PT012
Soil fertility management in potatoes on the Atherton tablelands

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Queensland Department of Primary Industries

Know-how for Horticulture™

PT012

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Industry Summary

A project has been completed on the Atherton Tableland which was designed to find out if additional fertilizers were needed to increase the yield of potatoes and subsequent rotational crops. By using large plot on-farm trials it was planned to increase the relevance of trial results to growers and thereby increase understanding of fertilizer practices (and other practices that vary crop yield) in crop farming in this district.

Potatoes

Twelve growers across the Tablelands cooperated by allowing a large portion of their potato crop to be treated. The treatments used were lime, potash, magnesium, zinc and boron. Once these were applied and worked in, the trial area was grown the same way as the main crop, including the normal or recommended fertilizer practices.

Soil and leaf samples were taken from each site to determine the fertility of the site as well as what changes might happen due to the extra fertilizer applied. These showed that most sites were reasonably well supplied with nutrients before the potato crop was fertilized. Some soils were low in pH (1), phosphorus (1), potassium (3), calcium (1), magnesium and zinc (2). Leaf analysis, after growers had applied their fertilizer, showed that all crops were well supplied with nutrients. The extra fertilizers applied did change the amounts of some nutrients but this change did not influence tuber yield and is only of academic importance.

The trials were dug, graded and weighed on grower's harvesters. The main result was that none of extra fertilizer applied increased tuber yield. In one case extra potash decreased tuber yield slightly.

The next crop

The crop following potatoes (peanut-5, maize-6 and pasture-1) was grown without reapplying the extra fertilizers treatments to find out whether any residual fertilizer would change yields. No yield increases were found except at one site with very low pH (~ 5.0) where lime application prior to potatoes increased maize yield slightly. At one site peanut yield was decreased by the single addition of potassium, magnesium and boron.

The second crop

The soils were resampled and extra fertilizers (as previously) were reapplied to the same plots prior to the next crop (peanuts-5, maize-3, Dolichos lablab-3 and potatoes-1). Again crop yields did not increase due to the extra fertilizer. Soil analysis showed that slight increases in zinc were detected but generally soil fertility was maintained by cropping practices.

The deliberate attempt to involve growers in the management, harvest (the time spent on the potato diggers with groups of growers was a outstanding period of information exchange in this project) and post harvest meetings has increased growers understanding of fertilizer practices and variability of yield due to other factors. This has been shown by increased grower tests of different fertilizers. However, more grower involvement in earlier planning stages may have considerably increased grower ownership of results with an increased adoption of better fertilizer practices. An approach that uses better adult learning processes is being proposed to address this potential gain.

Technical Summary

Twelve *on farm* - large plot trials were conducted to determine whether extra nutrients are needed to increase potato yield or quality in the Atherton Tableland district. The effect of such practices on crop rotation was also investigated. The type of investigation adopted was specifically used to improve technology transfer about crop nutrition, rotations and soil conditions.

Potato crops

Extra calcium (lime), magnesium, potassium, zinc and boron were applied to the soil surface and worked in prior to planting. Growers applied their normal fertilizer program as well as normal commercial growing practices to these crops.

Potato crops were harvested, graded and weighed on commercial diggers. Samples were taken and used for specific gravity and internal investigation.

None of the treatments applied resulted in a yield increase. At one site added potassium decreased yield of ware tubers by 7 %. Potassium application decreased specific gravity at three sites but no other treatment effects were found for internal tuber qualities.

Differences in chemical composition of leaf and petiole were detected, but as no common cause and effect was found and as these effects did not produce yield differences, these compositional effects were not considered important in interpreting production factors during these trials.

Subsequent rotational crops

The crop (6 maize, 5 peanut and 1 pasture) grown immediately following the potato crop did not have the nutrient reapplied. This was done to examine the possibility of residual nutrient carry over. Only two sites showed a yield response, with a maize yield increase to lime (6 %) and a peanut yield decline to single application of magnesium, boron or potassium. All other sites showed no yield response to any residual nutrients.

The following crop (5 peanut, 3 maize, 3 Dolichos lablab and 1 potato) was also monitored with full soil sampling and reapplication of the treatments (excepting lime). Again all sites showed no yield response to the applied nutrients.

It is concluded that, under existing common grower practices (including fertilizer), no additional nutrients are required to increase crop yield in Atherton Tableland cropping systems that include potatoes.

Technology transfer

The deliberate attempt to involve growers in the management, harvest (the time spent on the potato diggers with groups of growers was a outstanding period of technology transfer in this project) and post harvest evaluation has increased growers understanding of fertilizer practices and variability of yield due to other factors. This has been exemplified by increased grower tests of different fertilizers.

