CIAT is a nonprofit organization devoted to the agricultural and economic development of the lowland tropics. The Government of Colombia provides support as host country for CIAT and furnishes a 522-hectare farm near Cali for CIAT's headquarters. Collaborative work with the Instituto Colombiano Agropecuario (ICA) is carried out mainly at its Experimental Centers at Turipaná and Carimagua. CIAT is financed by a number of donors represented in the Consultative Group for International Agricultural Research. During the current year these donors are the United States Agency for International Development (USAID), the Rockefeller Foundation, the Ford Foundation, the W.K. Kellogg Foundation, the Canadian International Development Agency (CIDA), the International Bank for Reconstruction and Development (IBRD) through the International Development Association (IDA), the Interamerican Development Bank (IBD), the United Nations Environment Programme, the Ministry of Overseas Development of the United Kingdom and the governments of Australia, Belgium, the Federal Republic of Germany, the Netherlands and Switzerland. In addition, special project funds are supplied by various of the aforementioned entities plus the International Development Research Centre (IDRC) of Canada. Information and conclusions reported herein do not necessarily reflect the position of any of the aforementioned agencies, foundations or governments.

Rice production systems

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Cables CINATROP

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* Left during 1975
** Assignment divided between two programs.

CONTENTS

Rice production systems

HIGHLIGHTS IN 1975

Extensive testing of 14 promising rice lines was completed and six were selected for further evaluation, purification and multiplication. It is expected that one or two of the most promising lines will be named and released as varieties in 1976.

Breeding to develop a large quantity of germplasm with resistance to the rice blast disease has progressed along two approaches. One approach attempts to combine multiple sources of resistance into new varieties. A total of 587 multiple crosses were produced and from these, resistant plants were selected and transplanted in the field to provide an enormous source of resistance. In the second approach, a modified, multiline procedure is being employed to combine blast resistance with favorable agronomic characteristics.

Progress has been made in the chemical control of weeds and volunteer and red rice. The problem is especially difficult as selective herbicides are not effective against the volunteer rice as a weed. Combinations of herbicides were tested and some effectively controlled pest plants while not harming the later seeded rice.

Knotgrass, another important weed in rice, propagates both by seed and stolons and a two-stage program is necessary to achieve proper control. Stolons must be eliminated before planting the crop, then standard herbicides for controlling germinating grass seeds can be used.

An irrigation pump was developed which combines low production and operating costs with a simple method of installation in a concrete culvert. The pump is powered from the PTO of a tractor. Final design plans will be released in 1976.

Theoretical work was done to improve machine mobility in soft fields and the results successfully applied at the Palmira station. When lugs are removed from large tires and the tires inflated to a low pressure the increased deflection and surface contact area provides improved traction and superior mobility.

Various CIAT units have cooperated to develop a continuous rice production system for the Palmira station. The system will facilitate research and training functions by providing fields at various stages of rice production throughout the year.

ECONOMICS

Economics research in the Rice Program has been directed to documenting and analyzing the impact of new rice varieties in Latin America. The study is composed of two major parts: (a) a general review of rice areas, yields, production and trade in Latin America and the Caribbean, with emphasis on measuring the contribution to output of the new high-yielding varieties (HYV's); and (b) a detailed analysis of the economic benefits from the new varieties in Colombia with attention to the distribution of the benefits.

The first part of the study involves a survey of all major rice producing countries in the region, to obtain the data for estimating the contribution of the new varieties to production. This survey, now being conducted in collaboration with national and international agencies, will provide data to up-date the information provided in the 1972 Annual Report.

Table 1 has been constructed from preliminary survey data. The results are shown by region in Latin America. Brazil has been excluded from the analysis. While she produces about one-half of Latin America's rice, the majority comes from the upland sector, where yields are very low. Inclusion of Brazil would mask the impact of the HYV's in other regions. For Latin America (excluding Brazil), the preliminary estimate is that rice production was 40 percent higher in 1974 than it would have been in the absence of HYV's. This figure could be overstated due to some confounding with irrigation (especially in the data shown for South America), but conversely no allowance is made for the fact that some of the expansion in areas may not have taken place in the absence of HYV's.

