
$N_1P_2K_0Cu_0$	2.77	1.24	ab
$N_2P_0K_1Cu_2$	2.30	1.03	b
$N_0P_1K_0Cu_1$	2.04	0.91	b

Standard error of a treatment mean = 0.5987 tonne/ha

*Statistical grouping determined by Duncan's Multiple Range Test.

All other treatment combinations tested produced yields less than 2.04 tonnes/hectare (0.91 short tons/acre). The treatment $N_2P_1K_0Cu_1$ was not significantly different from treatments $N_2P_1K_2Cu_1$ and $N_1P_2K_0Cu_0$ but was significantly better than all other treatments. Treatment $N_2P_1K_0Cu_2$ received the application of:-

-- 22.4 kg nitrogen per hectare (20 lbs N/acre) at panicle initiation stage;
-- 28 kg phosphate per hectare (25 lbs P_2O_5/acre) before sowing;
-- no potash;
-- 4.48 kg Copper per hectare (4 lbs Cu/acre) at 91 days after sowing.

The N'K'Cu''' interaction with a value of 0.276± 0.077 tonne/ha was found to be significant at the 1% level of probability. No other interaction or main effect (of N,P,K or Cu) was significant.

Three of the five best treatments whose mean yields are presented in Table 1 are components of the N'K'Cu''' interaction -- $n_2p_1k_0cu_2$ and $n_2p_2k_2cu_1$ are positive components, while $n_0p_1k_0cu_1$ is negative.

Because the results were obtained under considerable Blast disease stress it is likely that they are not relevant to situations where Blast disease is absent or at a low level of incidence. However, it is unlikely that such disease free conditions will occur on the Morass Peat since the indications from small observation plots of three Guyanese rice varieties (Varieties "N", Rustic, and Champion) and two Colombian varieties (CICA-9 and CICA-8) sown at the end of January 1982 are that Helminthosporium (Cochliobolus) will be the other major disease in rice on the Morass Peat. No symptoms of Blast disease were found in any of the varieties sown at the end of January 1982, but CICA-8 and CICA-9 were moderately infected by Helminthosporium with approximately 20% of the leaf area damaged.

The major pest of rice observed on the Morass Peat is a small grasshopper (identification in progress) which damages the rice crop at the heading stage by chewing through the hulls (lemma and palea) and consuming the anthers thus causing a high incidence of spikelet infertility since pollination and fertilization do not occur after such type of damage. Control of this grasshopper is obtained by spraying with diazinon (Basudin) at the rate of 1.4 litres product per hectare (1 pint product per acre) in 73-91 litres of water per hectare (16-20 gallons water per acre), or by using carbaryl (Sevin 85% WP) at the rate of 1.12 - 1.14 kg product per hectare (1-25 lbs product per acre) in similar volumes of water to those stated above. Two sprayings are necessary, the first application at initial heading and the second at 7 - 10 days later. These sprayings will also simultaneously control the stink bug (paddy bug) - a pentatomid bug which has been observed at a low level of infestation. This bug damages the grain by sucking during the period from the "milk stage" to the "early dough stage". During the sucking process the bugs introduce microflora on their stylets into the developing grain.

The microflora subsequently may cause discolouration of the grain that is noticeable even when the paddy is processed as white rice as is done at the BRUMDEC mill. Generally, paddy-bug-damaged grains produce higher percentages of broken rice during the milling process than undamaged grains for samples that are similar with respect to other factors.

5. APPRAISAL OF CICA-8

In the experiments carried out on the mineral and Morass Peat soils the following observations were made concerning the agronomic behaviour of the variety CICA-8:-

(i) This variety cannot tolerate continuous submergence during establishment of the crop after sowing. Consequently, plots must be thoroughly drained either before sowing or within one day after sowing. This non-tolerance of the variety to submergence not exceeding 7.5cm (3 inches) depth during the crop establishment period immediately following sowing necessitates a water-management system entailing regular flushing of the plots during the period up to three weeks after sowing. This intermittent flushing to provide moisture to the developing rice plants without flooding is most favourable for the growth and development of weeds.

(ii) The variety CICA-8 was found to be very succeptible to Helminthosporium oryzae (Cochliobolus miyabeanus) on both the mineral and Morass Peat soils.

On the mineral soils only a few small lesions of Blast disease (Pyricularia oryzae) were found on this variety, but on the Morass Peat in the October sown crop the variety was very succeptible to Blast disease.