However, lack of grower input in the early planning stages has probably reduced the effectiveness of extension outcomes. This has been seen in that some of the group having seen the evidence firsthand, have still continued to apply unnecessary nutrients. They don't 'own' the results. Improved educational processes are being proposed in an endeavour to overcome this deficiency.

Recommendations

Extension/adoption by industry of research findings.

Continuing extension activities should build on the foundations laid by the project.

Increased input from growers in deciding the priorities and implementing their development should be facilitated.

Adult education making use of small groups and problem solving will increase the understanding and adoption not only of the work reported here but of many facets that fall within the farming systems of this region.

Groups so formed should contain members of the agribusiness community so that overall drive for sustainable agriculture can be achieved.

Recommend soil and plant chemical analytical data be made available for development of, and inclusion in, extension material to promote optimal fertilizer usage by Australian potato growers.

Directions for future research and/or activities supported by the HRDC.

The use of broadcast superphosphate prior to planting potatoes be investigated.

The overuse of nitrogenous fertilizers be addressed. That both these problems problems (especially the latter) be addressed by working through the adult learning processes mentioned in the previous section.

Financial/commercial benefits of adoption of research findings.

The straight economic analysis of not applying unnecessary fertilizer can be gauged by an expected cost decrease in the order of $ 85 /ha alone. The cutting back of nitrogenous fertilizer identified in this project would mean a further decrease of cost of approximately $ 110/ha. Multiplying this by the average acreage of approximately 500 hectares gives a crude estimate of saving of $ 92 500 per annum if all growers adopted these recommendations.

No loss in yield would accompany these reduced costs and possible increases in tuber quality could accrue if potassium fertilizer was correctly supplied. While the market does not overtly pay for a specific 'quality', market price does reflect the perception of tuber quality such as bloom and storability. Increased quality would enhance the region's favour in the marketplace thus increasing the long term price stability to growers.

As well as the economic sustainability the inappropriate use of fertilizers can lead to degradation of surface and underground water and other natural resources e.g. the great barrier reef. These costs are difficult to estimate but are receiving much more public eminence.

Publicity given to potato growers prominence in reducing down stream effects of agriculture would help to build the much sought after, 'clean' image.

Technical report

Introduction

The potato industry on the Atherton Tableland in 1989 consisted of 80 growers. Production was 30 000 tonnes with a gross value of $20 million (a year of high prices). Average returns are 25 000 tonnes with a gross value of $10 million.

Industry representatives at consultative meetings with officers of the Queensland Department of Primary Industries and agribusiness expressed concern about yield variability between years and among paddocks. They considered that crop nutritional effects may be playing a major role in this variability. Crop nutritional research was highly ranked in priority setting for the local industry.

Extensive research programs on nitrogen and phosphorus have been conducted for potatoes with financial support from industry and these requirements are well understood.

However, requirements for other nutrients and responses to varying soil conditions are not understood. Past observations in potatoes and in associated crops have not provided clear solutions to perceived nutritional problems.

The friability, excellent drainage and structural robustness of these soils means they have high potential value, especially for 'under soil' crops such as potatoes and peanuts. Hence, it is particularly important to develop means to manage and maintain soil fertility.

Potato production on the Atherton Tableland is intensive and costly. All crops are fully irrigated with high pest control inputs required for production in this tropical environment. Yield must be high and consistent to cover the high costs of production. Unreliable yields threaten the continued viability of production and the immediate returns, which are generally good due to the areas ability to supply high quality - 'out of season' potatoes to the domestic market.

Recent moves to export potatoes to Asia from the Atherton Tablelands and to supply on contract for processing, provide growers with alternative marketing outlets, but again these will be jeopardized if yields and quality cannot be maintained at consistently high levels.

Therefore is was decided to conduct a project to identify nutritional restraints to potato yield and quality, and to carry out this research in such a way that increased information would be gained by growers about nutritional aspects of potato production within the framework of their cropping practices.

Materials and methods

Site selection

Twelve sites were established across the major potato growing areas of the Atherton Tableland (approx. 17°S and 145°E). These sites were all about to grow a 'winter' crop of potatoes. Crops were planted between April and July and harvested between August and November. These sites were pegged and surface (0-10cm) soil samples were taken and analyzed (first sampling in figs. 1,2 & 3) for pH(1:5 soil:H_2O), Organic Carbon % (Walkley and Black 1934), Phosphorus ppm (bicarb), Exchangeable Sodium, Potassium, Calcium and Magnesium (m.e./100g), EDTA extractions of manganese, copper, iron and zinc, hot $CaCl_2$-extractable B (Aitken *et al*), (two sites only).

