PN-ABA-919

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

DATE: 9/30/88

MEMORANDUM

TO: AID/PPC/CDIE/DI, room 209 SA-18

FROM: AID/SCI, Victoria Ose VO

SUBJECT: Transmittal of AID/SCI Progress Report(s)

Attached for permanent retention/proper disposition is the following:

AID/SCI Progress Report No. 3. F-16
FINAL

+ manuscript

Attachment

PPC/CDIE

UNIVERSITY OF CALIFORNIA, DAVIS

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DEPARTMENT OF LAND, AIR AND WATER RESOURCES

HOAGLAND HALL
DAVIS, CALIFORNIA 95616

July 24, 1987

FINAL

3. F-16 d

Dr. John Malcolm
AID
S&T/AG
Washington, D.C. 20523

Dear Dr. Malcolm:

Enclosed please find the final report for grant #DPE-5542-G-SS-4016-00. As stated in the report, some aspects of the experimentation and data analysis are still in progress, and we will send you reprints of our published scientific communications as they become available. Our overall conclusion is that foliar P fertilization is a promising technology that warrants further attention. We thank you for your support and cooperation.

Yours sincerely,

Jonathan Lynch

JL:kb
cc: Dr. André Läuchli
Dr. Emanuel Epstein
Dr. Minners

Enclosure

Rec'd in ... SEP 29 1988

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DEPARTMENT OF LAND, AIR AND WATER RESOURCES

HOAGLAND HALL
DAVIS, CALIFORNIA 95616

FINAL

3F-16

7-24-87

Final report on grant # DPE-5542-G-SS-4016-00

"Phosphorus deficiency in tropical dry bean production: an approach through foliar fertilization."

Summary

Phosphorus (P) deficiency is a primary constraint to bean (*Phaseolus vulgaris*) production in the tropics. We investigated the merit of foliar P fertilization (applied as commercial grade ammonium polyphosphate) as a way of circumventing soil P fixation and increasing the efficiency of P fertilization. In field studies in Brazil we determined the optimal concentration and timing of foliar P application. We found that different bean genotypes were differentially sensitive to foliar P damage. Foliar P fertilization significantly enhanced vegetative growth of beans grown in the field. In greenhouse studies under controlled fertility conditions we found that foliar P fertilization enhanced vegetative growth, particularly in marginal P conditions, by stimulating leaf area development. We conclude that foliar P fertilization is a promising new technology for marginal P soils of the tropics that warrants future investigation and development.

Introduction

The common bean (*Phaseolus vulgaris*) is a significant food resource in the developing nations of the tropics and subtropics. A primary constraint on bean production in these regions is an inadequate supply of the essential plant nutrient, phosphorus (P). Many of the old, highly weathered soils characteristic of the humid tropics contain very little available P. For example, in tropical America over 80% of the total land area is deficient in P. Beans (and legumes in general) are particularly sensitive to P deficiency, since symbiotic nitrogen fixation by rhizobia in root nodules has a high P requirement. Conventional P fertilization is often ineffective in correcting P deficiency because of the ability of many tropical soils to chemically 'fix' applied P into forms that are unavailable to plants. Conventional P fertilization is also increasingly costly on account of dwindling P supplies and high energy costs.

An attractive alternative to conventional fertilization is foliar fertilization, a technique in which nutrient formulations (in this case, containing P) are applied directly to plant foliage as sprays. The foliarly-applied nutrients can be absorbed by shoot tissues and used to meet the plant's nutritional requirements. This technique would be of particular interest in the tropics, since it circumvents the problem of soil P fixation, and could thereby dramatically increase the efficiency of fertilizer utilization.

The objective of our research was to evaluate and develop foliar P fertilization as an efficient method of enhancing tropical bean production. Our research had two distinct components; a field component in Brazil under the direct supervision of Dr. Micheal Thung, a CIAT bean agronomist outposted at CNPAF/EMBRAPA, and a more physiolcgical component conducted under controlled conditions at the Davis campus of the University of California. This report provides a brief summary of our studies and conclusions. Both field and greenhouse studies are still in progress as of this writing, and we have collected a large number of data that remain to be analyzed over the coming months. In

consequence this report does not represent our final conclusions, which will be made available to AID as published reports in scientific journals as reprints become available.

Field Studies in Brazil

The intention of our first field experiment was to identify the toxicity threshold of our foliar fertilizer formulation. The first season's planting of this experiment was abandoned because of unseasonal rain, but the second planting, in April of 1985, was carried through to completion under the supervision of Dr. Micheal Thung, our Brazilian collaborator. Nine concentrations of the fertilizer formulation (ammonium polyphosphate with L77 surfactant) were applied to P-deficient bean plants (cv EMP 84) at 4 different stages of ontogeny. At 4 times during the season plants were harvested for growth analysis, including leaf area, biomass, and biomass partitioning. Throughout crop development the toxicity of the foliar treatments was visually scored. At the end of the season the beans were harvested and subjected to conventional yield component analysis.

The toxicity threshold of the foliar treatment was between 6 and 12 % ammonium polyphosphate, much higher than anticipated. In fact, after the first application the concentration of the treatments was increased by a factor of 8 in order to obtain leaf burning. This is promising in that it means a significant quantity of P can be applied to the leaves without causing burning.

Statistical analysis of the yield data indicated that the foliar treatments did not significantly influence yield parameters, which may in part reflect the small number of replicates (4) and the great variability of field-grown *Phaseolus* plantings. However, foliar treatments did increases leaf area and plant dry weight at the final harvest.

In the 1986 growing season we characterized the genotypic variability of sensitivity to foliar fertilizer application. Based upon data from the first

experiment, we used an APP concentration of 10% applied early in vegetative growth to 300 genotypes in order to produce leaf damage. Ten days after the foliar treatment Dr. Thung visually scored the treated leaves for leaf damage on a 10 point scale. At maturity total seed yield was measured. Significant genotypic variation in response to foliar treatment was observed in each of the bean groups examined, and specific genotypes having the most extreme responses to foliar application were identified. Substantial variation in the relationship between leaf damage and subsequent yield reduction was also observed. In particular, elite black bean lines were able to withstand significant leaf damage without comparable yield reductions.

