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ADAPTIVE RESEARCH PROGRAMME

Technical Report NO.2

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ADAPTIVE RESEARCH PROGRAMME
Technical Report NO.2

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ADAPTIVE RESEARCH AGRONOMIST

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LEGEND

	INTERNATIONAL BOUNDARY
	PROVINCIAL BOUNDARY
	DIVISIONAL BOUNDARY
	MAIN ROADS
	OTHER ROADS
	TRIALS. DELINEATION

Map 1



NIGERIA

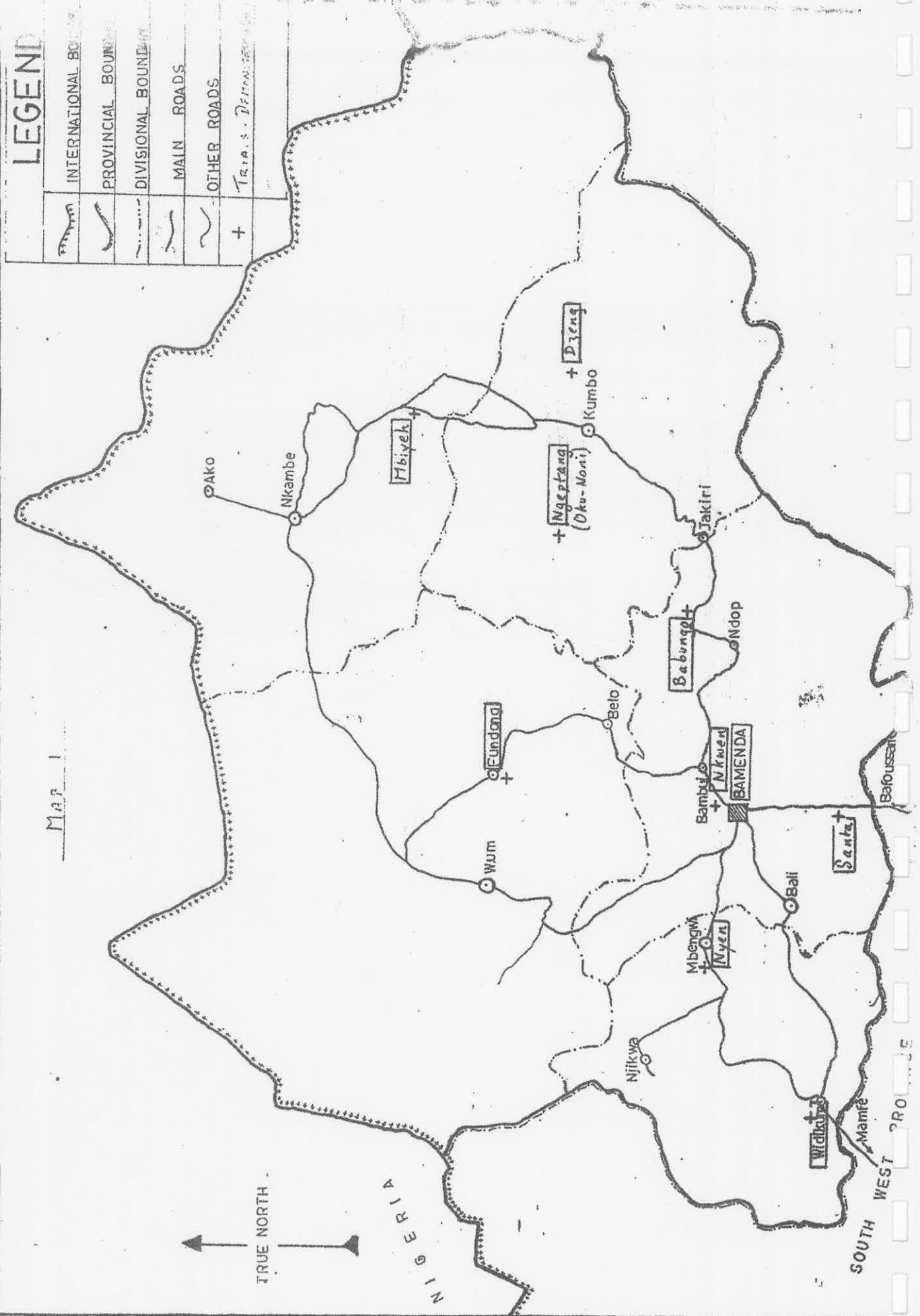


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Les résultats d'expériences et d'observations réalisées au champ dans nos Centres d'Essais et de Demonstrations (TDC's), sont examinés en fonction surtout des formulations faites des objectifs du Programme de la Recherche Agronomique Adaptée et des directives suggérées pour les phases postérieures d'expansion et de développement du Programme.

Les Programmes de Vulgarisation et de Recherche Adaptée tel qu'ils sont définis sous la Mission de Développement du Nord-Ouest (MIDENO), représentent ensemble un concept totalement innovatif du développement agricole, compte tenu bien sûr de l'appui d'un grand nombre de petits planteurs.

Avec l'extension et la modification du service de Vulgarisation Agricole et avec l'établissement effectif des Centres d'Essais et de Demonstrations, il existe maintenant, un peu partout dans la Province du Nord-Ouest un bien structural de base entre tout d'abord les planteurs avec leurs productions potentielles et leurs difficultés techniques et ensuite les ressources d'investigation des divers établissements de l'Institut de la Recherche Agronomique.

Le degré du succès opérationnel réalisé dans le souci d'atteindre l'objectif d'établissement de ce lien a été le sujet de plusieurs évaluations indépendantes. Des rapports favorables ont été présentés sur le niveau du progrès et des résultats réalisés et ceux-ci ont confirmé la valeur de la voie adoptée par le Projet.

Bien que la liaison entre les divers secteurs intervenant dans le développement agricole est clairement vitale, il est tout aussi nécessaire de se procurer continuellement de nouvelles informations techniques devant cadrer avec les systèmes si développés. Le rôle majeur du Programme de la Recherche Adaptée est par conséquent complémentaire aux travaux de l'IRA, en fournissant au service de la Vulgarisation, des informations relevant des conditions culturelles et des problèmes des cultivateurs de la Province du Nord-Ouest.

Le Programme d'expériences conduit dans les TDC's était formulé afin de fournir pareilles informations tel que le décrit le Rapport. Du à la nature des investigations sur le terrain, un certain nombre de saisons est souvent utile pour le développement définitif d'une nouvelle idée, étant entendu qu'un autre temps est encore nécessaire au Service de la Vulgarisation afin qu'il encourage l'adoption des techniques nouvelles par

Le Programme de la Recherche Agronomique Adaptée est encore au grand début de ses nombreuses séquences. Toutefois, le Rapport décrit les expériences de court terme dans lesquelles, après trois saisons de recherches conduites sur plusieurs cites, les objectifs prédefinies de ces expériences ont maintenant été atteints (dans le cas des cites établis en premier lieu).

Les données recueillies en 1985 et 1986 (avec ceux de 1984 présentées dans le Rapport Technique No.1), font donc appel à un certain nombre de conclusions tirées de deux Essai Variétal de maïs et des essais d'association Maïs/Haricot/Arachide et Maïs/Haricot.

Des changements sont proposés sur plusieurs recommandations concernant les variétés de maïs, recommandations mises en circulation avec le concours du Service de la Vulgarisation; nous pensons pertinemment au besoin d'introduire la variété "Ekona White" dans les zones de moyenne altitude du Département de la Momo et le désir d'éliminer la variété "MLC" des zones de haute altitude des départements du Bui et du Donga-Mantung. Initialement, et comme mesure intermédiaire, la dernière proposition pourrait être réalisée en multipliant une bonne variété locale adaptée qui a été récemment identifiée. Il est espéré, qu'après cette phase interimaire, le matériel actuellement développé par le programme IRA/MCRE pourrait donner naissance à de nouvelles séries de variétés de maïs potentielles, mieux adaptées aux zones d'altitude.

Les résultats des expériences en association suggèrent que la recommandation suivante devrait être retenue, si l'on considère l'association culturale Maïs/Haricot/Arachide: Premier desherbage six semaines après le semis du maïs, deuxième desherbage, si la population d'herbes l'exige, (si la population d'herbes est importante) 4 - 6 semaines après le premier. Il existe toutefois une bonne évidence de suggérer que les populations de plants de maïs soient accrues de 50% à 100% (voir les Sections II et III pour plus de détails) afin de pouvoir maximiser les bénéfices de l'association toute entière, pourvu que des configurations spécifiques de plantings soient adoptées.

Le Programme expérimental confirme aujourd'hui l'extrême importance de continuer à encourager l'établissement des méthodes appropriées à la Province, de continuer à améliorer les conditions pédologiques et l'habileté des sols à soutenir une production à long terme. Dans le Rapport qui suit sont décrites les différentes politiques adoptées par le Programme de la Recherche Adaptée afin d'atteindre les objectifs précités.

The experiment results and TDC field observations to date are reviewed in relation to overall Adaptive Research Programme objectives and suggested directions for further phases of programme development and expansion are formulated.

The Extension and Adaptive Research Programmes as designed under the North-West Rural Development Project, together represent a totally innovative concept of agricultural development in support of large numbers of small-scale farmers.

Through the expansion and modification of the Extension Service and the establishment of the Trials and Demonstration Centres, there now exists in the North-West Province a broadly based structural linkage between the farmers, with their technical difficulties and production potentials, and the investigative resources of the various establishments of the national Institute of Agronomic Research.

The degree of operational success achieved in meeting the objective of linkage establishment, has been the subject of several independent evaluations. Favourable reports have been made of the rate of progress and the results achieved, which have confirmed the value of the approach adopted by the Project.

Whilst liaison between the various sectors involved in agricultural development is clearly vital, it is also necessary to continually provide new technical information to feed through the systems so developed. A major role of the Adaptive Research Programme is therefore to complement the work of IRA in providing to the Extension Service, information relevant to farming conditions and farmers' circumstances in the N.W. Province.

The field experiment programme on the TDC's was expressly designed to provide such information and is described in the Report. Due to the very nature of field investigation, a number of seasons is often needed to develop definitive new information, and further time necessary for the Extension Service to encourage adoption of new techniques by the farming community. The impact of new technology on crop production thus takes time to become apparent.

The Adaptive Research Programme is still in the very early stages of this sequence of events. However, the Report describes the shorter term experiments in which, after up to three seasons research on several sites, the pre-defined experiment objectives have now been met (in the case of earlier established sites.)

The 1985 and 1986 data, (together with that from 1984 given in Technical Report No.1), thus allow a number of conclusions to be drawn from two of the Maize Variety Trials, and from the Maize/beans/groundnuts and Maize/beans Intercropping Trials.

Changes are proposed in several of the maize variety recommendations issued via the Extension Service; namely the need to introduce Ekona White to mid-altitude areas of Momo Division, and the desirability of phasing out MLC at the highest farming altitudes in Bui and Donga-Mantung Divisions. Initially, and as an interim measure, the latter would be done by multiplication of a well adapted local variety which has recently been identified. Following this, it is hoped that materials currently being developed by the IRA/NCRE programme would lead to production of a new series of potentially higher yielding maize varieties.

Intercropping experiment results suggest that the recommendation to weed maize after 6 weeks, and again after a further 4 - 6 weeks if weed populations are high, should be retained for maize grown in association with beans and groundnuts. There is however, good evidence to suggest that maize populations in the mixed plantings could be increased by 50 or as much as 100 per cent (see sections II and III for details) to maximize benefits from the association as a whole, provided specific planting configurations are used.

Programme experience to date confirms the extreme importance of continuing to focus on designing methods, appropriate to the province, to improve soil conditions and the ability of soils to sustain crop production over the longer term. The approaches adopted towards achieving this under the Adaptive Research Programme are described in the following report,

1. INTRODUCTION

The purposes of the Report are threefold :

- to describe and discuss experiment results from the Trials and Demonstration Centres (TDCs) in relation to the objectives of the Adaptive Research Programme.
- to summarize the overall technical approach to and achievements of the Programme to date.
- to briefly consider future directions for the Adaptive Research Programme in the North West Province.

The progress in development of the TDC infrastructure and associated administrative and financial operations, have been reported on extensively elsewhere. ⁽¹⁾ It is sufficient to record here that in the period covered by this report, six centres were in full operation for the main 1985 crop season, a seventh began operations with its tree crop programme in July 1985, and all nine TDCs carried the main arable crop research programme in the 1986 season. Locations of the TDCs are shown in Map 1, and brief site characteristics are summarized in Appendix 1. Weather data available from six TDCs in 1984, 1985 and 1986, are presented in Appendix 2.

By comparison with the experimentation in 1984 ⁽²⁾, that of 1985 and 1986 showed a continuing improvement in the uniformity of data collected. This was a reflection of improvements in both soil conditions (on the earlier established sites) and the overall standard of crop handling and recording of information on the part of the senior TDC staff.

The principles described in Report No. 1 governing the establishment of field experiments, and the system used for presentation of results were also followed for the 1985 and 1986 experiments. Where considered appropriate as a means of further elucidating performance across sites and seasons, and estimating the consistency of results treatment effects were also ranked for each parameter from highest to lowest. This approach was particularly valuable in interpretation of several of the intercropping experiments as an adjunct to the development of data representing the overall CFA value of production from the crop association (See Appendix 3 for derivation of the values used).

-
- (1) -Adaptive Research Component: Internal Mid-Project Review, May 1985
-Adaptive Research Component submission to IFAD/AFDB Supervisory Missions between 1983 and November 1986.
-Quarterly and Annual Reports of the MIDENO Project (1983 - date).
- (2) Adaptive Research Agronomist. Adaptive Research Programme, Technical Report No. 1, MIDENO, December 1985.

It should be borne in mind that the value data, being based on market prices per kilogram, tend to reflect the pattern of response to experiment treatments of the crop which contributes the largest proportion of the total weight of production from all component crops.

Value of total production was therefore not an entirely satisfactory measure in itself of an overall treatment effect on the association. However, the magnitude of an individual crop's response to a given treatment was at times sufficient to modify the impact on final value of the association of the crop with the larger weight contribution.

Analysis of 1985 and 1986 data was carried out using a Texas Instruments TI-66 programmable calculator, although it is intended to computerize this exercise in the near future.

It will be noted that Section II discusses only results from short-term arable crop experiments. Data will continue to be collected from the longer term fallowing and coffee intercropping experiments to be reported on later.

2. 1985/86 EXPERIMENTS : RESULTS AND DISCUSSION

The following sections present the results from the series of short-term arable crop experiments conducted on the TDCs, and discuss their implications for future agronomic recommendations.

Descriptions are grouped by experiment to facilitate comparison of treatment effects across sites, and results are discussed both in terms of individual experiments and the overall outcome of the series.

A number of the experiments have been run (as at the end of the 1986 season) for three seasons, often on a number of sites. Available results suggest that many parameters may now be discontinued, having achieved the objectives for which they were designed.

2.1. MAIZE VARIETY EXPERIMENTS

Two series of variety experiments were conducted in 1985. With the establishment of the Widikum TDC in January 1986, a third series was included thereby allowing an assessment of yield potentials in high, medium - low and low altitude environments in the province.

Experiments were of randomized block design, comprising 4 varieties (high and low elevation series) and 6 varieties (medium-low elevation series) in 5 replications. Data from the three series are given in Table 1 - 3, and discussion of the results from each series is presented below.

