PN-AAW-965
ISN = 49882

A STUDY OF FARMERS INTERCROPPING PRACTICES AND OBJECTIVES, AND THE PERFORMANCE OF MAIZE / CEREAL PATTERNS, IN THE UPPER RIVER DIVISION, 1985.

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March 1986.

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2. PROGRAMME OBJECTIVES AND METHODS

The goal of this study was to develop information on farmers' intercropping practices in Upper River Division (URD) which, together with results from in-country and regional research, would assist in the formulation of appropriate on-station and on-farm experimental programmes in 1986. The programme embarked upon had three components - farm level survey, on-farm experimentation and literature review.

2.1. The Farm Level Survey Component

The farm level survey component consisted of a single shot questionnaire with the objective of identifying which crops are intercropped and the patterns employed in as many locations as possible, and an informal survey to be conducted in villages where on-farm trials were established with the objective of understanding the farmers' reasons for intercropping and the rationale behind their choice of pattern and other relevant management practices.

2.2. The On-Farm Experimentation Component

The on farm experimentation component consisted of a superimposed fertiliser trial (using an adapted demonstration design) on the most important early cereal/late cereal mixtures in two parts of URD. The objective of the on-farm trials were threefold:

- to examine the response of farmer planted intercropping patterns to two positive rates of fertiliser;
- to examine response behaviour over a range of crop ratios and populations;
- to encourage the active participation by farmers in the informal survey work.

Early cereal/late cereal patterns were chosen because Mixed Farming Project were carrying out multilocation trials on maize/legume patterns.

2.3. The Literature Review

The literature review involved a collection of references on intercropping research, both agronomic and socio-economic, which together with the results of in-country research would assist in the identification of potential intercropping technology improvements relevant to Gambian farmers.

3. PROGRAMME IMPLEMENTATION

3.1. Farm Level Survey Component

A formal survey instrument was designed and tested (Appendix A) but for reasons discussed below the on-farm experimental programme soaked up a much larger proportion of time than originally envisaged, preventing widespread use of the questionnaire. A large amount of information on planting patterns and management practices was nevertheless obtained through the on-farm trials by informal discussion and field measurement of crop spacings and populations. This was supported by reconnaissance surveys in Kantora, Fulladu East and Sandu where limited additional field sampling was carried out.

3.2. On Farm Experimentation

In discussion with the Agricultural Assistant (AA) at Mankama Kunda DEC. Mr Mbemba Dahaba, maize/sorghum (sambajabo) was identified as the most common cereal/cereal mixture in the area. At Fatoto DEC Mr Hurri Jallow (AA) indentified maize/late millet as the most common pattern. Both AAs expressed a keen interest in intercropping and the PAO Basse, Mr Tamsir Jagne, agreed that they could collaborate as far as their existing extension duties permitted.

The following superimposed trial design specification was decided on:

Design : Randomised Complete Block

Replications : Two (folded)

Treatments : T1 = 0 fertiliser
T2= half recommended rate for base crop(38-15-15)
T3 = full recomm. rate for base crop (76-30-30)

Plot size : 20m x 20m

Trial size : 40m x 60m

Net plot size: 10m x 10m

Management : Farmer's mangement all practices except fertiliser application.

Fertiliser Management:

1. Basal application: broadcast evenly over the plot immediately prior to land preparation or banded in the row and incorporated as soon as possible after emergence.

2. Top dressing N: banded in the row and incorporated three weeks after planting.

Incorporation to be carried out by farmer using his choice of method under supervision.

The target was to establish 12 - 15 trials in approximately three villages around Fatoto DEC and the same for Mankama Kunda DEC.

The following criteria was established for farmer selection to be carried out by the AAs:

1. the farmer is intending to grow the relevant intercrop;

2. he has a field of approximately half a hectare to which fertiliser has not so far been applied this season;

3. he is genuinely interested in experimentation and not participating solely for the inputs;

4. he is respected by the community and its leadership.

Participating farmers had to agree to the following conditions:

1. the farmer will manage the experiment in the same way as the rest of his fields;

2. the farmer will not apply any fertiliser within the experimental area;

3. the farmer will not remove any green cobs from within the experimental area;

4. the farmer will contact the AA at least 4 days prior to harvest in order that a message can be sent to Sapu;

5. the farmer will allow the removal of a portion of the harvest from the experiment.

In return researchers undertook to provide fertiliser and return all produce to the farmer.

In the event 12 maize/late millet trials and 1 maize/sorghum/late millet trial were established in the Fatoto DEC circle - 4 at Nyamanarr, 4 at Garowal, 3 at Kolikunda and 2 at Kukuyel. One trial was lost because a relative working for the farmer added fertiliser, one never received a top derssing because the farmer was too busy with his shop to incorporate, one farmer harvested the entire trial, one the maize portion and one farmer had a maize crop failure. This left 9 complete trial data sets (including the maize crop failure) and one incomplete (intercrop only).

Due to difficulties in farmer selection only 5 maize/sorghum and 1 maize/sorghum/late millet were established in the Mankama Kunda DEC circle - 2 at Bantakore, 2 at Sare Talata, 1 at Sare Wulem and one at Medina Samba Jawo. One trial failed completely due to lack of weed control, in two trials one of the two crops was harvested by the farmer. This leaves three complete data sets and two incomplete trial data sets.

The implementation absorbed a large proportion of time and fuel because of the wide range in the planting date of maize (25 June to 23 July) which resulted in repeated visits to all locations to ensure that fertiliser basal application and top dressing were as timely as possible. This spread of planting dates was due largely to a 16 day dry spell after just 10 days of rainfall in both the Fatoto area (31 June to 16 July) and Mankama Kunda (28 June to 14 July). Just over half the trial farmers were not able to carry out land preparation until after the dry spell had broken. In some cases the delay was further excerbated by lack of equipment. For those who had been able to plant early basal application could not be carried out until rainfall resumed because the soil was too dry and the plants too small to withstand mechanical incroporation. Apart from absorbing a large proportion of the time earmarked for survey work (basal application was not completed on all trials until end July and top dressing until end August) this event greatly increased the variability in yield data which we had naively hoped would stem primarily from crop ratios and populations.

The remaining time between top dressing and harvest could not be fully utilized for survey work because of a breakdown with the unit's vehicle which remained unavailable until early December, at a time when the two pool vehicles at Sapu were in high demand. Petrol received in mid-September was inadequate to complete harvesting operations and none has been received since.

3.3. Literature Review

A large number of reviews and articles on intercropping research and farmer practice in the West African semi-arid tropics have been collected with assistance from the ODA library in London, but with the plethora of consultancies in seed multiplication and research since January, only a few have been studied in depth. Whilst not relieved of this responsibility a large part of the application of such a review to the design of intercropping research in the coming season has been provided by Professor Willey.

4. FARMERS OBJECTIVES AND PRACTICES IN REGARD TO INTERCROPPING IN URD

Only seven formal questionnaires were completed (see Table 1) and therefore the results can be considered no more than indicative. They are presented, nevertheless, as a springboard for a broader assessment based on information recorded from the 19 co-operator farmers during trial implementation (e.g. time of planting interval between base crop and intercrop) and many informal discussions about the reason for particular practices. In order to assess trends in cropping patterns and the extent of intercropping across the division reconaissance visits were made through Kantora, Fulladu East and Sandu districts. Wulli district was omitted due to lack of time and transportation difficulties but a visit had been made the previous season and was reported on by T. Jagne and D. Boughton.

TABLE 1. FORMAL QUESTIONNAIRE RESPONDENTS BY LOCATION

VILLAGE	DISTRICT	ETHNICITY	TRIAL CO-OPERATOR	TOTAL
Garawol	Kantora	Serahuli	Yes	3
Kulari	Fulladu. E	Serahuli	No	1
Dampha Kunda	"	Jahanka	No	1
Sara Talata	"	Mandinka	No	1
" "	"	Fula	Yes	1
				7

4.1. Cropping Patterns and the Extent of Intercropping

Amongst the seven farming units there was considerable heterogeneity in terms of land allocation priorities but any trends that exist were unlikely to emerge from such a small sample (see Table 2). All units grew maize, late millet, and sorghum which competed equally for first priority in land allocation. Five units grew sorghum, four rice, and two cotton. The three units ranking maize as first or second priority were all Serahuli.

TABLE 2. NUMBER OF QUESTIONNAIRE RESPONDENTS RANKING A GIVEN CROP IN ORDER OF AREA CULTIVATED BY THE FARMING UNIT

C R O P	1	2	3	4	5	TOTAL
Maize	2	1	4	-	-	7
Sorghum	1	1	-	2	1	5
Late Millet	2	1	1	-	2	7
Groundnut	2	2	2	1	-	7
Cotton	-	1	1	-	-	2
Rice	-	1	-	3	-	4

Throughout Kantora and Fulladu East maize was the principal cash crop for Serahuli men. The women cultivate groundnuts, primarily for kitchen use as they are responsible for supplying ingredients to go with the cous, although any surplus is sold for cash at a premium in the parallel market. Consequently confectionary types are grown, the 120 day "tiajango" (three seed nut) and Philippine pink, the former/more common as it avoids clashing with the harvest of maize. This gender division in crop production appears to have spread amongst other ethnic groups although their emphasis on maize is less relative to late millet and sorghum.

Sandu provides an exception to any generalizations that can be made about Fulladu East and Kantora. Once away from the districts eastern border the importance of maize diminishes. In the Fula villages along the border from Darsilami to Naude early millet is grown on a significant scale. West and south of Naude early millet is grown as a significant scale. West and south of Naude, where villages are populated by the Mandinka, it disappears with sorghum and late millet the main cereals. Maize is beginning to expand beyond the backyard areas but sandy infertile soils are a constraint. Groundnut is extensively grown, primarily 28/206 but with considerable admixture of Philippine pink and off-types. Cotton fields are sparse compared to the northern stretch. Throughout Sandu farmers complained bitterly about striga, and red rot was endemic in the sorghum.

With the exception of Sandu district almost every maize field is intercropped, as was the case with our formal survey participants (see Table 3). Between Bansang and Basse the most common intercrop is sorghum (sambajabo) but late millet is common too. East of Basse, late millet is the most common intercrop although sorghum is also found. Occassionally one may find both intercropped with maize in the same field. Cowpea is also intercropped with maize, often as an additional intercrop in maize/late millet fields at a very low density.

TABLE 3. FREQUENCY OF SCALE CROPPING VERSUS INTERCROPPING FOR CROPS GROWN BY QUESTIONNAIRE RESPONDENT FARMING UNITS

CROP	NO. OF FIELDS SOLE CROPPED	(%)	NO OF FIELDS INTERCROPPED	(%)
Maize	0	0	48	100
Groundnut	18	16	96	84
Sorghum	11	61	7	39
Late Millet	20	91	2	9
Rice	2	50	2	50
Cotton	11	100	0	0

Groundnut is frequently intercropped with cereals (late millet or sorghum) and sometimes with cowpea. The latter was particularly common along the border between Sandu and Wulli districts south of Darsilami. Our feeling is that the proportion of groundnut sole cropped is underestimated in the table and a fugure of 50% would be more representative.

Sorghum and late millet are mainly grown in sole stands and a lower proportion of sorghum is intercropped than that indicated by our questionnaiire respondents. Most of the sorghums grown west of Basse appear to be sambajabo types, whereas east of Basse longer duration varieties are predominant. Cotton appears universally sole cropped being a recently introduced and heavily supervised package. Of the two rice fields that were not sole cropped one was a hydromorphic area where maize was intercropped (this case will be discussed below) and the other is an irrigated field where potatoes and okra are grown on the bunds. Given a sample of only four fields nothing can be concluded however.

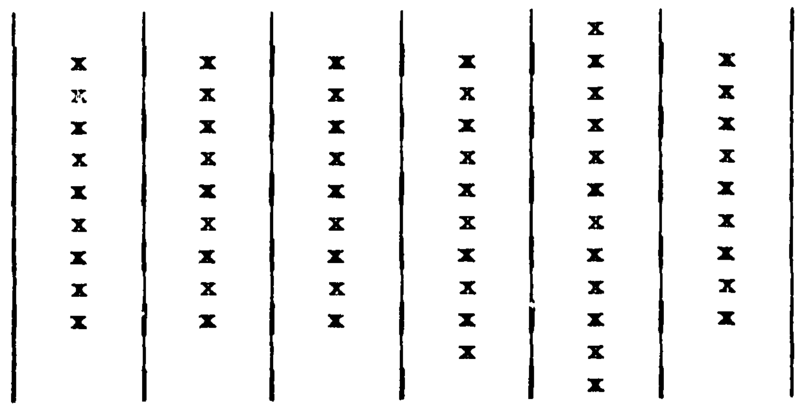
4.2. Systems of Intercropping Developed by URD Farmers

4.2.1. Maize Based Intercropping Systems

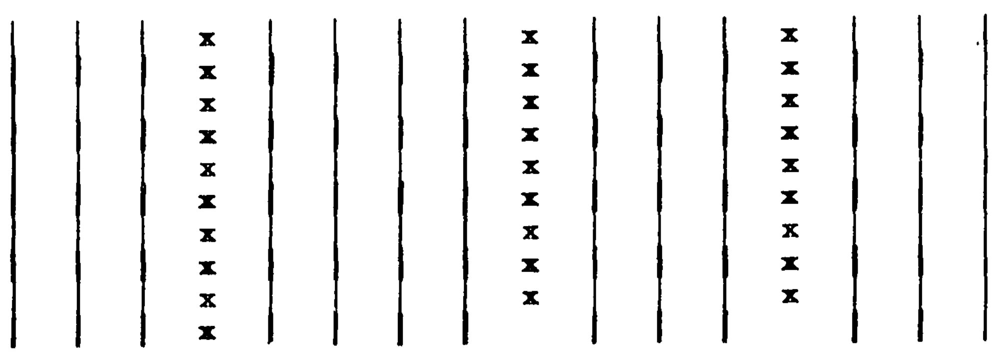
It is difficult to find consistency in planting patterms for maize/late millet intercropping even within a given locality. A distinction can be made between patterns where the two crops are planted in separate rows as opposed to being mixed within the row but farmers rarely argued their particular choice with fervour for its advantages over alternatives. Many did not consider it important to be consistent within the same field, whilst appearing to have desired target proportions of the two crops in mind. Farmers did generally consider, however, that it is better to leave on interval of 7-14 days between planting the maize and late millet, to allow the former to become established. The exception to this practice is when the maize itself is planted late as occassioned by last season's early dry period. Gaps in the maize rows are usually filled by transplanting late millet thinnings. Some examples of maize/late millet patterns are given in Figure 1.