Our objective in the 1987 growing season was to conduct a detailed yield trial using the optimized treatment parameters (genotype, fertilizer concentration, application timing). Data from this experiment have not yet been analyzed. If significant effects on yield are obtained we plan to repeat the study and report our findings in an international scientific journal such as *Agronomy Journal*.

Physiological Work in California

Our initial efforts in Davis were directed towards the design and construction of an automated greenhouse sand-culture system capable of sustaining plant growth over extended periods at realistically low P concentrations. The maintenance of realistic P concentrations under controlled fertility conditions is a major technical obstacle to mechanistic studies of low P fertility. The computer-controlled system we developed, which is also applicable to mycorrhizal studies, represents an original contribution to the field of P fertility research and will be the subject of a technical report in an international scientific journal such as *Journal of Plant Nutrition*.

The sand culture system was fully functional in the fall of 1985, at which point we conducted the first greenhouse experiment. The objective of the first experiment was to determine the effects of foliar APP application on

vegetative growth over time. Our conclusion was that foliar APP application significantly enhanced vegetative growth of plants grown under limiting P conditions, despite the fact that our greenhouse plants had considerably more leaf damage following foliar treatment than field-grown plants exposed to the same APP concentration. Detailed gas exchange analysis of the leaves indicated that foliar APP application may have had some effect on the carbon assimilatory apparatus in the leaves.

During the 1986 growing season we conducted two detailed growth studies to determine if foliar APP application enhanced vegetative growth by stimulating carbon assimilation. Leaf photosynthesis, leaf initiation, and leaf area were measured over time in response to foliar APP application at three levels of soil P in the presence or absence of mycorrhizae. The effect of foliar treatment on leaf N, P, K, Ca, Mg, Fe, Zn, Al, and B content was determined. Carbon availability in the plant was monitored by analysis of starch and sugar levels in source and sink leaves at midday and predawn harvests. As of this writing we are just finishing all the sample analysis and are beginning to integrate the data. Visual evaluation and fresh weight data show that foliar APP treatment significantly enhanced plant growth under low P regimes. Foliar P application particularly enhanced leaf enlargement, which may have catalytically stimulated growth by increasing biomass partitioning to leaf area. Firm conclusions from these studies must await an integrated analysis of the data, which will occur over the next several months. We expect to submit a report of our findings to an international scientific journal such as *Crop Science*.

In the 1987 growing season we want to determine the effect of APP application during reproductive growth on yield parameters. As of this writing this experiment is in progress.

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DEPARTMENT OF LAND, AIR AND WATER RESOURCES

HOAGLAND HALL
DAVIS, CALIFORNIA 95616

November 3, 1986

Dr. John Malcolm
Agency for International Development
S&T/AG
Room 406B SA-18
Washington, D.C. 20523

RE: Grant # DPE-5542-G-SS-4016-00

Dear Dr. Malcolm:

We are sending you an analysis of the most recent field experiment completed in Brazil. In November the next field experiment (AID-3) will begin. AID-3 will be the comprehensive, detailed yield study based upon the findings of earlier field experiments.

In addition to the field studies, considerable physiological work is in progress in Davis. The growing season in Davis is approaching its end and we will now turn our attention to analyzing and evaluating the large amount of data generated this summer and fall. We will send you reports of our conclusions as the data is evaluated.

Sincerely,

André Läuchli
Professor of Plant Nutrition

Emanuel Epstein
Professor of Plant Nutrition

Jonathan Lynch
Research Assistant

AL:EE:JL:cf

Enclosure

AID Update

10-24-86

Introduction

Early this summer Dr. Thung performed experiment "AID-2" at Goiania in Brazil. The purpose of this experiment was to screen a wide range of bean genotypes for their response to an excessive foliar application of APP (ammonium polyphosphate), with the intention of identifying genotypes that were particularly sensitive or tolerant to the leaf burning caused by excessive foliar fertilization. Unusual genotypes could then be used in physiological studies to determine the nature of genotypic tolerance to foliar treatment. It was also our intention to select a relatively tolerant genotype for this fall's detailed growth study (experiment AID-3) in order to maximize our chances of obtaining a positive growth response.

Procedures

Growth Conditions

Bean seeds were planted on April 26 1986 (seedlings emerged on May 7 1986) in a P-fixing Oxisol with low Al saturation in Goiania, Brasil. The soil had a pH $\geq$ 5.0, organic matter < 1 %, exchangeable K content of 185 ppm, 0.2 mEq Al/100 ml soil, and available P of 3 ppm (Bray's #2). Prior to planting, the soil was amended with 10 kg/ha borax, 25 kg/ha $ZnSO_4$, and 20 kg/ha of N as $(NH_4)_2SO_4$. Seeds were planted at 250,000 plants/ha. Fifteen seedlings emerged in each meter of row, and at harvest 12 plants remained in each meter of row. Genotypes were arranged in blocks of 3 rows 5 m in length and 50 cm apart. Each genotype was present in two blocks at different positions in the field. The crop was treated with the systemic insecticide Azodine and irrigated twice, at preflowering (early June) and fruit set (last week of June).

Treatment Application

Early in vegetative development 2 of the 3 rows in each block were treated with 10 % APP in water and detergent as a drenching foliar spray. This concentration of APP seriously injured the plants in earlier experiments.

Treatment Evaluation

Ten days after the foliar treatment Dr. Thung visually scored the burning of treated leaves on a scale of 1 to 9, scores of 1-3 being tolerant, 4-6 being intermediate, and 7-9 being susceptible. Within each of these categories the three possible levels correspond to light, medium, and severe symptoms. in general, a score greater than 6 is agronomically unacceptable. Dr. Thung is adept at using this scoring system for his routine agronomic evaluation of genotypes and is confident of the

objectivity and reproducibility of the scores. At maturity the blocks were harvested and the total seed yield for the treated and untreated rows was recorded. Seed was harvested at 20% RH and weighed at 40 % RH to standardize moisture content. The yield data and the leaf burn scoring are the data that I have analyzed and will be discussing below. The data are arranged in blocks of similar genotypes that were grown in these groupings in the field. The genotypic groupings are largely by seed color, since seed color is a major genetic discriminant within *P. vulgaris*.