2.1.1. Maize varieties for higher elevations

The experiment includes a short-list of varieties bred by IRA for farming areas above 800 metres, and is designed to assess yield potential at higher elevations (1500m and above) in the North West Province.

Conducted at three sites in 1984, the experiment was repeated on four sites in both 1985 and 1986. Results are presented in Table 1. Since harvest stand counts did not differ between varieties on any of the sites, yield effects expressed may be taken as a genuine reflection of yield potential.

Overall experiment yield levels at Mbiyeh and Santa compared favourably with those of 1984, averaging 1.56 tonnes/hectare (shelled grain) and 3.09t/ha. respectively over the two years.

At Dzeng, a site with severe soil problems, yields were greatly improved following incorporation of cattle manure to sections of the farm during land preparation (see also Section III).

At the very highest elevation sites (Dzeng and Mbiyeh), there was again no evidence of the available varieties giving any yield advantage over local maize.

At Santa and Fundong TDCs (1650 and 1500 metres respectively), a different picture has emerged, with the variety COCA tending to outyield other available varieties. The only exception to this was at Fundong in 1985 where "Local" gave the highest yield. 1986 Fundong data show that although Local produced more cobs, the weight of grain per cob was far higher for COCA. Accordingly, COCA should continue to be the recommended variety in these medium-high altitude zones.

BACOA has generally not proved well suited to growing conditions above 1500m. However, its relative earliness of maturity (averaging about 190 days) was comparable to Local at Mbiyeh and Dzeng, and this, together with its yellow grain may make it attractive to some farmers.

It is to be noted that the growing season for maize around 2000m. altitude is $6\frac{1}{2}$ - 7 months, compared with some $5 - 5\frac{1}{2}$ months at 1000 - 1400m. (the zone to which the varieties under test seem to be better suited - see below). The early variety BACOA takes longer to mature at the higher elevations, but still retains its relative earliness compared to the other varieties. Whilst this may be considered beneficial the advantage may to some extent be offset by the variety's ripening at the very height of the rainy season. Later maturing varieties, ripening as the rains diminish, are easier for farmers to dry to a storable moisture content.

Based on the earlier results from the Adaptive Research Programme, and the experience of the IRA Testing and Liaison Unit (TLU) at Bambui, a new maize breeding programme was established by the National Cereals Research and Extension Project (NCRE). The Programme aims to develop varieties specifically suitable for the long, cold growing conditions experienced at the highest farming altitude in the Province.

Experiment results from the Dzeng and Mbiyeh TDCs in 1984 and 1985, suggested that further measures should be adopted to provide farmers with the best currently available local seed for the higher altitudes.

TABLE 1

SHORT - LIST MAIZE VARIETY EXPERIMENTS
VARIETIES FOR HIGHER ELEVATIONS

a) Yield of Cobs (kg/ha)

VARIETY	1985	1986	1985	1986	1985	1986	1985	1986
COCA	3800	4500	2040	8700	8730	4860	10280	9360
BACOA	2900	5400	1900	7700	5660	2620	7640	8000
MLC	4500	3700	1700	8000	7020	4290	9460	8160
LOCAL	2600	5300	2350	11300	5800	3530	11470	6820
S.E. of Difference	873	942	529	1550	1070	695	1078	463
S.E.	585	666	374	1096	757	492	762	328
C.V. (%)	40	32	42	27	25	29	18	9
F. Ratio	2.0	1.4	0.5	2.2	3.6*	3.9*	4.5*	10.1**

b) Yield of Shelled Grain (kg/ha)

VARIETY	1985	1986	1985	1986	1985	1986	1985	1986
COCA	1250	2280	630	3805	4800	2660	5130	
BACOA	1180	2320	790	3065	3550	1710	4120	
MLC	1570	1660	590	3185	3860	2350	4490	
LOCAL	1500	2190	1030	4765	3700	2100	2610	
S.E. of Difference	372	430	265	504	673	374	632	
S.E.	263	304	187	355	476	265	447	
C.V. (%)	43	32	55	21	27	27	24	
F. Ratio	0.5	1.0	1.1	4.8*	1.4	2.3	5.7*	

c) Stand Count at Harvest ('000/ha)

VARIETY	MBIYEH		DZENG		SANTA		FUNDONG	
	1985	1986	1985	1986	1985	1986	1985	1986
COCA	39.2	32.8	27.6	46.0	48.8	39.0	38.6	49.4
BACOA	39.0	38.2	30.4	45.6	48.6	37.2	39.2	47.2
MLC	41.2	34.4	24.6	48.4	47.4	38.6	35.4	44.0
LOCAL	42.4	39.2	32.8	42.8	48.6	37.8	41.2	46.4
S.E. of Difference	4.1	5.0	6.1	2.5	1.1	1.8	3.5	1.9
S.E.	2.9	3.5	4.3	1.8	0.7	1.3	2.4	1.3
C.V. (%)	1.6	22	17	9	3	7	14	6
F. Ratio	0.3	0.7	2.7	1.7	0.7	0.4	1.0	2.7

d) Number of Cobs at Harvest ('000/ha)

VARIETY	MBIYEH		DZENG		SANTA		FUNDONG	
	1985	1986	1985	1986	1985	1986	1985	1986
COCA	33.8	34.8	18.8	58.4	48.4	36.4	45.8	44.0
BACOA	34.4	37.4	19.6	47.8	44.6	31.6	41.4	43.0
MLC	35.6	31.0	16.8	52.2	42.2	36.2	45.4	39.6
LOCAL	35.6	33.4	21.0	47.2	45.8	32.4	45.4	49.8
S.E. of Difference	5.9	5.0	4.3	4.4	3.5	4.0	4.3	2.0
S.E.	4.2	3.5	3.0	3.1	2.5	2.8	3.0	1.4
C.V. (%)	26	23	35	14	12	19	15	7
F. Ratio	0.4	0.6	0.3	2.7	1.1	0.8	0.5	8.6**

Selected samples of the best Local maize from the highland areas of Bui and Donga-Mantung Divisions, were planted in "ear plots" at Mbiyeh TDC in 1986.

This well adopted local material is thought to have been derived from earlier importations of the Kenyan variety, Kitale Synthetic II. Cobs used in the Mbiyeh 1986 plantings were accordingly chosen by the IRA Bambui maize breeder for their similarity to typical Kitale Synthetic II. In addition, new stock of Kitale Synthetic II was included as a plot in the Mbiyeh plantings to allow half-sib crossing. Cobs were again carefully selected from those plants expressing desirable morphological characteristics in 1986., seed from these cobs will provide the basis for further multiplication from 1987 season onwards. In this way, we may ensure that all farmers at the highest elevations, who are in contact with the agricultural extension service, can quickly have access to the best currently available maize stocks, as a stop-gap measure until such time as NCRE has produced heavier yielding replacements. Seed of this "selected local" should be used to phase out supply of MLC, the currently recommended variety for the high altitude zone, as quickly as stocks allow. Having served its purpose of classifying the maize varieties responses to higher altitude conditions in the Province, this series of experiments will now be discontinued. It is suggested that it be replaced in due course with an experiment to test a short-list of potential varieties developed from NCRE's High Altitude Population.

2.1.2. Maize varieties for medium-low elevations

With the establishment of TDCs at Babungo and Oku-Noni⁽¹⁾ in the 1985 season and early 1986 respectively, the second series of maize variety experiments was carried on four centres in 1986. Available data from 1985 and 1986 are presented in Table 2.

Generally, high yields were obtained through^{out} with particularly good results from the new site in Oku-Noni where grain yields ranged from 3.7 - 6.4 tonnes per hectare.

(1) Following a recent instruction from the Senior Divisional Officer of Bui Division, the TDC herein referred to as "Oku-Noni TDC", will in future operate under the name of its village location and be known as "NGEPTANG TDC."

TABLE 2

SHORT - LIST MAIZE VARIETY EXPERIMENTS
 VARIETIES FOR MEDIUM - LOW ELEVATIONS

a) Yield of Cobs (kg/ha)

VARIETY	NYEN (1200m)		NKWEN (1200m)		BABUNGO (1100m)		OKU-NONI (1400m)
	1985	1986	1985	1986	1986	1986	1986
COCA	6500	4670	8650	7300	7140		11000
BACOA	5500	5110	7650	5400	4080		9000
MLC (KASAI)	4800	5760	8250	- (5700)	- (5300)		8600
EKONA WHITE	6600	6030	7950	6500	6200		8600
EKONA YELLOW	5400	5010	7050	4500	3200		6800
LOCAL	5080	4040	6650	4300	4200		6600
S.E. of Difference	1261	918	518	771	831		760
S.E.	892	649	366	545	588		537
C.V. (%)	35	28	11	22	26		14
F. Ratio	0.7	1.2	4.2**	4.5	6.3**		9.0**

b) Yield of Shelled Grain (kg/ha)

VARIETY						
COCA	3875	2325	3860	4040	4717	6400
BACOA	3585	3210	3620	3560	2952	4900
MLC (KASAI)	2915	3195	3710	- (3340)	- (3070)	5000
EKONA WHITE	4190	3034	3630	3700	4420	4300
EKONA YELLOW	3300	3750	3460	3240	1952	3700
LOCAL	2995	2235	3300	2600	3175	3700
S.E. of Difference	757	760	247	383	584	527
S.E.	535	538	175	271	413	374
C.V. (%)	34	41	11	18	27	18
F. Ratio	0.9	1.2	1.2	3.2*	6.1**	7.5**

Notes:

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- (1) Variety KASAI replaced MLC in this experiment in 1986 at Babungo and Nkwen only.
- (2) 1986 was the first year of arable crop experiments at Babungo and Oku-Noni.

c) Stand Count at Harvest ('000/ha)

VARIETY	NYEN		NKWEN		BABUNGO	OKU-NONI
	1985	1986	1985	1986	1986	1986
COCA	30.4	28.6	42.4	34.8	31.0	39.4
BACOA	32.2	32.6	45.0	37.6	26.4	39.0
MLC (KASAI)	26.6	30.8	44.4	- (33.6)	- (27.0)	39.4
EKONA WHITE	35.2	31.8	46.4	37.2	28.4	38.2
EKONA YELLOW	32.4	28.0	43.8	27.4	23.6	37.0
LOCAL	34.6	29.6	46.4	38.6	28.2	39.0
S.E. of Difference	3.6	3.1	2.3	1.9	2.2	1.4
S.E.	2.5	2.2	1.6	1.3	1.5	1.0
C.V. (%)	18	16	8	9	13	6
F. Ratio	1.5	0.7	0.9	9.5**	2.5	0.9

d) Number of Cobs at Harvest ('000/ha)

VARIETY						
COCA	32.2	31.4	39.4	33.8	34.0	41.6
BACOA	35.0	32.4	42.4	28.8	30.0	39.4
MLC (KASAI)	29.0	32.4	41.8	- (31.4)	- (26.6)	37.0
EKONA WHITE	38.6	30.8	43.2	34.4	32.6	35.8
EKONA YELLOW	35.2	29.4	42.6	25.6	22.4	34.0
LOCAL	34.6	31.8	42.0	32.2	27.0	36.8
S.E. of Difference	4.2	3.7	2.6	4.5	3.1	2.6
S.E.	2.9	2.6	1.8	3.2	2.2	1.8
C.V. (%)	19	19	10	23	17	11
F. Ratio	1.2	0.2	0.5	1.1	3.9*	2.2

At the suggestion of IRA Bambui, the variety KASAI I, of Zaire origin, was included in place of MLC at Babungo and Nkwen in 1986. Although it performed reasonably well, it offered no yield advantage over COCA.

The currently recommended variety for this altitude zone (COCA) yielded very well at Oku-Noni and Babungo, and out-ranked other entries at Nkwen in 1985 (cob weight) and 1986 (grain weight).

Harvest counts at Nkwen in 1986 were lowest for Ekona Yellow.

Both KASAI I and COCA had relatively low final stand counts, but grain data suggest that compensation was made for this with higher yields per plant.

COCA clearly did not display similar yield advantages at Nyen, where the varieties bred for lowland conditions performed equally well. Given that the yields of Ekona White and COCA have proved similar now in three years' testing at Nyen, and that the foliar diseases to which the crop is exposed in this area are of lowland races, it is suggested that the recommended variety for mid-altitude Momo Division be changed from COCA to Ekona White. This would ensure that farmers would gain advantage from the disease resistance characteristics of this lowland variety in any years of severe disease incidence and would not be losing in seasons with a more mild attack.

Ekona Yellow would seem not to offer quite the same advantages at Nyen as Ekona White, and is clearly not appropriate in the other three locations where it suffered from a relatively low survival rate (Nkwen and Babungo) and produced fewer cobs (Babungo).

On the basis of the above assessments, the experiment may now be discontinued at Nyen, but should be considered for continuation at the other three sites including both Kasai I and MLC, but excluding Ekona Yellow. Any additional variety testing could then await further development from the NCRE programme.

2.1.3. Maize varieties for low elevations

Results from this experiment at Widikum are given in Table 3.

Ekona White, with a grain yield of approximately 4 tonnes/ha. was clearly better than the other varieties under test. It also produced more and larger cobs. Although Ekona Yellow had a lower stand count at harvest, its final grain yield was comparable with that of MLC and Local.

TABLE 3

SHORT - LIST MAIZE VARIETY EXPERIMENTS

VARIETIES FOR LOW ELEVATIONS

WIDIKUM 1986

Variety	Yield of Cobs (kg/ha)	Yield of grain (kg/ha)	Number of Cobs ('000/ha)	Stand at harvest ('000/ha)
EKONA WHITE	11950	4040	46.0	48.4
EKONA YELLOW	7100	2750	36.4	43.8
MLC	7700	2820	39.4	48.8
LOCAL	9640	2250	39.6	46.8
S.E. of Difference	896	491	2.6	1.1
S.E.	634	347	1.8	0.8
C.V. (%)	19	31	12	4
F. Ratio	11.9**	4.8*	4.9*	9.1**

This experiment should continue for a further one or two seasons to see if Ekona White maintains its apparent advantage, and to confirm whether Ekona Yellow could be recommended if its stand count can be improved. The lower stand count may however prove to be an indication of this variety's not being appropriate for the Widikum environment.

2.2. INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

The maize/beans/groundnuts series of intercropping experiments again comprised four separate but related investigations in 1985 :-

- an assessment of weed control and fertilizer responses
- the optimum timing of a single weeding
- the effects on the association of introducing named varieties
- the effects of manipulating planting arrangements and plant populations.

For reasons discussed below (see section 2.2.3), the third experiment concerning "improved" named varieties was dropped in 1986.

A wider evaluation of the remaining three experiments was made possible by the expansion of the adaptive research programme's facilities following the opening of the Babungo and Oku-Noni TDCs.

Once again interpretation of the resultant data has been done in two stages, with the examination of individual component crop data being followed by the development of the common denominator (CFA value) through which a direct comparison can be made of overall treatment effects. Treatment effects have also been further clarified by producing summaries of the yield rankings of the individual crop components together with a ranking of overall values under each treatment.

2.2.1. Weed Control and Fertilizer Response

The experiment contained eight treatments comprising all the combinations of four levels of weed control and two levels of fertilizer (NPK, 20:10:10) application; a 4 x 2 Factorial design in five replications at each of the four sites.