FIG. 1. FARMER PLANTED MAIZE/LATE MILLET INTERCROPPING PATTERNS

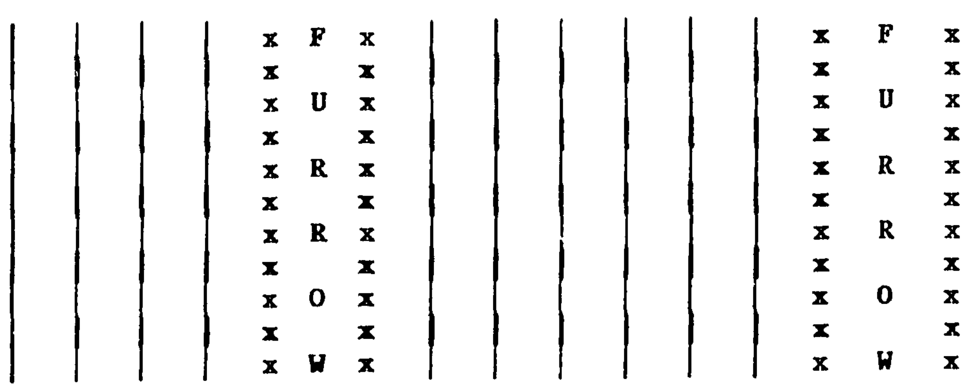
Pattern a: alternating rows of maize and late millet (regular)



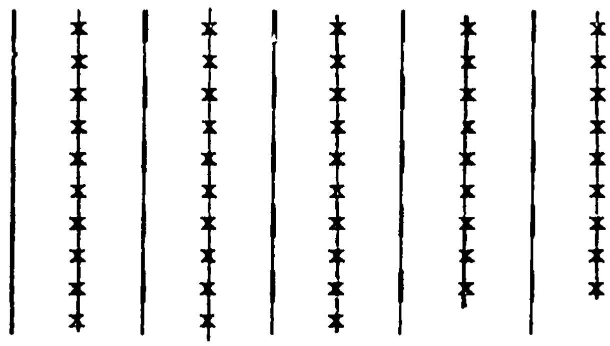
Pattern b: single row of late millet squeezed in between every third and fourth of rourth and fifth maize row (irregular).



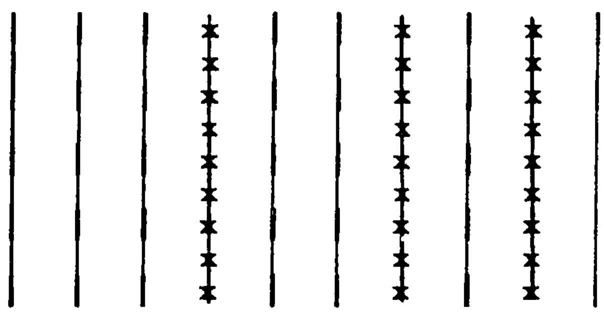
Pattern c: "bed and furrow" system; four to six rows of maize on bed and a row of late millet on either side of the furrow made by the plough.



Pattern d: alternating rows of maize, and maize and late millet mixed within the row (regular).



Pattern e: one to four rows of maize followed by one of maize and late millet mixed within the row (irregular).

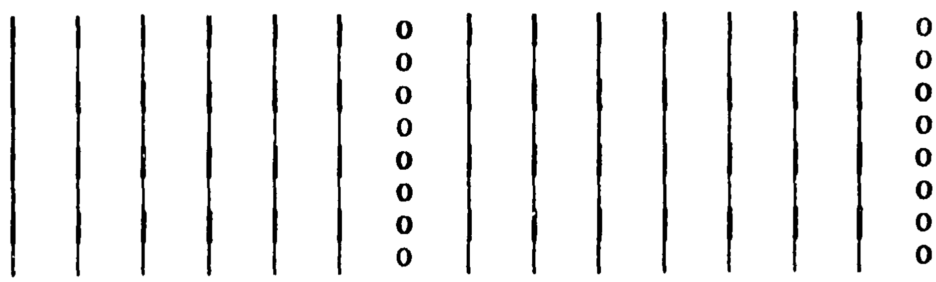


Maize/sorghum intercropping patterns were more consistent with the sorghum (sambajabo) generally confined to rows, and with a higher proportion of maize rows than in maize/late millet patterns. The reason given is that the height of the late millet does not exceed that of maize until after the latter has flowered, whereas the reverse is true of sorghum with more detrimental effects. Keeping the sorghum in its own row, with a greater distance between rows, helps overcome this disadvantage. It was suprising, in view of this reasoning, that only about half the farmers with whom the practice was discussed favored a time of planting interval. However, the main reason given for prefering sambajabo to a late millet intercrop was the shortness of the growing season and this may dissuade farmers from leaving an interval despite the advantage it would give the maize. If the shading story is correct there is an obvious implication for choice of variety in maize/sorghum patterns, although the characteristic of resistance to bird damage afforded sambajabo by its drooping head is important in view of the lower savings in grain yield to birdscaring activities for the intercrop, as opposed to fields with sole stands, once the maize has been removed. The practice of gap filling the maize rows with thinnings from the intercrop was equally as prevalent for maize sorghum patterns as for maize/late millet. Some examples of maize/sorghum patterns are given in Figure 2.

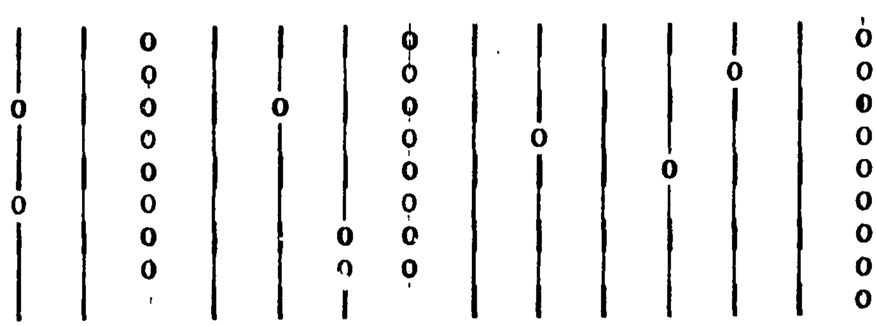
FIG. 2

FARMERS PLANTED MAIZE/SORGHUM INTERCROPPING PATTERNS

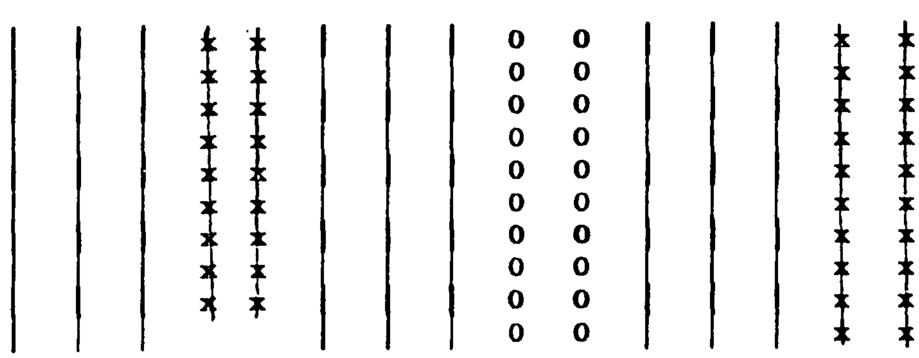
Pattern a: six to eight rows of maize followed by one of sambajabo (irregular)



Pattern b: four to eight rows of maize followed by one of sambajabo . (irregular), and gap filling.



Pattern c: three rows of maize followed by two rows of maize and late millet mixed within the row followed by three rows of maize followed by two rows of sambabajabo (regular).



One important feature of farmers' intercropping patterns that we neglected to study rigorously was choice of maize variety. Certainly cultivars resembling NCB were seen, but many farmers were growing varieties that can be harvested in 60-70 days. This was particularly true of farmers planting maize/sorghum patterns in the Mankama Kunda area, where the maize was sought primarily to bring an end to the hungry gap rather than for sale. It would certainly seem a reasonable hypothesis that farmers growing maize in intercropping patterns primarily for food are likely to choose short duration varieties, and that farmers growing maize primarily as a cash crop (as the Serahuli do) are likely to choose the longer duration fertiliser responsive NCB: but it must be far more rigorously tested than our all too casual observations permit.

A striking feature of maize based intercropping patterns is the low populations relative to that recommended by the Department of Agriculture. From Table 4 it will be seen that maize populations ranged from 11400 to 28750 plants/hectare (mean 19200) compared with a recommended density of 53300/hectare. Only a small part of this difference is likely to be accounted for by plant mortality (the farmers populations are based on harvest counts). In a sub sample of three farms plant mortality from first weeding to harvest was just under 5%. Maize populations at harvest in maize/late millet trials averaged only 36% of the recommended planting density, and in maize/sorghum trials only 38%. Although we have not yet made a complete analysis for each type of pattern the difference appears to arise more from within row spacings than between row. We need to carry out a follow up study to find out whether farmers deliberately plant a reduced stand (e.g. by blocking up holes in in the seeder plate) or whether poor germination is the cause (bearing in mind the dry period at the beginning of the season).

Late millet intercrop populations averaged 66% of the researchers guideline (there being no firm recommendation). It should be noted though that whereas researchers use a spacing of 90cm x 90cm (giving approximately 12350 hills/hectare) thinned to 3-4 plants/hill, farmers averaged only 4800 hills per hectare but harvested 6 panicles/hill. None of the trial farmers considered it necessary to thin their late millet, except in conjunction with transplanting in order to fill gaps in the maize. Sorghum intercrop populations were very similar to late millet but because of the higher recommended planting density (88900 plants/hectare) these represent correspondingly lower proportions of a sole stand.

Combined proportions (which represent a parallel measure to the Land Equivalent Ratio in population terms) are lower than one would expect if competition is to be optimal, averaging 1.04 for maize/late millet and only 0.73 for maize/sorghum, assuming recommended populations are well founded.

TABLE 4a. SUMMARY OF PLANT POPULATIONS PER HECTARE AT HARVEST AND PROPORTIONS OF SOLE CROP RECOMMENDATION FOR FARMER PLANTED MAIZE/LATE MILLET INTERCROPPING PATTERNS

C R O P	n 1/	POPULATION / HA			PROPORTION		
		LOW	HIGH	MEAN	LOW	HIGH	MEAN
Maize	6	11400	28750	19200	0.21	0.54	0.36
Late Millet 2/	9	16517	43400	28800	0.38	1.0	0.66
Combined	6				0.82	1.52	1.04

1/ n refers to number of farms. Each value presented is the mean of 6 plots (three treatments x two replications

2/ Late millet populations and proportions are based on the number of panicles.

TABLE 4b. SUMMARY OF PLANT POPULATIONS PER HECTARE AT HARVEST AND PROPORTIONS OF SOLE CROP RECOMMENDATIONS FOR FARMER PLANTED MAIZE/SORGHUM INTERCROPPING TRIALS

C R O P	n 1	POPULATION / HA			PROPORTION		
		LOW	HIGH	MEAN	LOW	HIGH	MEAN
Maize	3	14700	24000	20050	0.28	0.45	0.38
Sorghum	5	11583	39650	26100	0.13	0.45	0.29
Combined	3				0.58	3/ 0.89	0.73

3/ This high was attained by the inclusion of an additional intercrop, late millet, at a density of 15000 plants/hectare unthinned.

Little information, regrettably, was obtained on fertilization practices. From observation farmers effectively use what they can obtain when they can obtain it. For the majority of farmers in Garowal this meant applying compound fertiliser at the end of August although some who had kept urea back from last season boradcast it after first weeding. Few had grasped the importance of incorporating fertiliser or earthing up maize, considering it an unnecessary additional effort. In discussion, however, they responded favourably to the idea of applying fertiliser immediately prior to weeding in order to achieve two objectives at once. The more enthusiastic farmers who earthed up maize in trial plots at our request often continued the practice in the rest of their field. In Suduwol farmers were purchasing KCL in 25 kg bags at D6.25 per bag and broadcasting it on their fields. Another input frequently obtained from Senegal was pre-emergence herbicide for cotton (Igran Combi Mix) which when applied to maize/late millet fields appeared to have a severely detrimental effect on the germination of late millet. Only one farmer was found to observe a different fertiliser regine for the base and intercrop, although there are probably many more. He was applying and incorporating urea along late millet rows in the early vegetative phase, and was intending to save some for the maize to be applied at cob formation.

4.2.2. Groundnut Based Cropping Systems

Although intercropping of groundnut, primarily with late millet or sorghum, is very common it is usually practised in an unsystematic manner with a view to obtaining a small bonus without reducing the yield of groundnut. Where a system is followed two methods of planting can be distinguished. In the first the occassional row of intercrop is squeezed into a full stand of groundnut. In the second, row space is deliberately left for planting the intercrop after the groundnut is completed. In both situations the intercrop is planted at a low density. One row to every six to nine rows of groundnut is usual in the first case, two rows to every eight to twelve rows of groundnut in the latter, almost always using the same between row spacing for the cereal intercrop as for the groundnut. Although far less common than a cereal intercrop cowepea is nonetheless frequently used as well. Invariably it is planted at a low density due to the high cost of seed (D1.00 for a small tomato tin). One factor which facilitates the use of cowpea is that most farmers will have a groundnut field far enough away from the village so that domestic animals won't eat it, and not so far away that wild animals will pose a problem. Maize, on the other hand, is generally grown close to the compound because apart from soil fertility considerations monkeys can be a major pest. Most farmers prefer to grow cowpea with either groundnut or maize rather than sorghum or late millet. Not only do they consider it performs less well intercropped with longer duration cereals but it is impossible to avoid damaging the cowpea when harvesting it.

4.2.3. Sorghum Based Cropping Systems

The very few cases encountered were all sambajabo/late millet with four to 5 rows of sambajabo followed by one of late millet. No investigations were carried out apart from noting its existance.