It would be incorrect to attribute all increased production solely to the improved genetic potential of the HYV's. Expanded use of inputs, improved cultural practices and the roles of national and grower organizations are all important complementary inputs.

Rice production in Colombia has doubled since 1968, due entirely to expanded area and yields in the irrigated

Table 1 Estimated contribution of high yielding varieties (HYV's) of rice to total yields in regions of Latin America, 1974.

		Mexico and Caribbean	Central America	South America (excl Brazil)	Colombia (irrigated)	Latin America (excl. Brazil)
1 Total area	(1,000 ha)	452.0	257.1	1,088.0	273.0	1,797 0
2 Total production	(1,000 tons)	1,022.0	472.2	3,647.1	1,420 1	5,141.4
3. Yield	(tons/ha)	2.261	1.837	3.352	5.203	2.861
4. HYV's area	(1,000 ha)	200.4	157.9	386.6	279.2	744 9
5. Traditional area	(1,000 ha)	251 6	99 2	701 4	2 7	1,052.1
6. Traditional yield	(tons/ha)	1.779	1.284	2.399	3.100	2 040
7 Traditional production	(1,000 tons)	447.6	127.4	1,682.6	8.5	2,146.4
8. HYV's production	(1,000 tons)	574.4	344.9	1,964.5	1,411.7	2,995 0
9. HYV's yield	(tons/ha)	2 866	2.184	5.082	5.224	4.021
10. Yield margin	(tons/ha)	1.087	0.900	2.683	2.124	1.981
11. Additional production	(1,000 tons)	217.9	142.1	1 037.2	573 9	1,475.6
12. Additional production	(%)	27.1	43.0	39 7	67.8	40.3

Sources and derivations: (1), (2): U.S. Dept. of Agri. (4) CIAT, HYV's surveys, 1972 and 1974. (5): (1) - (4) (6): Average yield 1960-64 (7): (5) x (6) (8): (2) - (7). (10): (9) - (6). (11): (10) x (4).

$$(12): \frac{(11)}{(2) - (11)} \times 100$$

sector. The competitive position of the upland sector, where yields have been constant at 1.5 tons|ha, was reduced and the proportion of national output from the upland sector fell from 32 to 10 percent. Irrigated yields rose from about 3 tons|ha when Bluebonnet 50 was the major variety to almost 5.5 tons|ha with the new dwarf rices (1974 Annual Report). The sowings of dwarf rices rose from 5.5 percent of the irrigated area in 1969 to almost 100 percent in 1974. The estimated yields of Bluebonnet 50 and the HYV's at the farm level are shown in Table 2.

As a result of rapidly expanded production in Colombia, real prices received by producers in 1972 were almost half the 1965 level, recovering somewhat by 1974 (Table 2). This has meant that Colombian consumers have benefitted from the technological change.. Net incomes of producers (after meeting variable costs) would have been higher without the new varieties.

This pattern of the distribution of the benefits has resulted because the extra production was very largely sold on the domestic market, where the demand for rice is moderately inelastic. Rice exports have been indirectly discouraged because of the tariff policies favoring the manufacturing sector. With these tariffs, the exchange rate can be maintained at a level lower than would apply in their absence, thereby making exporting less attractive.

The retail price of rice in Colombia has not tended to cheapen as has farm price (Table 2). As a result, the rice marketing margin has risen very substantially. This margin is the difference between the retail price and the farm price expressed as a percentage of the farm price. Prior to 1968 it had been constant or falling. With greatly expanded production, the milling, transport and distribution activities had to handle almost twice the volume of rice between 1968 and 1973. However, preliminary analyses suggest that an increase in the margin from 115 percent (in 1968) to 218 percent (in 1973) was much greater than could be accounted for by rising costs in these activities. Thus, some benefits attributed to consumers may have

Table 2. **Yields and prices for Bluebonnet 50 and high yielding varieties (HYV's) of rice in Colombia, 1964-74.**

	Estimated yield, Bluebonnet 50 (tons|ha)	Estimated yield, HYV's (tons, ha)	Producer price, paddy ($Col|ton)*	Retail price, milled ($Col|ton)*	Marketing margin**
1964	3.09	3.25	1,347	3.480	158
1965	3.01	3.85	1,592	3,850	142
1966	3.02	-***	1,507	3,568	137
1967	3.29	5.84	1,418	3,259	130
1968	3.16	5.65	1,452	3,117	115
1969	3.04	5.51	1,217	2,877	136
1970	3.34	6.07	1,121	2,727	143
1971	3.42	6.29	1.044	2,735	162
1972	3.02	5.49	893	2,493	170
1973	2.94	5.37	978	3,113	218
1974	2.84	5.22	1,151	3,321	188

* Expressed in 1964 $(Col.)