(iii) Lodging of up to 100% was observed on the mineral soil with this variety. The situations in which the crop was severely lodged suggests that the predisposing factor was the depth of flooding. The crop lodged more readily where depth of flooding exceeded 10 cm (4 inches). High nitrogen availability to the

plant does not appear to be as important a factor as depth of flooding in predisposing the plant to lodging. Only a very low incidence of lodging occurred in the first experiment carried out on the Morass Peat in which 144 of the 216 plots received nitrogen applications at panicle initiation stage. In that experiment, which was pump-irrigated, it was not possible to maintain a continuous flood for more than one day due to the high percolation and seepage rates.

(iv) When the plants of CICA-8 were infected by Helminthosporium oryzae it was observed that the bulk of the infection invariably occurred during the period from after heading through to maturity.

(v) The variety CICA-8 appears to be weakly photoperiod-sensitive, requiring almost 3 weeks longer to reach maturity when sown in March - April as compared to September - October sowing. This reaction to photoperiod will necessitate a change in the absolute timing of the nitrogen fertilizer top-dressing since the panicle initiation stage will be reached approximately 3 weeks later (at about 84 days after sowing) when this variety is sown in March - April.
It seems likely that the rice crop of CICA-8 sown in March - April will require a slightly higher rate of nitrogen fertilizer application initially than is at present used, in order that a higher degree of expression of tillering potential can be achieved during the extended vegetative period of the March - April sown crop. Initially, 157 kg sulphate of ammonia per hectare (140 lbs sulphate of ammonia per acre) should be applied to the March - April crop of CICA-8 during the period from just before sowing to 3 weeks after sowing.

(vi) CICA-8 is more suitable for cultivation on the

mineral soils of the project area than on the Morass Peat. On the latter type of soil the high susceptibility of this variety to Blast disease and to Helminthosporium results in unstable levels of yield.

6. SUPPLEMENTARY RESULTS OF EXPERIMENT P2/1/81

The results of the analyses of soil and plant samples were received from the Ministry of Agriculture on 5th and 8th March, 1982 (soil sample analyses) and on 14th April, 1982 (plant samples analyses).

The range of values observed for plant nutrients which were not variables in the experiment are given in Table 2. Throughout the range of values observed for the different nutrients no deficiency symptoms were noticed.
From the data obtained on soil and plant analyses, correlation analyses were carried out for selected pairs of characteristics. The correlation coefficients obtained are presented in Table 3.

Significant correlation coefficients were obtained for

(i) % nitrogen in the plant at 63 days after sowing (over all levels of nitrogen fertilization) and grain yield ($r=0.336^{*}$).

(ii) % nitrogen in the plant at 63 days after sowing, at the 112 kg.N per hectare (100 lbs N per acre) level of fertilization, and grain yield ($r=0.654^{*}$).

(iii) % nitrogen in the soil at 63 days after sowing and % nitrogen in the plant at 63 days after sowing ($r=0.351^{*}$).

None of the other pairs of characters examined showed significant correlation coefficients.

Table 2. Range of values observed for some plant nutrients in soil and plant samples. Soil type: Cashew Clay. Rice variety: CICA-8.

Type of sample	Time of sampling (DAS)*	Range and (mean) of values observed									
		M.eq/100g soil			P.p.m. in soil or plant					% in plant	
		Ca	Mg	Na	Zn	Mn	Cu	Fe	Mo	Mg	Ca
Soil	21 DAS	39.5-60.25 (45.71)	3.71-5.00 (4.30)	0.44-0.94 (0.56)	5.0-14.0 (8.2)	64.0-135.0 (103.1)	8.72-14.[illegible] (10.[illegible]1)	145.0-517.5 (335.7)	-	-	-
Soil	63 DAS	20.75-56.5 (42.98)	2.84-4.92 (3.99)	0.07-0.40 (0.23)	4.3-16.8 (8.4)	74.0-201.0 (106.8)	6.0-19.6 (12.4)	72.5-900.0 (381.6)	-	-	-
Plant	21 DAS	-	-	-	-	-	-	-	633.3-3333.3 (1233.7)	0.19-0.47 (0.31)	0.52-1.75 (0.80)
Plant	42 DAS	-	-	-	17.8-52.4 (31.9)	22.5-239.5 (136.3)	2.0-9.0 (3.9)	19.5-3937.5 (959.6)	500-2150 (974.8)	0.15-0.40 (0.23)	0.42-1.01 (0.69)
Plant	63 DAS	-	-	-	14.4-59.3 (27.2)	53.0-405.0 (120.5)	1.0-7.8 (2.7)	100-1015 (502.4)	275-1166.6 (571.5)	-	0.30-0.95 (0.57)

*DAS= Days after sowing.