Sites were pegged with permanent markers to facilitate further activities and encompassed a full paddock length to provide large plots and ease of working. Plot sizes ranged from 28 to 63 metres long and were 7.32 m wide (8 rows, 0.9144m apart).

Treatments

Seven treatments were used, these were:-

1. Control - nothing extra applied
2. Lime applied at 2.5 t/ha
3. Lime as in 2, plus Zn at 15 kg/ha as $ZnSO_4$
4. Potassium applied at 50 kg/ha as K_2SO_4
5. Magnesium applied at 30 kg/ha as $MgSO_4$
6. Boron applied at 2.5 kg/ha as Sodium polyborate (Solubor)
7. All nutrients applied above

Treatments were fully randomized in three replications at each site. Fertilizers were applied as water soluble products through a high volume spray boom and thoroughly mixed in prior to planting. It must be emphasized that these treatments were applied as extra to what the growers applied to his crop.

Crop production

Crops were planted, fertilized, irrigated, protected and harvested by the grower using commercial practices. Crop growth was observed and leaf samples (yfel+p) were collected at early flower, washed, dried and analyzed for nitrogen, phosphorus, potassium, calcium, magnesium, boron, copper, iron, and manganese by standard laboratory procedures.

Tuber harvest and quality

Tubers were dug, weighed and graded with commercial harvesters. A 15 kg subsample was collected for specific gravity and internal defect investigation.

The next crop

Crops of peanuts (5), maize (6) and pasture were grown on the potato plots without any treatment fertilizer applied. These crops were grown and harvested commercially. A mobile field weighing bin was used measure plot yields from the harvesters.

The second crop

Growers prepared their ground as normal,and soil samples (0-10cm) were taken and analysed as before (second sampling in figs. 1,2 &3). The same treatments were reapplied as for the potatoes except that extra lime was not added. The second rotational crop (maize 3, peanuts 5, Dolichos lablab 3 and potato 1) was grown and yields measured as before. At two sites (established in 1990) a third rotational crop (one peanut and one maize) was grown following soil sampling and treatment addition.

Statistical analysis

All data were statistically analyzed using ANOVA with F and lsd (P=0.05) discrimination.

Technology transfer

All sites were prominently marked with signs advertising the project and funding bodies. Several media releases were made through local and national papers, journals and radio outlets. Growers were (formally and informally) told of their results and summaries of district experiences were shared. Written reports were presented annually to each grower and subsequent time allowed for discussion of these results and interchange of information in a relaxed group setting.

Results

A summary of soil fertility across the sites and comparing initial samples with later "nil-control" samples (figures 1,2 & 3) indicates that decreases in pH, exchangeable calcium and zinc values were common. Also an increase in phosphorus availability commonly resulted from growers cropping practices.