4.2.4. Rice Based Cropping Systems

Although only one example was encountered we felt it worth reporting. Male farmers at Kulari have integrated upland cereals into a recently cleared hydromorphic toposequence. On the higher evelations maize is grown intercropped with sorghum. Further down early maturing rice is grown in rows 50 cm apart with maize squeezed in after every second or third row. In the lowest elevations, where flooding can be expected, a four month duration rice variety is sole cropped. The level of flooding caught farmers by surprise this year, with between 30 cm and 40 cm of standing water where last year soils were parched and yields down to a tenth of what had been hoped for. In response to this farmers' simply uprooted the maize to allow the rice more light.

Nevertheless the practice of intercropping rice and maize in the middle elevation is neatly adapted to the likely range in height of the water table between seasons. In a wetter year the rice will do well, in a drier one the maize. Even this year Kulari farmers fared better than other villages who abandoned rice altogether in favor of sole upland crops on swamp fringes and suffered a total loss.

The land where this pattern was growing had been ploughed using oxen or horses after the first rains and both the rice and the maize had been sown by seeder. Areas expected to flood were cleared and sown to sole crop rice by hand before the rains. During the season the men devoted the mornings to their upland fields and in the evening came to the hydromorphic area. This was their third year of experience with animal traction on riceland, and with the rice/maize intercropping pattern.

4.2.5. Cotton Based Cropping Systems?

Although, no doubt to the relief of the cotton project, no examples of intercropping were found, it might be prudent for researchers to keep a foot in the door. Cowpea prices frequently rise to over D5000/ton in the lumos. Would it not be worthwhile to try out an erect, photoperiod insentive cultivar (say 90 days), which could be grown between alternate pairs of cotton rows, thus benefitting from the spraying regime already in use?

4.3. Farmers Objectives with Special Reference to Maize Based Cropping Systems

The two reasons for intercropping maize, given over and over by farmers, were yield stability and additional benefit.

Farmers well know the sensitivity of maize to drought, but also that it's short duration enables it to escape an early end to the rains. Late millet on the other hand, while vulnerable to a shortened growing season, is very tolerant to drought in the early stages. Thus, the farmers reason, if one crop suffers something will nevertheless be reaped from the other. The practice is employed essentially as an insurance policy against very poor returns to the land and labor invested. The more articulate farmers go further still, claiming that the presence of late millet in a maize crop reduces the rate at which moisture is lost from the soil during a dry spell.

The importance of an additional benefit, or bonus, which underlies the practice of intercropping groundnut in particular, was frequently associated with comments on increasing land scarcity. In Nyanamarr, on the southern border of Kantora, a number of farmers are renting fields in Senegal despite the acknowledged outmigration of youth. Around Basse, farmers attribute growing land scarcity to the increasing number of civil servants who cultivate fields. In Sare Wulem, near Mankama Kunda, farmers claim the Forestry Department are preventing them from clearing land which for generations has formed part of a long term rotation.

In the light of our discussions with farmers, and the trial results to be presented in the next section, we would like to hypothesise an additional reason, which is in some respect a development of both the above. Many farmers want to expand their production of maize but their sandy soils, frequently striga infested, cannot support a sole maize crop. Neither can they count with any degree of confidence or obtaining sufficient quantities of fertiliser at the right time. Maize based intercropping patterns, particularly where late millet is the intercrop, permit a modest increase in the production of maize while still providing an adequate overall return to land and labor by virtue of the millet yield.

1. Introduction and acknowledgements.

This study was requested by the Agricultural Research Advisory Board at its meeting in Jenoi, April 1985. The objective was to investigate farmers' existing intercropping practices with a view to assisting in the design of relevant on and off-station experimental programmes. For logistical reasons the decision was taken to focus on Upper River Division where intercropping was known to be prevalent. Subsequently it was thought important not only to document farmers' practices, and their reasons, but also to evaluate their performance. Hence a farmer managed experimental component was added. We do not discuss the body of knowledge on the advantages of intercropping (whether biological or economic) as this is well documented elsewhere (for example Fussell and Serafini 1985, Willey 1979, Norman 1974).

We would like to thank our colleagues in the extension service who collaborated in this study – Mbemba Dahaba (AA Mankama Kunda DEC), Hurri Jallow (formerly AA at Fatoto DEC), and Tamsir Jagne (PAO Basse). Much hard work was put into the on-farm trials by Sapu upland agronomy staff – Cherno Bojang, Momodu Nyang, and Modu Faye. Thanks are due to Ramesh Singh of Action Aid and Jens Kristenssen, FAO Fertiliser Project for advice on analysis. Last but not least Alison Boughton put in many hours on the calculator without once threatening one of the authors with divorce.

C19. How many days seed to harvest for base crop?: ________________

20. How many days seed to harvest for intercrops?: ________________

D1. What does the farmer consider to be the advantages of the intercropping pattern documented in section C? Explore the reasons for these advantages with the farmer. Try to pinpoint and rank his motives for doing it.

D2. What does the farmer consider to be the dis-advantages of this pattern?

D3. Does the farmer perceive any advantages/dis-advantages from changing the ratio of the base crop and intercrops?

D4. For how many years has the farmer been using this intercropping system?

C. For one of the more important intercropping patterns for which there is a nearby field, record the following information. Indicate the relevant field on the B2 form.

1. Field area (measured if possible): ______________
2. Distance from compound: ______________
3. Base crop: ______________ 4. Intercrops: ______________
5. For which crops is seed dressing used?: ______________
6. TOP interval: ______________
7. Method of planting base crop: ______________
8. Method of planting intercrops: ______________
9. Illustrate arrangement of plants in the field:

10. Number of rows in 10m strip (three estimates using measuring tape)

    S1: ______ S2: ______ S3: ______

11. Number of plants in 5m strip (four estimates using measuring tape)

    S1: ______ S2: ______ S3: ______ S4: ______

12. Was thinning carried out for base crop?: ______________
13. Was thinning carried out for intercrops?: ______________
14. Number of plants per hill for base crop (25 stations): ______________
15. Number of plants per hill for intercrops (25 stations): ______________
16. Was farm yard manure applied to the field this year?: ______________
17. Did the farmer make a first application of fertiliser?: ______________

    Type applied: ______________ Quantity applied: ______________

    Time applied (DAP): ______________ Incorporated?: ______________

18. Did the farmer apply a top dressing of fertiliser?: ______________

    Type applied: ______________ Quantity applied: ______________

CROP	No.	AREA	Dis.	INTERCROPS	PLANTING SYSTEM	SSP	CPD	UREA	

SURVEY OF INTERCROPPING PRACTICES IN UPPER RIVER DIVISION, THE GAMBIA, 1985.

Agronomy and Farming Systems Unit, Sapu.

Enumerator: ________________ Date: __________

A.1. Name: ________________ 2. Sex: ______ 3. Age: ___ 4. Ethnicity: __________

5. Village: ______________ 6. District: ______________ 7. D.E.C.: ____________

8. Status: ______________________________ 9. Co-op (if a mem.): ______________

B.1. List crops grown by dabada (or compound if not divided into farming units) in order of land area allocated.

CROP	Number of fields.
(i)	
(ii)	
(iii)	
(iv)	
(v)	
(vi)	
(vii)	
(viii)	

Note: Be careful to note whether the dabada has access to rainfed or irrigated riceland, and whether or not it is utilised. Reasons for non-utilisation may be noted below.

B.2. For each field of each crop note on the accompanying sheet the area (if known), the distance from the compound (backyard, near to the village, far away), intercrops and planting system (if any), and fertiliser applied. ANY ABBREVIATIONS USED ON THE FORM CAN BE LISTED BELOW FOR EASE OF ANALYSIS.

5. Agro-economic analysis of farmer managed intercropping trials.

5.1 Maize / late millet intercropping trials

As stated in section 3·2 nine out of twelve maize / late millet trials were harvested, including one where the maize failed completely. Eight are analysed here , as the trial with both sorghum and late millet intercrops is included in the next section because sorghum proved the more important of the two. To recap, two fertiliser rates (corresponding to the half and full sole maize recommended application rates) and a zero control were superimposed onto farmer planted intercropping patterns. The yield and yield component data exhibit a high level of variability due to differences between sites in both the physical environment and management (planting patterns, base crop and intercrop populations, time of planting etc.). The wide variation in planting dates occasioned by the early dry spell, (reflected in the rainfall distribution shown in figure 3) also resulted in varying time of basal application and top dressing.

Yield data for the maize base crop, the late millet intercrop and the total yield are presented in table 5. Combined analysis of variance was carried out separately for each. From table 6 it can be seen that there are highly significant differences between sites in every one. Treatment differences are highly significant only for the combined yields, significant at 5% for late millet and insignificant for maize. No significant site by treatment interactions are revealed.

Yield response for the base crop and intercrop are represented graphically in figure 5, and for the combined total in figure 6. The solid line joins the mean values for each fertiliser level, whilst the dotted lines indicate the range in values. In both crops the mean response is small but the behaviour between fertiliser levels quite different. Whereas in maize there is a much larger response between the half and the full rate compared to the zero and half, the reverse is true for late millet where yields were slightly lower on average at the full rate compared to the half. These opposite trends result in a much more even response between levels for the combined yield. The proportion of total yield accounted for by maize at different fertiliser levels reflects the response behaviour of the two crops. With no additional fertiliser 44% of total yield is accounted for by maize, averaged for all farms. At half rate, where millet accounts for most of the combined response,

Fig. 3. 1985 WET SEASON RAINFALL AT TEN DAY INTERVALS FOR FATOTO DEC. MANKAMA KUNDA DEC. AND BASSE (mm)

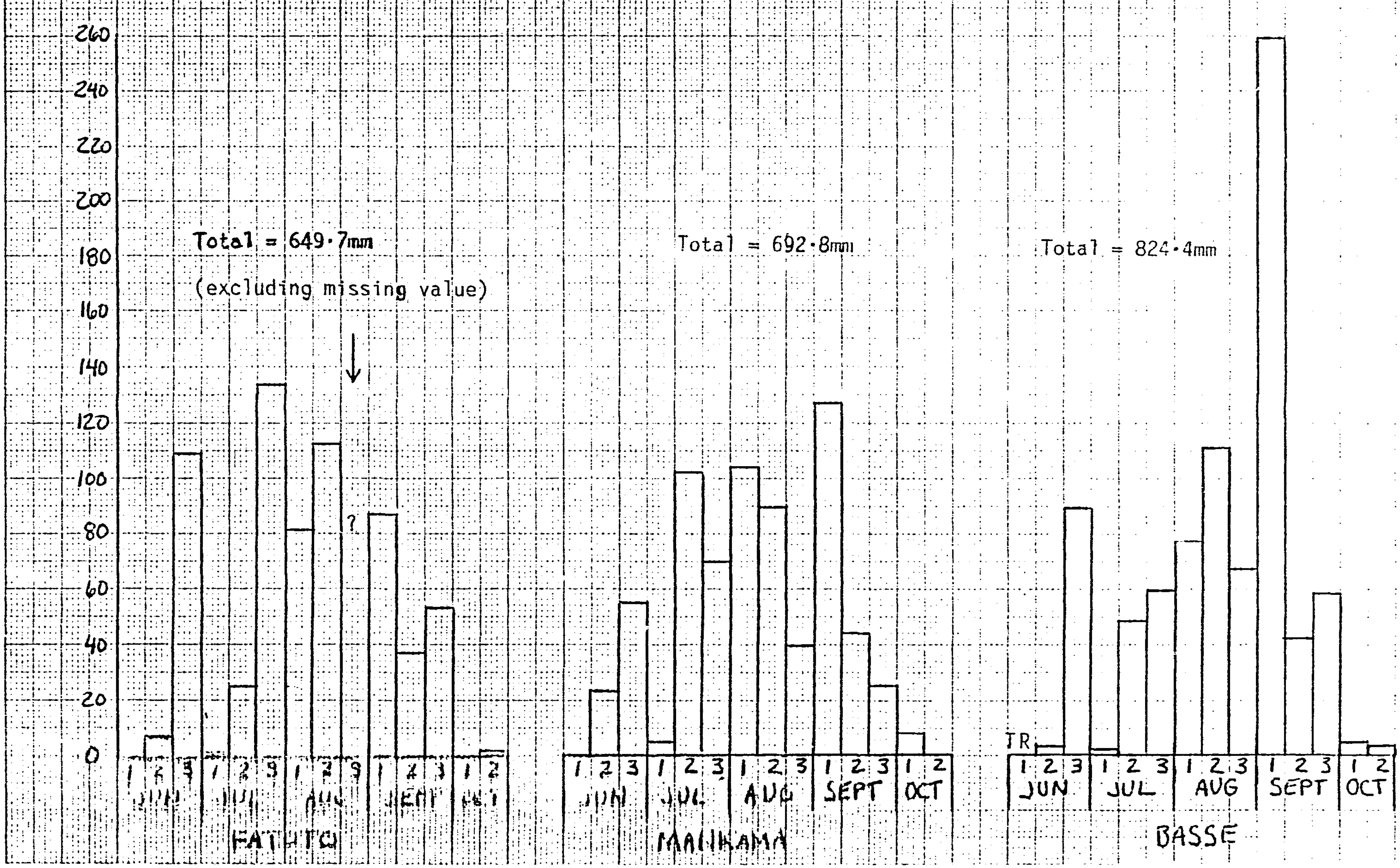


Table 5. Yield data for maize, late millet and combined total from eight trials in Upper River Division (Kg / Ha)

5.1. MAIZE (base crop)

TREATMENT	LOW	HIGH	MEAN	CV	EFFECT
0 - 0 - 0	0	1080	403	93%	
38-15-15	0	1290	454	105%	+51
76-30-30	0	1420	618	91%	+215

$LSD_{.10}$ = 216 Kg

5.2. LATE MILLET (intercrop)

TREATMENT	LOW	HIGH	MEAN	CV	EFFECT
0 - 0 - 0	260	890	440	48%	
38-15-15	350	1270	625	47%	+185
76-30-30	200	900	544	48%	+104

$LSD_{.05}$ = 193 Kg $LSD_{.10}$ = 158 Kg

5.3. COMBINED TOTAL

TREATMENT	LOW	HIGH	MEAN	CV	EFFECT
0 - 0 - 0	340	1480	843	45%	
38-15-15	500	1830	1079	45%	+236
76-30-30	600	2000	1161	44%	+319