** 100 (Retail Price - Producer Price)|Producer Price

*** Less than 2 percent of the area was sown to HYV's.

accrued as returns to factors in this sector. While not altering the total benefits from new rice varieties, this aspect has important distributional implications, and future work will examine the components of this increase.

BREEDING

Potential new varieties

In 1975, the CIAT Rice Program continued cooperation with the Instituto Colombiano Agropecuario (ICA) in developing, testing and multiplying promising lines for future varieties. Fourteen lines were tested at 21 locations with irrigation and at three locations without irrigation in major rice areas of Colombia. These regional trials were financed by the Federación Nacional de Arroceros (FEDEARROZ), conducted by personnel of FEDEARROZ and ICA, and evaluated by staff of those groups and CIAT.

Table 3 shows average yields for the 14 lines and the five commercial varieties in five major climatic and rice producing regions of Colombia. Nursery and field trials were also conducted in Guatemala, Panama and Costa Rica and information

Table 3. **Average rice yields (kg|ha)* of 14 lines and 5 varieties in 21 irrigated regional trials in Colombia (1975A).**

	Valle and Cauca(4)**	Tolima and Huila(6)	Atlantic Coast(4)	Northeast Zone(3)	Meta (4)	Average, all locations
Lines						
4403	6,337	8,914	6,676	6,853	5,307	7,029
4418	5,745	7,715	7,110	6,690	4,875	6,559
4419	7,736	8,000	6,461	5,613	4,886	6,805
4421	7,096	8,956	6,878	6,398	4,902	7,065
4422	7,884	9,221	6,326	6,573	4,509	7,128
4436	5,499	6,910	5,963	5,373	3,715	5,614
4438	7,216	6,625	5,981	6,250	4,437	5,681
4440	8,870	8,725	7,563	7,456	5,445	7,579
4444	7,459	8,451	7,020	6,983	4,943	6,981
4461	5,960	6,696	6,535	6,180	3,444	5,880
4462	5,874	7,290	7,201	7,166	4,525	6,475
4467	7,771	7,496	6,086	6,513	4,466	6,521
4468	8,515	8,095	7,266	8,270	4,876	7,372
4469	7,175	7,890	6,140	7,316	2,637	6,334
Commercial varieties						
CICA 6	5,725	7,296	6,183	6,070	2,827	5,835
CICA 4	6,496	7,091	6,711	6,173	3,298	6,088
IR 8	6,881	7,061	6,223	5,743	2,096	5,828
IR 22	5,710	6,218	6,315	5,290	3,068	5,481
Bluebonnet 50	4,222	4,254	4,698	4,446	2,586	4,107

* Yields are for dry paddy rice.

** Number of trial locations in each zone collected on resistance to rice blast disease caused by *Pyricularia oryzae*. Six lines were selected from the 14 based upon their yields and observations of blast resistance, lodging, **Sogatodes** reaction, growth cycle, plant height, shattering rate and milling and grain quality. Table 4 compares reactions to rice blast and the milling quality of the six lines with commercial varieties. After another season of regional trials, one or two of the lines will be named as varieties and basic seed will be released in 1976 for certified seed production. Figure 1 compares the quality and length of grains of the six promising lines.

Seed multiplication

Extensive purification and multiplication of the 14 advanced genetic lines were accomplished during 1975. Two-hundred-fifty panicle selections of each line were planted in seedbeds and material of each panicle was then transplanted into a single row to observe uniformity of plant type and yield. Eight lines were rejected because of undesirable plant characteristics or because of reported susceptibility to rice blast in the regional trials.