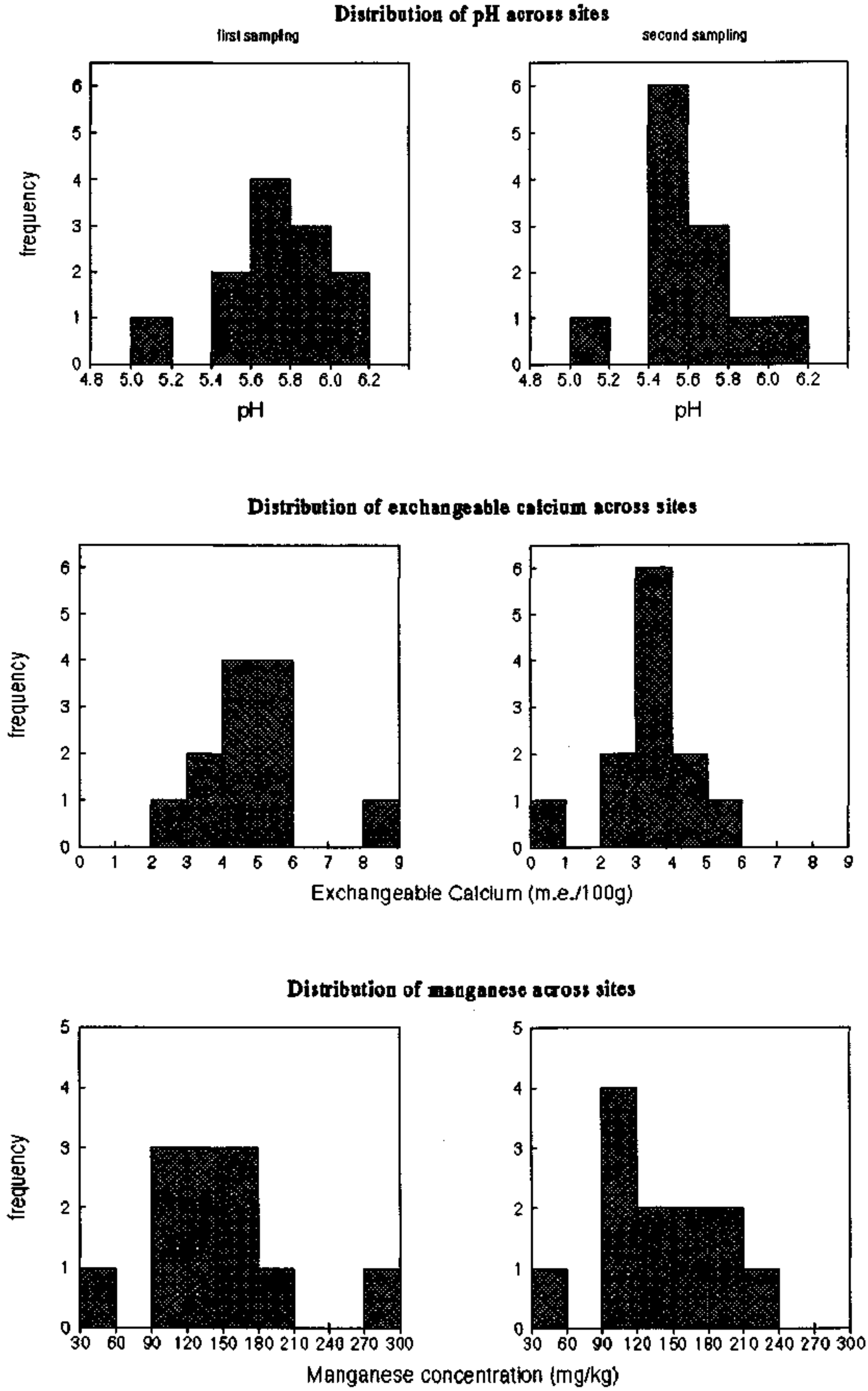

Figure 1. Changes in soil pH, calcium and manganese due to time and cropping practices