Table 3. Correlation coefficients for selected pairs of characters: Experiment P2/1/81. Rice variety: CICA-8. Soil type: Cashew Clay.

Characters	%N in plant at 63 DAS	%P in plant at 63 DAS	%K in plant at 63 DAS	Grain yield (T/ha)
%N in soil at 63 DAS	0.351*	-	-	-
%P in plant at 63 DAS	-0.152	-	-	0.100
%N in plant at 63 DAS over all levels of N fertilization	-	-	-	0.336*
%N in plant at 42 DAS	-	-	-	0.095
%N in plant (at N_0 level of fertilization) at 63 DAS	-	-	-	0.255
%N in plant (at N_1 level of fertilization) at 63 DAS	-	-	-	0.301
%N in plant (at N_2 level of fertilization) at 63 DAS	-	-	-	0.654*
P_2O_5 ppm available in soil at 63 DAS	-	-0.027	-	0.100
K_2O ppm available in soil at 63 DAS	-	-	-0.055	-
%K in plant at 63 DAS	-	-	-	-0.146
%P in plant at 42 DAS	-	-	-	0.152
%K in plant at 42 DAS	-	-	-	-0.226

DAS= Days after sowing.

The mean level of %N in the plants at 63 DAS, at the N_2 level (112 kg N/ha = 100 lbs N/ac), over all levels of phosphate and potash was 1.96%, and the mean grain yield at the N_2 level was 3.39 tonnes per hectare (t/ha) equivalent to 1.51 short tons per acre (t/ac).

Values of %N in plants at 63 DAS at the N_2 level which were greater than the mean, i.e. greater than 1.96%, showed an average value of 2.35%N, and those plots which showed above-average %N also as a group showed above-average yield of 4.24 t/ha (1.89 t/ac).

At 42 DAS the mean %N in the plants from these plots was 2.03%. Values of %N in the plants at 63 DAS at the N_2 level which were equal to or less than the mean, i.e. equal to or less than 1.96%, showed an average value of 1.76%N, and those plots which showed below-average %N also as a group showed below-average yield of 2.96 t/ha (1.32 t/ac). At 42 DAS the mean %N in plants from these plots was 1.69%.

These results indicate that the plots which on average showed plant N-content of approximately 2.4% were more efficient in utilizing the nitrogen fertilizer applied at panicle initiation stage and at heading for the production of grain.

It is indicated that in the production fields we should try to achieve an average plant nitrogen content of at least 2.4% at the panicle initiation stage. The nitrogen content of rice plants should be monitored at 42 DAS . The critical value of %N at this stage is indicated to be 2.1%N, so that by the time panicle initiation stage is reached (at 63 DAS in the August - October sown crop of CICA-8, and at 31 DAS in the March - April sown crop of CICA-8) some corrective measures can be taken. This study did not investigate the effect of N-application at 42 -63 DAS and we would have to use an arbitrary level of N-fertilizer to correct any observed deficiency, until this aspect can be studied.

Comparison of N_1 and N_2 mean values of N-content of plants at 63 DAS indicates that 45 kg sulphate of ammonia/ha (40 lbs/ac) increased the N-content of rice plants by 0.1% in absolute terms.

This fertilizer , however, was applied at 21 DAS, i.e. 6 weeks prior to sampling of plants for analyses. It is expected that rice plants at 42 - 63 DAS will utilize nitrogen top-dressings with greater efficiency.

7. SEMI-COMMERCIAL RICE PRODUCTION

In October 1981, at the end of the meeting of the BPMTFC Board of Directors held at Tlim, the Rice Production Specialist was invited to address the members of the Board on the alternatives for development of the mineral soils block comprised of Fields 1 - 9.

Two alternative methods of developing the area to make it more suitable for rice cultivation were outlined:

1. To subdivide each field into 1.6 - 2 hectares(4 - 5 acres) rectangular sections and to level within each section.
2. To remove the intervals between fields, refill with soil, and to contour-level the entire area giving 2/10ths foot difference between levees.