1985 data are given in Tables 4 - 6, and 1986 data in Tables 7 - 11. Results are first presented in the form of 2-way tables to focus the reader's attention on the relative contributions to observed effects of the weeding and fertilizer treatments. Tables 6 and 11 then present summaries of grain yields together with the overall value of the production derived under each treatment regime.

It should be noted throughout that the beans could only be potentially influenced by treatment W_0 - W_2 , since they were harvested prior to the specified timing of W_3 .

NYEN TDC - 1985

Experiment results are given in Tables 4 and 6.

Due to an error in the application of the third weeding treatment, W_2 and W_3 were effectively the same.

As may have been anticipated, there was a marked positive impact on grain yields in maize and groundnuts from the first weeding, of 55 per cent and 282 per cent respectively. No additional yield increase was derived from the second weeding in maize, but it did provide a further 6 per cent yield increase in groundnuts. In the case of the groundnuts the higher yields appear to have been at least in part the result of more plants surviving to contribute to harvest under improved weed control regimes, whereas the maize yield increase resulted from heavier yields per plant.

Weeding did allow more bean plants to survive to harvest and there is an indication that this could have been reflected in final yield.

However bean yield data was extremely variable and masked any definitive treatment effect.

Availability of the additional fertilizer under F_2 (albeit still at a modest rate of application) increased maize cob yields, but neither this nor the impact of the second weeding on groundnuts were reflected in similar increases in the overall value of production.

NYEN TDC - 1986

Experiment results are given in Tables 7 and 11.

The third weeding treatment was correctly applied in 1986, this validating the full series of treatment combinations. Maize cobs and grain yields showed a greater overall response to fertilizer than in both previous seasons, possibly reflecting the reduced weed control problems associated with the continued improvement in farm management of the Centre as a whole. Nevertheless both the first and second weedings raised yields, and the first weeding also generated improved stand counts at harvest and produced more cobs.

The additional fertilizer under F_2 appears to have caused partial compensation for the greater weed competition under W_0 and W_1 in terms of final maize yields.

Whilst no marked fertilizer or weed control effects were observed in beans, groundnut yields were again overwhelmingly influenced by increasing levels of weed control with 100 per cent increase from W₁, a further 475 per cent increase from W₂ and a still further increase of 46 per cent from W₃.

However, having converted all grain production data to a combined CFA value, the yield benefit to groundnuts from W₃ is not reflected in total value from the crop association, which more closely relates to the pattern of the maize yield's contribution.

NKWEN TDC - 1985

Experiment results are given in Tables 5 and 6.

In view of the lack of weeds at the scheduled time of the third weeding this operation was not carried out. Treatments involving W₂ and W₃ were therefore the same.

The results indicate a positive response to both W₁ and W₂ with respect to maize and groundnut yields. The influence of additional fertilizer under the F₂ regime made a larger contribution than the weeding treatments to maize cob and grain yield increases. However, only increasing levels of weed control affected groundnut yields with a 111 per cent increase from W₁ and a further 167 per cent increase from W₂, evidently related to an improved stand count and the numbers of cobs produced were increased only by the first weeding.

There were no observed effects of either weed control or fertilizer application on bean yields. Since early weed control would normally be expected to positively influence bean yields, it seems probable that under conditions of only a relatively light weed infestation, the quick-growing beans outpaced the weeds and so avoided any adverse yield effect. This argument is borne out by the positive impact of removing subsequent weed growth on yields of both the slower growing crops-groundnuts and maize.

Converting the data to values of production reveals increased values through both the improved weed control and the additional fertilizer application. This is a clear reflection of the pattern of maize response to the treatments and emphasizes the importance of the maize status in this association value terms.

TABLE 4

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

I WEED CONTROL/FERTILIZER RESPONSE

NYEN 1985

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Total
F ₁	4400	7600	6400	7133	25533
F ₂	5867	8267	8600	7867	30601
Weeding Total	10267	15867	15000	15000	56134
S.E. (1)	1056	F Ratio: F		5.8*	CV (%) 24
S.E. (2)	746			5.8**	
S.E. (3)	528			0.5	

Abbreviations

Treatments:

F₁ = NPK (20:10:10) at 2 bags per hectareF₂ = NPK (20:10:10) at 4 bags per hectareW₀ = NO weeding after plantingW₁ = 1 weeding at 4 weeksW₂ = 2 weedings at 4 weeks and 8 weeksW₃ = 3 weedings at 4, 8 and 12 weeks

(the timing of the third weeding precludes any impact on yield of beans but would influence maize and groundnut yields).

S.E. (1) = Standard Error of values in the body of the table.

S.E. (2) = Standard Error of weeding totals.

S.E. (3) = Standard Error of Fertilizer totals.

F = Fertilizer effect

W = Weeding effect

F W = Fertilizer/Weeding interaction

CV (%) = Coefficient of Variation.

b) MAIZE: Yield of shelled grain (kg/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	2780	4763	3963	4460	15966
F_2	3430	4887	5313	4660	18290
Weeding Totals	6210	9650	9276	9120	34256
S.E. (1)	631	F Ratio: F		3.4	C.V. (%) 23
S.E. (2)	446	W		6.3**	
S.E. (3)	315	FW		0.8	

c) MAIZE: Stand count at harvest ('000/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	26.0	25.9	27.1	26.7	105.7
F_2	25.3	26.0	26.4	25.2	102.9
Weeding Totals	51.3	51.9	53.5	51.9	208.6
S.E. (1)	1.1	F Ratio: F		1.5	CV (%) 7
S.E. (2)	0.8	W		0.7	
S.E. (3)	0.5	FW		0.4	

d) BEANS: Yield of shelled beans (kg/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	173	477	283	329	1262
F_2	230	333	240	217	1020
Weeding Totals	403	810	523	546	2282
S.E. (1)	114	F Ratio: F		1.1	CV (%) 63
S.E. (2)	80	W		2.3	
S.E. (3)	57	FW		0.6	

e) BEANS: Stand Count at Harvest (1000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	37.7	42.4	39.5	40.5	160.1
F ₂	37.9	40.0	38.5	39.5	155.9
Weeding Totals	75.6	82.4	78.0	80.0	316.0
S.E. (1)	1.7	F Ratio: F 1.6		CV (%) 7	
S.E. (2)	1.2	W 3.0*			
S.E. (3)	0.8	FW 0.4			

f) GROUNDNUT: Yield of shelled groundnuts (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	26	153	210	147	536
F ₂	46	122	81	173	422
Weeding Totals	72	275	291	320	958
S.E. (1)	48	F Ratio: F 1.4		CV (%) 63	
S.E. (2)	34	W 5.7**			
S.E. (3)	24	FW 2.3			

g) GROUNDNUTS: Stand Count at harvest (1000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	36.9	54.9	53.3	51.3	196.4
F ₂	38.1	50.3	49.3	50.7	188.4
Weeding Totals	75.0	105.2	102.6	102.0	384.8
S.E. (1)	4.2	F Ratio: F 0.2		CV (%) 14	
S.E. (2)	3.0	W 11.3**			
S.E. (3)	2.1	FW 0.4			

h) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W_0	W_1	W_2	W_3	Fertilizer Total
F_1	365.9	679.9	557.3	614.3	2217.4
F_2	456.8	661.2	686.9	620.8	2425.7
Weeding Totals	822.7	1341.1	1244.2	1235.1	4643.1
S.E. (1)	78.7	F Ratio		F 1.8	C.V. (%) 7.1
S.E. (2)	55.6			W 8.6**	
S.e. (3)	39.3			FW 0.8	

TABLE 5

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

I WEED CONTROL/FERTILIZER RESPONSENKWEN 1985

A) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	3533	4867	5600	5000	19000
F ₂	4600	5600	6600	7067	23867
Weeding Totals	8133	10467	12200	12067	42867
S.E. (1)	825	F Ratio: F			8.7**
S.E. (2)	583	W			5.3**
S.E. (3)	413	FW			0.5
				CV (%)	24

b) MAIZE: Yield of Grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	2000	3067	3133	2800	11000
F ₂	2600	3267	3867	3800	13534
Weeding Totals	4600	6334	7000	6600	24534
S.E. (1)	453	F Ratio: F			7.8**
S.E. (2)	320	W			5.5**
S.E. (3)	227	FW			0.5
				CV (%)	23

c) MAIZE: Number of Cobs Produced ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	19.5	26.3	24.4	24.0	94.2
F ₂	20.8	24.8	24.7	26.0	96.3
Weeding Totals	40.3	51.1	49.1	50.0	190.5
S.E. (1) 2.2	F Ratio: F 0.2				CV (%) 15
S.E. (2) 1.6	W 5.1**				
S.E. (3) 1.1	FW 0.5				

d) MAIZE: Stand Count at Harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	26.0	27.1	25.9	26.5	105.5
F ₂	24.8	26.9	25.7	26.1	103.5
Weeding Totals	50.8	54.0	51.6	52.6	209.0
S.E. (1) 0.7	F Ratio: F 1.7				CV (%) 4
S.E. (2) 0.5	W 3.8*				
S.E. (3) 0.4	FW 0.5				

e) BEANS: Yield of shelled beans (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	207	299	321	233	1040
F ₂	239	253	245	271	1008
Weeding Totals	446	552	546	504	2048
S.E. (1) 45	F Ratio: F 0.1				CV (%) 27
S.E. (2) 32	W 1.2				
S.E. (3) 23	FW 1.2				

f) GROUNDNUT'S: Yield of shelled groundnuts (kg/ha)

		W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁		35	85	211	196	527
F ₂		39	71	205	212	527
Weeding Totals		74	156	416	408	1054
S.E. (1)	23	F Ratio:		F	0.0	CV (%) 28
S.E. (2)	16			W	57.4**	
S.E. (3)	12			FW	0.3	

g) GROUNDNUTS: Stand Count at Harvest ('000/ha)

		W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁		56.4	59.9	61.6	63.5	241.4
F ₂		58.0	60.4	61.7	62.4	242.5
Weeding Totals		114.4	120.3	123.3	125.9	483.9
S.E. (1)	2.2	F Ratio:		F	0.1	CV (%) 6
S.E. (2)	1.5			W	5.2**	
S.E. (3)	1.1			FW	0.3	

h) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

		W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁		236.9	384.7	429.3	379.5	1430.4
F ₂		313.5	392.4	491.3	491.2	1688.4
Weeding Totals		550.4	777.1	920.6	870.7	3118.8
S.E. (1)	46.7	F Ratio:		F	7.6*	CV (%) 19
S.E. (2)	33.0			W	12.3**	
S.E. (3)	23.4			FW	0.9	

TABLE 6

INTERCROPPING EXPERIMENTS -- MAIZE/BEANS/GROUNDNUTSI WEED CONTROL/FERTILIZER RESPONSE

Grain Yields (kg/ha) and Value of Production ('000 CFA/ha)

-- 1985

TREATMENT	NYEN				NKWEN			
	M	B	G	Value	M	B	G	Value
W0 F1	2780	173	26	365.9	2000	207	35	236.9
W0 F2	3430	230	46	456.8	2600	239	39	313.5
W1 F1	4763	477	153	679.9	3067	299	85	384.7
W1 F2	4887	333	122	661.2	3267	253	71	392.4
W2 F1	3963	283	210	557.3	3133	301	211	429.3
W2 F2	5313	240	81	686.9	3867	245	205	491.3
W3 F1	3963	329	147	614.3	2800	233	196	379.5
W3 F2	5313	217	183	620.8	3800	271	212	491.2
S.E.	631	114	48	78.7	453	45	23	46.7

TABLE 7

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

I WEED CONTROL/FERTILIZER RESPONSE

NYEN 1986

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	1493	2333	3133	3640	10599
F ₂	2707	3720	3800	3667	13894
Weeding Totals	4200	6053	6933	7307	24493
S.E. (1) 457	F Ratio: F 13.0**				CV (%) 24
S.E. (2) 323	W 9.2**				
S.E. (3) 228	FW 1.8				

b) MAIZE: Yield of Grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	727	1253	1920	2060	5960
F ₂	1373	2040	2073	2013	7499
Weeding Totals	2100	3293	3993	4073	13459
S.E. (1) 294	F Ratio: F 6.9*				CV (%) 28
S.E. (2) 208	W 9.7**				
S.E. (3) 147	FW 1.8				

c) MAIZE: Number of Cobs produced ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	19.1	22.0	24.1	22.7	87.9
F ₂	22.1	23.5	22.9	24.3	92.8
Weeding Totals	41.2	45.5	47.0	47.0	180.7
S.E. (1) 1.1	F Ratio: F 3.3				CV (%) 8
S.E. (2) 0.8	W 4.3*				
S.E. (3) 0.6	FW 1.8				

d) MAIZE: Stand Count at Harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	18.8	21.9	22.9	22.7	86.3
F ₂	22.0	23.2	22.3	23.9	91.4
Weeding Totals	40.8	45.1	45.2	46.6	177.7
S.E. (1)	1.3	F Ratio: F 3.6		CV (%) 10	
S.E. (2)	0.9	W 3.5*			
S.E. (3)	0.7	FW 1.4			

e) BEANS: Yield of shelled beans (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	39	61	69	93	262
F ₂	57	81	77	47	262
Weeding Totals	96	142	146	140	524
S.E. (1)	21	F Ratio: F 0.0		CV (%) 50	
S.E. (2)	15	W 1.25			
S.E. (3)	10	FW 2.25			

f) BEANS: Stand Count at Harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	21.3	27.9	26.4	27.3	102.9
F ₂	21.5	22.3	26.8	26.1	96.7
Weeding Totals	42.8	50.2	53.2	53.4	199.6
S.E. (1)	4.6	F Ratio: F 0.5		CV (%) 29	
S.E. (2)	3.2	W 1.2			
S.E. (3)	2.3	FW 0.4			

g) GROUNDNUTS: Yield of shelled groundnuts (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	3	3	25	37	68
F ₂	1	5	21	31	58
Weeding Totals	4	8	46	68	126
S.E. (1)	7	F Ratio: F 0.6		CV (%) 74	
S.E. (2)	5	W 17.9**			
S.E. (3)	4	FW 0.2			

h) GROUNDNUTS: Stand Count at Harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	2.0	11.2	22.3	24.1	59.6
F ₂	3.5	12.3	18.8	20.7	55.3
Weeding Totals	5.5	23.5	41.1	44.8	114.9
S.E. (1)	4.2	F Ratio: F 0.3		CV (%) 47	
S.E. (2)	3.0	W 18.2**			
S.E. (3)	2.1	FW 0.4			

i) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	94.5	160.5	243.7	267.2	765.9
F ₂	173.1	256.5	263.2	251.9	944.7
Weeding Totals	267.6	417.0	506.9	519.1	1710.6
S.E. (1)	36.4	F Ratio: F 6.0*		CV (%) 27	
S.E. (2)	25.7	W 30.5**			
S.E. (3)	18.2	FW 2.0			