$LSD_{.05}$ = 228 Kg $LSD_{.10}$ = 187 Kg

Table 6 FINAL COMBINED ANOVA TABLE

MAIZE / LATE MILLET INTERCROPPING TRIAL YIELDS

MAIZE	df	SS	MS	F ratio
Sites	7	821·16	117·31	19·52**
Reps. within sites	8	38·98	4·8725	1·01^{ns}
Treatments	2	40·355	20·1775	3·3579^{ns}
Site x Treatments	14	84·125	6·0089	1·25^{ns}
Residual	16	77·6	4·825	

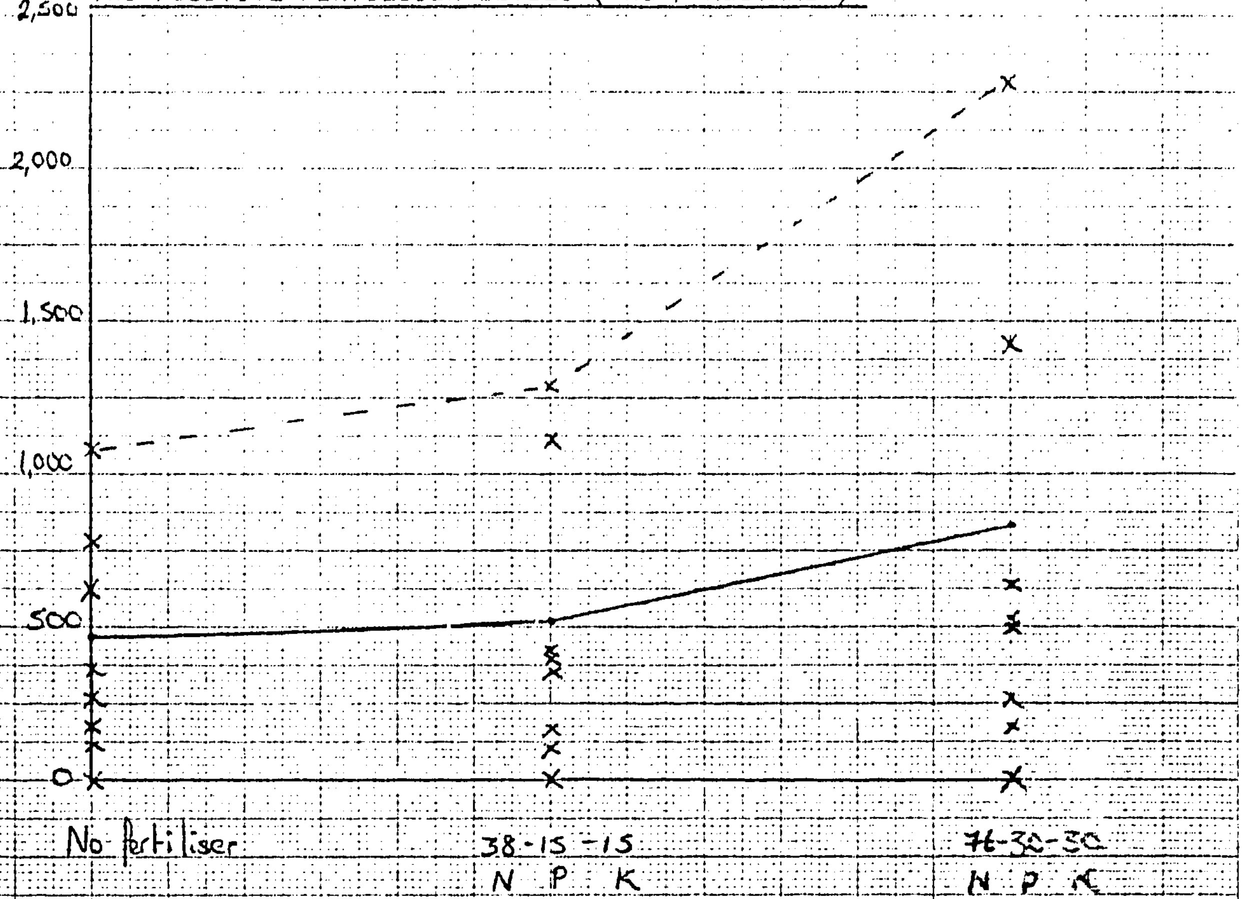
LATE MILLET	df	SS	MS	F ratio
Sites	7	209·17	29·88	9·26**
Reps within sites	3	10·16	1·27	0·52^{ns}
Treatments	2	27·515	13·7575	4·26*
Site x treatments	14	45·175	3·2268	1·315^{ns}
Residual	16	39·27	2·4544	

COMBINED TOTAL	df	SS	MS	F ratio
Sites	7	777·13	111·02	24·63**
Reps. within sites	8	18·11	2·2638	0·407^{ns}
Treatments	2	87·585	43·7925	9·714**
Site x Treatments	14	63·115	4·5082	1·232^{ns}
Residual	16	88·89	5·5556	

** Significant at 1% * Significant at 5%

Note: because the treatments F ratio for maize is close to that required for significance at 5% (F=3·74) the LSD at 10% is included in Table 5 for indicative purposes.

Fig. 5a MAIZE YIELDS IN MAIZE/LATE MILLET INTERCROPPING TRIALS AT ZERO AND TWO POSITIVE FERTILISER LEVELS (KG / HECTARE)



~~Fig. 5b LATE MILLET YIELDS IN MAIZE / LATE MILLET INTERCROPPING TRIALS AT~~ ZERO AND TWO POSITIVE FERTILISER LEVELS (KG / HECTARE)

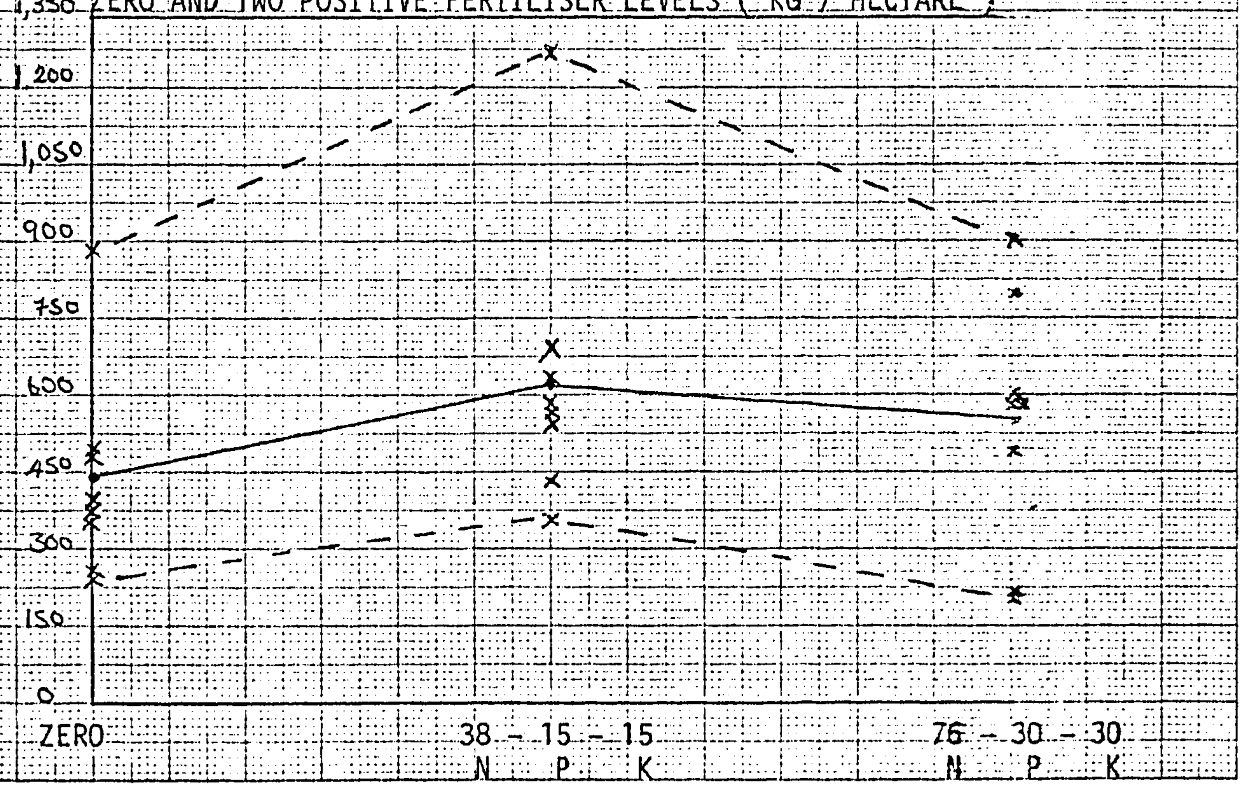
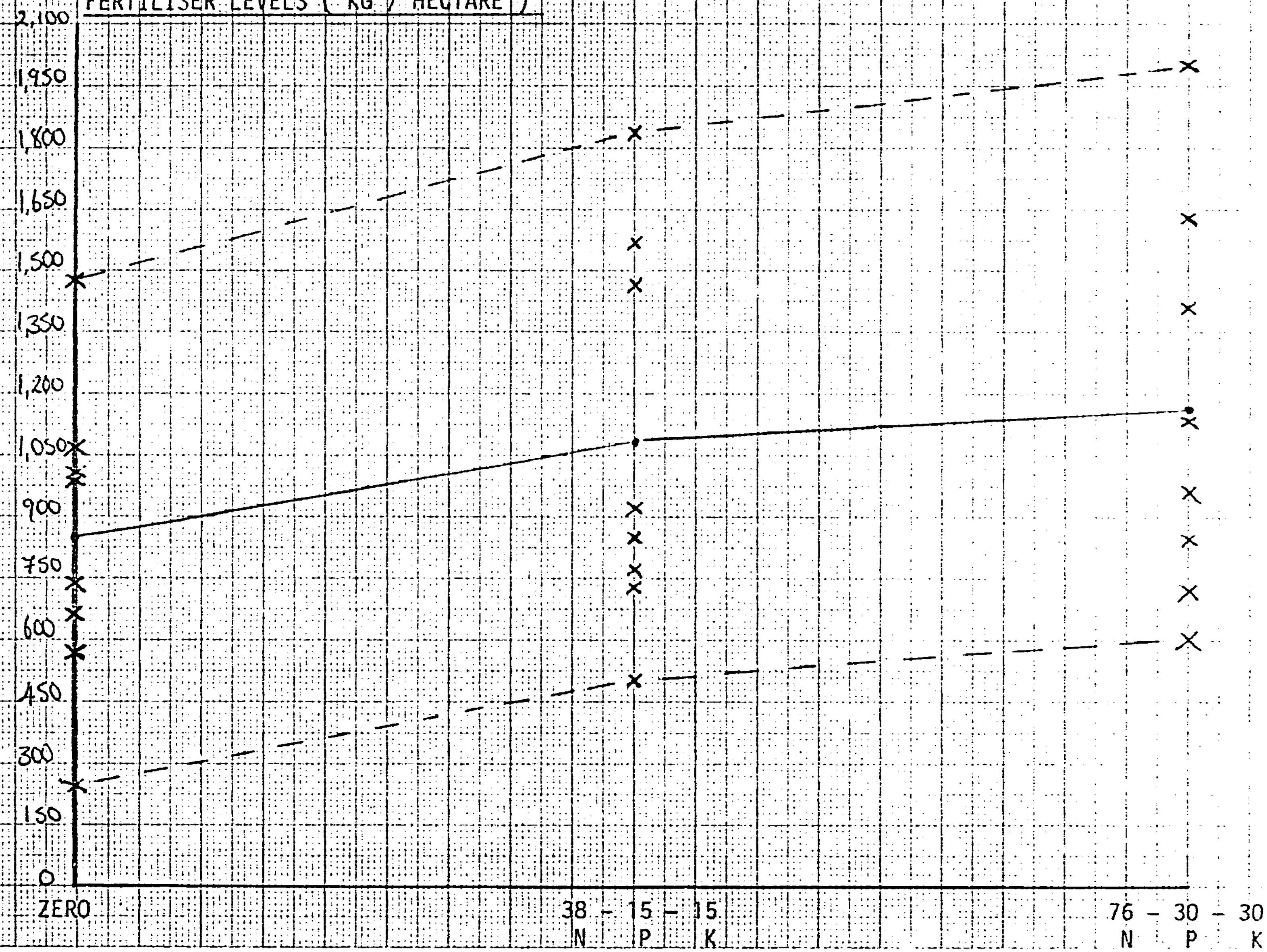


Fig.6 TOTAL YIELDS IN MAIZE / LATE MILLET INTERCROPPING TRIALS AT ZERO AND TWO POSITIVE FERTILISER LEVELS (KG / HECTARE)



39% is accounted for by maize. This value rises to 52% at the full rate, where the yield response of maize is greater and in the case of late millet is negative.

In order to understand the yield response of the base crop and intercrop an analysis of yield components was carried out. Yield component data for maize/late millet trials are presented in table 7 where the principal components (those which when multiplied together equal the grain yield) are identified by capital letters. The numbers of hills, plants, cobs or panicles, and the weight of dry cobs (or panicles) and grain were all directly measured at harvest, whilst other values e.g. weight per panicle, were calculated from them. Plant counts for late millet were not taken at harvest because of the near impossibility of distinguishing main stems from tillers. Directly measured values are per net plot (100m^2). Mean values and ranges relate to the number of replications in the "n" column for the corresponding row. Given the number of measurements and the physical difficulties in carrying them out, error is unavoidable. Therefore for each crop we state the difference between grain weight calculated from yield components and grain weight obtained by direct measurement, as a percentage of the latter, to indicate the degree of measurement error.

The small increase in mean maize yields from zero to half rate appears due to the fact that increases in the number of cobs, and the grain weight to cob weight ratio, were largely offset by a fall in the weight per cob of 21%. The much larger increase in maize grain yields between the half and full fertiliser rates (36%) arose because further increases in both the number of cobs and grain weight to cob weight ratio were not offset in this way, weight per cob actually registering a small increase as well. Grain weights calculated from principal yield components differed from the direct measurement by +10%, -4%, and -5% at the zero, half, and full fertiliser rate respectively.