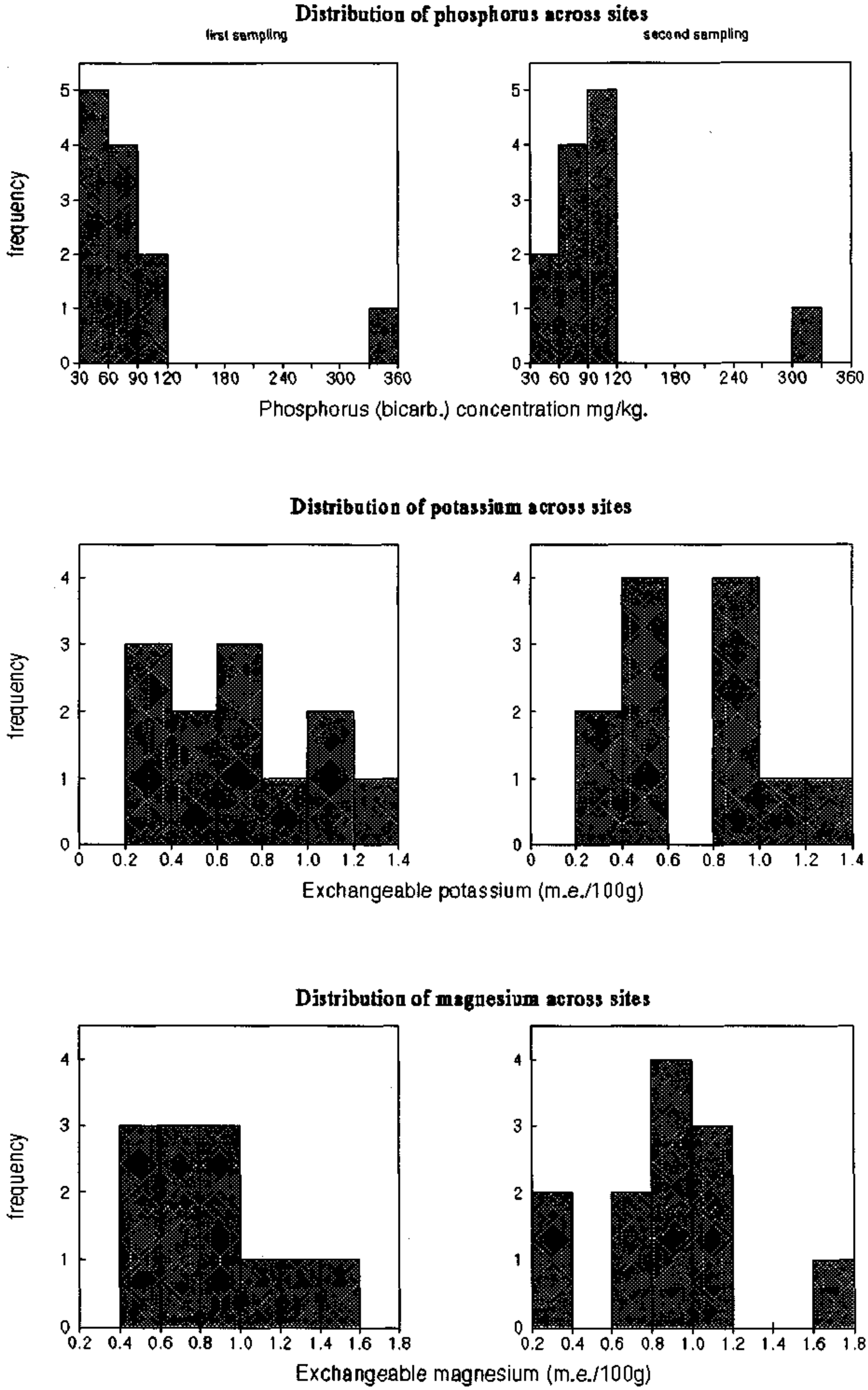

Figure 2. Changes in soil phosphorus, potassium and magnesium due time and cropping practices

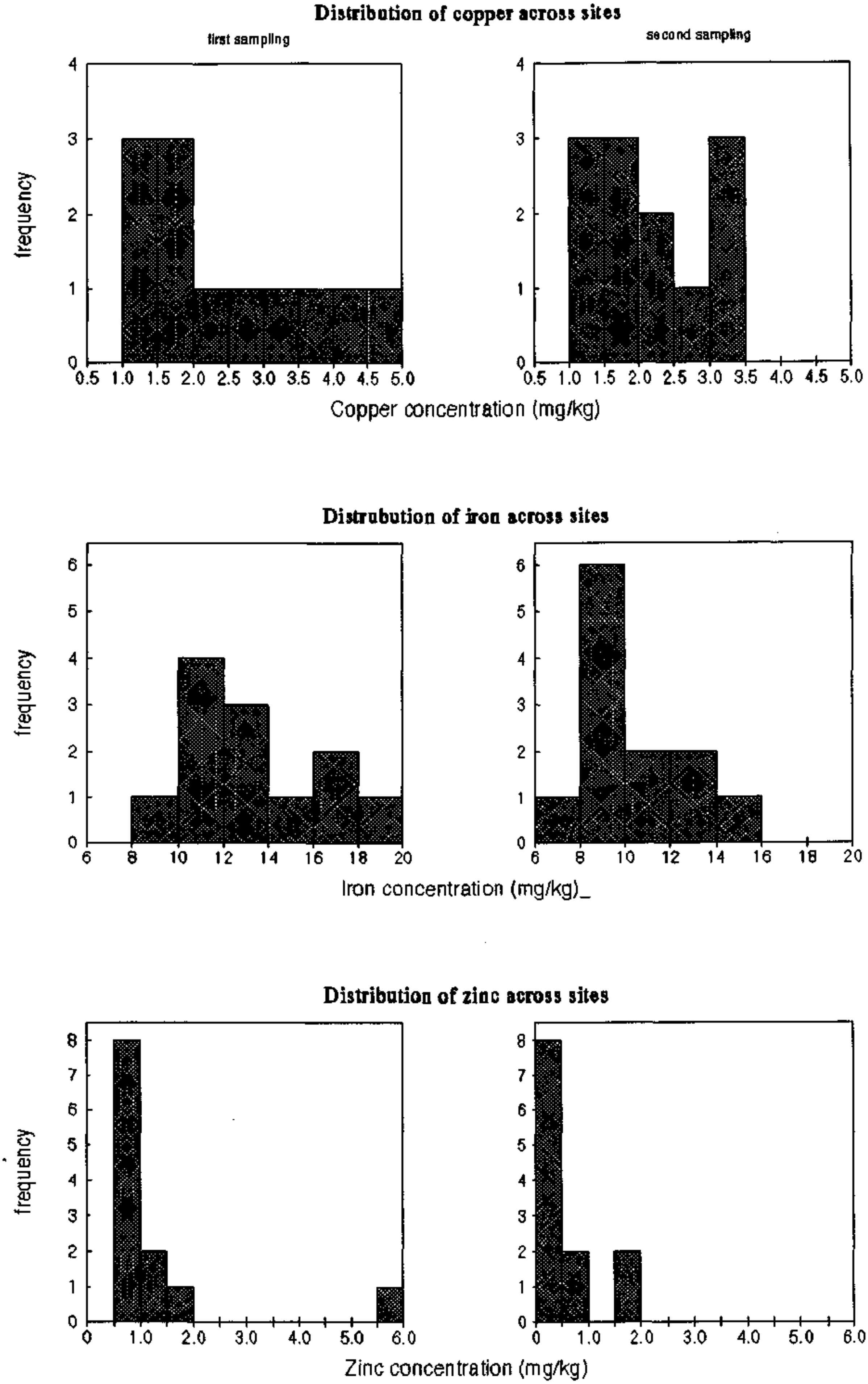

Figure 3. Changes in soil copper, iron and zinc due to time and cropping practices

A summary of growers rotations prior and during this project (Table 1) shows the range of cropping practices and the increased use of green manuring (fodder sorghum) prior to potatoes.