Concerning the second alternative, the experience of the sugar-cane growers in removing intervals and refilling had shown that the refilled interval strips are difficult to traverse with field machinery when the land is wet. This point was emphasized by my counterpart, Mr.Derrick Smith, in discussions prior to the meeting. Consequently, the second alternative would have a serious disadvantage.

With either of the alternatives the tillage methods recommended depending on weather conditions were:

1. Ploughing + 2 harrowings + flooding, puddling, and final levelling under flooded conditions; or
2. Harrowing wet land, flooding, puddling, and final levelling under flooded conditions.

Equipment for accomplishing under-water levelling had been indicated in the initial review.(1)

In the semi-commercial plantings which began in March 1982 the system of cultivation was modified according to the type of equipment available for land preparation. The equipment available could be used to work the fields only in the dry state. Dry-tilled fields were subdivided by contour-levees set out at approximately 7.5 cm (3 in.) difference in levels.

The contour-levees were drawn up using a row-crop ridger. The small size of the levees resulted in seepage from higher to lower sections and effective water control and subsequently weed control within the sections could not be achieved. Up to the end of the period under report the planting of semi-commercial fields was in progress.

8. RECOMMENDATIONS FOR SEMI-COMMERCIAL RICE PRODUCTION ON THE MINERAL SOIL AREA (FIELDS 1 - 9)

8.1 Development and Land Preparation

The idea of subdividing a field into 1.6 - 2 hectares (4 - 5 acres) rectangular sections, levelling within each section after ploughing, harrowing, followed by flooding, puddling, and a final levelling under flooded conditions should be tried.

The use of contour-levees to subdivide the field as was done in the March - April 1981 crop should continue provided that:

- -- larger levees which can be compacted during the levee-building process can be built;
- -- additional levelling be done within each contour-levee section using a rear-mounted blade similar to that built for the Kubota tractor but of width 3.05m (10 ft.). This levelling can be carried out under dry or flooded conditions depending on the tillage operations used in preparing the seedbed.

It is necessary that the technical and professional agricultural staff of BRIMEC should get the experience of successfully cultivating the rice crop using each of the following systems for preparing the seedbed:

- -- Dry tillage to a fine tilth followed by dry final levelling, flooding, draining, and sowing.
- -- Dry tillage to a semi-fine tilth of 7.5 - 10 cm (3-4 in.) aggregates followed by flooding, puddling, final levelling under flooded conditions , then draining and sowing.
- -- Wet tillage only to bring the field to a puddled state followed by final levelling under flooded conditions, then draining and sowing.

When suitable new rice varieties which can also tolerate submergence at sowing in 7.5 - 10 cm. (3 - 4 in.) flood are identified, complete draining of prepared fields will no longer be necessary to establish the rice crop. These three general systems of seedbed preparation take into account variable weather conditions during the land preparation period, and one can change from dry to wet tillage methods to overcome the effects of unseasonal rainfall during this period.

8.2 Fertilizer Usage

Further work needs to be done to determine the appropriate combination of rates of nitrogen and phosphate for fertilizing the rice crop in each of the main sowing seasons : March - April and November - December. There is a clear indication , however, that when potash is used in combination with nitrogen and phosphate, yield reductions are likely to occur. The levels of nitrogen and phosphate determined from the work of the Japanese Team of Rice Experts should continue in use on the semi-commercial production fields but with no usage of potash. The semi-commercial production fields should thus be fertilized at the rate of 64.4 kg.N/ha (57.5 lbs.N/ac) + 28.8 kg.P_2O_5/ha (25.7 lbs P_2O_5/ac).
These levels of N and P_2O_5 compare with 56 kg.N/ha and 28 kgP_2O_5/ha (50 lbs.N/ac and 25 lbs.P_2O_5/ac) identified as one of the eight best treatments which gave statistically similar yields.

All of the phosphate fertilizer should be drilled into the soil or broadcast and incorporated. Drilling will provide for greater availability since less immobilization will occur. It will be practical to drill the phosphate when dry tillage is used to prepare the seedbed. For other systems of seedbed preparation which involve puddling, phosphate should be applied before seedbed preparation is completed so that the fertilizer can be incorporated.

Micronutrient usage centres around the correction of zinc deficiency. The zinc content of samples of soil taken from each quarter-section of each of the fields numbered 1 through 9 ranged from 3 - 10 ppm. The pH of those samples ranged from 6.05 - 7.90.
The first observed case of zinc deficiency occurred on a site

which showed a mean pH of 7.48 (range 7.4 - 7.6) and a mean zinc content of 5.25 (range 3 - 7) ppm.
A liquid formulation of a zinc chelate having an effective factor of 10:1 when used at the rate of 0.34 kg.Zn/ha (0.3 lb.Zn/ac) was found to correct the deficiency.