The relatively large increase of 46% in late millet grain yields between the zero and half fertiliser rate is due to increases in weight per panicle, number of panicles and grain to panicle weight ratio (21%, 14·5% and 8% respectively). The small decrease in late millet yields at the full fertiliser rate was almost entirely due to a fall in weight per panicle of 8%. It has been suggested that a higher level of bird damage on full rate plots may have been partially responsible. We cannot draw any conclusions about this but

Table 7 MAIZE YIELD COMPONENT VALUES FROM MAIZE/LATE MILLET INTERCROPPING TRIALS

		NO FERTILISER			38 – 15 – 15				76 – 30 – 30			
	n	Range	x	s.d.	Range	x	s.d.	%±	Range	x	s.d.	%±
hills / net plot	12	68 – 195	144	63·4	67 – 227	129	51·4	–10·5	51 – 235	124	58·8	–4·3
plants / net plot	12	87 – 270	196	52·2	88 – 298	192	76·9	–2·2	67 – 340	189	84·6	–1·6
plants / hill	12	0·7 – 2·4	1·5	0·43	1·1 – 2·1	1·5	0·33	0	1·2 – 2·1	1.6	0·26	+4·0
COBS / NET PLOT	14	22 – 186	97	54·4	21 – 247	107	72·9	+9·5	38 – 207	123.3	50.3	+15·8
cobs / plant	12	0·13–0·92	0.5	0.24	0.18 –1·54	0·64	0·34	+28·2	0·3–1·18	0·73	0·25	+12·8
cob weight / net plot	12	0·6 – 22·4	7·28	7·45	1·2 – 26·6	7·1	8·36	–2·5	1·6–21·8	8·27	7·0	+16·4
WEIGHT PER COB (g)	12	8·1–209·1	81·5	64·1	34 –133·3	64·4	32·5	–20·0	39·6–123·9	68.1	34.9	+5.7
GRAIN : COB WEIGHT	12	0·27–0·78	0·56	0·18	0·39–0·79	0·63	0·10	+11·7	0·55–0·79	0·70	0·08	+12·3
GRAIN / NET PLOT (Kg)	14	0·2–11·8	4·03	3·72	0·8–13·0	4·54	4·76	+12·7	1·0–17·2	6·18	5·6	+36·1

LATE MILLET YIELD COMPONENT VALUES FROM MAIZE/LATE MILLET INTERCROPPING TRIALS

	n	Range	x	s.d.	Range	x	s.d.	%±	Range	x	s.d.	%±
hills / net plot	16	18 – 61	44·81	12·05	36 – 74	51·25	10·65	+14·4	33 – 68	49·94	10·44	–2·6
PANICLES / NET PLOT	18	120 – 414	263.4	86.1	122 – 580	301.5	127.2	+14.5	106 – 649	298.6	149.2	–1.0
panicles / hill	16	2·9 – 11·7	5·9	2·1	2·7 – 8·5	5·5	1·67	–7·4	2·5 – 8·3	4·7	2·0	–5·9
panicle weight / n.p.	18	2·2 – 13·2	7·24	3·43	3·6 – 22·2	9·84	4·58	+35·9	3·2 – 16·6	8·80	4·03	–10·6
WEIGHT PER PANICLE (g)	18	10·3 – 43·2	27·8	9·7	12·8 – 50·8	33·6	8·3	+21·0	14·5 –44·0	31·1	8·0	–8·0
GRAIN : PANICLE WT.	18	0·32 – 0·73	0·55	0·09	0·54 – 0·69	0·6	0·03	+8·0	0·3 – 0·92	0·62	0·14	+3·4
GRAIN / NET PLOT (Kg)	18	1·0 – 9·0	4·06	2·21	2·4 – 13·4	5·92	2·92	+45·8	1·8 – 9·2	5·36	2·46	–9·5

full fertiliser treatments respectively.

We suspect two principal reasons for the decline in grain yields at the full rate compared to the half. Firstly, both basal application and top dressing were distributed as evenly as possible throughout the plot. Effectively the late millet was receiving the same level of fertiliser application as the maize whereas the sole crop recommendation for the millet is only half that amount. Secondly, top dressing was carried out at the maize panicle initiation growth stage for both crops simultaneously. Since panicle initiation occurs considerably later in late millet and the maize was often planted first, the intercrop was being top dressed far too early. Bearing in mind that farmers rarely thinned their late millet it seems plausible to suggest that this high level of fertilisation combined with early top dressing resulted in excessive vegetative growth that could not subsequently support a comparable grain yield. Whilst a trend for straw weight to increase with fertiliser rate was observed (1·38 Kg, 1·52 Kg and 1·82 Kg per net plot for zero, half and full fertiliser rate respectively), with data for only six farms these differences were not significant at 95%. Nevertheless, where the base crop and intercrop are known to differ in their individual responses to fertiliser, research on improved management practices for intercropping systems should permit different levels for each. Similarily, where critical growth stages are reached at widely differing times during the season staggered top dressing applications may be desirable, although not necessarily feasible for the farmer to implement.

In order to better understand the response to fertiliser across locations for the base crop, intercrop and combined yield, modified stability analysis was carried out (Hildebrand and Poey 1985). It will be recalled that the combined ANOVA showed highly significant differences between sites in every case. These are due, for any given treatment, to differences in a wide range of physical factors (soil fertility and physical properties, rainfall amount and distribution, pest incidence) and management factors (planting pattern, base and intercrop populations, time of planting, time of fertiliser application etc). Since the yield at any one given location is the product of all these factors, a site giving a high yield can be characterised as a "good" environment and one generating a low yield a "poor" environment. Thus environment can be quantified by averaging the yield from all treatments at any site and this variable is termed the E index (e). The relationship between the yield response to a given treatment and environment can then be examined using least squares regression. Since maize is known to be sensitive to both physical and management factors "e" values for each site have been calculated

In fig. 7a it can be seen that maize yields respond to environment at all fertiliser levels and that yield differences between them are greater the better the environment. A converse trend is apparent in the case of late millet (fig.7b). The negative trend observed between yield and environmental index for all treatments implies higher yields in poorer environments, probably due to reduced competition from the ineffective maize base crop. Since the slopes are not significantly different from zero it can be concluded that late millet is relatively unresponsive to environment. This characteristic enables it to perform a stabilising function across environments, demonstrated by the higher intercepts and lower slopes for the combined yield relationships compared to those for maize (see fig.8). If the hypothesis advanced is correct that one of the objectives for intercropping is to increase production of maize from infertile fields in the absence of assured access to fertiliser, while at the same time getting a reasonable total grain return to the land and labour invested, then the maize / late millet pattern goes a long way to achieving it.

At the end of the day farmers will only adopt new technology if it is adequately profitable in relation to the level of risk involved and existing alternatives. We therefore compare the profitability of fertiliser use on maize based intercropping patterns with that for 15 sole maize demonstrations in Upper River Division. In doing so it should be borne in mind that the objectives of the sole maize demonstrations differed from those of the superimposed trial. In addition to demonstrating the benefits of fertiliser use and management the former demonstrated other improved cultural practices as well, such as spacing, seed dressing, weeding, land preparation, crop protection and crop rotation. On the trials however, farmers used their own husbandry practices in all respects other than fertiliser management.

The low mean response of farmer planted and managed maize / late millet intercropping patterns is reflected in very poor financial returns using the non-subsidised fertiliser price (see table 8). The mean response at the half rate of 236 Kg (row 2 in the table) resulted in a value:cost ratio of 1·17 (row 11), i.e. a return of only D1·17 per D1·00 invested. At the full rate the value:cost ratio falls to 0·79, implying a loss of 21 bututs per dalasi invested. The yield increase of only 83 Kg between the half and full rate (row 4) results in a return to the additional fertiliser cost (row 8), termed the marginal value:cost ratio, of only 41 bututs per dalasi invested (row 12). Looking at each on farm trial individually as opposed to the average situation, 5 [illegible] half rate and 6 at the full rate as

Maize grain yield response to environment at zero (To), half ($T\frac{1}{2}$) and full fertiliser ($T\frac{1}{1}$) levels.

Fig 7a

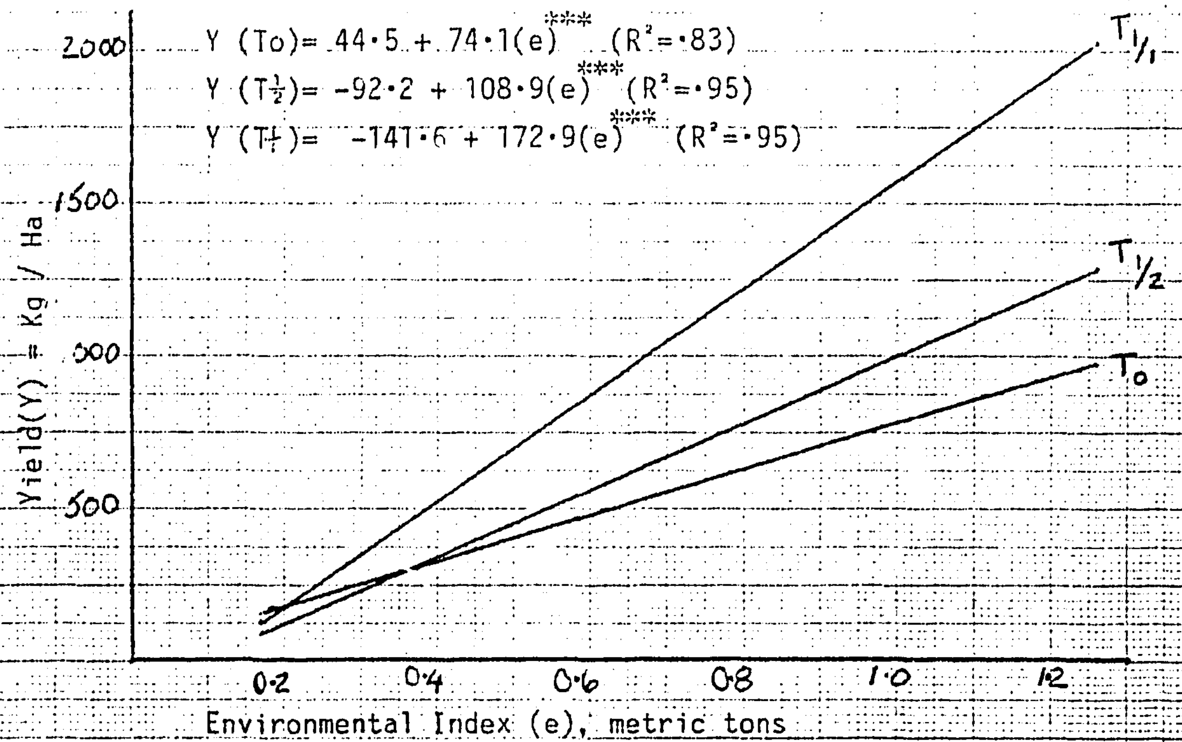
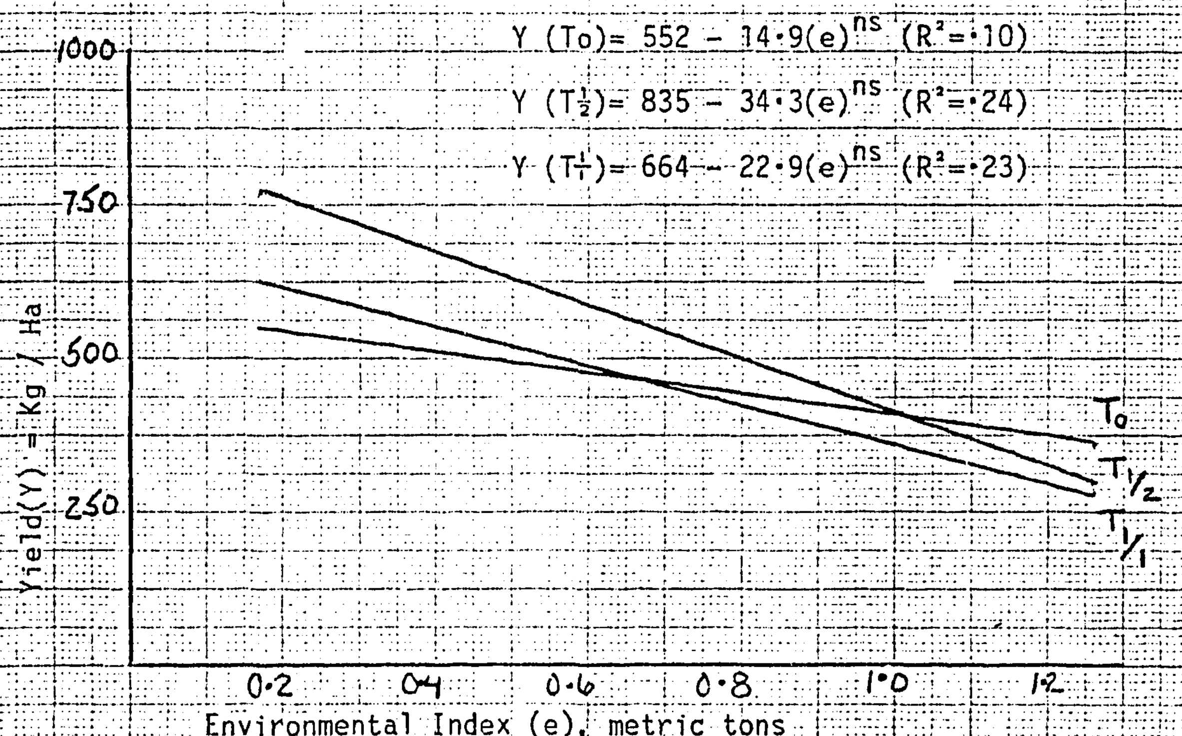
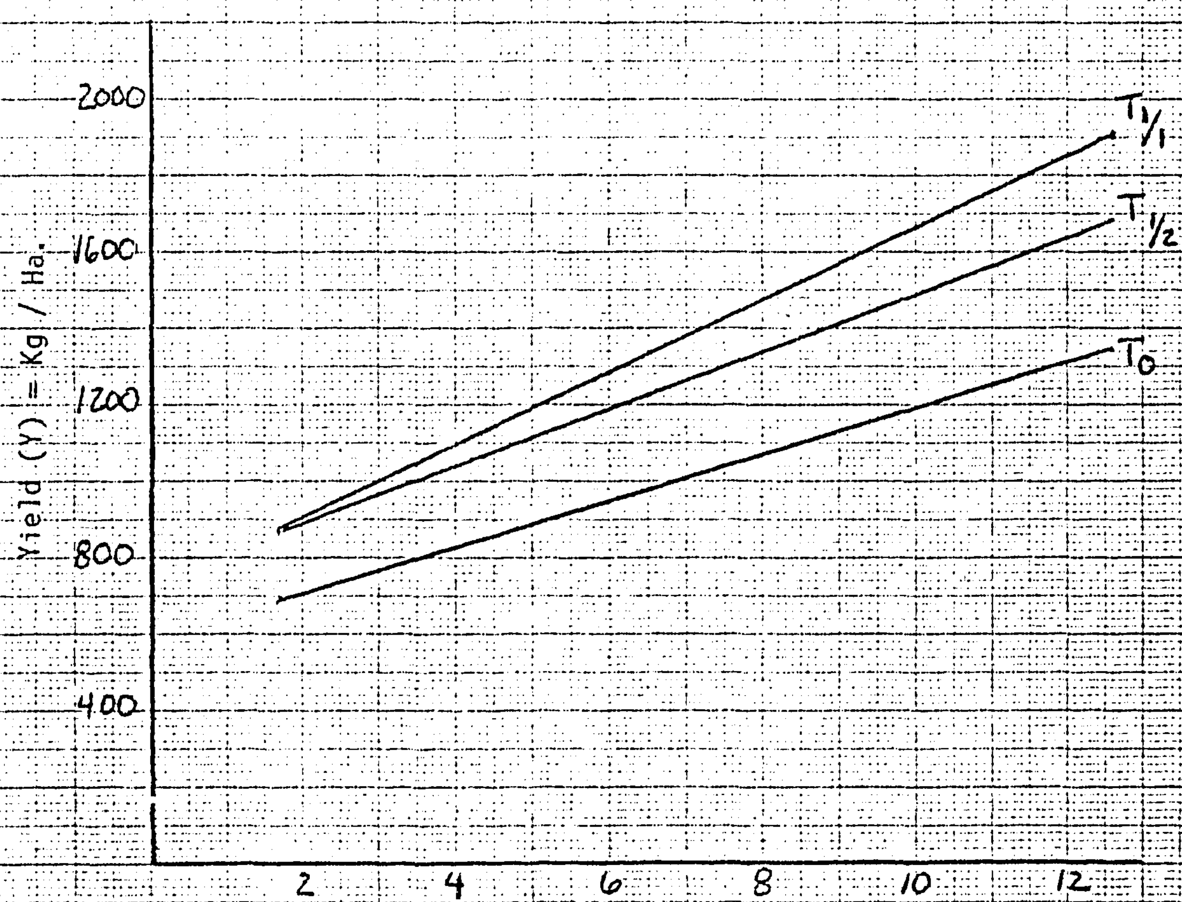