TABLE 6

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

I WEED CONTROL/FERTILIZER RESPONSE

NKWEN 1986

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	4133	3933	4667	5067	17800
F ₂	4467	5333	4867	5000	19667
Weeding Totals	8600	9266	9534	10067	37467
S.E. (1)	432	F Ratio:		F 4.7*	CV (%) 15
S.E. (2)	305		W	2.0	
S.E. (3)	216		FW	2.2	

b) MAIZE: Yield of shelled grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	2573	2073	2547	2747	9940
F ₂	2813	2900	2560	2667	10940
Weeding Totals	5386	4973	5107	5414	20880
S.E. (1)	287	F Ratio:		F 3.0	CV (%) 17
S.E. (2)	203		W	0.6	
S.E. (3)	144		FW	2.0	

c) MAIZE: Number of Cobs produced ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	23.5	24.0	27.3	25.9	100.7
F ₂	25.1	25.5	25.1	25.7	101.4
Weeding Totals	48.6	49.5	52.4	51.6	202.1
S.E. (1)	1.8	F Ratio:		F 0.03	CV (%) 11
S.E. (2)	1.3		W	1.0	
S.E. (3)	0.9		FW	1.0	

d) MAIZE: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	26.3	25.9	26.5	25.3	104.0
F ₂	24.9	24.4	25.2	25.7	100.2
Weeding Totals	51.2	50.3	51.7	51.0	204.2
S.E. (1)	0.9	F Ratio: F		4.8*	CV (%) 5
S.E. (2)	0.6	w		0.5	
S.E. (3)	0.4	FW		1.1	

e) BEANS: Yield of shelled beans (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	116	123	104	122	465
F ₂	98	121	114	92	425
Weeding Totals	214	244	218	214	890
S.E. (1)	19	F Ratio: F		1.1	CV (%) 27
S.E. (2)	13	W		0.6	
S.E. (3)	9	FW		0.9	

f) BEANS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	43.9	45.2	43.1	45.6	177.8
F ₂	43.9	44.8	41.7	40.4	170.8
Weeding Totals	87.8	90.0	84.8	86.0	348.6
S.E. (1)	2.1	F Ratio: F		2.0	CV (%) 7
S.E. (2)	1.5	W		1.2	
S.E. (3)	1.0	FW		1.3	

e) GROUNDNUTS: Yield of shelled groundnuts (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	27	30	59	94	210
F ₂	27	51	42	46	166
Weeding Totals	54	81	101	140	376
S.E. (1)	17	F Ratio:		F 1.6	CV (%) 58
S.E. (2)	12		W	4.3*	
S.E. (3)	9		FW	2.8	

h) GROUNDNUTS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	46.3	47.3	54.8	57.9	206.3
F ₂	43.2	50.9	47.9	51.7	193.7
Weeding Totals	89.5	98.2	102.7	109.6	400.0
S.E. (1)	4.6	F Ratio:		F 1.9	CV (%) 14
S.E. (2)	3.2		W	3.4*	
S.E. (3)	2.3		FW	1.1	

i) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	286.0	238.0	290.4	324.0	1138.4
F ₂	306.5	326.3	288.4	296.4	1217.6
Weeding Totals	592.5	564.3	578.8	620.4	2356.0
S.E. (1)	30.9	F Ratio:		F 1.6	CV (%) 17
S.E. (2)	21.9		W	0.6	
S.E. (3)	15.5		FW	2.6	

TABLE 9

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

I WEED CONTROL/FERTILIZER RESPONSE

BABUNGO 1986

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	560	267	973	1413	3213
F ₂	987	400	2040	1680	5107
Weeding Totals	1543	667	3013	3093	8320
S.E. (1) 299	F Ratio: F 10.0**				CV (%) 45
S.E. (2) 211	W 15.6**				
S.E. (3) 149	FW 1.9				

b) MAIZE: Number of Cobs produced ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Total
F ₁	8.7	6.7	13.7	16.0	45.1
F ₂	13.5	9.9	20.9	17.1	61.4
Weeding Totals	22.2	16.6	34.6	33.1	106.5
S.E. (1) 2.3	F Ratio: F 12.3**				CV (%) 28
S.E. (2) 1.6	W 14.2**				
S.E. (3) 1.2	FW 1.2				

c) MAIZE: Stand Count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₂	Fertilizer Totals
F ₁	15.2	17.9	18.1	19.9	71.1
F ₂	16.1	20.4	20.5	19.3	76.3
Weeding Totals	31.3	38.3	38.6	39.2	147.4
S.E. (1) 2.4	F Ratio: F 1.3		CV (%) 20		
S.E. (2) 1.7	W 2.4				
S.E. (3) 1.2	FW 0.4				

d) BEANS: Yield of shelled beans (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	193	187	233	273	886
F ₂	200	220	247	240	907
Weeding Totals	393	407	480	513	1793
S.E. (1) 48	F Ratio: F 0.0		CV (%) 34		
S.E. (2) 34	W 1.7				
S.E. (3) 24	FW 0.2				

c) BEANS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Total
F ₁	29.9	31.5	34.9	33.9	130.2
F ₂	34.1	30.5	35.6	34.5	134.7
Weeding Totals	64.0	62.0	70.5	68.4	264.9
S.E. (1) 2.4	F Ratio: F 1.0		CV (%) 11		
S.E. (2) 1.7	W 2.7				
S.E. (3) 1.2	FW 0.9				

f) GROUNDNUTS: Yield of shelled groundnuts (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	560	373	593	520	2046
F ₂	647	313	640	833	2433
Weeding Totals	1207	686	1233	1353	4479
S.E. (1)	104	F Ratio: F 3.5		CV (%) 29	
S.E. (2)	74	W 8.1**			
S.E. (3)	52	FW 2.3			

g) GROUNDNUTS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	54.7	52.3	58.0	56.5	221.5
F ₂	58.5	42.8	58.8	55.2	215.3
Weeding Totals	113.2	95.1	116.8	111.7	436.8
S.E. (1)	3.9	F Ratio: F 0.6		CV (%) 11	
S.E. (2)	2.8	W 6.2*			
S.E. (3)	1.9	FW 2.1			

h) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	226.7	155.9	261.6	266.5	910.7
F ₂	272.3	149.1	326.0	365.9	1113.3
Weeding Totals	499.0	305.0	587.6	632.4	2024.0
S.E. (1)	40.2	F Ratio: F 6.3*		CV (%) 25	
S.E. (2)	28.4	W 13.0**			
S.E. (3)	20.1	FW 1.2			

TABLE 10

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTSI WEED CONTROL/FERTILIZER RESPONSEOKU-NONI 1986

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	5067	7200	7200	7867	27334
F ₂	5867	8533	7600	8533	30533
Weeding Totals	10934	15733	14800	16400	57867
S.E. (1) 780	F Ratio:		F	4.2*	CV (%) 17
S.E. (2) 552			W	9.8**	
S.E. (3) 390			FW	0.3	

b) MAIZE: Yield of Grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	2600	4000	4200	4333	15133
F ₂	3667	4467	4200	4800	17134
Weeding Totals	6267	8467	8400	9133	32267
S.E. (1) 479	F Ratio:		F	4.4*	CV (%) 19
S.E. (2) 339			W	6.8**	
S.E. (3) 239			FW	0.8	

c) MAIZE: Number of Cobs produced ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	23.2	25.6	26.8	26.9	102.5
F ₂	25.7	29.1	27.9	27.2	109.9
Weeding Totals	48.9	54.7	54.7	54.1	212.4
S.E. (1) 1.4	F Ratio: F 8.1**				CV (%) 8
S.E. (2) 1.0	W 4.3*				
S.E. (3) 0.7	FW 0.8				

d) MAIZE: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	24.8	26.3	25.3	26.1	102.5
F ₂	26.0	26.5	26.0	25.5	104.0
Weeding Totals	50.8	52.8	51.3	51.6	206.5
S.E. (1) 0.9	F Ratio: F 0.7				CV (%) 5
S.E. (2) 0.6	W 1.0				
S.E. (3) 0.4	FW 0.9				

e) BEANS: Yield of shelled beans (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	667	600	700	633	2600
F ₂	600	733	667	633	2633
Weeding Totals	1267	1333	1367	1266	5233
S.E. (1) 74	F Ratio: F 0.1				CV (%) 18
S.E. (2) 52	W 0.5				
S.E. (3) 37	FW 1.4				

f) BEANS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	35.6	34.8	36.0	37.9	144.3
F ₂	34.4	37.6	36.0	35.6	143.6
Weeding Totals	70.0	72.4	72.0	73.5	287.9
S.E. (1) 1.7	F Ratio		F	0.04	CV (%) 7
S.E. (2) 1.2			W	0.7	
S.E. (3) 0.8			FW	1.7	

g) GROUNDNUTS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	10.9	24.8	28.8	27.6	92.1
F ₂	6.9	24.9	32.1	36.0	99.9
Weeding Totals	17.8	49.7	60.9	63.6	192.0
S.E. (1) 3.8	F Ratio:		F	1.1	CV (%) 25
S.E. (2) 2.7			W	30.0**	
S.E. (3) 1.9			FW	1.9	

h) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W ₀	W ₁	W ₂	W ₂	Fertilizer Totals
F ₁	341.1	475.7	508.3	513.3	1841.4
F ₂	442.4	539.3	504.1	559.9	2045.7
Weeding Totals	786.5	1015.0	1012.4	1073.2	3887.1
S.E. (1) 51.3	F Ratio:		F	4.0	CV (%) 17
S.E. (2) 36.2			W	6.1**	
S.E. (3) 25.6			FW	0.7	

TABLE 11

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

I WEED CONTROL/FERTILIZER RESPONSE

Grain Yields (kg/ha) and Value of Production ('000 CFA/ha) - 1986

Treatment	NYEN			NKWEN			BABUNGO			OKU - NONI		
	M	B	G	M	B	G	M ⁽¹⁾	B	G	M	B	G ⁽²⁾ Value
W0 F1	727	39	3	2573	116	27	560	193	560	2600	667	344.1
W0 F2	1373	57	1	2813	98	27	987	200	647	3667	600	442.4
W1 F1	1253	61	3	2073	123	30	267	187	373	4000	600	475.7
W1 F2	2040	81	5	2900	121	51	400	220	313	4467	733	539.3
W2 F1	1920	69	25	2547	104	59	973	233	593	4200	700	508.3
W2 F2	2073	77	21	2560	114	42	2040	247	640	4200	667	504.1
W3 F1	2060	93	37	2747	122	94	1413	273	520	4333	633	513.3
W3 F2	2013	47	31	2667	92	46	1680	240	833	4800	633	559.9
S. E.	294	21	7	287	19	17	299	48	104	479	74	51.3

(1) Cob yield at Babungo

(2) Groundnut data not available: negligible yields (see text)

NKWEN TDC - 1986

Experiment results are given in Tables 8 and 11.

Yield levels of all crops in this experiment were higher in 1986 than in 1985. However there were few observed treatment effects.

Maize cob yields were greater at the higher level of fertilizer application, evidently from greater individual plant yields since fewer plants contributed to harvest in the treatment involving F₂. The reason for the latter observation is unclear, especially as there was no effect of weed control on maize yields.

Increasing levels of weed control did benefit the groundnuts in the association where W₃ yields were 159 per cent higher than those under W₀.

There were no observed effects on either bean yields, or total production data converted to CFA values. The coefficients of variation for most parameters described are much lower than in the past and show an improved level of data uniformity. There is therefore no question of data irregularities masking treatment effects. Rather the results suggest a further decline in the importance of weeds on this site as a factor in governing yields. The 1986 season represents the fourth year of operations at the Nkwén TDC, and it is clear, both from site observation, and the results of experiments, that overall weed infestation has declined under the good level of management which has been maintained. This has important implications for the extension programme, suggesting that recommended weed control practice should be to have at least two weedings in land newly brought out of fallow, reducing this to a single or two early weedings as weed population decline.

BABUNGO TDC - 1986

Experiment results are given in Tables 9 and 11.

The most striking effect observed in this experiment at Babungu was the low yield, of both maize and groundnuts, in the treatments having only a single occasion of weeding when compared with zero-weeding or multiple-weeding treatments. The effect did not occur in the bean crop where neither the fertilizer nor weeding treatments led to marked changes in yield.

The combined implication of these observations is that one or more weed species were allowed to develop as a result of the action of first weeding, species which had been suppressed by others - less detrimental

to maize and groundnuts - in the unweeded plots. The quickly maturing beans, in the field only for three months, were clearly not affected by this later weed growth, whereas the more slow-growing maize and groundnuts crops suffered from increased weed competition. The W₂F₁ and W₂F₂ results show that removal of the second stage of weed growth led to improved maize and groundnut yields. It would be valuable to identify this purported competitive weed species.

The additional fertilizer provided under the F₂ regime increased only maize yields, and this is reflected in the overall CFA value of production given in Table 9(h).

OKU-NONI TDC - 1986

Experiment results are given in Tables 10 and 11.

Although no groundnut yield data are available, a number of the other parameters measured gave useful information.

Increased maize yields (cob and grain weights) were obtained from the higher rate of fertilizer application at all levels of weed control, the effect being particularly prominent under W₁ and W₂. Since none of the treatments affected the maize stand count, the increased yield can be related to the larger number of cobs produced in plots having at least one weeding and receiving the higher rate of fertilizer.

Although only stand count data are available for groundnuts, they reveal a very marked positive impact from increasing degrees of weed control. No treatment effects were seen in beans.

Since the CFA value of production data in Table 10 (h) are based only on maize and bean yields, they are of lesser interest than value data from the other TDCs. Nevertheless they do, together with maize yield data confirm the importance at this site of the third occasion of weeding in this first season of operations at the Centre.

The failure of the groundnuts to provide any substantial crop will be further examined in 1987. Groundnuts are a common crop of the area, and although the TDC soils are rather heavy and not ideally suited to groundnuts, they should not be expected to so drastically reduce yields.

2.2.2. Timing of a single weeding

The experiment, a Randomized Block in 4 Replications, was conducted on two sites in 1985 and four sites in 1986. It was designed to observe the effect on yields of the component crops and the value of total production from the association, of a single occasion of weed control carried out at different times after sowing. All three crops were sown at the same time. Results from the experiments are given in Table 12.

At Babungo, the maize data showed considerable irregularity. A severe infestation of a soil-borne insect pest, tentatively identified as the larval stage of the Maize rootworm, Buphonella africana, caused heavy losses of newly emerged maize seedlings. Considerable re-sowing was necessary and as a result, the maize stand established was of differing ages, with plants responding differently to the weeding treatments depending on their stage of development at that time. At Oku-Noni, the highest maize yields were obtained from weeding at the 4 - 6 week stage, and at Nyen (1985) at the 4 - 8 week stage. No marked effects were observed at Nkwen (1985 and 1986) or Nyen (1986) probably reflecting the declining level of weed infestation on these longer-established Centres.

No effects were observed on bean yields at any of the sites, but groundnut yields showed marked responses - Table 12(g), suggesting that timing of weed control was more important in the crops with a longer growing season.

Table 12(j) ranks the six times of weed control in terms of the grain yields produced at each site and the value of total production. By accumulating these rankings into a total score for each parameter, it becomes clear that the most effective time to carry out a single weeding is 6 weeks after sowing. (Table 12k)

Although delaying the weeding until after 6 weeks led to only a small decline in yield in groundnuts, it had an adverse overall impact on the crop association.