Results

See attached sheets. Note that the 'Roxo' and 'Mulatinho' data sets were analyzed in two separate sets because of their large size.

Conclusions

Significant genotypic variation in response to foliar treatment was observed in each of the bean groups examined. The genotypes in each group that had the most extreme burning and yield responses to foliar application are identified in the 'Results' section.

Statistical analysis of the data was problematic because of the large number of genotypes and small number of replicates in most of the groups. Therefore, significant 'treatment by genotype interactions', which would be evidence of differential overall genotypic responses to the foliar treatment, were not observed. However, individual genotypes were identified that fell outside the 95% confidence limits for their respective groups. The most outlying genotypes are identified in the 'Results' section: these may be candidates for future experimentation.

Leaf burning led to reduced final yields in the "high potential Carioca" lines, the "promising Carioca lines", "high potential black lines", red lines, Mulatinho lines, and the bulk Carioca lines. The "promising black lines" did not show this relationship. Substantial genotypic variation in the relationship between burning and reduced yield was obtained.

Black Beans

66 genotypes tested
(Dr. Thung's designation = LALTOPTP)

Burning

		Best genotypes	score	Worst genotypes	score
average score:	5.86	72	4.0	316	8.0
std dev:	1.23	492	4.5	85	7.5
		238	4.5		

95 % confidence limits: 5.56 to 6.16

	factor	p
Kruskal-Wallis results	genotype	ns

Yield (% of control)

		Best genotypes	yield	Worst genotypes	yield
average yield:	51.8	492	80.2	498	39.0
std dev:	13.3	238	68.9	225	39.8
		191	67.1	283	40.5

95 % confidence limits: 48.5 to 55.0

	factor	p
ANOVA results:	genotype	0.0013
	treatment	0.0001
	genotype X treatment	0.9700

Interaction of burning and yield:

Negative correlation of burning and yield (Figure 1).
Best black bean genotype is 492.

LALTOPTP

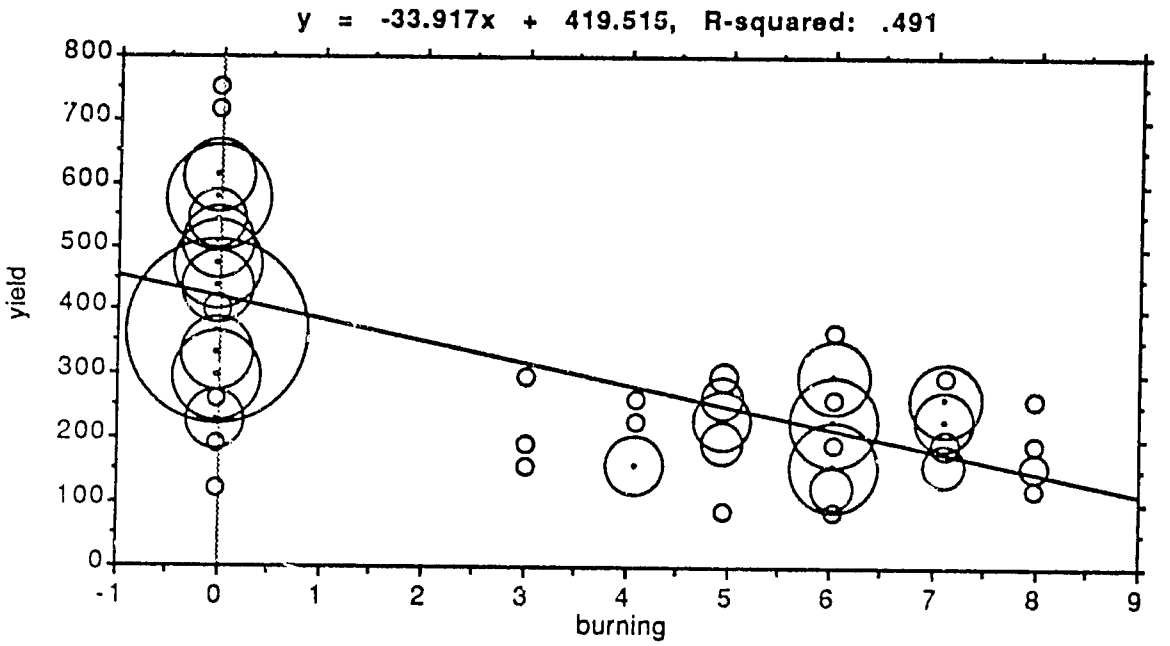

Figure 1

Simple Regression X_1: burning Y_1: yield

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
131	.701	.491	.487	106.257

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	1417723.412	1417723.412	125.567
RESIDUAL	130	1467775.83	11290.583	p = 1.0000E-4
TOTAL	131	2885499.242		

No Residual Statistics Computed

Simple Regression X_1: burning Y_1: yield

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	419.515				
SLOPE	-33.917	3.027	-.701	11.206	1.0000E-4

Confidence Intervals Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:
MEAN (X,Y)	301.777	338.375	304.753	335.399
SLOPE	-39.906	-27.929	-38.932	-28.903

Promising Black Bean Lines 5 genotypes tested
(Dr. Thung's designation = PRETOPR)

Burning

		Best genotypes	score	Worst genotypes	score
average score:	3.89	BAT 67	3.3	SPB 1	5.0
std dev:	1.13				

95 % confidence limits: 3.33 to 4.45

	factor	p
Kruskal-Wallis results	genotype	ns

Yield (% of control)

		Best genotypes	yield	Worst genotypes	yield
average yield:	94.4	Rio Tibagi	106.4	BAT 451	87.1
std dev:	17.1				

95 % confidence limits: 86.4 to 102.4

	factor	p
ANOVA results:	genotype	0.1095
	treatment	0.2153
	genotype X treatment	0.9355

Interaction of burning and yield:

No correlation of burning and yield (Figure 2).
Best promising black bean line is Rio Tibagi.