It is necessary that the zinc content of the soil in fields 1 - 9 be monitored after each crop in order to assess whether or not zinc fertilization will be needed.

At the International Rice Research Institute[5], the study of more than 300 Philippine soils indicated that zinc deficiency is associated with one or more of these characteristics:

-- pH greater than 6.8
-- organic carbon greater than 3.0%
-- available zinc less than 1.0 ppm
-- water-soluble silicon greater than 100 ppm
-- magnesium to calcium ratio greater than 1.0
-- total chromium greater than 0.1%

Vitosh, Warncke and Lucas[6] have given guidelines for zinc application on mineral and organic soils which take into account the relationship whereby as pH of the soil rises above 6.7, higher levels of zinc need to be present in the soil to prevent a deficiency of this element from occurring.

The mean pH of the soils in the semi-commercial block (Fields 1-9) estimated from the analyses of 40 samples of soil was found to be pH 7.16. Ten of those samples showed a pH of 7.5 or greater, and 11 samples had pH values in the range 7.0 - 7.4.
Vitosh et al[6] indicate that at pH levels of 7.5 or greater it is probable that a response to zinc fertilization will be obtained when the soil test shows 5 - 10 ppm zinc, and that it is possible that a response will be obtained when the soil test shows 11 - 15 ppm zinc. Consequently, because water-soluble zinc concentration decreases when the soil is flooded in spite of the decrease in pH resulting from CO_2 accumulation[7], and also because it is not possible to delineate those areas in the semi-commercial block

where zinc amelioration is likely not to be needed due to the unevenness and patchiness of the condition, it is recommended that each entire field be treated with zinc.
If zinc sulphate is used the rate should be 3.4 kg.Zn/ha (3 lbs Zn/ac). If a liquid zinc chelate formulation with an effective factor of 10:1 is used , the rate should be 0.34 kg. Zn/ha (0.3 lb Zn/ac). Or, if a powdered zinc chelate formulation is used with an effective factor of 4:1, then the rate should be 0.35 kg. Zn/ha (0.75 lb Zn/ac).

Material cost for these two types of zinc chelates are as follows:

-- Liquid zinc chelate (7%Zn) at the rate of 4.7 litres/ha (0.5 US gallon/ac). The material is sold in 5 US gallon containers at US$36.00/5 US gallon. Material cost /acre will be J$6.44 .

-- Powdered zinc chelate (14.2%Zn) at the rate of 6.0 kg/ha (5.3 lbs/ac). The material is sold at J$5.25/lb locally. Material cost per acre will be J$27.83 .

It is recommended that the liquid zinc chelate formulation be used since even when the application cost is added its use will have a cost advantage over the powdered formulation even when that is admixed with basal phosphate fertilizer and applied at no extra cost.

3.3 Plant Protection

3.3.1. Weed control

For controlling weeds in the semi-commercial fields, well-levelled land and effective water-control within levied sections are basic requirments. Under such conditions the use of 11.2 litres propanil + 0.7 - 1.4 litres 2,4-D per hectare (1 gln. propanil + 0.5 - 1.0 pt. 2,4-D/ac) is recommended to be used when weeds are at the 1 - 3-leaf stage. Wet tillage during the final stages of land preparation combined with appropriate wet-levelling also contribute to weed control.

8.3.2. Armyworm control

To control armyworm the field should be flooded to temporarily submerge the rice plants, or the field should be sprayed with trichlorfon (Dipterex) at the rate of 0.84 - 1.12 kg. product per hectare (0.75 - 1.0 lb/ac).

8.3.3. Grasshopper control

On the mineral soil area grasshopper damage to the rice crop was observed to be the shredding of the leaf from the tip and extending towards the leaf base for a distance of approximately 9 cm. (3.5 in.), in contrast to the damage which occurs on the peat where the particles are attacked. Recommended control measures are diazinon (Basudin) at 1.4 litres product/hectare (1 pint/ac), or carbaryl (Sevin) at 1,12 - 1.4 kg product/hectare (1.0 - 1.25 lbs/ac).