TABLE 12

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

II TIMING OF SINGLE WEEDING

a) Maize: Yield of Cobs (kg/ha)

	NYEN		NKWEN		BABUNGO	OKU-NONI
	1985	1986	1985	1986	1986	1986
WEEDING AT:						
2 weeds	3763	8267	5500	3600	1787	5167
4 weeds	5817	6600	5417	3933	1400	6000
6 weeks	6124	7400	5917	4400	1647	5833
8 weeks	7217	6533	4500	2867	1853	5500
10 weeks	4646	6400	5083	4067	1600	5333
12 weeks	3979	5800	4583	3533	1533	3500
S.E. of Difference	1011	931	474	482	489	579
S.E.	716	658	335	340	346	410
C.V. (%)	27	19	13	18	42	16
F. Ratio	3.6*	1.7	2.7	2.6	0.2	4.8**

b) Maize: Yield of Shelled Grain (kg/ha)

2 weeks	1940	4773	3733	2333	1120	2833
4 weeks	3200	3787	3067	2333	773	3420
6 weeks	3333	4207	3333	3000	933	3333
8 weeks	4000	3727	2833	1733	1240	2920
10 weeks	2473	3760	2833	2533	1160	2667
12 weeks	2147	3453	2733	2200	1020	1833
S.E. of Difference	558	552	504	386	311	387
S.E.	395	390	357	273	220	273
C.V. (%)	28	20	22	23	42	19
F. Ratio	4.0*	1.5	1.2	2.3	0.6	4.3*

c) Maize: Stand Count at Harvest ('000/ha)

	NYEN		NKWEN		BABUNGO	OKU-NDINI
	1985	1986	1985	1986	1986	1986
2 weeks	25.3	29.9	26.2	24.8	19.3	25.7
4 weeks	26.5	29.2	25.7	26.3	20.5	25.5
6 weeks	26.0	29.2	25.7	26.8	16.8	25.3
8 weeks	26.3	29.3	25.0	26.2	19.2	25.3
10 weeks	25.8	31.2	26.3	25.5	16.7	25.7
12 weeks	25.2	30.7	27.3	26.2	20.0	24.8
S.E. of Difference	0.9	1.5	0.5	1.1	3.3	0.9
S.E.	0.7	1.1	0.4	0.8	2.3	0.6
C.V. (%)	5.1	7	3	6	25	5
F. Ratio	0.7	0.6	4.8**	0.8	0.5	0.2

d) Maize: Number of Cobs at Harvest ('000/ha)

2 weeks	n.a	29.3	24.8	24.3	18.5	24.8
4 weeks		29.2	24.8	22.5	17.3	24.7
6 weeks		29.0	24.2	24.8	15.2	26.0
8 weeks		28.3	19.5	25.0	19.3	25.5
10 weeks		30.5	23.5	24.5	17.0	25.2
12 weeks		30.2	23.7	22.5	17.3	23.2
S.E. of Difference		1.5	1.3	1.2	3.7	1.9
S.E.		1.1	0.9	0.9	2.6	1.4
C.V. (%)		7	8	7	30	11
F. Ratio		0.5	4.5*	1.8	0.3	0.5

e) Beans: Yield of dry beans (kg/ha)

	NYEN		NKWEN		BABUNGO	OKU-NONI	(1)
	1985	1986	1985	1986	1986	1986	
2 weeks	350	260	302	127	287	700	
4 weeks	179	247	320	155	247	633	
6 weeks	124	227	355	432	333	567	
8 weeks	227	167	342	103	293	600	
10 weeks	129	153	283	128	267	520	
12 weeks	124	207	310	121	320	533	
S.E. of Difference	78	45	56	178	56	77	
S.E.	55	32	39	126	40	54	
C.V. (%)	58	30	24	142	27	18	
F. Ratio	2.6	1.8	0.4	1.0	0.7	1.6	

f) Beans: Stand Count at Harvest ('000/ha)

2 weeks	43.2	41.0	n.a	43.8	33.3	41.2
4 weeks	38.0	37.2		42.2	32.0	40.2
6 weeks	39.2	39.5		44.7	33.3	39.7
8 weeks	42.0	39.7		42.2	35.0	38.0
10 weeks	35.3	36.2		44.0	38.0	37.2
12 weeks	39.5	39.3		43.7	36.3	39.0
S.E. of Difference	2.6	3.0		1.8	3.5	1.7
S.E.	1.8	2.1		1.2	2.4	1.2
C.V. (%)	9	11		6	14	6
F. Ratio	2.3	0.7		0.7	0.8	1.5

(1) Shelled fresh weight.

g) Groundnuts: Yield of dry nuts (kg/ha)

	NYEN		NKWEN		BABUNGO	OKU-NC II
	1985	1986	1985	1986	1986	1986
2 weeks	58	53	117	27	227	
4 weeks	150	113	153	30	280	
6 weeks	187	167	213	49	373	n.a.
8 weeks	117	127	250	11	527	
10 weeks	133	107	242	80	420	
12 weeks	83	147	163	80	513	
S.E. of Difference	27	44	37	16	84	
S.E.	19	31	26	11	60	
C.V. (%)	31	53	27	48	31	
F. Ratio	6.1**	1.4	4.2*	6.9**	4.1*	

h) Groundnuts: Stand Count at Harvest ('000/ha)

2 weeks	56.0	39.3	59.7	53.5	30.3	32.5
4 weeks	57.0	43.7	60.7	52.0	39.2	38.3
6 weeks	60.0	46.2	61.8	55.5	34.2	30.2
8 weeks	54.7	45.9	61.5	49.3	47.8	29.3
10 weeks	53.5	43.9	62.8	51.8	45.8	36.5
12 weeks	54.5	42.7	58.7	59.2	47.7	28.2
S.E. of Difference	3.9	5.1	2.2	3.5	5.7	6.6
S.E.	2.8	3.6	1.6	2.5	4.1	4.7
C.V. (%)	10	17	5	9	20	29
F. Ratio	0.7	0.5	0.9	1.9	3.4*	0.8

i) Total Value of Production ('000 CFA/ha)

	NYEN		NKWEN		BABUNGO	OKU-J NI
	1985	1986	1985	1986	1986	1986
2 weeks	306.2	622.7	462.8	266.2	219.2	371.7
4 weeks	437.2	512.5	410.3	267.7	196.3	421.5
6 weeks	449.5	567.7	459.5	335.2	253.5	401.7
8 weeks	535.0	492.7	418.2	194.5	319.5	367.5
10 weeks	339.0	491.3	405.5	296.3	276.7	331.5
12 weeks	291.5	522.0	378.5	261.8	300.5	250.5
S.E. of Difference	72.1	60.6	56.2	39.3	43.8	43.5
S.E.	51.0	42.9	39.7	27.8	31.0	30.8
C.V. (%)	26	16	19	21	24	17
F. Ratio	3.5*	1.4	0.7	2.8	2.3	4.

(j) Yield rankings in individual experiments - 1985/1986

Maize Grain Yield Bean Yield Groundnut Yield CFA Value of Production

treatment (2)	NY				NK				BA				ON			
	85	86	85	86	85	86	85	86	85	86	85	86	85	86	85	86
2 weeks	6	1	1	3=	3	4	1	5	4	4	1	6	6	5	6	3
4 weeks	3	3	3	3=	6	1	2	3	2	6	2	4	5	4	5	1
6 weeks	2	2	2	1	5	2	3	1	1	4	1	1	3	3	4	n.a.
8 weeks	1	5	4=	6	1	3	2	2	6	3	3	4	3	1	6	1
10 weeks	4	4	4=	2	2	5	6	6	3	5	6	3	5	2	1=	3
12 weeks	5	6	6	5	4	6	5	4	4	5	2	5	2	4	1=	2

(k) Accumulated ranking SCORES (3)

	Maize	Beans	Groundnuts	Value
2 weeks	18	16	29	19
4 weeks	19	18	20	21
6 Weeks	15	15	12	13
8 weeks	20	21	15	20
10 weeks	21	30	14	25
12 weeks	32	25	14	28

Notes:

- (1) Ranking of the yields/value of production from highest treatment (1) to lowest (6).
- (2) A single weeding after the number of weeks shown.
- (3) The sum of treatment rankings for each parameter in Table 12 (j).

2.2.3. Introduction of "Improved" Varieties

The experiment examines the relative advantages of introducing named varieties of the component crops into the maize/bean/groundnuts association in place of "Local" varieties. The named varieties used were :-

Maize	COCA
Beans	Ph 330
Groundnuts	A - 65 - 13

There were no differences in maize plant survival to harvest nor in the number of cobs contributing to harvest. However, cob and grain yields were clearly higher in treatments involving COCA than in those using "Local" maize, regardless of whether COCA was associated with improved or local legumes.

Beans stand counts were markedly higher in the local variety, but there was no evidence to suggest any link between this and the type of maize or groundnut variety used in the association. The three highest bean yields at both Nyen and Nkwen involved the local variety, seemingly unaffected by the associated maize variety, and it was noted that Ph 330 was later maturing than local beans. This would in itself have increased the possibility of competition with maize at its maximum stage of leaf development. In the case of groundnuts, higher yields involved both the Local and improved varieties, and at Nkwen the higher groundnut yield was linked with the presence of local maize and not COCA.

Average yields (kg/ha.) of the four 'Local' and four 'Improved' treatments for each crop were :

	Nyen		Nkwen	
	Improved	Local	Improved	Local
Maize	2721	1348	4667	2407
Beans	35	79	200	289
Groundnuts	106	139	209	217

Yield differences were observed for each crop at Nyen, but these were not translated into different values of overall production. At Nkwen, the higher value derived from the presence of COCA maize, and at Nyen the highest absolute values also involved the improved maize although the effect just fails to reach significance ($p=0.05$).

TABLE 13

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

III INTRODUCTION OF "IMPROVED" VARIETIES - 1985

MAIZE

	Stand at Harvest ('000/ha)		No. of Cobs ('000/ha)		Fresh Cob Wt. (kg /ha)		Shelled Grain Wt. (kg /ha)	
	Nyen	Nkwen	Nyen	Nkwen	Nyen	Nkwen	Nyen	Nkwen
TREATMENT:								
L L L	13.3	24.7		24.0	1841	5500	1291	2433
I L L	20.7	26.3		25.7	3667	7667	2267	4667
I I L	23.0	27.0		26.7	4667	7567	3017	4667
I L I	23.0	25.7		25.7	4333	7567	2767	5000
L I I	16.0	24.7	n.a.	22.0	2459	5167	1192	2217
I L I	20.2	25.7		24.7	4357	5667	1641	2517
L L L	17.7	24.3		23.7	2459	5833	1267	2459
I I I	21.0	26.7		26.0	4500	8000	2833	4333
S.E. of Difference	3.2	1.5		1.7	863	441	675	355
S.E.	2.3	1.1		1.2	610	312	477	251
C.V. (%)	24	8		10	35	9	47	14
F. Ratio	2.2	0.9		1.6	3.3*	13.9*	2.6*	23.7**

I = "Improved" named variety

L = Local variety

0.01/0.02

b) BEANS

TREATMENT	Stand at Harvest ('000/ha)		Fresh Pod Wt. (kg/ha)		Shelled Grain Wt. (kg/ha)	
	Nyen	Nkwen	Nyen	Nkwen	Nyen	Nkwen
L L L	26.3	62.3	125		67	307
I L L	28.7	61.8	184		49	239
I I L	10.7	51.0	67		27	172
I L I	34.0	65.3	184		81	297
L I I	9.3	49.0	73	n.a.	31	225
L L I	32.3	70.3	359		119	313
L I L	9.3	49.0	68		27	219
I I I	16.0	50.8	161		55	183
S.E. of Difference	4.8	7.1	60		31	54
S.E.	3.4	5.0	42		22	38
C.V. (%)	32	17	56		77	31
F. Ratio	9.9**	2.9*	5.2**		2.6*	2.1

c) GROUNDNUTS

TREATMENT						
L L L	52.3	55.3	817		181	253
I L L	56.0	60.0	741		131	180
I I L	48.7	55.0	741		147	193
I L I	52.0	56.0	367		93	193
L I I	53.3	55.7	400	n.a.	92	204
L L I	58.7	58.0	575		148	260
L I L	54.0	50.7	659		96	240
I I I	56.0	56.0	367		92	180
S.E. of Difference	3.9	4.3	74		21	51
S.E.	2.7	3.0	52		15	36
C.V. (%)	10	11	18		24	34
F. Ratio	1.3	0.8	12.4**		5.4**	0.8

d) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	NYEN	NKWEN
L L L	196.0	427.0
I L L	298.7	604.7
I I L	385.3	584.7
I L I	357.2	662.0
L I I	162.3	361.7
L L I	241.7	440.0
L I - I	170.3	394.7
I I I	359.7	551.7
S.E. of Difference	84.1	42.9
S.E.	59.5	30.4
C.V. (%)	44	12
F. Ratio	2.3	13.4**

The results confirm that the named Phaseolus variety available is not well adapted to the conditions represented by either of these Centres; that COCA gives a marked advantage over Local at Nkwen but a much smaller advantage at Nyen (see also section 2.1.2. above); and that A - 65 - 13 and local groundnuts at Nkwen both performed better when associated with the less productive Local maize. This last observation suggests that the competitive influence of COCA in the association was a more important determinant of groundnut yield than the variety of groundnut used.

There is clearly a need to develop varieties of both beans and groundnuts which are better adapted to local conditions than the named varieties included here (see also section III below). Once such varieties are available, the apparent interaction of groundnut and maize yields from the association should be further investigated.

Following two seasons of investigation (1984 and 1985), and until better adapted legume varieties become available, the experiment has been discontinued.

2.2.4. Planting Arrangements/Plant Populations

The experiment was developed to examine the possibility of improving on the productivity of the maize/beans/groundnuts association through changes in the spatial arrangement of the component crops and/or the relative and total plant populations. Figure 1 illustrates the different planting arrangements employed.

The experiment was laid out as a Randomized Block with 4 Replications and the results are presented in Table 14.

Stand counts showed that the relative differences in population required in the experiment were achieved, thus allowing the data to be examined and interpreted in relation to the differences in planting arrangement. The theoretical, expected populations of the component crops are given in Table 15. In the case of treatment 6, with planting arranged according to local practice (and carried out by farmers), plant populations varied from site to site. Observations on site indicated that in this treatment, row planting was avoided. The legumes filled all available space between maize which was itself spaced out but not in any distinguishable pattern.

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

Planting Arrangements

Plan view of portion of ridge:

***** Beans sown at 30cms spacing
 xxxxxx Maize - see below for spacings
 oooooo Groundnuts sown at 20cms spacing

- | | |
|--|--|
| <p>1.</p> <pre> o o o o o o o * * * * * x x x x x x x x x * * * * * o o o o o o o </pre> | <p>4.</p> <pre> o o o o o o o o o xx xx xx xx xx xx xx xx xx xx xx xx xx xx * * * * * </pre> |
| <p>2.</p> <pre> o o o o o o o o o x x x x x x x x x x x x x x x x x x * * * * * </pre> | <p>5.</p> <pre> o o o o o o o o o x x x x x x x x x x x x x x x x x x * * * * * </pre> |
| <p>3.</p> <pre> o o o o o o o o o x x x x x x x x x x x x x x * * * * * </pre> | <p>6. Control planted
according to local
practice</p> |

1. Single row maize at 25cms spacing
2. Double row maize at 25cms within row spacing
50cms between rows
3. Double row maize at 50cms within & between rows
4. Double row maize at 50cms within & between rows and two plants
retained per hill
5. Double row maize at 25cms within row spacing
20cms between rows

(A plot comprises 4 ridges each 1.5m wide x 5m long)

In 1986, with the exception of Nyen TDC, the local practice gave the highest total plant populations. It is unclear whether this was a true reflection of local methods of planting, or whether, in planting on the TDCs farmers felt obliged to completely fill available space. (Further investigation of this on farmers' plots is needed since low population had been considered a factor limiting production).