PRETOPR

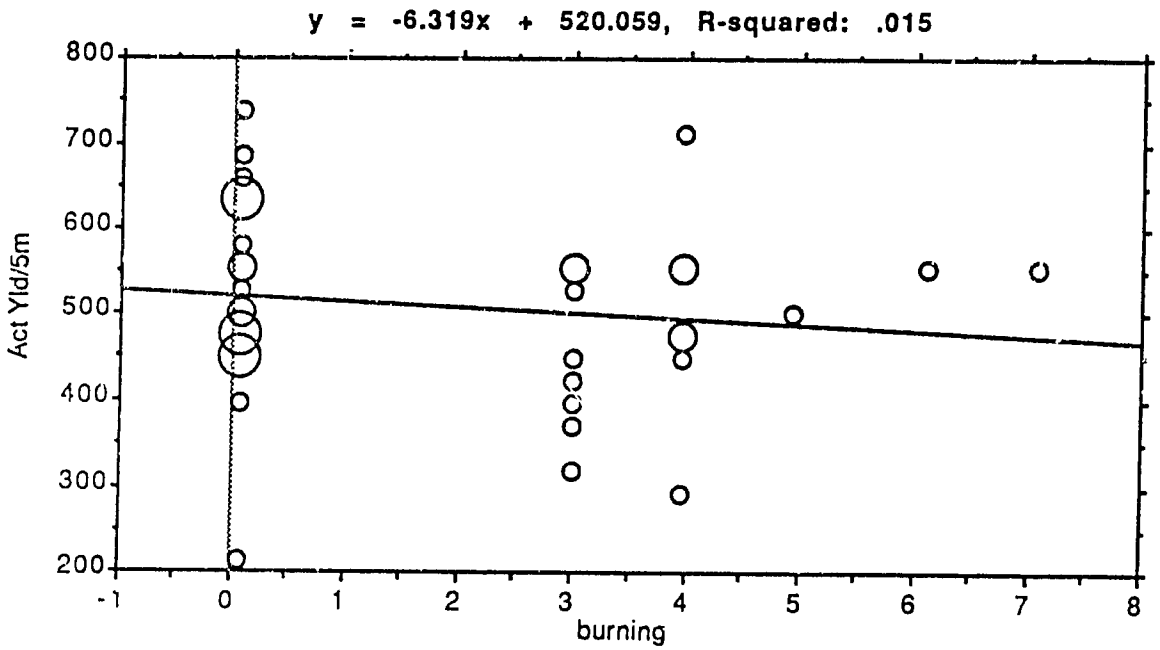

Figure 2

15

Simple Regression X_1: burning Y_1: Act Yld/5m

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
37	.121	.015	-.013	110.694

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	6590.819	6590.819	.538
RESIDUAL	36	441115.321	12253.203	P = .4681
TOTAL	37	447706.14		

No Residual Statistics Computed

Note: 2 cases deleted with missing values.

Simple Regression X_1: burning Y_1: Act Yld/5m

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	520.059				
SLOPE	-6.319	8.616	-.121	.733	.4681

Confidence Intervals Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:
MEAN (X,Y)	471.997	544.841	478.099	538.738
SLOPE	-23.795	11.157	-20.867	8.229

Figure 2

Carioca

36 genotypes tested
(Dr. Thung's designation = CARIOCA)

Burning

		Best genotypes	score	Worst genotypes	score
average score:	5.68	Carioca T	4.0	141	8.0
std dev:	1.17	A 282	4.0	150	7.0
		641	4.5	631	7.0
		169	4.5		
		714	4.5		

95 % confidence limits: 5.41 to 5.96

	factor	p
Kruskal-Wallis results	genotype	ns

Yield (% of control)

		Best genotypes	yield	Worst genotypes	yield
average yield:	95.8	149	126.2	82 PVMX 1637	53.8
std dev:	21.7	187	122.1	704	72.3
		635	114.7	82 PVMX 1638	76.5
		245	114.6		

95 % confidence limits: 90.7 to 100.9

	factor	p
ANOVA results:	genotype	0.3707
	treatment	0.1012
	genotype X treatment	0.3707

Interaction of burning and yield:

Slight negative correlation of burning and yield (Figure 3).
Best Carioca genotype is 149.