Fig 7b Late millet grain yield response to environment at zero (To), half ($T\frac{1}{2}$) and full fertiliser ($T\frac{1}{1}$) levels.



*** indicates that the slope estimate is significant at 1% probability.

Fig.8 Combined grain yield response to environment at zero(To), half($T\frac{1}{2}$) and full fertiliser(T) levels.



Environmental Index(e), metric tons.

$$Y(To) = 597 + 59{\cdot}2\ (e)^{**} \qquad (R^2 = {\cdot}67)$$

$$Y(T\tfrac{1}{2}) = 743 + 74{\cdot}6\ (e)^{*} \qquad (R^2 = {\cdot}51)$$

$$Y(T\ ) = 709 + 94{\cdot}8\ (e)^{***} \qquad (R^2 = {\cdot}76)$$

***, ** and *, indicates significance of the slope estimate at 1%, 5% and 10% probability respectively.

Table 8: Comparison of yield and economic results for maize/late millet intercropping trials and fifteen maize demonstrations in Upper River Division, 1985.

	SOLE MAIZE DEMONSTRATIONS[1]			MAIZE/LATE MILLET SUPERIMPOSED TRIALS		
1. Fertiliser level	0 - 0 - 0	38-15-15	76-30-30	0 - 0 - 0	38-15-15	76-30-30
2. Mean yield (kg/ha)	1274	1946	2438	843	1079	1161
3. Mean yield difference over control (kg/ha)	-	672	1164	-	236	319
4. Mean yield difference between levels (kg/ha)	-	672	492	-	236	83
5. Gross return at each level (D/ha) 3.x D0.80	-	538	931	-	189	255
6. Marginal return at each level (D/ha) 4.x D0.80	-	538	394	-	189	66
7. Cost of fertiliser at each level (D/ha)	-	161	322	-	161	322
8. Marginal cost of fertiliser (D/ha)	-	161	161	-	161	161
9. Net return or profit (D/ha) 5.-7.	-	377	609	-	23	-67
10. Marginal net return (D/ha) 6.-8.	-	377	233	-	23	-95
11. Value Cost Ratio (VCR) 5.÷ 7.	-	3.34	2.89	-	1.17	0.79
12. Marginal Value Cost Ratio. 6. ÷ 8.	-	3.34	2.45	-	1.17	0.41

[1] Source: Report on the Evaluation of Training and Extension Programmes 1985/6. Local Training Unit. Upper River Division.

can be seen below.

Table 9. Number of trials falling in a given value:cost ratio range at the half and full fertiliser rates.

VCR range	Half rate	Full rate
0 - .99	5	6
1 - 1.99	2	2
2 - 2.99	1	0

Evidently, fertiliser cannot be recommended on the basis of these results.

Much larger yield responses to fertiliser are reported for the sole maize demonstrations, in conjunction with other recommended cultural practices. Financial returns are correspondingly higher and represent a much more attractive investment opportunity for the farmer. If it were not for the fact that farmers give clear reasons for intercropping a very large proportion of the maize grown in URD, one might be tempted to dismiss it as an outmoded technology. The poor yield response to fertiliser in intercropping patterns compared to sole maize probably arises because in the latter case the package of practices is designed to achieve the best realistic result in the presence of fertiliser, whereas the farmers' intercropping package is designed to achieve the best realistic result in the likely event of it being inaccessible to him, or available only in small quantities.

The challenge to researchers therefore lies in adapting farmers' intercropping cultural practices to give a better yield response at moderate fertiliser levels, without losing the advantage of yield stability under adverse environmental conditions. In the case of maize/late millet intercropping patterns improvements might be sought through choice of variety (more responsive early maturing cultivars for farmers requiring early maize for consumption), increased maize plant populations, fertilisation proportional to row of each crop, and staggered time of top dressing application.

5·2 Maize / sorghum intercropping trials

Data from three maize / sorghum and two maize / sorghum / late millet trials are combined in this analysis as the late millet crop intercrop was secondary to the sorghum. Only two of the maize / sorghum trials are complete, maize having been harvested by the farmer in the third. In one of the two maize / sorghum / late millet trials the late millet was harvested by the farmer, the team having no fuel to get there in time. The same randomised complete block design and treatment levels were used for maize / sorghum as for maize / late millet, and the same analyses have been carried out.

Yield data for the maize base crop, sorghum intercrop and the total of the two are presented in table 10. The combined analysis of variance (table 11) reveals highly significant differences between sites in each case. Treatment differences are significant at 5% for the base crop and intercrop, and at 1% for the combined yield. There are no significant site by treatment interactions. With the exception of significance between maize treatments these results are the same as for maize / late millet trials.

Yield response for the base crop and intercrop are represented graphically in figure 9, and for the combined total in figure 10. Maize shows a similar response pattern between fertiliser levels with a sorghum intercrop as it does with late millet but mean yields are 90%, 73% and 81% higher at zero, half and full fertiliser rates respectively (compare table 10·1 with table 5·1). The sorghum intercrop shows a very similar response pattern between fertiliser levels to the maize base crop. As a result, the combined yield response is more than seven times as great between the half and full rate as between the zero and half. The behaviour of sorghum as an intercrop is therefore quite different from late millet, and average yields are somewhat lower except at the full rate (compare table 10·2 with table 5·2). The combination of higher base crop yields and slightly lower intercrop yields results in maize accounting for a considerably higher proportion of total yield in this pattern compared to maize / late millet. Maize accounted for 67%, 64% and 65% at zero, half and full fertiliser rates respectively. Comparisons have to be made cautiously however, in view of the smaller number of maize / sorghum trials.

Attempts to explain the response of maize grain yield at different fertiliser levels by analysing yield component data are made difficult by the degree of measurement error. Maize yields calculated from yield components compared to direct measurement are +22%, +12% and +17% for zero, half and full rates

Table 10 Yield data for maize, sorghum and combined total from five trials in Upper River Division. (Kg / Ha)

10·1 MAIZE (base crop: data for four sites only).

TREATMENT	LOW	HIGH	MEAN	CV	EFFECT
0 - 0 - 0	225	1360	764	61%	-
38-15-15	500	1540	785	64%	21
76-30-30	570	1970	1120	57%	355

$LSD_{.05}$ = 422 Kg $LSD_{.10}$ = 335 Kg

10.2 SORGHUM (intercrop; data from five sites).

TREATMENT	LOW	HIGH	MEAN	CV	EFFECT
0 - 0 - 0	120	570	326	88%	-
38-15-15	170	620	366	78%	40
76-30-30	120	790	536	64%	210

$LSD_{.05}$ = 193 Kg

10·3 COMBINED TOTAL (data for four sites only)

TREATMENT	LOW	HIGH	MEAN	CV	EFFECT
0 - 0 - 0	345	1490	1144	46%	-
38-15-15	670	1730	1210	43%	66
76-30-30	920	2090	1708	35%	498

$LSD_{.05}$ = 392 Kg

Table 11 FINAL COMBINED ANOVA TABLE

MAIZE / SORGHUM INTERCROPPING TRIALS

MAIZE (4 farms)	df	SS	MS	F ratio
Sites	3	488·47	162·82	27·41**
Reps. within site	4	52·41	13·1	2·56^{ns}
Treatments	2	63·89	31·95	5·38*
Site x Treatments	6	35·63	5·94	1·16^{ns}
Residual	8	40·89	5·11	-

SORGHUM (5 farms)	df	SS	MS	F ratio
Sites	4	153.35	38.34	21.91**
Reps. within site	5	54.43	10.89	3.23^{ns}
Treatments	2	24.87	12.44	7.11*
Site x Treatments	8	14.03	1.75	0.52^{ns}
Residual	10	33.69	3.37	

COMBINED TOTAL (4 farms)				
Sites	3	430.91	143.64	28.05**
Reps. within site	4	101.65	25.41	2.95^{ns}
Treatments	2	151.92	75.96	14.84**
Site x Treatments	6	30.71	5.12	0.60^{ns}
Residual	8	68.76	8.60	

** indicates significance at 1% * indicates significance at 5%

Fig 9a MAIZE YIELDS IN MAIZE/SORGHUM INTERCROPPING TRIALS AT ZERO AND TWO POSITIVE LEVELS OF FERTILISER (KG / HECTARE)

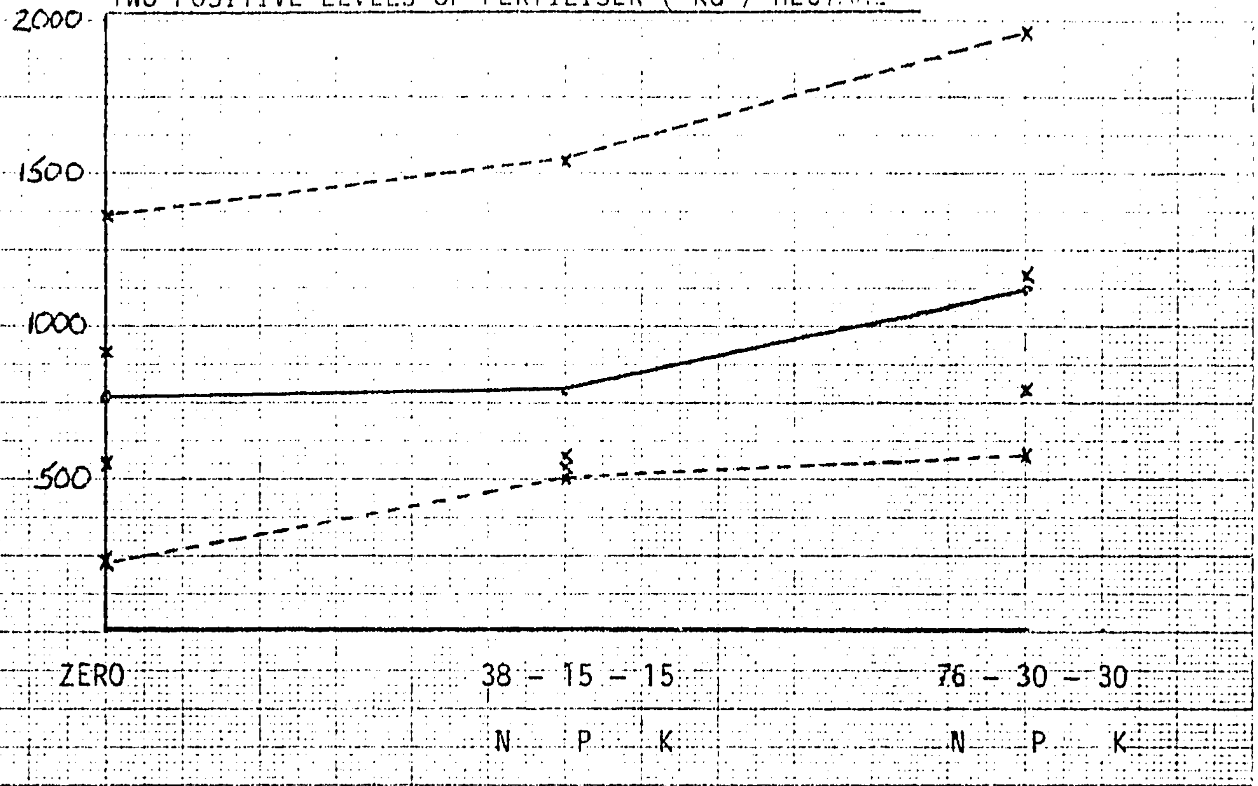


Fig 9b SORGHUM YIELDS IN MAIZE / SORGHUM INTERCROPPING TRIALS AT ZERO AND TWO POSITIVE LEVELS OF FERTILISER (KG / HECTARE)