Table 1. Rotations adopted by growers immediately prior to and during the trial period

Site	Previous summer	winter	first summer	second winter	second summer	third winter	third summer
1	forage sorghum	potatoes	maize	fallow	maize	fallow	peanuts
2	forage sorghum	potatoes	peanuts	fallow	maize	fallow	peanuts
3	forage sorghum	potatoes	maize	fallow	peanuts	n.a.	n.a.
4	peanuts	potatoes	maize	fallow	maize	n.a.	n.a.
5	forage sorghum	potatoes	peanuts	fallow	Dolichos	n.a.	n.a.
6	pasture	potatoes	peanuts	fallow	maize	n.a.	n.a.
7	forage sorghum	potatoes	peanuts	fallow	Dolichos	n.a.	n.a.
8	forage sorghum	potatoes	maize	fallow	peanuts	n.a.	n.a.
9	forage sorghum	potatoes	peanuts	triticale	maize	n.a.	n.a.
10	peanuts	potatoes	peanuts	fallow	Dolichos	n.a.	n.a.
11	peanuts	potatoes	maize	graze/fallow	peanuts	n.a.	n.a.
12	pasture	potatoes	cabbage	pasture	pasture	potatoes	n.a.

A summary of fertilizer practices during these cropping practices (Tables 2 & 3) indicates that growers are heavy users of N, P, and K fertilizers on potatoes and maize crops. Little fertilizer is applied to legume crops (peanuts and Dolichos lablab).

Table 2. Summation of fertilizer practices during the crop rotations across sites

Crop	Basal fertilizer type and application rate (kg/ha)				Side dressed fertilizer type and application (kg/ha)			
(number grown)	type *	max.	min.	mean	type	max.	min.	mean
Potatoes (13)	low analysis	2470	2223	2346(2)	urea	247	123	171(11)
	medium analysis	1976	1544	1845(11)	DAP	185	-	(1)
	high analysis	1482	1235	1358(2)	KCL	123	123	123(2)
Maize (10)	di-ammonium P	123	92.5	115(5)	urea	247	93	202(9)
	medium analysis	247	185	216(2)	-	-	-	-
Peanuts (10)	superphosphate	494	247	370(2)	none applied	-	-	-
Dolichos lablab(3)	none applied	-	-	-	none applied	-	-	-
Triticale (1)	none applied	-	-	-	urea	123	-	(1)

** low analysis fertilizer - based on single superphosphate, ammonium sulphate and potassium chloride/sulphate*
medium " " - based on triple superphosphate, ammonium sulphate and potassium chloride/sulphate
high " " - based on di-ammonium phosphate, and potassium chloride/sulphate

Table 3. Mean amount (kg/ha) of nutrient elements applied to cropping systems studied

Crop (number)	Nitrogen	Phosphate	Potassium	Calcium	Magnesium	Sulphate	Trace elements
Potatoes (13)	203	173	146	148	15(2)	152	(2)
Maize (10)	103	14	14(1)	-	-	-	-
Peanuts (10)	-	33(2)	-	78(2)	-	41(2)	(2)
Triticale (1)	57	-	-	-	-	-	-
Dolichos lablab(3)	-	-	-	-	-	-	-

Plant analysis of potatoes (Table 4) showed no areas of deficiency except for some suggestion low values for phosphorus in petiole samples (Maier *et al* 1987).

Table 4. Range of nutrient composition for potato tops (youngest fully expanded leaf plus petiole and petiole alone) and the sufficiency levels* for the twelve sites

nutrient & range	deficient	marginal	adequate	adequate plus	high
Nitrogen % whole tops 5.21 - 6.86	-	-	8	4	-
Phosphorus % " 0.39 - 0.59	-	-	7	5	-
Potassium % " 6.93 - 9.04	-	-	-	3	9
Calcium % " 1.14 - 2.05	-	-	10	1	1
Magnesium % " 0.41 - 0.66	-	-	6	6	-
Manganese mg/kg " 314 - 1492	-	-	-	-	5
Phosphorus % petioles 0.35 - 0.61	2	3	3	2	-
Potassium % " 13.91 - 16.07	-	-	-	1	9

** - Maier et al, 1987 and Reuter & Robinson, 1986*

A summary of potato (Table 5)and subsequent crops yields (Tables 6, 7 & 8) shows the high variability across grower's paddocks and across the region and indicates the few occasions that showed responses to the nutrients applied.