CARIOCA

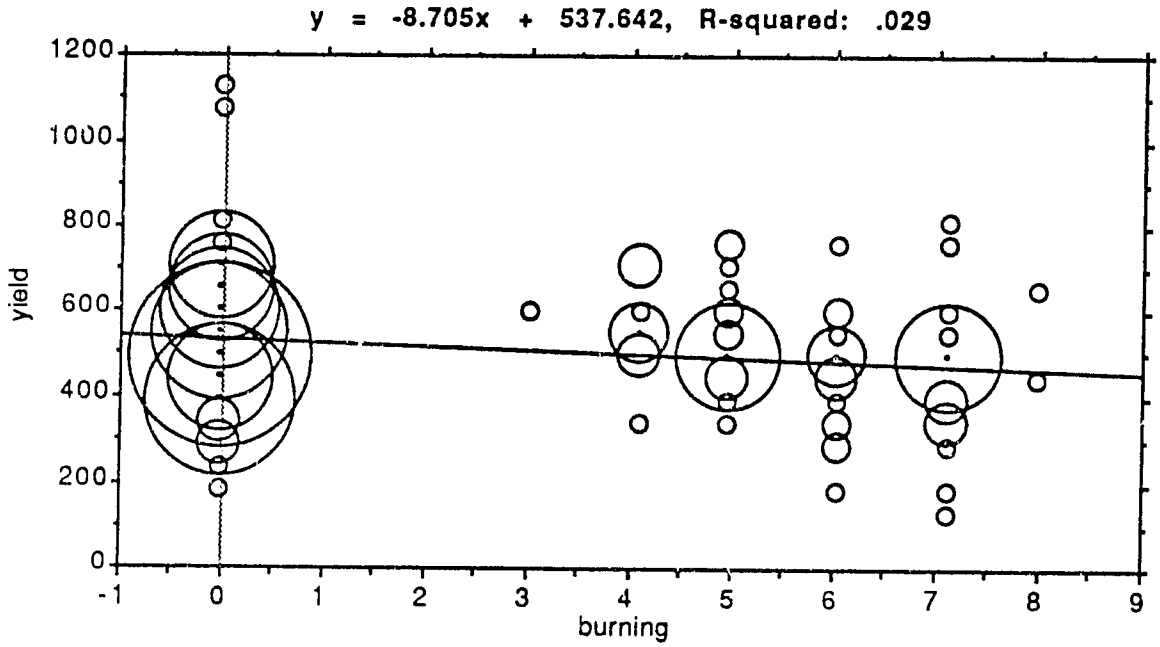

Figure 3

CARIOCA

Simple Regression X_1: burning Y_1: yield

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
143	.17	.029	.022	150.083

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	95436.372	95436.372	4.237
RESIDUAL	142	3198538.628	22524.92	p = .0414
TOTAL	143	3293975		

No Residual Statistics Computed

Simple Regression X_1: burning Y_1: yield

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	537.642				
SLOPE	-8.705	4.229	-.17	2.058	.0414

Confidence Intervals Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:
MEAN (X,Y)	488.19	537.643	492.208	533.626
SLOPE	-17.067	-.344	-15.708	-1.703

Figure 3

High Potential Carioca 16 genotypes tested
(Dr. Thung's designation = LALTOPTC)

Burning

		Best genotypes	score	Worst genotypes	score
average score:	5.96	132	4.5	306	6.5
std dev:	0.84	136	5.0	304	6.5
				288	6.5
				133	6.5

95 % confidence limits: 5.58 to 6.33

	factor	p
Kruskal-Wallis results	genotype	ns

Yield (% of control)

		Best genotypes	yield	Worst genotypes	yield
average yield:	52.2	133	82.1	304	33.6
std dev:	17.8	141	70.4	287	41.7

95 % confidence limits: 44.3 to 60.1

	factor	p
ANOVA results:	genotype	0.1832
	treatment	0.0001
	genotype X treatment	0.1832

Interaction of burning and yield:

Negative correlation of burning and yield (Figure 4).
Best high-potential Carioca genotype is 133.

LALTOPTC

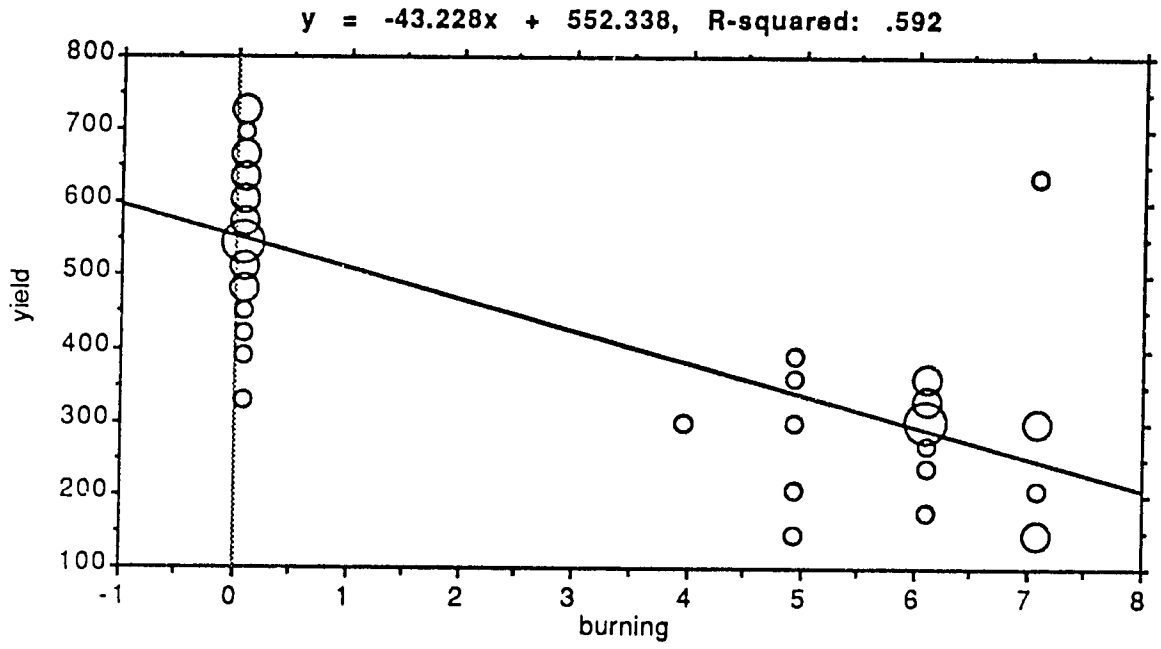

Figure 4

Simple Regression X_1: burning Y_1: yield

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
43	.769	.592	.582	111.532

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	756765.351	756765.351	60.836
RESIDUAL	42	522452.831	12439.353	p = 1.0000E-4
TOTAL	43	1279218.182		

No Residual Statistics Computed

Simple Regression X_1: burning Y_1: yield

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	552.338				
SLOPE	-43.228	5.542	-.769	7.8	1.0000E-4

Confidence Intervals Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:
MEAN (X,Y)	389.701	457.572	395.353	451.919
SLOPE	-54.414	-32.042	-52.551	-33.905

Figure 4

Promising Carioca Lines 5 genotypes tested
(Dr. Thung's designation = CARIOPR)

Burning

		Best genotypes	score	Worst genotypes	score
average score:	4.5	252	4.0	247	5.0
std dev:	1.1	281	4.0	Carioca	5.0

95 % confidence limits: 3.95 to 5.05

	factor	p
Kruskal-Wallis results:	genotype	ns

Yield (% of control)

		Best genotypes	yield	Worst genotypes	yield
average yield:	71.6	252	78.7	281	64.3
std dev:	10.3	283	76.0		

95 % confidence limits: 66.5 to 76.7

	factor	p
ANOVA results:	genotype	0.0007
	treatment	0.0001
	genotype X treatment	0.7437

Interaction of burning and yield:

Negative correlation of burning and yield (Figure 5).
Best promising Carioca genotype is 252.