Because of the seriousness of the rice blast disease on commercial varieties, seed multiplication of the six remaining blast resistant lines was accelerated by pulling young plants, separating their tillers and retransplanting. Table 5 shows the pedigrees and amount of seed produced for these lines. The resistant lines 4440 and 4444 were segregating for grain type and will be repurified and multiplied again in 1976.

A new system of continuous rice production discussed later in this report will be used for multiplying seed as necessary.

Table 4. **Reaction to *Pyricularia oryzae* and grain quality characteristics of 6 lines and 5 varieties of rice (1975A).***

	P. oryzae		Grain characteristics	
	Leaf reaction	Damage to neck (%)	Milling index (%)	Milled grain length (mm)**
Lines				
4421	Resistant	5	61.0	7.2
4422	Resistant	8	59.4	7.2
4440	Resistant	2	49.8	7.2
4444	Resistant	3	50.3	7.6
4461	Resistant	3	56.7	7.8
4462	Resistant	3	48.4	7 6
Varieties				
CICA 4	Susceptible	22	70.7	6 8
CICA 6	Moderately susceptible	16	72.7	7 0
IR 8	Susceptible	23	27.6	6.5
IR 22	Susceptible	18	71.0	7.0
Bluebonnet 50	Moderately susceptible	13	63.0	7.0

* Average of 21 regional trials in Colombia

** Whole white rice and 3|4 of normal size.

Figure 1. Comparison of lengths and physical appearances of seed of six advanced rice lines at CIAT.

Table 5 **Parentages of advanced lines of rice purified and multiplied by CIAT (1975).**

Line	Cross	Pedigree	Seed produced (kg)
4421	IR665-23-3-1 x F1 (IR841-63-5-104-1B x C46-15)	P901-22-11-2 6-1-1B	1,300
4422	IR665-23-3-1 x F1 (IR841-63-5-104-1B x C46-15)	P901-22-11-5 3-2-1B	1,333
4440	CICA 4 x F1 (IR665-23-2-1 x Tetep)	P918-25-1-4-2 3-1B	18
4444	CICA 4 x F1 (IR665-23-3-1 x Tetep)	P918-25-15-2 3-2-1B	360
4461	IR22 x F1 (IR930-147-8 x Col 1)	P881-19-22-12 1B-6-1B	420
4462	IR22 x F1 (IR930-147-8 x Col 1)	P881-19-22-12 1B-7-1B	1,000

Blast resistance

A small group of elite sources of blast resistance has been identified in the world collection of rice by the International Rice Research Institute (IRRI) and cooperating national programs. These sources have demonstrated broad resistance after several years of evaluation in many countries. The CIAT Rice Program has transferred resistance from four of these sources — Tetep, Dissi Hatif, C46-15 and Colombia 1 — into agronomically acceptable plant types. Breeder seed of superior resistant lines selected from these crosses was produced in 1975 for seed multiplication, regional testing and the release of new varieties in 1976. These new varieties carry resistance derived from only one parent. Experience indicates that single-source resistance breaks down after a few cycles of commercial plantings.

Two new approaches to blast breeding were initiated in 1975 to prolong resistance. The first method attempts to combine multiple sources of resistance in new varieties. To achieve this, ten blast-resistant, advanced lines were selected from yield trials. These lines carry different levels of resistance from Tetep, Dissi Hatif, C46-15 and Colombia 1. They were intercrossed to give 45 single crosses that were planted in March, 1975 only to produce the new crosses and not to be advanced to the field. A total of 587 multiple crosses were harvested in August, 1975.

The multiple crosses were produced by selectively combining the F_1 single crosses and crossing them with an additional line having the blast resistance of the variety Carreon, another source of broad resistance. Over 12,220 seeds were produced from these multiple crosses which recombine three or four distinct sources of resistance in each combination. Fifteen crossed seeds of each multiple cross were germinated, the seedlines exposed to blast disease, and the resistant ones transplanted in the field in October, 1975, providing an enormous source of resistance and other germplasm for selection.