Table 5. Mean yield and range of ware potatoes and treatment significance across sites and years

Site & year	Mean Yield t/ ha	Maximum Yield t/ ha	Minimum Yield t/ ha	Standard Deviation	Significant difference (treat.)
1 - 1990	34.1	40.3	24.2	n.a.	no
2 - 1990	32.9	37.2	25.3	n.a.	no
3 - 1991	23.9	27.2	19.4	2.17	no
4 - 1991	26.2	31.2	20.4	2.55	no
5 - 1991	47.4	52.1	43.7	2.17	no
6 - 1991	27.6	34.1	22.7	2.44	no
7 - 1991	34.2	40.6	28.8	2.97	no
8 - 1991	19.6	22.4	13.3	2.39	no
9 - 1991	35.3	40.4	29.0	3.11	no
10 - 1991	47.1	52.5	39.7	3.07	yes
11 - 1991	35.0	41.9	25.5	4.26	no
12 - 1991	35.1	42.1	25.7	3.29	no
12 - 1993	24.8	30.7	20.9	3.02	no

Table 6. Mean yield and range of maize and treatment significance across sites and years

Site & year	Mean Yield t/ha	Maximum Yield t/ha	Minimum Yield t/ha	Standard Deviation	Significant difference (treat.)
1 - 90/91	5.49	6.08	4.91	0.288	no
1 - 91/92	6.60	8.09	5.33	0.699	no
2 - 91/92	8.96	9.93	7.81	0.460	no
3 - 91/92	4.84	6.00	3.90	0.584	no
4 - 91/92	8.19	8.74	7.36	0.340	yes
8 - 91/92	6.41	7.26	5.55	0.519	no
11 - 91/92	8.66	9.24	7.91	0.342	no
6 - 92/93	6.57	7.88	5.73	0.567	no
9 - 92/93	7.15	8.51	4.60	1.117	no

Table 7. Mean yield and range of peanut (nut-in-shell) and treatment significance across sites and years

Site & year	Mean Yield t/ha	Maximum Yield t/ha	Minimum Yield t/ha	Standard Deviation	Significant difference (treat.)
2 - 90/91	1.89	2.69	1.18	0.368	yes
5 - 91/92	4.02	4.99	3.05	0.568	no
6 - 91/92	5.44	6.48	3.79	0.602	no
7 - 91/92	4.98	5.58	3.95	0.437	no
9 - 91/92	3.99	4.48	3.10	0.387	no
10 - 91/92	5.37	6.02	4.42	0.348	no
1 - 92/93	4.43	5.31	3.09	0.601	no
2 - 92/93	4.21	5.56	3.22	0.574	no
3 - 92/93	4.31	5.02	3.10	0.462	no
8 - 92/93	3.16	3.61	2.44	0.364	no
11 - 92/93	3.91	4.40	3.07	0.370	no

Table 8. Mean yield and range of Dolichos lablab and treatment significance across sites and years

Site & year	Mean Yield t/ha	Maximum Yield t/ha	Minimum Yield t/ha	Standard Deviation	Significant difference (treat.)
5 - 92/93	2.14	2.52	1.92	0.174	no
7 - 92/93	2.21	2.78	1.83	0.245	no
10 - 92/93	3.43	4.20	2.59	0.418	no

Only at three sites did the trials show a significant yield response (Table 9, 10 and 11) to the fertilizers applied.

Table 9. Effect of the residual extra nutrient treatments applied to the preceding potato crop on maize yield (site 4)

Treatment applied	Yield (t/ha)
Lime only	8.43
All extras	8.37
Lime plus zinc	8.34
Boron	8.32
Magnesium	8.27
Nil control	7.93
Potassium	7.67
Trial mean	8.19

LSD (p0.05) - 0.44

The lime and 'all' treatments were significantly better than the nil control.

Table 10. Effect of the residual extra nutrient treatments applied to the preceding potato crop on peanut yield (site 2)

Treatment applied	Yield (nut-in-shell) t/ha
Nil control	2.17
All extras	2.17
Lime only	2.01
Lime plus zinc	1.79
Magnesium	1.72
Potassium	1.72
Boron	1.62
Trial mean	1.89

LSD (p 0.05) - 0.38

Residual nutrients from the addition of magnesium, potassium and boron singly decreased the yield of peanuts. Combined additions (all extras) did not differ from nil control or from lime additions.