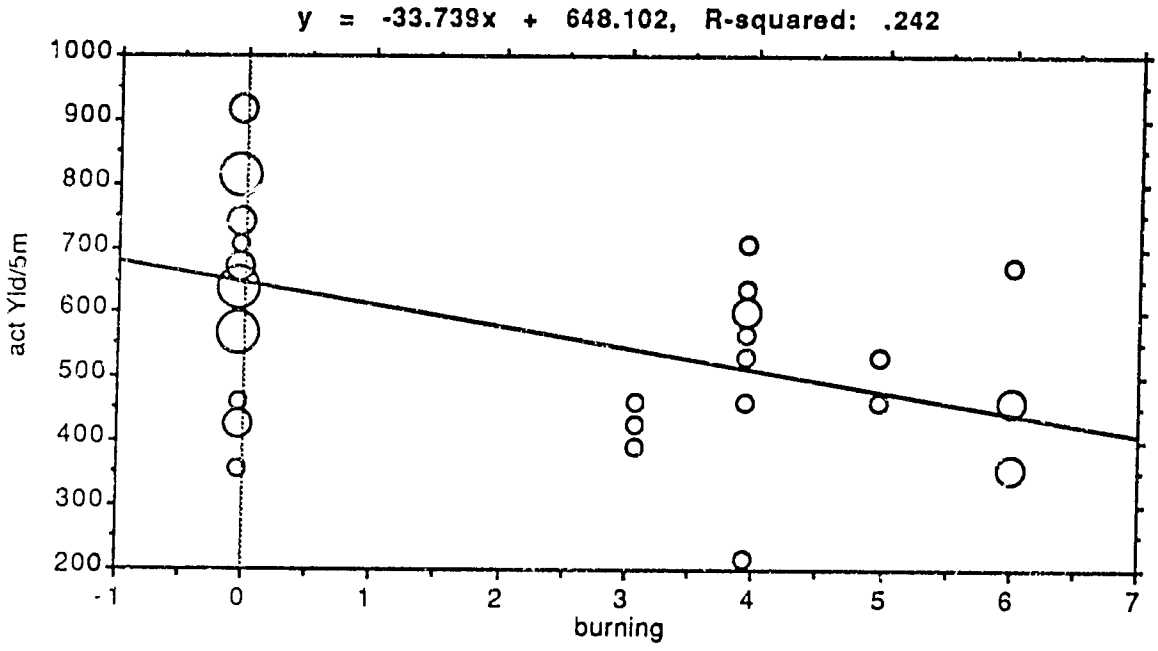
y = -33.739x + 648.102, R-squared: .242
1000
900
800
700
600
500
400
300
200
act Yld/5m
-1
0
1
2
3
4
5
6
7
burning

Figure 5

Simple Regression X_1: burning Y_1: act Yld/5m

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
37	.492	.242	.221	144.964

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	241717.664	241717.664	11.502
RESIDUAL	36	756521.716	21014.492	p = .0017
TOTAL	37	998239.38		

No Residual Statistics Computed

Note: 2 cases deleted with missing values.

Simple Regression X_1: burning Y_1: act Yld/5m

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	648.102				
SLOPE	-33.739	9.948	-.492	3.392	.0017

Confidence Intervals Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:
MEAN (X,Y)	528.486	623.882	536.478	615.89
SLOPE	-53.917	-13.561	-50.536	-16.942

Figure 5

Mulatinho

100 genotypes tested
(Dr. Thung's designation = MULAT)

Burning

		Best genotypes	score	Worst genotypes	score
average score:	6.61	23	3.5	7	8.0
std dev:	0.99	335	3.5	381	8.0
		611	3.5	549	7.5
		348	3.5		
		508	3.5		
		934	3.5		

Krusal-Wallis results: not possible due to large # of genotypes

Yield (% of control)

		Best genotypes	yield	Worst genotypes	yield
average yield:	93.3	LM 21303	158.3	356	52.5
std dev:	0.2	847	155.6	471	54.2
		427	147.9	37	58.3

ANOVA results: not possible due to large # of genotypes

Interaction of burning and yield:

Slight negative correlation of burning and yield (Figure 6a,6b).
Best mulatinho genotype is LM 21303.