The second approach to blast resistance breeding is a modified multiline procedure featuring two highly productive lines well-adapted in the Americas. The lines 4417 and 4421 were each crossed with a series of sources of broad resistance having good to excellent agronomic characters. F_1 combinations will be backcrossed in 1976 to lines 4417 and 4421 to recover their plant and grain types. Resistant selections from these backcrosses will be carried through the segregating generations while selecting for the phenotypes of the recurrent parents. By the F_7 generation a large number of phenotypically similar lines having distinct genes for resistance will be available for international evaluation. National programs can bulk seed of several similar lines carrying distinct resistance factors to produce their own multiline varieties.

International regional trials

The Rice Program has trained 68 rice technicians from 13 Latin American and Caribbean countries. Upon returning to their home countries, some of these persons continue to work closely with CIAT in evaluating genetic material developed at both IRRI and CIAT. Observations from these cooperative tests provide valuable information on the adaptation of certain genetic lines or varieties over a broad area and under many climatic and soil conditions. In recent years, CIAT has sent seed of promising lines and varieties to every rice-producing country in Latin America for evaluation. The rice agronomist has made annual visits to most of these national research sites to assist in evaluating the material, to assess the reliability of research results and to try to advise on ways of strengthening and improving the program.

In general, practically all the CIAT-IRRI lines are resistant to the races of blast in Central and Southern Brazil, Uruguay, Argentina, Paraguay and Bolivia. Lines and varieties that are susceptible to blast in Colombia are also usually susceptible in Guyana, Venezuela, Ecuador, Peru, and in Central American and Caribbean countries. Wherever the varieties are resistant and good cultural practices are used, the better dwarf plant, adapted material is yielding from one to two tons more per hectare than traditional local varieties.

AGRONOMY

Weed and volunteer rice control

Mechanical land preparation can destroy weeds and volunteer rice, however, this practice also brings up more weed seed to germinate later. Certain herbicides can control weeds during germination while others control established weeds. The objective is to select single herbicides or combinations which control weeds and which can also be applied in a manner to control volunteer and red rice. Control of the two rice weeds is urgently needed, especially in direct-seeded rice areas where two or more crops per year are possible. The dual control of weeds and volunteer or red rice rules out the use of selective herbicides.

Mechanical land preparation was compared to two applications of paraquat after rice and weeds had germinated. Three successive weed crops were killed by rotary tilling in dry soil in one treatment while paraquat was applied twice at ten-day intervals (0.5 kg|ha a.i. each time) in another treatment. Pregerminated seed was broadcast over the entire area. No additional weed control measures were made after seeding, however, had they been applied, it is possible that yields would not have differed. Results of these exploratory trials show that two applications of paraquat may be superior to dry land preparation. Much higher weed and volunteer rice infestations occurred in the rotary tilled plots due to bringing up weed seed from lower depths. Results with paraquat indicated that applying non-selective herbicides may effectively control weeds and volunteer rice before planting the main crop.

A series of experiments followed, one in which herbicides were applied to the soil before germination of weeds and volunteer rice, while in the second, herbicides were applied to the growing weeds and volunteer rice 18 to 25 days after germination.

Although some rice herbicides in the first experiment considerably reduced weed infestation, none was sufficiently effective in controlling volunteer rice germination. Only atrazine, a corn herbicide used as a check at 1 kg|ha active ingredient, effectively controlled germinating volunteer rice and weeds. In the second experiment, growing weeds and volunteer rice were best controlled by two applications of paraquat (0.5 kg|ha, each application) at 18 and 25 days after germination, although glyphosate at the same rates and times was almost as effective. A mixture of 4 kg|ha of MSMA + 1 kg|ha of 2,4-D also gave good control when applied 18 days after weeds and volunteer rice germinated.