As can be seen from Table 15, groundnuts represented a very high proportion of the total population in treatment 6 at Nkwen, and the legume population was generally more heavily emphasized in local planting. Only treatment 1 of the designed arrangements approached similar legume population.

Higher individual crop yields were closely associated with higher populations, but since similarly high maize populations were designed to be achieved in different ways, the data need to also be examined closely in relation to the planting arrangements.

In Table 14 (j) individual crop yields and overall CFA values of production have been ranked for all the experiments in this series to date (including 1984 data), to facilitate comparison of observed treatment effects across sites.

The uniformity of treatment effect across sites and years is striking. The only major exception occurred at Nyen in 1985, where the maize stand count at harvest under the local planting was considerably higher than the designed 'high' maize population of treatments 2, 4 and 5. This resulted in a very high grain yield (8.1 tonnes/hectare) which in turn contributed to the apparently abnormally high value of production. Similarly, extremely dense populations of beans and groundnuts were recorded in this case. Bean yields seem not to have suffered any adverse effect (the beans having matured before intense competition set in?), but the resultant overcrowding drastically reduced groundnut yields. Examination of Tables 14 (g) and (h) shows that groundnut yields were lowest in this treatment but from a final population twice the size of the "high groundnut" arrangements in treatment 1. Clearly the total population involved in this instance exceeded the level conveying initial advantage to the component crops. However, this effect did not observe the overall picture emerging from the complete series of data.

The best maize yields were achieved with those double-row plantings which allowed final populations equivalent to that recommended for maize grown as a pure crop (53,300/ha). Thus, treatments 2 and 5 ranked equal first overall, with single maize plants equally spaced out within the rows, and treatment 4, with two maize plants per hill and 50 cm between hills (both within and between rows), also gave good results. By far the best arrangement for beans and groundnuts was treatment 1 where the single central row of maize allowed more space for a high legume population. It is important to note however, that despite the similarly high (and in some cases even higher) legume populations achieved with the local planting methods, their total yield ranking scores were markedly higher (i.e. yields were lower). As noted above, the lack of any regular pattern to planting in treatment 6 resulted in legumes "filling-in" between maize plants. The legumes were subsequently seen to be increasingly shaded by the developing maize plants. Much less shading by the maize was possible in Arrangement 1, with the maize restricted to a single central row and the legumes growing relatively unhindered on the outer profile of the ridge. Experiment data clearly show the yield advantage gained from the more organised planting of Arrangement 1, despite fewer plants being involved.

Data from the remaining planting arrangements further illustrate the importance of the maize shading effect. Legume stand counts are here the same in each case, but the highest legume yield ranking scores (lowest yields) are seen in those arrangements involving 53,300 maize plants per hectare. Planting arrangement 3, gave an intermediate result tying in well with the greater amount of light reaching the legumes' leaf canopy through the more widely spaced, single maize plants. As Table 14 (j) shows, the best arrangement for the legumes is the worst in terms of maize yields. The reverse is true for groundnuts but not for beans. Examination of the yield data converted to CFA values of total production shows that the best balance of overall production from the arrangements under test, is given by arrangement 5, with arrangement 2 a close second. (The overall pattern of the value of production data, closely follows that for maize grain yield).

Arrangements 5 and 2 each comprise a double row of maize with a single plant per hill producing a final maize population equivalent to the recommendation for maize as sole - crop. In Arrangement 5, the maize rows are very close together (20 cm) allowing more light penetration to the outer profile of the ridge than Arrangement 2 and producing slightly better bean yields. Given the results of this series experiments and the continuation of similar relative prices for the component crops, a number of important conclusions can be given in summary.

The best legume yields were obtained from row planting all the crops, adopting the current recommended population for intercropped maize (approximately 25,000 maize plants/ha) and confining the maize row to the centre of the ridge. This is a particularly important result, since an earlier PEM Division Survey⁽¹⁾ had concluded that improved maize yields following adoption of the maize population recommendation, were derived at the expense of groundnut population and hence groundnut yield. The observed value of increased maize production was then reduced in the Survey on the basis of an assumed loss of intercrop benefits. The present series of experiments suggest (compare treatments 1 and 6) that groundnut and bean populations can be maintained at a sufficiently high level to raise legume production, over and above that from the local planting arrangement, by adopting row planting, whilst still allowing a maize population of 25,000/ha. as recommended.

Put another way, the TDC results suggest that the real increase in maize yields achieved by farmers adopting the maize recommendations (a package in which the population level is only one of several elements) may in fact have also benefitted from increased groundnut yields as a result of the lowering of groundnut population which was observed and the row planting of the crop association. Maize yields from Arrangement 1 on the TDCs ranged from 2.7 - 5.2 tonnes/ha. further implying that maize yields from this particular arrangement, may rise to levels higher than those shown to be obtained by farmers in the survey (approx. 3.2 tonnes/ha) whilst continuing to maximize legume yields.

(1) P.E.M. Division of MIDENO (February 1985)

Extension Service Survey : Report No. 2 : Maize package adoption 1984.

TABLE 14

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

IV PLANTING ARRANGEMENTS/PLANT POPULATIONS

a) Maize: Yield of Cobs (kg/ha)

TREATMENT	NYEM		NKWEN		BABUNGO	OKU-NONI
	1985	1986	1985	1986	1986	1986
1	9500	8083	7417	4500	4000	5500
2	13250	12000	9250	6333	6667	6500
3	9417	8750	8250	5587	5933	5167
4	13500	9167	10167	5500	7267	6000
5	13167	10500	9833	7667	7067	7000
6	15167	10167	7417	4500	4267	5500
S.E. of Difference	1167	480	714	712	381	729
S.E.	825	339	505	504	269	515
C.V. (%)	13	7	12	18	9	17
F. Ratio	8.1**	10.9**	5.7**	5.7**	27.9**	1.8

b) Maize: Yield of Shelled Grain (kg/ha)

1	5229	4360	4652	2833	2773	3000
2	7117	6327	5017	4033	4360	3417
3	5125	4907	4542	3573	3573	3250
4	6875	5120	5825	3273	4707	2833
5	6387	6140	5355	5033	4427	3667
6	8100	5653	4050	2900	2833	2667
S.E. of Difference	656	200	475	407	262	541
S.E.	464	142	336	288	185	382
C.V. (%)	14	5	14	16	10	24
F. Ratio	6.3**	28.7**	3.5*	8.3**	20.8**	1.0

c) Maize: Stand Count at Harvest ('000/ha)

TREATMENT	NYEN		NKWEN		BABUNGO	OKU-NONI
	1985	1986	1985	1986	1986	1986
1	22.2	28.3	25.8	24.2	24.7	23.0
2	36.3	55.8	49.0	43.0	39.5	48.8
3	21.7	33.2	26.7	25.2	25.8	25.2
4	41.2	46.7	48.8	46.2	43.3	48.2
5	40.2	52.2	46.5	48.0	43.5	45.2
6	57.2	52.7	31.3	52.3	34.8	35.3
S.E. of Difference	2.3	4.4	1.4	2.8	3.1	1.8
S.E.	1.7	3.1	1.0	2.0	2.2	1.3
C.V. (%)	9	14	5	10	13	7
F. Ratio	64.8**	13.5**	134.5**	38.0**	14.5**	80.9**

d) Maize: Number of Cobs at Harvest ('000/ha)

1	32.3	25.0	23.2	21.2	22.5
2	52.8	45.7	43.8	39.8	42.0
3	n.a.	35.3	27.2	23.8	27.5
4	46.7	44.5	41.8	39.3	42.7
5	52.2	42.2	42.0	44.0	40.2
6	54.5	29.8	46.0	30.0	30.3
S.E. of Difference	2.5	2.3	3.7	3.8	2.4
S.E.	1.8	1.7	2.6	2.7	1.7
C.V. (%)	8	9	14	16	10
F. Ratio	28.6**	32.5**	15.7**	10.7**	31.4**

e) Beans: Yield of Dry Beans (kg/ha)

TREATMENT	NYEN		NKWEN		BABUNGO	OKU-NONI
	1985	1986	1985	1986	1986	1986
1	421	207	169	209	413	767
2	124	93	80	76	213	333
3	148	93	67	69	213	387
4	108	80	57	47	233	500
5	100	93	45	51	247	460
6	367	180	119	81	393	753
S.E. of Difference	40	49	42	26	68	104
S.E.	28	35	30	18	48	73
C.V. (%)	27	54	67	41	34	28
F. Ratio	25.3**	2.5	2.4	10.8**	3.7*	6.3**

f) Beans: Stand Count at Harvest ('000/ha)

1	37.2	38.8	21.5	40.7	32.5	36.8
2	16.8	20.5	9.0	20.8	16.7	19.2
3	16.7	14.8	10.2	20.3	16.3	22.8
4	15.0	22.2	12.8	20.3	14.5	17.3
5	16.5	19.3	9.5	21.8	17.5	19.2
6	51.8	33.8	17.5	30.0	55.0	42.2
S.E. of Difference	1.9	4.6	3.5	1.7	3.3	6.3
S.E.	1.3	3.3	2.5	1.2	2.4	4.4
C.V. (%)	10	26	37	9	19	34
F. Ratio	131.9**	8.1**	4.1*	48.5**	45.4**	5.6**

(1) Differences exhibited in fresh pod weight.

(2) Fresh Shelled beans weight at Oku-noni.

g) Groundnuts: Yield of Dry Nuts (kg/ha)

TREATMENT	NYEN		NKWEN		BABUNGO	OKU-NONI
	1985	1986	1985	1986	1986	1986
1	113	36	189	38	360	
2	41	10	35	17	167	
3	79	27	93	14	173	
4	33	12	67	22	127	n.a.
5	30	14	55	13	147	
6	29	25	180	61	427	
S.E. of Difference	14	7	11	8	53	
S.E.	10	5	7	6	37	
C.V. (%)	38	46	15	42	32	
F. Ratio	11.3**	4.2*	77.6**	9.3**	11.9**	

h) Groundnuts: Stand Count at Harvest ('000/ha)

1	40.2	31.7	64.0	45.8	41.7	37.8
2	18.5	17.7	29.2	24.0	21.0	22.7
3	22.3	24.8	30.7	25.0	23.5	25.7
4	22.7	20.0	30.5	23.5	21.8	28.0
5	20.5	17.7	28.8	22.7	23.0	23.8
6	83.3	49.3	55.2	76.0	51.3	57.3
S.E. of Difference	6.9	3.4	2.0	3.1	4.9	4.2
S.E.	4.9	2.4	1.4	2.2	3.4	3.0
C.V. (%)	28	18	7	12	23	18
F. Ratio	26.3**	26.0**	127.6**	97.0**	14.0**	19.8**

i) Total Value of Production ('000/ha)

	NYEN		NKWEN		BABUNGO	OKU-NONI
	1985	1986	1985	1986	1986	1986
1	717.2	560.3	551.2	331.2	430.2	396.8
2	871.0	765.7	526.3	421.5	482.2	384.0
3	646.7	601.8	494.0	373.8	411.0	373.5
4	837.7	621.5	612.7	342.3	501.7	346.7
5	849.0	744.8	559.8	516.3	485.7	424.7
6	1031.5	705.8	479.8	322.2	453.0	361.3
S.E. of Difference	75.7	28.0	48.3	41.0	33.3	54.0
S.E.	53.5	19.8	34.1	29.0	23.6	38.2
C.V. (%)	13	6	13	15	10	20
F. Ratio	6.2**	17.9**	2.0	6.5**	2.2	0.5

(j) Yield and Value Rankings: 1934 - 1986

TREATMENT	Maize Grain										Bean Yield				Total	
	NY(1)		NY(2)		NY(3)		NK(1)		NK(2)		NK(3)		BA(3)		O/N	Score
	NY(1)	NY(2)	NY(3)	NY(1)	NY(3)	NY(1)	NK(1)	NK(2)	NK(3)	NK(1)	NK(3)	NK(1)	NK(3)	NK(1)		
1	6	5	6	5	6	5	4	4	6	6	4	1	1	1	1	8
2	1	2	1	2	1	2	3	3	2	3	2	3	6	5	6	35
3	4	6	5	4	5	4	5	3	3	4	6	4	5	5	5	30
4	2	3	4	3	4	3	1	4	1	4	3	6	4	4	3	38
5	3	4	2	1	2	1	2	1	1	2	1	3	6	3	4	33
6	5	1	3	6	3	6	6	6	5	5	4	2	2	2	2	20
Groundnut Yield																
1	1	1	1	2	1	2	1	2	2	2	2	5	3	5	2	33
2	6	3	6	4	6	4	6	4	4	4	4	2	3	3	3	19
3	3	2	2	5	3	5	3	5	3	5	3	3	6	6	4	37
4	4	4	5	6	4	6	4	3	6	6	1	4	1	1	6	27
5	5	5	4	3	5	4	5	6	5	3	2	2	2	2	1	16
6	2	6	3	1	3	1	2	1	1	6	6	6	4	4	5	36

(1) 1984 ; (2) 1985 ; (3) 1986

TABLE 15

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/GROUNDNUTS

Theoretical populations expected in planting arrangement experiment
(Treatments 1 - 5 as designed: Treatment 6 from counts at germination
in 1986)

Treatment	Maize	Beans	Groundnuts	Total Plants
1	26.670	42.670	64.000	133.340
2	53.330	21.330	32.000	106.660
3	26.670	21.330	32.000	80.000
4	53.330	21.330	32.000	106.660
5	53.330	21.330	32.000	106.660
6 Nyen	52.700 ⁽¹⁾	20.800	39.000	112.500
Nkwen	52.300 ⁽¹⁾	30.300	79.300	161.900
Babungo	34.800 ⁽¹⁾	67.000	63.800	165.600
Oku-Noni	35.300 ⁽¹⁾	58.650	63.500	157.450

(1) From counts at harvest.

Amongst the arrangements tested in the experiment, the best overall financial benefit was not obtained with the currently recommended 25,000/ha maize population but with more than double this figure, again supporting the contention that adoption of the recommended maize population is not in itself a reason to reduce overall benefits as a result of reduced associated intercrop values. It is important to also note that the highest overall value of production from the association did not come from maximising the yield of the most valuable component crop (groundnuts).

The TDC results show that the best overall financial value was obtained (with reduced legume yield contributions) by raising the maize population to the level of that for maize grown as a sole crop (53,300/ha), planted in two rows of single plants, and with a legume population reduced to levels at the lower end of the range of populations in the "local plantings" on the TDCs. These lower legume populations are comparable with those observed on farmers plots in the PEM Survey. In arrangements with more widely separated maize rows, beans were in closer proximity to the maize and subject to a correspondingly greater shading influence. With the maize rows only 20 cm apart on the centre of the ridge, the associated beans benefitted from the better light penetration to the outside of the ridge and yielded more heavily.