8.3.4. Stink Bug control

The rates of diazinon or carbaryl recommended for stink bug control are the same as those recommended for the control of grasshoppers. Monitoring "sweeps" using an insect net should be carried out at first heading and should continue in each headed field on a daily basis.
These "sweeps" should be made early in the morning or late in the afternoon when stink bugs if they are present will be more frequent on the upper portion of the plants.
Spraying should commence when the rate of catch is at least 1 stink bug/3 sweeps. Depending on the infestation level a second spraying may have to be given 10 - 12 days after the first. For all three of the pests mentioned cultural practices such as weeding of levees and roadsides will help to reduce the level of infestation in the rice crop.

8.3.5. Disease control

On the mineral soil area the main rice disease observed was Brown Leaf Spot (Helminthosporium oryzae). In each season the disease occurred on CICA-9 and CICA-8 when seed-set had already occurred. It did not appear to cause

any noticeable reduction in yield, in contrast to its effect on CICA-8 in the peat area. If the attack by this disease should occur earlier, e.g. just before or at heading, it is recommended that CICA-8 crops be sprayed with 1.68 kg Dithane M-45/hectare (1.5 lbs/acre). Dithane can be mixed with the grasshopper/stink bug control spray.
On the mineral soil area Blast disease is not of economic importance in the CICA-8 crop.

3.4 Application Methods for Seeding, Fertilizing, and Plant Protection

The benefits of using agricultural aircraft for seeding and for the application of fertilizer and plant protection chemicals in the semi-commercial cultivation need to be evaluated. This method of application produces a uniform distribution of material and will also enable the manager to carry out critical operations (weed control, fertilization, and pest control) at the appropriate time.

9. RECOMMENDATIONS FOR FUTURE APPLIED RESEARCH

9.1. Mineral Soil Area

The following aspects will require attention:

(i) Variety trials to identify which of the varieties known to be tolerant to zinc deficiency are suitably adapted to the BRIMDEC environment.

(ii) Herbicide trials to identify those herbicides which are effective against the wide range of grass weeds present in the area.

(iii) Fertilizer trials to follow up the indication that there is no need to apply potash when nitrogen and phosphate are used in combination to fertilize the rice crop in this area. Fertilizer trials to follow up the indication that when nitrogen fertilizer level is high (112 kg N/ha = 100 lbs N/ac), phosphate fertilizer level should be moderate (28 kg P_2O_5/ha = 25 lbs P_2O_5/ac), and when nitrogen level is moderate (56 kg N/ha = 50 lbs N/ac), phosphate level should be high (56 kg P_2O_5/ha = 50 lbs P_2O_5/ac).

(iv) Soil amelioration on areas from which a large amount of top-soil is removed in the process of land development.

(v) Monitoring of the zinc status in fields of the semi-commercial block and other areas identified for rice cultivation. Simultaneous monitoring of pH.

(vi) Quantification of the relationship between fertilizer -N applied after 42 DAS and the increase in %N in the plant, to be used as a guide for top-dressing to correct cases of low %N in the plant.

(vii) Comparison of different tillage/water management system combinations.

(viii) Pesticide trials to identify other pesticides that are at least as effective as diazinon and similar or lower in cost per acre.

(ix) Seed production

9.2. Morass Peat Area

The following aspects will require attention:

(i) Variety trials to identify at least one variety that is better adapted to the Morass Peat environment than CICA-8.

(ii) Fertilizer and herbicide trials on the peat using better adapted varieties.

(iii) Evaluating different methods of establishing the rice crop on the peat soils.

(iv) Investigation of rice/other crops farming system on the peat soils.

9.3. Rice Quality and Milling Tests

(i) In the variety testing work adequate attention should be given to varieties which have acceptable milled rice appearance and acceptable cooking characteristics.

(ii) Assessment of the milling recovery of promising varieties in terms of %head rice, %brokens, and total recovery. This should be done before any extensive cultivation is attempted.

9.4. Training

The training of professional staff at the International Institutes or University Research Stations where work on rice is carried out should be an essential component of the research programme. There are several centres from which to choose.

For rice research and rice production training the centres recommended are:

-- the International Rice Research Institute in the Philippines;
-- the International Center for Tropical Agriculture in Colombia;
-- the International Institute for Tropical Agriculture in Nigeria;
-- the Agricultural Experiment Station of Louisiana State University at Crowley, Louisiana;
-- the Agricultural Experiment Station at Stuttgart, Arkansas;
-- the Agricultural Experiment Station at Beaumont, Texas.

For training in seed technology the centre recommended is:

-- the Seed Technology Laboratory of Mississippi State University.

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