Residual herbicide effects

Atrazine, which controlled volunteer rice, grasses and broadleaf weeds best, normally has a residual effect in the soil for several months. Preliminary tests in 1974 with different flooding periods indicated that flooding nullified the residual effect of atrazine and several other herbicides. Additional herbicide trials with atrazine, metribuzin, alachlor, 2,4-D, terbutryn and RH2512 were made in 1975. After flooding for 30 days the areas were drained and seeded with pregerminated rice. Figure 2 illustrates good control of volunteer rice and weeds with a mixture of alachlor and

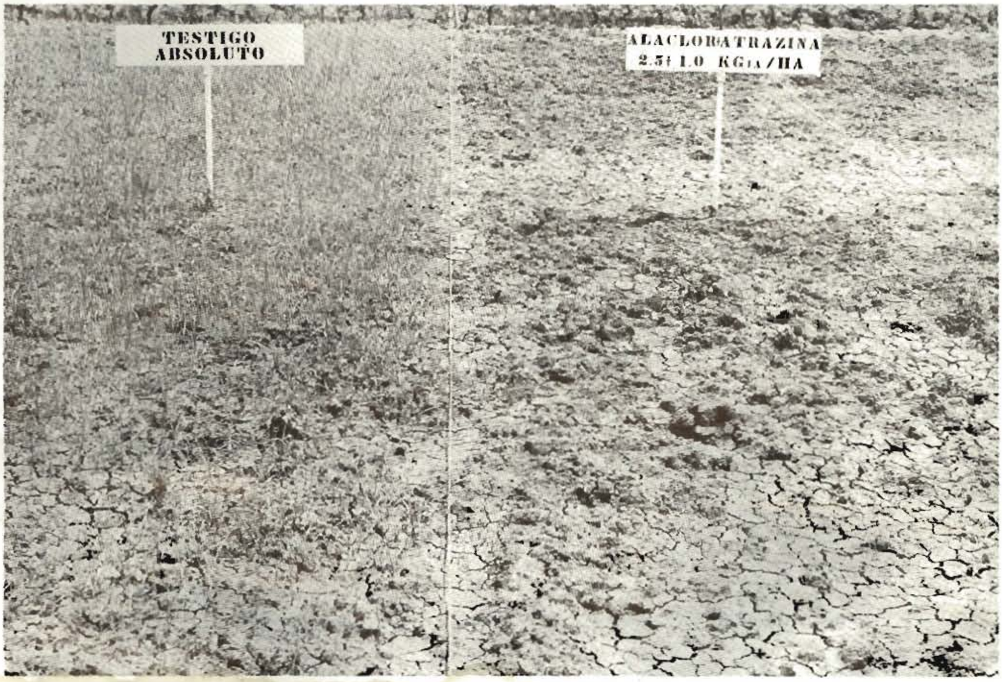

Figure 2. A combination of alachlor and atrazine effectively controls volunteer rice and weeds in rice paddies.

Figure 3. No residual effects from herbicides are evident if the paddy is flooded for 30 days before planting.

atrazine while Figure 3 shows no residual effect on growth of rice seeded after flooding for 30 days.

Three herbicides, atrazine, metribuzin and linuron, were applied at recommended, double, triple and|or quadruple rates. Volunteer rice and weed control and the residual effect on rice planted after one month of flooding were evaluated with the results shown in Table 6. Atrazine controlled volunteer rice and weeds best but also killed from 16 to 40 percent of the rice planted after 30 days of flooding. Metribuzin and linuron controlled both rice and weeds well and also had little or no residual effect on reseeded rice after the flooding period, although the 2.0 kg|ha rate of metribuzin did retard growth of a few of the rice plants. Further experiments are in progress to better define the herbicide, rate and time of flooding and other cultural practices before recommending residual herbicides to control volunteer rice and weeds.

The knotgrass problem

The grassy weed *Paspalum distichum* (knotgrass) is spreading rapidly in rice growing areas. It usually encroaches from the edge of the field and bunds by means of stolons but it also is a prolific seed producer. In the screenhouse, six herbicides were evaluated for control of knotgrass established by seed or stolons.

None of the herbicides tested was effective against stolons while several were excellent in killing germinating seeds. Propanil was most effective when applied at the 2-3 leaf stage since knotgrass hadn't completely emerged when the application was made at the single leaf stage. Oxadizon and butachlor also controlled germinating seeds well. No herbicide seriously injured the rice.

If knotgrass arises from stolons, no effective pre- or postemergence treatments can be recommended for use in rice. Stolons should be eliminated before planting rice by mechanical or chemical means, then germinating seeds may be controlled by standard herbicide applications for control of germinating grass seed and grasses in the 1-3 leaf stage.