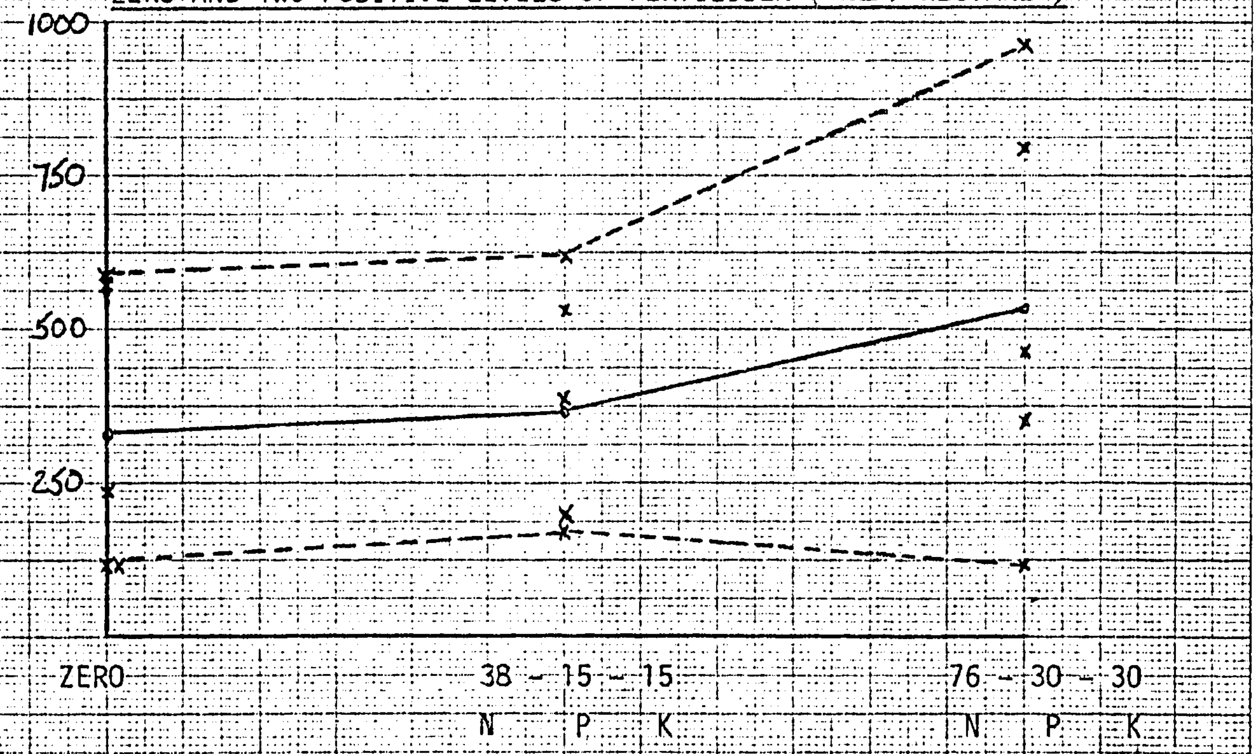


Fig. 10 TOTAL YIELDS IN MAIZE/SORGHUM INTERCROPPING TRIALS AT ZERO AND TWO POSITIVE RATES OF FERTILISER (KG / HECTARE)

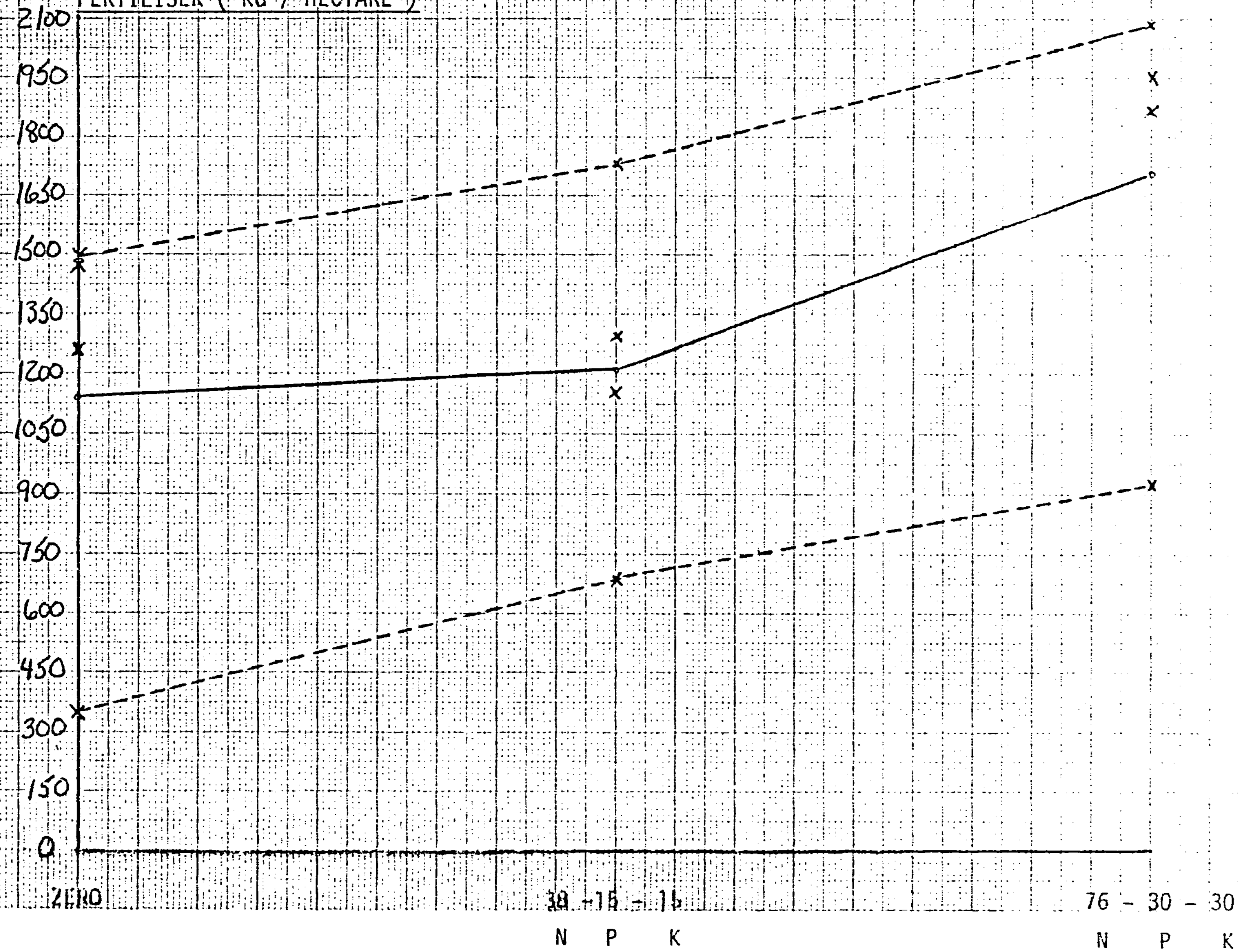


Table 12 MAIZE YIELD COMPONENT VALUES FROM MAIZE/SORGHUM INTERCROPPING TRIALS

		NO FERTILISER			38 – 15 – 15				76 – 30 – 30			
	n	Range	x	s.d.	Range	x	s.d.	%±	Range	x	s.d.	%±
hills / net plot	6	71 – 200	125·3	46·5	63 – 199	127·8	56·6	+2·0	62 – 185	122·2	43·6	-4·4
plants / net plot	6	146 – 245	206·2	41·2	138 – 273	204·0	53·3	-1·1	131 – 286	191·3	59·9	-6·2
plants / hill	6	1.1 – 2·1	1.75	0·33	1·3 – 2·2	1·72	0·35	-1·5	1·2 – 2·1	1·62	0·29	-5·8
COBS / NET PLOT	6	95 – 245	160·5	53·0	90 – 254	147·3	70·4	-8·2	102 – 350	180·3	70·4	+22·4
cobs / plant	6	0·6 – 1·1	0·77	0·18	0·4 – 0·9	0·70	0.17	-9·6	0·7 – 1·2	0·92	0·22	+32·4
cob weight / net plot	6	5·8 – 22·6	12·87	6·15	4·8 – 25	12·60	8·22	-2·1	8·8 – 36·8	18·53	10·22	+47·1
WEIGHT PER COB (g)	6	60·4 – 96·6	77·4	15·5	49 – 107	79·8	26·6	+3·1	74·8 – 125·7	100·6	17·8	+26·1
GRAIN : COB WEIGHT	6	0·7 – 0·8	0·75	0·05	0·5 – 0·8	0·75	0·12	-0·6	0·6 – 0·8	0·72	0·08	-3·0
GRAIN / NET PLOT (Kg)	8	1·9 – 15·0	7·64	4·67	3·6 – 18·0	7·85	5·02	+2·7	5·2 – 24·2	11·20	6·42	+42·7

SORGHUM YIELD COMPONENT VALUES FROM MAIZE/SORGHUM INTERCROPPING TRIALS

		NO FERTILISER			38 – 15 – 15				76 – 30 – 30			
	n	Range	x	s.d.	Range	x	s.d.	%±	Range	x	s.d.	%±
hills / net plot	6	25 – 144	56.2	33.9	19 – 132	57.2	37.4	+1.8	23 – 117	64.9	32.3	+13.5
plants / net plot	6	97 – 656	258.7	169.4	72 – 580	232.3	163.0	-10.2	89 – 512	291.6	132.5	+25.5
plants / hill	10	2.6 – 5.9	4.46	0.88	2·9 – 5.3	4.01	0·74	-10.1	3.4 – 5.6	4.58	0·62	+14.2
PANICLES / NET PLOT	8	75 – 607	237·1	166·1	63 – 485	232·6	135·0	-1·9	87 – 349	259·0	98·7	+11·3
panicles / plant	8	0·7 – 0·9	0·89	0·11	0·8 – 3·2	1.21	0·80	+35·4	0·7 – 1·0	0·93	0·11	-23·2
panicle weight / n.p.	10	1·0 – 14·2	5·12	4·46	1·6 – 16·6	5·78	4·80	+12·9	1.6 – 16·0	8·28	5·16	+43·3
WEIGHT PER PANICLE	8	9·3 – 55·5	25·8	17·1	13·4 – 49·0	28·1	14·3	+9·1	16·0 – 48·6	31·6	13·2	+12·4
GRAIN : PANICLE WT.	10	0·5 – 0·8	0·65	0·08	0·4 – 1·0	0·65	0·16	-0·2	0·5 – 0·7	0·63	0·07	-3·9
GRAIN / NET PLOT (Kg)	10	0·8 – 9·2	3·26	2·87	0·8 – 9·6	3·66	2·87	+12·3	1·0 – 10·6	5·36	3.45	+46·4

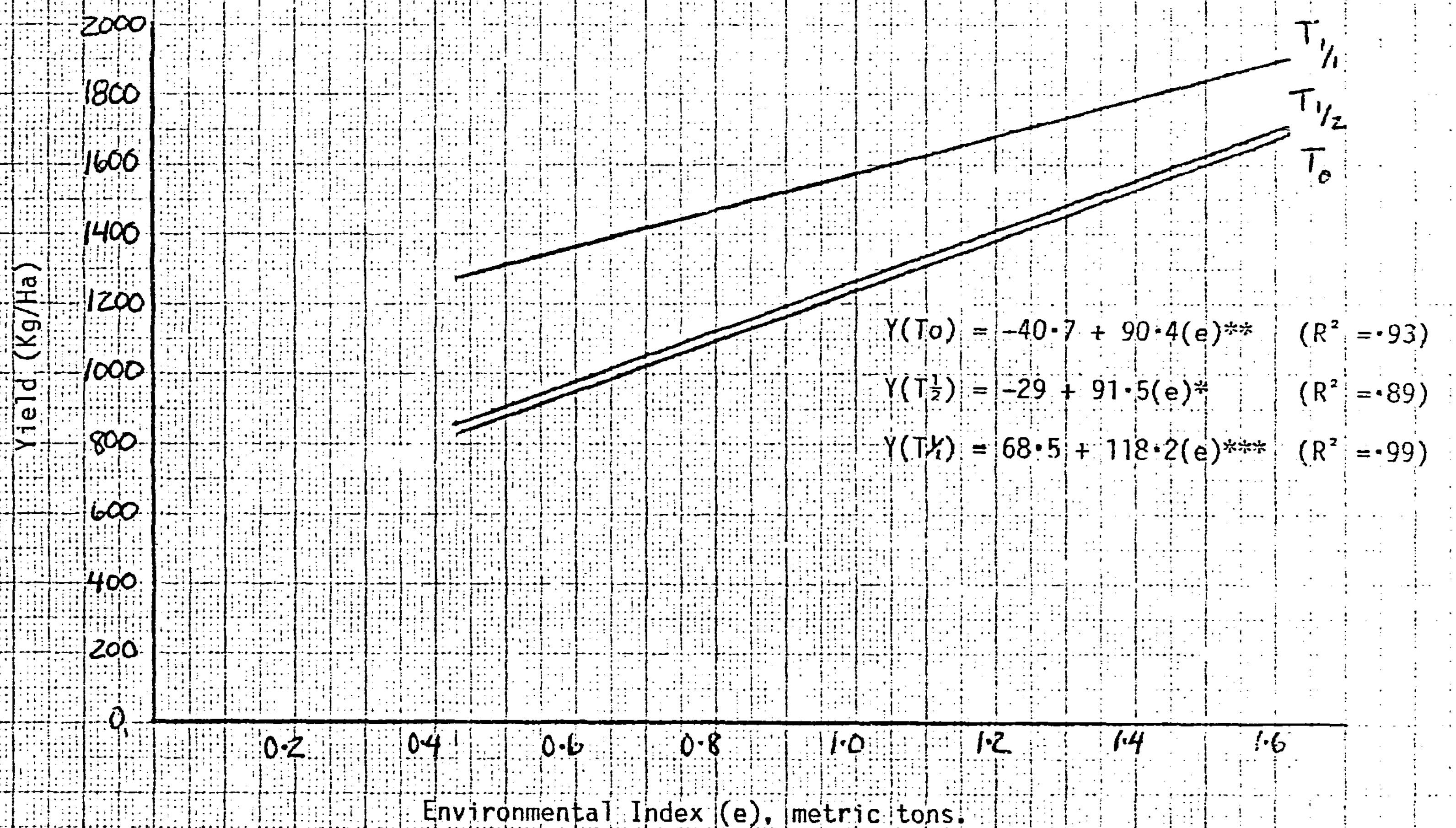
between the zero and half rate are not large enough in relation to measurement error to explain the lack of response with any confidence. For the 43% increase in grain yield between the half and full rate however, a 22% increase in number of cobs combined with a 26% increase in weight per cob are likely to be responsible. The 46% increase in sorghum grain yield between the half and full rate appears due to the corresponding yield components, number of panicles and weight per panicle. For the small yield increase from zero to half a similar percentage change in weight per panicle is recorded, a decrease in plant population having been compensated for by an increase in panicles per plant. Caution is again called for in interpreting the data with errors of +22%, +16% and -4% at the zero, half and full fertiliser rates.