Mulatinho part 1

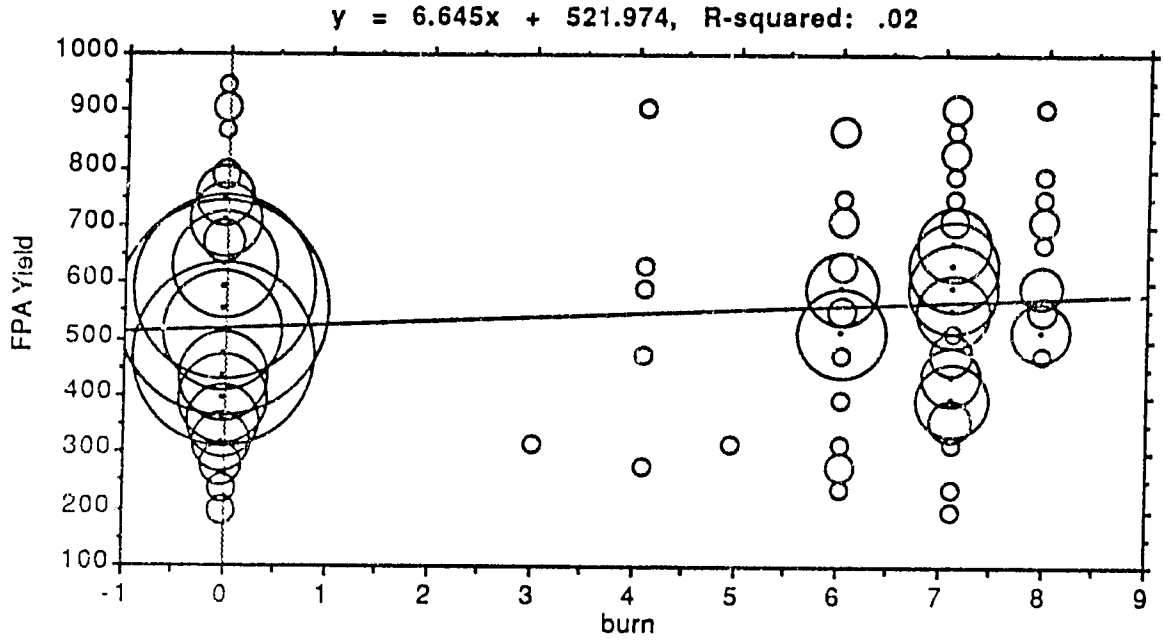

Figure 6a

Mulatinho part 1

Simple Regression X_1: burn Y_1: FPA Yield

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
197	.141	.02	.015	160.455

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	102033.316	102038.316	3.963
RESIDUAL	196	5046182.391	25745.829	p = .0479
TOTAL	197	5148220.707		

No Residual Statistics Computed

Simple Regression X_1: burn Y_1: FPA Yield

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	521.974				
SLOPE	6.645	3.338	.141	1.991	.0479

Confidence Intervals Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:
MEAN (X,Y)	521.701	566.683	525.345	563.039
SLOPE	.062	13.229	1.128	12.162

Figure 6a

Mulatinho part 2

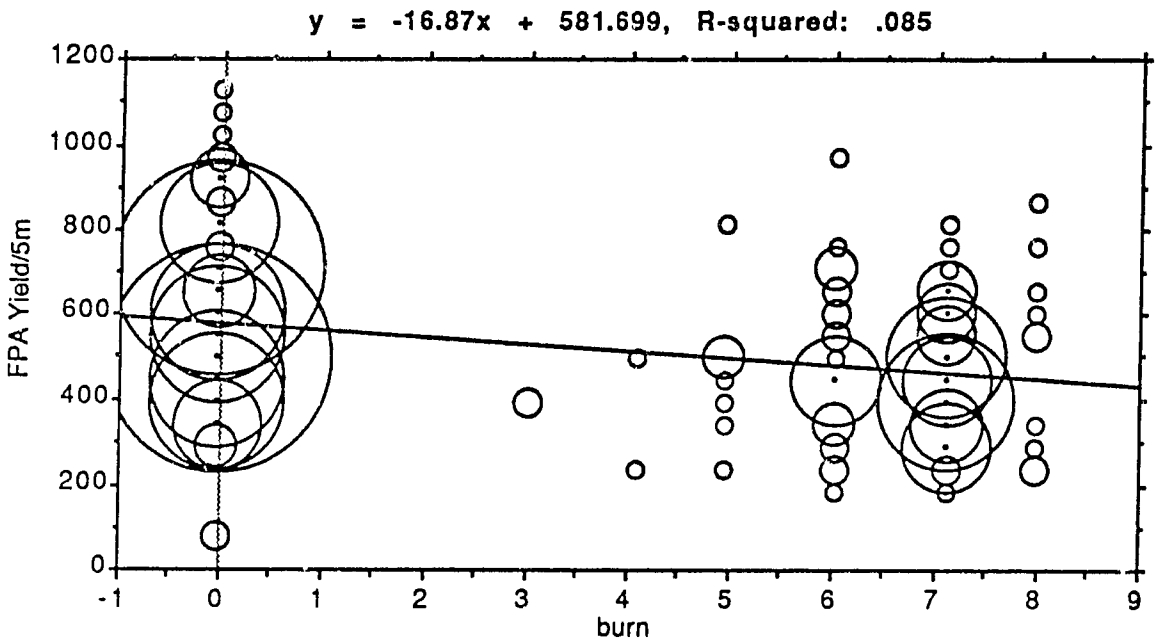

Figure 6b

Mulatinho part 2

Simple Regression X_1: burn Y_1: FPA Yield/5m

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
201	.291	.085	.08	186.367

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	642255.445	642255.445	18.491
RESIDUAL	200	6946521.287	34732.606	p = 1.0000E-4
TOTAL	201	7588776.733		

No Residual Statistics Computed

Simple Regression X_1: burn Y_1: FPA Yield/5m

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	581.699				
SLOPE	-16.87	3.923	-.291	4.3	1.0000E-4

Confidence Intervals Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:
MEAN (X,Y)	501.22	552.939	505.408	548.75
SLOPE	-24.607	-9.134	-23.354	-10.387

Figure 6b

Roxo

72 genotypes tested
(Dr. Thung's designation = ROXO)

Burning

		Best genotypes	score	Worst genotypes	score
average score:	6.3	1360	5.0	748	7.5
std dev:	0.74	999	5.0		
		206	5.0		

95 % confidence limits: 6.17 to 6.44

	factor	p
Kruskal-Wallis results:	genotype	ns

Yield (% of control)

		Best genotypes	yield	Worst genotypes	yield
average yield:	91.9	82 PVBZ 1839	149.4	82b var 112	66.0
std dev:	19.8	1010	134.5	23	70.0
		201	118.7		

95 % confidence limits: 88.4 to 95.4

ANOVA results: not possible due to large # of genotypes

Interaction of burning and yield:

Slight negative correlation of burning and yield (Figure 7a,7b).
Best roxo genotype is 82 PVBZ 1839.