Table 11. Effect of the extra nutrient treatments applied to the potato crop yield (site 10)

Treatment applied	Yield ware tubers t/ha
Nil control	48.85
Boron	48.39
Magnesium	47.22
All extras	47.11
Lime only	46.46
Lime plus zinc	46.28
Potassium	45.21
Trial mean	47.07

LSD (p 0.05) - 2.23

Addition of lime or lime plus zinc, as well as potassium reduced the yield of ware potatoes. Single applications of boron or magnesium and combined nutrients (all extras) did not differ from the nil control. This site had a pH of 6.2 before application of lime.

At three sites the added treatments reduced the specific gravity compared to the nil control (Table 12). Extra potassium was responsible at two site while the combination of all treatments was the likely cause at the other.

Table 12. Quality of ware tubers assessed by specific gravity and internal examination

Site No	Variety	Mean Specific Gravity	Any Significant Diff. due to treatment	Result of internal and examination
1	Atlantic	1.095	K Decreased	Hollow Heart *
2	Sebago	1.072	None	Slight fleck *
3	Sebago	1.082	All deceased	No defects detected
4	Sebago	1.084	K decreased	Sample bruised easily
5	Winlock	1.081	None	High percent flecking *
6	Sebago	1.071	None	No defects detected
7	Sebago	1.070	None	No defects detected
8	Sebago	1.074	None	No defects detected
9	Sebago	1.074	None	Slight Hollow heart *
10	Atlantic	1.093	None	Moderate hollow heart *
11	Atlantic	1.088	None	Moderate hollow heart *
12	Sebago	1.078	None	No defects detected

* *these effects were not due to any applied treatments*

Discussion

The weather conditions (particularly rainfall) during the trials has varied widely. For the potato crop 1990 and 1991 were sunnier than usual and the Sebago cultivar reacted adversely to this with lower than average yields. The summer of 90/91 was drier than usual during March and this reduced district yields of maize and peanuts. While in 1991/92 good growing conditions prevailed and above average yields were harvested in all crops. In the summer of 92/93 very dry conditions occurred in late February and all of March (lowest rainfall on record) crop yields suffered accordingly.

Lime incorporation occurred six to eight weeks prior to potato planting. Earlier placement is considered more appropriate in this area but was constrained by the project logistics.

Previous application of lime at sites 1, 3 and 7 reduced the amount of lime spread on treated plots to prevent the likely occurrence of the disease, common scab. This was taken into account during interpretation and may have masked the potential for improvement due to lime addition, although results from comparable sites did not respond to the lime additions.

No incidence of common scab was recorded in treated potato crops.

Incorporation of applied nutrients was considered thorough, though some method for incorporation within the fertilizer band at planting may produce different results, as experienced by Pregno and Armour (1992).

Application of fertilizer to potatoes by growers, in most cases, appeared to be excessively high in nitrogen (Lawrence *et al* 1985). Forty-six percent of growers applied more than 20 kg N/ha above recommended rates. Only one site (11) had less than recommended rates and yields were still well within district average. Subsequent surveys of these growers showed and increasing application in the next potato crop with substantial decrease in the last potato crop. This high rate of nitrogen usage is of concern for both the economic and environmental sustainability of the industry in this district.

Fertilizer applications to summer crops in the rotation are within district recommendations.

The results achieved during this project indicate that addition of extra calcium, potassium, magnesium, boron or zinc above growers current fertilizer practices did not increase yields of potatoes or subsequent rotational crops at the majority of sites. In one case (site 4) the yield of maize was improved by the application of lime. This site had the lowest soil pH (5.0) and is now clearly identified as needing amelioration.

This lack of yield response has been found despite instances of low levels of calcium, zinc and magnesium questioning the appropriateness of the testing or it's interpretation for these tropical soils and/or cultivars. Plant analysis confirmed that no deficiencies for the added nutrients existed in potatoes, and while the treatments did change the chemical composition of the sampled part, this change was not related to yield response and confirms the state of non-deficiency.

The technology transfer aspects of the project were enhanced by 'on-farm, large scale plots' and by involving the growers in both in casual and formal discussion. One indicator of increased grower interest has been demonstrated by the increased strip-testing of fertilizer types and rates by cooperators. This in itself has generated useful discussion focus and suggests that the current emphasis in rural extension methodology addressing adult education in action groups will be of even greater benefit to the development and adoption of better farm management practices. It is into this area that further action is planned.

Conclusions

No extra fertilizer above that already applied by growers is needed to grow potatoes on the Atherton Tableland.

To much fertilizer especially nitrogen is being used for potato production.

More extension activities are needed to integrate fertilizer knowledge within the whole crop production system. These activities should utilize adult education processes.

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