The "hoja blanca" threat

"Hoja blanca" is an important disease occurring in cycles, the last epidemic being

Table 6. **Residual effects of three herbicides in the soil after flooding for one month before planting rice.**

	Application rate (kg|ha) a.i.)	Volunteer rice and weed control (%)	Rice damaged from residual effects (%)
atrazine	2.0	90	16.66*
atrazine	4.0	98	30.00*
atrazine	6.0	98	40.00*
metribuzin	0.5	80	0
metribuzin	1.0	85	0
metribuzin	2.0	90	6.66**
linuron	1.5	80	0
linuron	3.0	85	0
linuron	4.0	90	0

* Dead plants

** Retarded growth.

in 1957-64. The vector of the virus is the plant hopper, *Sogatodes oryzicola*, which can also destroy rice crops through direct feeding. CIAT's Rice Program has emphasized resistance to **Sogatodes** and all the newer varieties are resistant to this vector. Only CICA 4 is also resistant to the virus but field observations indicate that resistance to **Sogatodes** protects the variety from virus attack. No hoja blanca outbreak or **Sogatodes** damage has been confirmed through 1974, since the release of the new dwarf varieties.

Anticipating a possible new cycle of hoja blanca or the appearance of a new race of the insect vector, CIAT has requested cooperating national programs to report virus or insect damage in commercial dwarf varieties. Two reports of problems with the IR 8 variety in Colombia were investigated this year. In one instance a field was severely damaged by hoja blanca and **Sogatodes**. Insects were collected at both of the locations, multiplied at CIAT and evaluated on a set of varieties of known reaction to direct feeding injury. None of the insects collected were found to be from a new race.

In Peru a report of virus damage in IR 8 and local varieties was investigated and severe hoja blanca attack was confirmed although few insects were present. The affected fields were all transplanted crops. It is apparent that virus infection occurred in the seedbeds before transplanting, an early growth stage when no variety is resistant to the virus. An insecticide application in the seedbeds was recommended to control **Sogatodes**, and thus the virus, in future crops. No evidence suggests the presence of a new race of **Sogatodes** in Peru.

A report of heavy virus and insect damage in IR 8 and other varieties was also received from Cuba. A set of differental varieties was sent to Cuba to clarify varietal reactions. A reciprocal set of Cuban varieties was requested for evaluation at CIAT but has not yet been received.

ENGINEERING STUDIES

Water control

A 24-inch diameter, axial flow pump was completed, installed and tested during 1975. This pump, when driven at 540 rpm from the power takeoff of a tractor, delivered 55 to 63 cubic meters per minute against a variable head from 0 to 180 centimeters. The pump is designed for ease of local manufacture and low cost — both of the pump and its installation and operation. Design changes are being made before release of the designs in 1976. The most interesting feature is the simple mounting of the pump in a horizontal, concrete pipe culvert installed in a drain crossing under a road or protective levee.

Machine mobility

Since tractor mobility in saturated fields in an important factor in rice production for enabling efficient water leveling, wetland preparation and transport of harvested grain from fields, the agricultural engineer worked on this problem while on study leave at Louisiana State University. Prediction equations were developed for torque, traction, rolling resistance, and sinkage of pneumatic tires in soft clay soils. These equations combine the variables of tire width, diameter, deflection, weight on tire and soil cone index values. Figure 4 illustrates the relationship between measured pull and predicted pull. In a practical application of the theory at CIAT, worn-out lugs were removed from a used 23.1 x 26-inch rice and cane tire to permit the tire to fit within the limited space of a combine made for smaller tires. The smooth tires were inflated to about 3 psi or less allowing a large deflection on the soil surface. This deflection provided better mobility.