2.3. INTERCROPPING EXPERIMENTS - MAIZE/BEANS

The maize/beans series of experiments was designed to examine the interaction under a range of agronomic practices, of these crops which are commonly grown together in the higher elevation farming areas of the Province.

Three separate but related experiments investigated :

- the effects of manipulating planting arrangements and plant populations
- weed control and fertilizer response
- the optimum timing for a single occasion of weed control.

The experiments were conducted on four TDCs (Mbiyeh, Dzeng, Santa and Fundong) in 1985 and 1986. As recorded in the previous Technical Report⁽¹⁾, considerable difficulties had been experienced with experimentation on particularly Dzeng and Santa TDCs as the result of their soil pest infestations and (especially in the case of Dzeng) the very poor and variable soil structure and fertility.

(1) ADAPTIVE RESEARCH AGRONOMIST : Adaptive Research Programme:
Technical Report No. 1 (December 1985).

Gradual improvements in soil characteristics have been made through incorporation of organic matter, and soil-borne pests were controlled through treatment of seed with a systemic insecticide (Marshal 25ST) at planting. Together the management practices adopted allowed much better crop establishment and as a result more uniform, reliable data was collected from experiments. (Note the lower general levels of co-efficients of variation for the parameters recorded in 1985 and 1986 compared with those for 1984).

Interpretation of the experiment results follows a similar format to the discussion of maize/beans/groundnuts experiments in Section 2.2, and the data are summarized in Tables 16 - 28.

2.3.1. Planting Arrangements/Plant Populations

Figure 2 illustrates the different planting arrangements tested in this experiment which was designed to examine the influence of maize/bean planting configurations on the productivity of the association.

The experiment was laid out as a Randomized Block with 4 Replications, and the results are summarized in Table 16.

The relative differences in populations required in the experiment were largely achieved, allowing the data to be interpreted in relation to designed differences in planting configurations. The theoretical, expected populations of the component crops in 1986 are given in Table 17. Considerable local variation was seen in the populations of treatment 6 where planting was done by farmers in accordance with local practice, and this clearly affected the uniformity of ranking of maize yields from this arrangement - see Table 16 (h). Particularly high total plant populations were achieved in this treatment at Mbiyeh and Fundong, and this is an important point to keep in mind in data interpretation. At Dzeng, total plant counts were comparable with the designed "low" population arrangement, and at Santa overall population under the local practices was the lowest of the population under test.

As observed in the similar maize/beans/groundnuts experiment (see Section 2.2.4 above), row planting was avoided in planting maize/beans in Treatment 6. Maize seed was sown in an irregular arrangement across the ridge, with the beans used to fill-in the intervening spaces.

FIGURE 2

INTERCROPPING EXPERIMENTS - MAIZE/BEANSPlanting Arrangements

Plan view of portion of ridge:

x x x x x - maize at 20cms spacing
 o o o o o - beans at 30cms spacing

1.
 o o o o o o
 o o o o o o
 x x x x x x
 o o o o o o
 o o o o o o

4.
 xx o xx o xx o xx
 o o o o o o o o
 xx o xx o xx o xx

2.
 o o o o o o
 o o o o o o
 x x x x x x
 o o o o o o
 o o o o o o

5.
 o o o o o o o o
 x x x x x x x x
 x x x x x x x x
 o o o o o o o o

3.
 x x x x x x
 o o o o o o o o
 x x x x x x

6. Control planted
 according to local
 practice

1. Single row maize at 20cms spacing

2. Single row maize at 25cms spacing

3. Double row maize at 25cms within row spacing

50cms between row spacing

4. Double row maize at 50cms within and between rows and with two plants retained per hill; beans within and between maize rows.

5. Double row maize at 25cms within row spacing

20cms between rows

(A plot comprises 4 ridges each 1.5m wide x 5m long)

Planting according to local practice gave roughly equal proportions of maize and beans at Mbiyeh and Santa, whilst beans represented 58 per cent of the total population at Dzeng and 46 per cent at Fundong.

Observed yield effects related to the stand counts achieved, although as Figure 2 and Table 17 show, comparable populations were designed to be achieved in several different ways. Maize grain yield differences recorded at Dzeng (1986) and Santa (1985 and 1986) related to the higher number of cobs contributing to yield as a result of improved final stand counts. Similar stand and cob count differences in other experiments were not reflected in grain yield.

Bearing in mind the serious soil problems associated with these higher elevation sites, maize yields were very satisfactory, with the continuing improvements at Dzeng being particularly noteworthy. Grain yields at Dzeng in 1986 compared favourably not only to yields on other sites in this experiment series, but also to those on some of the medium elevation sites.

Major bean yield differences were recorded at all sites in 1985 and 1986 with the single exception of Fundong in 1986. The marked improvement in yields at Mbiyeh and at Dzeng (quantitative information not available) derived to a considerable extent from the better early establishment achieved through the use of systemic insecticide as a seed treatment.

In Table 16 (h) individual crop yields and overall CFA values of production have been ranked for all the experiments conducted in this series (including those of 1984), to simplify comparison of observed treatment effects across sites.

Although uniformity of effect was not always quite so marked as in the similar maize/bean/groundnuts experiment (because of the varying populations in Treatment 6) a clear picture of the relative performance of the different arrangements nevertheless emerged.

The best maize yields were produced by Arrangement 3 with its two widely spaced rows of maize 50 cm apart and with 25 cm between single plants within the rows. This arrangement gives a population equivalent to that recommended for maize grown as a sole crop (53,300/ha.). Interestingly, in the other configurations giving this population, two centrally placed rows also gave consistently good results, (once soil problems at Dzeng and Mbiyeh had been reduced), but Arrangement 4 surprisingly performed less well.

The best (lowest) maize ranking score (Arrangement 3) was clearly associated with the worst overall bean score, although the reverse was not the case. The poor bean yield in Arrangement 3 - with beans sown as a single row between two maize rows - gives a strong indication of the adverse effect on beans of shading by surrounding maize plants. By far the best bean yields were in Arrangement 1 and 2 which allowed high bean populations to be established by maximising available space on the outer parts of the ridge. Similarly high bean populations in the local plantings at Mbiyeh and Fundong in 1986 did not give a proportionate yield increase. This must relate to the irregular planting arrangement of maize which surrounded the beans, caused increased shading and hence reduced bean yield. The currently recommended maize population in a crop association (of approximately 25,000 plants/ha and here represented by Arrangement 2), was shown in these experiments to provide good conditions for the associated bean crop planted to either side of the single central row of maize.

Arrangement 4, with beans both within and between maize rows, gave only moderate bean yields. Since the configuration is similar to, although more formally arranged than the local planting system, the result further illustrates the shading problem and emphasizes the significance of adopting an appropriate planting configuration in a crop association.

Examination of the data converted to overall values of crop production reveals a different picture. The maximum value was not derived by maximising the contribution of the more valuable component crop (beans), but from Arrangement 5 which involved the maximum designed maize population, and gave high (although not the highest) maize yields and only moderate to low bean yields.

If high bean yields from the maize/bean association are a major priority for the farmer, results from Arrangement 1 suggest that this can be achieved, with still a high overall value of production, whilst raising the maize population to 33,000/ha. At this population level (with its correspondingly higher maize yield), maize can still be restricted to a single row permitting the maximum bean population to be grown to either side with minimum shading from the maize.

TABLE 16

INTERCROPPING EXPERIMENTS - MAIZE/BEANS

I PLANTING ARRANGEMENTS/PLANT POPULATIONS

a) Maize: Yield of cobs (kg/ha)

TREATMENT (1)	MBIYEH		DZENG		SANTA		FUNDONG	
	1985	1986	1985	1986	1985	1986	1985	1986
1	3867	5833	4253	7500	5107	4749	4867	5583
2	3067	4583	3667	6083	5020	4425	5453	4592
3	4000	7333	5167	7583	8427	7353	6873	5692
4	3133	5917	3873	5167	4927	5902	6493	5509
5	3667	6333	4627	8708	8100	6309	7693	6025
6	3667	6500	3707	5833	5140	4823	7560	6433
S.E. of Difference	910	784	1052	465	556	423	620	580
S.E.	643	554	744	329	393	299	438	410
CV (%)	29	18	35	10	13	11	14	15
F Ratio	0.6	2.7	0.6	16.4**	17.9**	14.2**	6.7**	2.3

b) Maize: Yield of shelled Grain (kg/ha)

TREATMENT	1	2	3	4	5	6	S.E. of Difference	S.E.	C.V. (%)	F Ratio
1	1917	3040	1913	3213	2607	2837	2600	2483		
2	1660	2153	1747	2620	2500	2645	2493	1900		
3	2040	3600	2433	3333	4193	4309	3060	2417		
4	1550	3127	1833	2227	2493	3375	2607	2500		
5	1727	3260	2193	3687	4020	3545	3540	2733		
6	1750	3087	3407	2327	2660	2743	2693	3133		
S.E. of Difference	420	437	930	247	313	266	460	608		
S.E.	297	309	657	175	221	188	326	430		
C.V. (%)	34	20	58	12	14	12	23	34		
F Ratio	0.4	2.4	0.9	11.5**	13.0**	11.4**	1.5	0.9		

c) Maize: Stand Count at Harvest

TREATMENT	MBIYEH		DZENG		SANTA		FUNBONG	
	1985	1986	1985	1986	1985	1986	1985	1986
1	21.6	31.8	26.7	34.0	31.7	26.5	24.2	27.7
2	19.7	25.8	23.5	28.3	24.8	22.8	20.7	32.3
3	32.8	49.3	44.4	48.5	52.8	46.7	43.2	51.8
4	28.7	41.8	29.7	28.3	39.2	42.2	38.3	28.2
5	34.9	47.3	45.3	50.7	52.7	44.2	44.5	52.5
6	41.5	94.8	27.0	30.3	25.3	60.3	54.7	74.8
S.E. of Difference	3.1	1.6	2.4	2.2	2.2	2.3	2.4	2.4
S.E.	2.2	1.1	1.7	1.5	1.6	1.6	1.7	1.7
C.V. (%)	12	5	10	8	8	8	9	8
F Ratio	21.5**	484.0**	32.0**	44.4**	66.7**	72.4**	55.9**	124.0**

d) Number of Cobs at Harvest ('000/ha)

TREATMENT								
1	32.3	39.8			28.0	25.5	25.3	27.0
2	25.7	29.2			24.7	23.8	23.2	30.7
3	36.5	54.0	n.a.	n.a.	47.5	44.7	42.5	46.0
4	30.7	42.5			29.7	37.0	36.7	45.3
5	33.7	50.2			48.8	39.3	45.7	48.5
6	40.2	73.8			24.0	43.7	55.2	68.7
S.E. of Difference	5.5	4.3			2.5	2.3	3.2	4.2
S.E.	3.9	3.0			1.8	1.6	2.2	2.9
C.V. (%)	23	13			11	9	12	13
F Ratio	1.6	25.3**			39.9**	31.8**	30.3**	25.4**

e) Beans: Yield of dry beans (kg/ha)

TREATMENT	MBIYEH		DZENG		SANTA		FUNDONG	
	1985	1986	1985	1986	1985	1986	1985	1986
1	179	792		460	490	213	208	287
2	175	575		513	562	200	213	273
3	42	117	n.a.	220	217	93	60	133
4	50	283		367	350	133	100	193
5	96	317		200	349	107	150	167
6	58	385		293	349	120	150	187
S.E. of Difference	41	118		68	36	35	47	57
S.E.	29	83		48	25	24	33	40
C.V. (%)	58	41		28	13	34	44	39
F Ratio	4.7**	8.2**		6.9**	23.6**	4.2*	3.4*	2.2

f) Beans: Stand Count at Harvest ('000/ha)

TREATMENT								
1	48.2	76.0		55.7	104.3	49.0	61.0	66.0
2	53.2	75.5		65.7	116.8	47.0	60.0	76.5
3	11.7	19.7	n.a.	17.3	27.3	15.2	15.3	18.8
4	24.4	39.3		42.3	60.3	23.2	31.8	43.8
5	26.0	36.0		28.8	66.8	25.2	33.5	34.7
6	37.6	62.5		32.8	51.3	26.7	53.0	58.5
S.E. of Difference	4.9	2.4		5.0	11.4	6.4	3.3	7.8
S.E.	3.4	1.7		3.5	8.0	4.6	2.3	5.5
C.V. (%)	16	6		17	23	29	11	22
F Ratio	32.6**	195.4**		25.6**	17.4**	9.1**	62.6**	14.8**

g) Total Value of Production ('000 CFA/ha)

TREATMENT	MBIYEH		DZENG		SANTA		FUNDONG	
	1985	1986	1985	1986	1985	1986	1985	1986
1	160.8	314.7		353.2	289.0	258.2	219.7	243.3
2	141.7	224.3		305.5	293.3	241.3	237.4	196.3
3	154.0	276.5	n.a.	334.7	364.2	352.3	254.1	212.0
4	119.2	261.3		251.0	255.7	286.8	239.7	228.5
5	154.0	274.8		364.5	374.5	294.5	339.9	242.5
6	134.8	270.2		251.7	268.5	234.8	285.5	276.5
S.E. of Difference	33.2	41.2		23.9	25.8	24.2	37.0	52.4
S.E.	23.5	29.2		16.9	18.2	17.1	26.2	37.0
C.V. (%)	33	22		11	12	12	20	32
F Ratio	0.4	1.0		8.7**	7.5**	6.5**	2.8	0.6

(1) Only maize data available for 1985.

Yield and Value Rankings: 1984 - 1986

Maize Grain Yield

Maize Grain Yield											Bean Yield											Total
MB ⁽¹⁾	MB ⁽²⁾	MB ⁽³⁾	DZ ⁽¹⁾	DZ ⁽²⁾	DZ ⁽³⁾	S ⁽¹⁾	S ⁽²⁾	S ⁽³⁾	F ⁽²⁾	F ⁽³⁾	MB	MB	MB	DZ	DZ	DZ	S	S	S	F	F	Total
4	2	5	4	4	3	5	4	4	5	4	1	1	1	2		2	2	1	2	1	1	11
6	5	6	5	6	4	4	5	6	6	6	2	2	2		1		1	2	1	2	13	
1	1	1	1	2	2	2	1	1	2	5	6	6	6	n.a.	n.a.	5	n.a.	6	6	6	6	47
5	6	3	2	5	6	3	6	3	4	3	4	5	5	3		3	3	3	5	3	31	
3	4	2	6	3	1	1	2	2	1	2	4	3	4	6		4	4	5	3	5	34	
2	3	4	3	1	5	6	3	5	3	1	3	4	3	4		4	4	4	3	4	29	

CFA Value of Production

	1	2	3	4	5	6
1	3	1	1	2	4	23
2	6	4	6	4	3	39
3	2	2	n.a.	3	n.a.	20
4	5	6	5	6	6	39
5	4	2	3	1	2	17
6	1	5	4	5	6	29

(1) 1984; (2) 1985; (3) 1986

TABLE 17

INTERCROPPING EXPERIMENTS - MAIZE/BEANS

Theoretical populations expected in planting arrangement experiment.