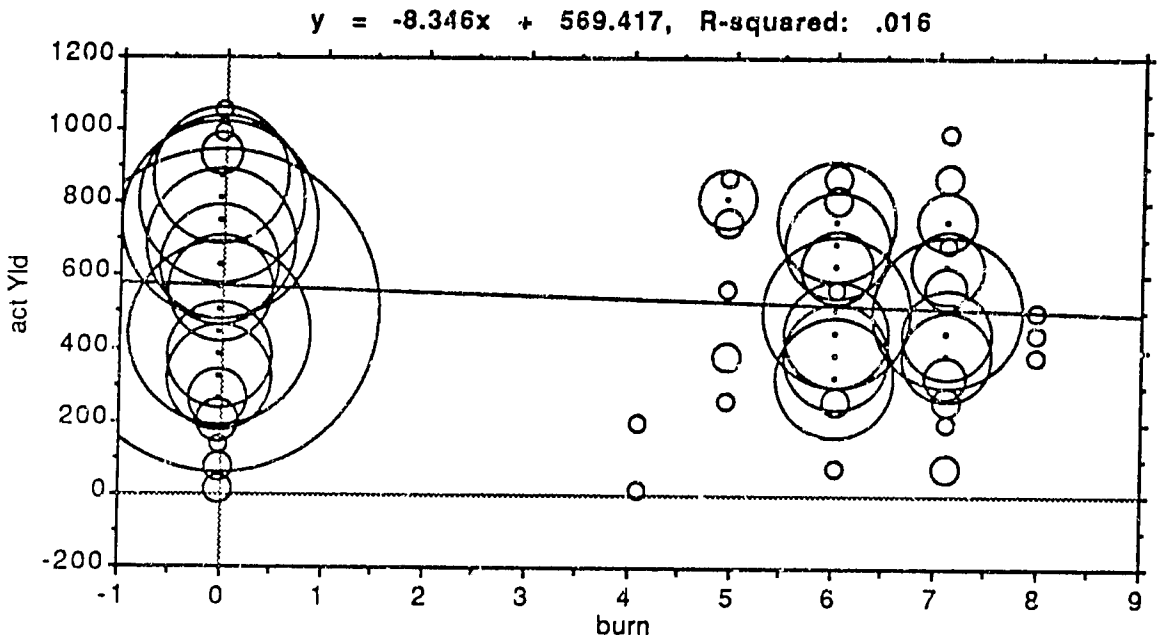
y = -8.346x + 569.417, R-squared: .016
1200
1000
800
600
400
200
0
-200
act Yld
-1
0
1
2
3
4
5
6
7
8
9
burn

Figure 7a

Simple Regression X_1: burn Y_1: act Yld

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
243	.128	.016	.012	206.892

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	173380.208	173380.208	4.051
RESIDUAL	242	10358652.579	42804.349	p = .0453
TOTAL	243	10532032.787		

No Residual Statistics Computed

Simple Regression X_1: burn Y_1: act Yld

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	569.417				
SLOPE	-8.346	4.147	-.128	2.013	.0453

Confidence Intervals Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:
MEAN (X,Y)	517.022	569.207	521.243	564.986
SLOPE	-16.514	-.177	-15.193	-1.498

Figure 7a

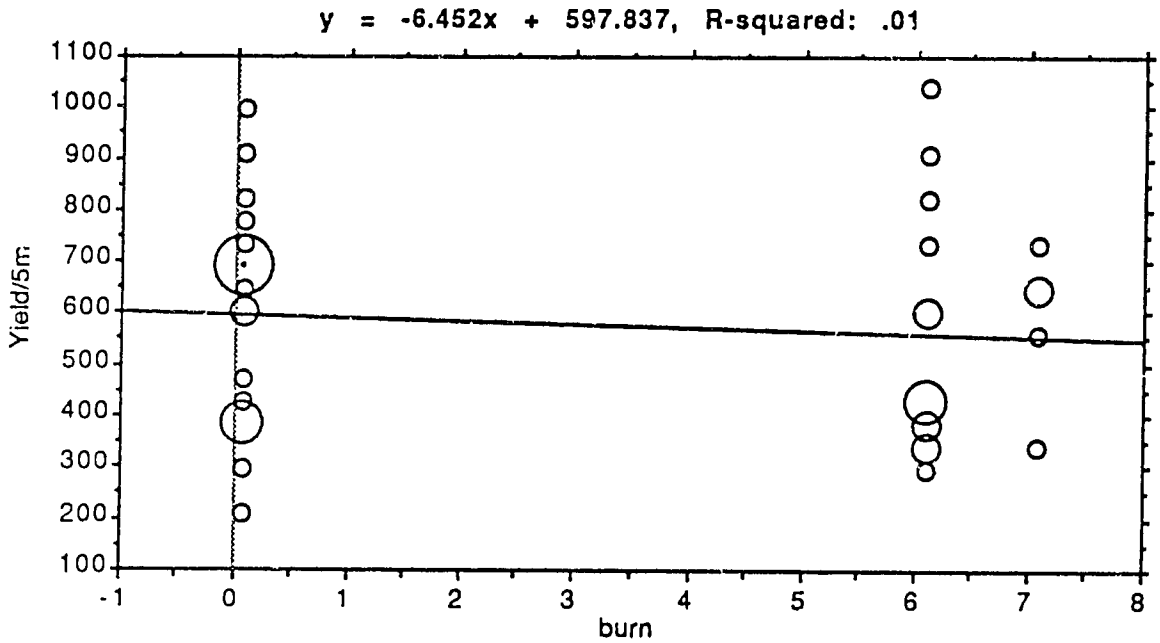
y = -6.452x + 597.837, R-squared: .01
Yield/5m
1100
1000
900
800
700
600
500
400
300
200
100
-1
0
1
2
3
4
5
6
7
8
burn

Figure 7b

Simple Regression X_1: burn Y_1: FPA Yld/5m

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
37	.101	.01	-.017	212.863

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	16902.697	16902.697	.373
RESIDUAL	36	1631184.146	45310.671	p = .5452
TOTAL	37	1648086.842		

No Residual Statistics Computed

Simple Regression X_1: burn Y_1: FPA Yld/5m

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	573.621				
SLOPE	.18	.295	.101	.611	.5452

Confidence Intervals Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:
MEAN (X,Y)	507.592	647.671	519.328	635.936
SLOPE	-.418	.777	-.317	.677

Figure 7b