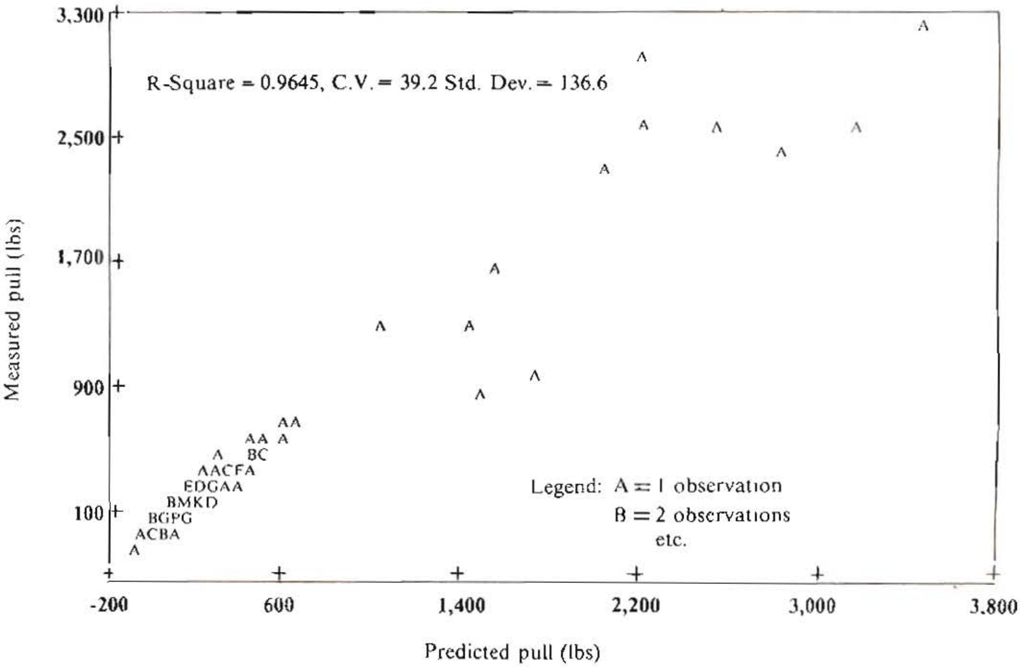

Figure 4. **Measured versus predicted net traction or pull for implement tires of various sizes.**

Figure 5. **A smooth tire inflated to a low pressure provides improved mobility for this combine in soft soils at CIAT.**

CONTINUOUS RICE PRODUCTION

CIAT's Experiment Station Operations unit and the Training and Conferences and Rice Programs have initiated a project to develop an intensive and continuous rice production system on the Palmira station. The objective is to modify and integrate the best of Asian technology to Latin American conditions and to fully utilize the land, labor, water, and other resources at all times.

Fields are prepared and puddled in water to achieve soil conditions typical of Asia, then pregerminated rice is broadcast seeded. Two to five hectares of rice have been planted each week since August, 1975. Prior to August a similar program existed but with only periodic plantings as time and conditions permitted. Although these occasional plantings were largely made to level and leach soils, and to improve irrigation and soil uniformity for later cropping, valuable experience, practical training and a cash crop were obtained. Good stable yields are possible during all seasons. Since 1972, almost 1,300 tons of rice have been produced with an average yield of 5.8 tons|ha.

TRAINING

This year four trainees — from Brazil, Paraguay, the Dominican Republic and Guatemala — were trained in the Rice Program, and 17 others in crop production training spent part of their time in rice production.

The continuous rice production scheme mentioned earlier will strengthen training for rice production specialists in the future by providing fields at all stages of production, at all times. The availability of rice at all growth stages will permit trainees to participate in all operations and see problems without waiting, as would be the case with only one planting per season. The training time can be condensed by moving the trainee through all phases of rice production, and at the same time, the trainee can return or progress to any phase where more concentration is necessary.

Combining seed production into the program will form a complete package of rice technology: land development, land preparation, irrigation, planting, fertilizing, weed and insect control, problem identification, harvesting, drying, processing, marketing, and management of labor, machines and money. This integrated training will be on a field scale where the best practices are used and new technology or modifications are field tested before being recommended to farmers. Cost data will be obtained; most budget costs will be met from sales of seed and commercial rice. The effort is expected to serve as a pilot project for possible within-country production, demonstration and training centers.

Extensive travel to all rice-growing countries in Latin America has enabled program staff to collect photographs of almost every problem that might be found in growing rice. An identification manual containing color photographs of the most important insect, disease and other rice production problems of the region was published this year. The booklet is expected to be of great value to rice technicians and producers in identifying production problems.

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* This list includes only journal articles published outside CIAT's series.