Using modified stability analysis it can be seen in Fig. 11 that, as in the maize/late millet patterns, maize responds to environment at all fertiliser levels, and that yield differences between levels are greater the better the environment. For the sorghum intercrop the relationships between yield and environmental index are not significantly different from zero, indicating that it is relatively unresponsive to environment (Fig.12). Thus it appears to share the same property of stabilising combined yield across environments as late millet, but this cannot be demonstrated by comparison of the combined yield relationships (Fig.13) with maize because the former are not significant with data from only four sites. The trend to higher sorghum yields in poorer environments is probably associated with reduced competition from the maize base crop. The steeper negative trend between yield and environment at the full rate reflects increasingly effective competition from maize as environment improves.

Because there are only four complete maize/sorghum data sets economic analysis has been carried out for each one using the same approach as for maize/late millet. The results are given in summary form in table 13. Whilst none of the farmers would have incurred a financial loss at the full fertiliser rate (value:cost ratios exceed one) profit margins are not adequate to recommend it and compare unfavourably with those reported for sole maize demonstrations (see table 8). Full fertiliser rate marginal value:cost ratios (the financial return to the additional cost incurred when using the full rate instead of the half) are higher than value:cost ratios for farms 1 to 3 because the yield increase is much greater than that achieved by the half rate.

The higher profitability of fertiliser use on sole crop maize demonstrations compared with maize intercropping begs the question " why is it a virtually

Fig. 11. Maize grain yield response (in maize/sorghum intercropping patterns) to environment at zero (To), half ($T\frac{1}{2}$) and full fertiliser ($T\frac{1}{1}$) levels.



***, ** and * indicate significance of the slope estimate at 1%, 5% and 10% probability respectively.

Fig. 12. Sorghum grain yield response (in maize / sorghum intercropping patterns) at zero (To), half ($T\frac{1}{2}$) and full ($T\frac{1}{1}$) fertiliser levels.

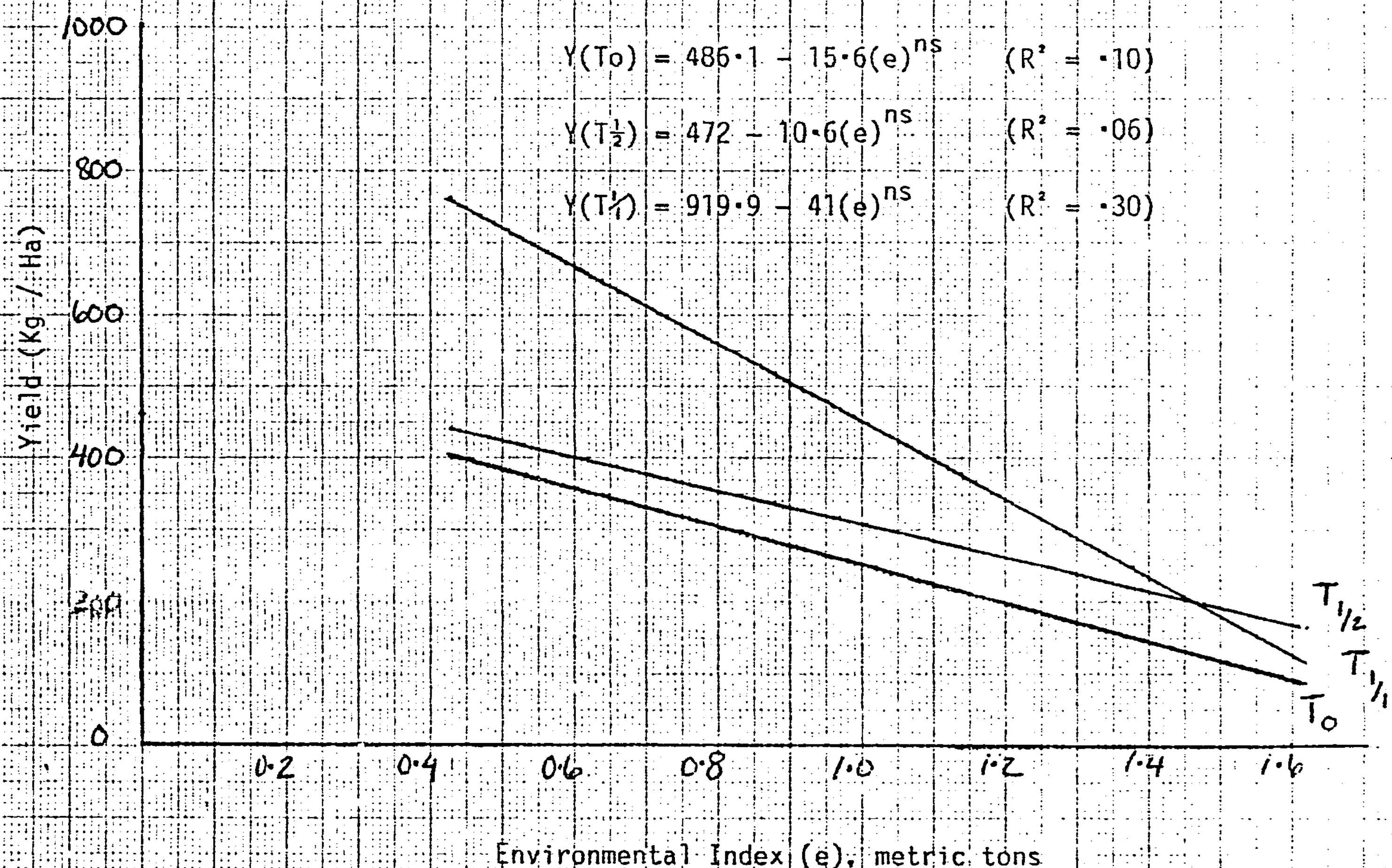


Fig 13 Combined grain yield response of maize/sorghum patterns to environment at zero (To), half ($T\frac{1}{2}$) and full ($T\frac{1}{1}$) fertiliser levels.

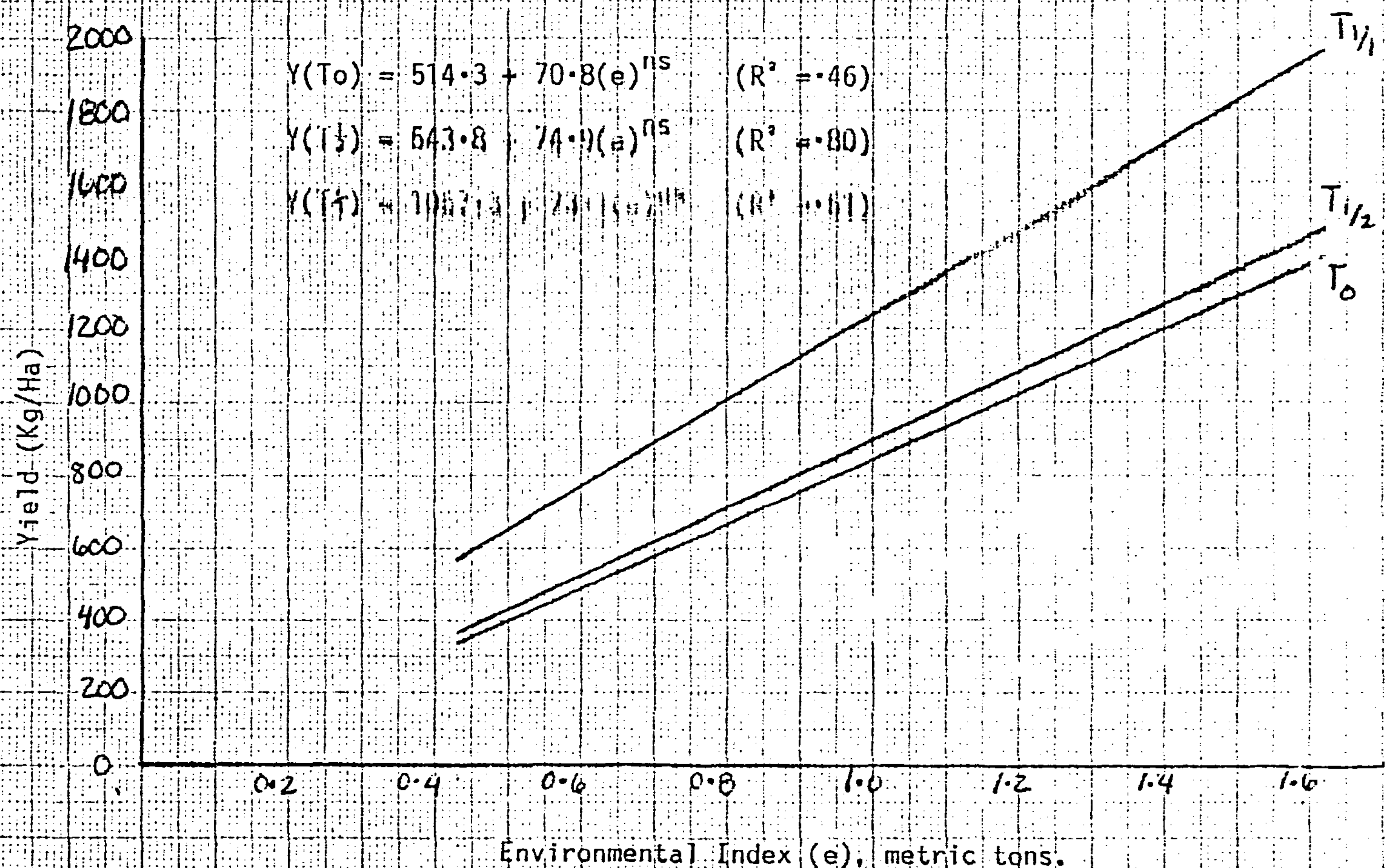


Table 13. Summary economic assessment of combined yield response to fertiliser for 4 maize/sorghum intercropping trials.

Fertiliser level	Farm 1			Farm 2			Farm 3			Farm 4		
	yield	VCR	MVCR	yield	VCR	MVCR	yield	VCR	MVCR	yield	VCR	MVCR
ZERO	1490	–	–	1480	–	–	1260	–	–	345	–	–
38-15-15	1150	-1.69	-1.69	1730	1.24	1.24	1290	0.15	0.15	670	1.61	1.61
76-30-30	1950	1.14	3.98	2090	1.52	1.79	187-	1.52	2.88	920	1.43	1.24

VCR = value cost ratio

MVCR = marginal value cost ratio

non-existent practice in so much of URD?" A number of reasonable hypotheses can be advanced and the following is not intended to be an exhaustive list:-

1. Maize based cereal / cereal intercropping is a longstanding practice in URD capable of returning reasonable yields under adverse environmental conditions, a characteristic farmers are reluctant to part with.

2. Environmental conditions are not predictable. Any of the trials enjoying a "good" environment this year might be "poor" next due to factors such as poor germination, drought or pest attack.

3 Farmers have not yet had sufficient exposure to the practices and results of fertiliser use on sole maize demonstrations to adequately evaluate it as an alternative. Less than 10% of male URD farmers attended a demonstration field day for any crop (19 out of the total of 66 demonstrations being maize).

4. Farmers have little confidence that they will be able to obtain fertiliser in adequate quantities whether due to lack of availability, cash or credit and therefore prefer to rely on their traditional intercropping patterns which are adapted to low soil fertility. This season, for example, only 3 co-operative societies qualified for credit in URD and the remainder had to wait until mid-August before even compound fertiliser became available.

5. Farmers who have been exposed to demonstrations doubt whether they can achieve as good results under their own management conditions.

6. Conclusions

1. Of the major crops grown in Upper River Division maize and groundnut are the most commonly intercropped. Whilst maize is considerably less important in area terms it is widely intercropped with late millet, sorghum (sambajabo) and, to a lesser extent, cowpea (often as an additional low density intercrop). A wide variety of planting patterns are in use but maize populations are consistently low. Groundnut is less frequently and less systematically intercropped, usually with cereals but occasionally cowpea, and at a low density.

2. The main objective in maize based cereal / cereal intercropping patterns is yield stability in the face of uncertain environmental conditions, particularly rainfall. The strategy appears especially appropriate where farmers wish to increase maize production on infertile soils in the absence of assured access to fertiliser in sufficient quantity at the right time. This may be an important factor behind low plant populations for maize. For groundnut intercropping the principal objective is an additional bonus to the full groundnut yield.

3. Yield response to fertiliser applied to maize / sorghum and maize / late millet patterns is not economic under prevailing husbandry practices. Analysis of trial data supports the farmers' view that intercropping stabilises under poor environmental conditions (including husbandry levels).

4. Both groundnut and maize based intercropping systems can be improved upon through close collaboration between the extension and research services.

   4.1. In the case of maize / cereal patterns the challenge is to improve response to moderate applications of fertiliser without sacrificing yield stability. Improvements can be sought through varietal selection, plant populations and ratios, intercrop allocation of fertiliser and time of application.

   4.2. Maize / cowpea intercropping is far less widespread than desirable given the high financial and nutritional value of cowpea. This is due to the scarcity and high cost of cowpea seed, in turn the result of low production and storage losses. Cotton should also be considered as a candidate for intercropping with cowpea if the latter can benefit from

4.3. The main challenge in groundnut based cropping systems is to increase cereal intercrop yields to the point where they justify the additional effort required by systematic planting, without significantly reducing yields.

4.4. A critical medium term priority is to identify potential intercropping systems, for testing on-farm, which will contribute to improving soil fertility and physical properties whilst providing an attractive financial reward to farmers in the short run. Unless addressed with determination yield gains from improved cultural practices may be short lived as a result of environmental degradation.

5. Farmers reactions to multilocation trials and on-farm demonstrations will need to be carefully monitored in order to identify both potential constraints to adoption and possible improvements in technology design.

****

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