(Treatments 1 - 5 as designed: Treatment 6 from counts at germination in 1986)

TREATMENT	Maize	Beans	Total plants
1	33.000	64.000	97.000
2	26.660	64.000	90.660
3	53.330	21.300	74.630
4	53.330	21.300	74.630
5	53.330	42.650	95.980
6 Mbiyeh	60.000	65.650	125.650
Dzeng	29.500	41.500	71.000
Santa	30.000	28.650	58.650
Fundong	86.000	71.800	157.800

2.3.2. Weed Control and Fertilizer Response

The experiment contained eight treatments comprising all the combinations of four levels of weed control and two levels of fertilizer (NPK, 20:10:10) application; 4 x 2 Factorial design in five replications at each of the four higher elevation sites.

1985 data are given in Tables 18 - 22, and 1986 data in Tables 23 - 27.

With the longer growing season at higher elevations, the third occasion of weeding (12 weeks after planting) under treatments involving W₃, was done prior to harvesting the beans, although probably too late to have potentially more than a marginal effect on bean yields.

MBIYEH TDC - 1985

Experiment results are given in Tables 18 and 22.

Partitioning treatment effects into their constituents shows that only weed control created the observed differences in the maize and bean parameters recorded.

Maize yields (cob and grain weights) did not benefit from the first occasion of weeding, but showed a marked increase to W₂ treatments involving two occasions of weeding at 4 weeks and 8 weeks after planting. A further weeding at 12 weeks had no effect on maize yield. Table 18 (d) shows that neither the level of weed control nor the level of fertilizer affected the number of plants surviving to harvest. Table 18 (c) however, suggests that the higher yields in plots having at least two occasions of weeding resulted from more cobs contributing to harvest.

In comparison, bean yields were improved (143 per cent) by receiving at least a single weeding, and showed a further 54 per cent increase from a second weeding after 8 weeks. In each case the yield increase reflected improved harvest stand counts. Data converted to a value of total production from the association followed the pattern for maize with major advantage derived from two occasions of weed control.

MBIYEH TDC - 1986

Experiment results are given in Tables 23 and 27.

In contrast to 1985 results, maize yields were positively affected by the first occasion of weed control but not by either a second or third weeding.

The significance of the weed control/fertilizer response interaction suggests the F₂ fertilizer rate had a beneficial effect in unweeded plots, but no advantage in weeded plots where the weed control's influence on F₁ yields was then dominant. This further suggests that the higher rate of fertilizer application was not sufficient to greatly increase weed growth and that the removal of early weeds which did exist had a more important effect at the lower fertility level.

Bean yields responded principally to the first occasion of weed control, although the second weeding was also of benefit at the higher level of fertilizer application. The third occasion of weed control at 12 weeks after planting was just prior to the bean harvest, so bean yield potential would already have been realized and the weeding therefore would have had no effect. The interaction of fertilizer rate and weed control seen in Table 23 (f) may therefore be partly spurious (see the W₃ data) although it remains possible that stand count survival was positively influenced by the higher fertilizer rate provided there was a degree of weed control. The corollary being that without weed control, the extra fertilizer increased the competitive effect of weeds to an extent detrimental to survival of the beans.

Taken together with the maize grain data this illustrates how the weed competition has quite different influences on the maize and bean crops. In maize, plant survival per se is much less affected by competition than plant vigour. Hence, with extra fertilizer applied to the maize, yield compensation can occur - see Table 23 (b). In beans the competition results in loss of stand, with the effect exacerbated by additional fertilizer - Table 23 (f), where further weed growth eliminates more bean plants.

Data converted to values of production - Table 23 (g) - confirmed the overall impact of the early weeding at 4 weeks, and showed that the contrasting effects on beans and maize of higher rates of fertilizer in unweeded plots cancelled each other out in value terms.

DZENG TDC - 1985

Experiment results are given in Tables 19 and 22.

Due to an harvesting error, only maize data are available from the 1985 experiment.

Maize stand counts were improved under the W₂ weeding regime only. However cob and grain yields benefitted both from the weeding after 4 weeks and again from the second weeding, indicating that although the earliest weeding

did not affect the number of plants surviving to harvest, it did allow individual plants to yield more heavily.

Grain yield under W_1 was 260 per cent higher than W_0 , and W_2 a further 37 per cent higher than W_1 . Neither a third occasion of weed control nor the higher rate of fertilizer application had any measurable effect.

DZENG TDC - 1986

Experiment results are given in Tables 24 and 27.

The Coefficients of Variation observed in (especially maize) data from Dzeng in 1986 are a clear indication of the considerable improvement in soil conditions since the TDC began its operations.

Only the first occasion of weeding was effective in increasing maize cob and grain yields in 1986, evidently from improved yields per plant since stand counts were not similarly affected. The extra fertilizer provided to treatments involving F2 was beneficial to grain yields in unweeded plots and also in those weeded three times. Bean yield was increased by the early weeding at 4 weeks after planting. This was partly the result of higher stand counts which were over 69 per cent higher in weeded compared with unweeded plots. Since yields were 100 per cent improved by weeding individual plant yields clearly also benefitted. A small response also came from the third weeding.

The fertilizer response seen in the maize did not occur in beans, and was not sufficiently large to be reflected in overall production value. Weed control influences were again dominant in value terms with advantage gained from both the first and third weedings. The result is unusual among the TDC experiments in this series in that it is a reflection of the bean response to the treatments under test. However, a comparison of Tables 24 (b) and (d) shows that the maize grain "weeding totals" followed a similar pattern to those for bean yield although the influence of the third weeding was greater in beans. With both crops reacting similarly to the treatments the converted value data reinforced the pattern of the bean yield data.

SANTA TDC - 1985

Experiment results are given in Tables 20 and 22.

Again increasing levels of weed control up to two occasions generated the major observed effects.

Maize yields were improved by both a single weeding at 4 weeks and a subsequent weeding at 8 weeks after planting. The former reflected an increased stand count from W_1 . Since W_2 did not affect stand count but did affect the number of cobs produced, the W_2 effect on maize yield evidently derived from a better cob: plant ratio in plots weeded twice. Although fertilizer applied at a rate of 4 bags/ha. gave no measurable advantage over a rate of 2 bags/ha., an interaction effect between fertilizer and weed control was observed for maize grain yield.

Table 20 (b) shows that measured yields were higher with the higher rate of fertilizer from $W_0 - W_2$, but under the W_3 regime F_1 gave the better response.

Since weed control and not fertilizer application was shown to be of overriding importance, this would suggest that the higher rate of fertilizer generated increased early weed growth, the removal of which caused the maize relief from competition, hence generating a yield response. Clearly a similar increase in the weed population did not occur after 8 weeks and as a result $F_2 W_3$ showed no improvement over $F_1 W_3$. N.B. the data do not show any significant difference in yield between F_1 and F_2 at W_3 . The interaction effect is rather measuring the change of pattern between F_2 data from W_0 to W_2 , and that of $F_2 W_3$.

Bean yields responded to receiving at least a single weeding after 4 weeks. Table 20(f) indicates that this was the result of improved stand counts in the weeded plots. Subsequent weedings had no measurable effect and it may therefore be assumed that beans had already achieved their yield potential prior to the time of the second weeding at the end of June. (N.B. Santa TDC at an altitude of 1650m has a shorter growing season than either Dzeng or Mbiyeh where later weed control may still have an opportunity to influence yields).

Overall values of production from the association showed the marked benefit from W_1 but also reflected the maize yield response to a second weeding.

SANTA TDC - 1986

Experiment results are given in Tables 25 and 27.

Maize cob yields showed a progressive increase from both the first and second weedings at the lower level of fertilizer, and the first weeding also had a major impact at the higher rate of fertilizer application. Both the first and third weedings affect^{ed} grain yields.

The impact of the early weeding on yield derived to a minor extent from an increased stand and higher numbers of cobs contributing to harvest, but mainly from increased individual plant yield, (the percentage increase in yield being much higher than the increases in either stand count or cob number).

Beans were harvested on 9th July following a third occasion of weeding in the W₃ treatment on 25th June. Since the beans would have achieved their yield potential by the time of third weeding, W₂ and W₃ treatments were effectively the same with respect to the bean crop.

Bean stand survival was improved by the earliest weeding. The higher fertilizer rate in F₂ appears to have caused added weed growth after the first (4 weeks) weeding, which did not occur under the F₁ regimes. Competition from such a flush of weeds could account for the reduced stand counts seen in W₂/W₃ in Table 25(f). The yield advantage of F₁W₂ over F₂W₂ is however relatively larger than can be accounted for solely by the difference in stand count. It therefore seems probable that weed competition also reduced yields of surviving bean plants and possibly encouraged them to promote more vegetative growth in response to the competition rather than diverting resources into yield. The combined effects contributed to the F₁ Fertilizer Total being markedly higher than that of F₂.

The impact of these "fertilizer" effects on beans was reduced when data from both crops in the association were converted to CFA value and analysed jointly. The extra fertilizer of F₂ was beneficial in the unweeded plot, but elsewhere value data reflected the benefits to maize and beans of the first weeding and to maize of the third weeding.

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TABLE 18

INTERCROPPING EXPERIMENTS - MAIZE/BEANS

II WEED CONTROL/FERTILIZER RESPONSE

MBIYEH 1985

a) MAIZE: Yield of Cobs (kg/ha)

		W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁		1733	1800	2667	2533	8733
F ₂		1400	1867	3133	2933	9333
Weeding Totals		3133	3667	5800	5466	18066
S.E. (1)	512	F Ratio: F 0.3				CV (%) 36
S.E. (2)	362	W 6.6**				
S.E. (3)	256	FW 0.5				

b) MAIZE: Yield of shelled grain (kg/ha)

		W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁		733	720	1107	960	3520
F ₂		593	747	1367	1207	3914
Weeding Totals		1326	1467	2474	2167	7434
S.E. (1)	251	F Ratio: F 0.6				CV (%) 43
S.E. (2)	178	W 4.8**				
S.E. (3)	126	FW 0.6				

c) MAIZE: Number of Cobs produced ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	17.5	16.8	22.3	20.5	77.1
F ₂	13.7	16.1	24.4	23.7	77.9
Weeding Totals	31.2	32.9	46.7	44.2	155.0
S.E. (1)	3.8	F Ratio: F 0.008			CV (%) 31
S.E. (2)	2.7	W 4.3*			
S.E. (3)	1.9	FW 0.6			

d) MAIZE: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	19.3	20.5	21.7	21.6	83.1
F ₂	16.7	18.3	22.1	22.3	79.4
Weeding Totals	36.0	38.8	43.8	43.9	162.5
S.E. (1)	3.1	F Ratio: F 0.3			CV (%) 24
S.E. (2)	2.2	W 1.7			
S.E. (3)	1.5	FW 0.3			

e) BEANS: Yield of shelled beans (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	50	130	133	197	510
F ₂	53	120	253	230	656
Weeding Totals	103	250	386	427	1166
S.E. (1)	51	F Ratio: F 2.1			CV (%) 55
S.E. (2)	36	W 8.3**			
S.E. (3)	25	FW 1.3			

f) BEANS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	43.3	55.2	67.2	59.9	225.6
F ₂	32.1	51.5	69.5	67.3	220.4
Weeding Totals	75.4	106.7	136.7	127.2	446.0

S.E. (1) 6.7 F Ratio: F 0.2 CV (%) 19
 S.E. (2) 4.7 W 16.4**
 S.E. (3) 3.3 FW 1.4

g) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	59.6	68.1	96.3	92.9	316.9
F ₂	49.7	68.7	129.3	115.2	362.9
Weeding Totals	109.3	136.8	225.6	208.1	679.8

S.E. (1) 20.3 F Ratio: F 1.3 CV (%) 38
 S.E. (2) 14.4 W 7.5**
 S.E. (3) 10.2 FW 0.9

TABLE 19
INTERCROPPING EXPERIMENTS - MAIZE/BEANS
II WEED CONTROL/FERTILIZER RESPONSE
DZENG 1985

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	1133	4033	5000	4573	14739
F ₂	1733	3627	4367	4567	14294
Weeding Totals	2866	7660	9367	9140	29033
S.E. (1)	475	F Ratio: F 0.2 CV (%) 21			
S.E. (2)	336	W 40.5**			
S.E. (3)	238	FW 1.3			

b) MAIZE: Yield of shelled grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	243	1344	1820	1312	4719
F ₂	453	1159	1601	1687	4900
Weeding Totals	696	2503	3421	2999	9619
S.E. (1)	261	F Ratio: F 0.1 CV (%) 34			
S.E. (2)	185	W 21.1**			
S.E. (3)	131	FW 1.3			

c) MAIZE: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	22.3	21.8	25.3	23.7	93.1
F ₂	22.8	23.1	24.2	22.9	93.0
Weeding Totals	45.1	44.9	49.5	46.6	186.1
S.E. (1)	1.8	F Ratio: F 0.01 CV (%) 6			
S.E. (2)	1.3	W 5.4*			
S.E. (3)	0.9	FW 1.4			

TABLE 20

INTERCROPPING EXPERIMENTS - MAIZE/BEANSII WEED CONTROL/FERTILIZER RESPONSESANTA 1985

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	481	2450	3112	3716	9768
F ₂	881	2780	4943	3839	12443
Weeding Totals	1362	5239	8055	7555	22211

S.E. (1) 716 F Ratio: F 3.5 CV (%) 41
 S.E. (2) 506 W 18.2**
 S.E. (3) 358 FW 1.2

b) MAIZE: Yield of shelled grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	227	1440	1853	2700	6220
F ₂	453	1547	2927	2180	7107
Weeding Totals	680	2987	4780	4880	13327

S.E. (1) 364 F Ratio: F 1.5 CV (%) 35
 S.E. (2) 257 W 29.3**
 S.E. (3) 182 FW 3.2*

c) MAIZE: Number of Cobs produced ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	8.4	16.8	20.1	25.9	71.2
F ₂	9.3	19.7	27.2	23.1	79.3
Weeding Totals	17.7	36.5	47.3	49.0	150.5
S.E. (1)	2.7	F Ratio: F		2.2	CV (%) 23
S.E. (2)	1.9	W		27.7**	
S.E. (3)	1.4	FW		3	

d) MAIZE: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	23.2	25.9	24.4	26.5	100.0
F ₂	23.2	24.4	26.0	26.0	99.6
Weeding Totals	46.4	50.3	50.4	52.5	199.6
S.E. (1)	1.0	F Ratio: F		0.04	CV (%) 5
S.E. (2)	0.7	W		6.0**	
S.E. (3)	0.5	FW		1.5	

e) BEANS: Yield of shelled beans (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	192	293	300	233	1018
F ₂	192	293	304	311	1100
Weeding Totals	384	586	604	544	2118
S.E. (1)	52	F Ratio: F		0.6	CV (%) 31
S.E. (2)	37	W		3.7*	
S.E. (3)	26	FW		0.5	

f) BEANS: Stand count at harvest ('000/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	29.7	64.7	69.7	68.5	232.6
F_2	25.3	51.1	66.7	77.1	220.2
Weeding Totals	55.0	115.8	136.4	145.6	452.8
S.E. (1) 9.8	F Ratio: F 0.4				CV (%) 31
S.E. (2) 6.9	W 17.4**				
S.E. (3) 4.9	FW 0.9				

g) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	51.5	163.9	197.2	251.2	663.8
F_2	69.1	172.0	281.6	224.8	747.5
Weeding Totals	120.6	335.9	478.8	476.0	1411.3
S.E. (1) 33.8	F Ratio: F 1.5				CV (%) 30
S.E. (2) 23.9	W 24.9**				
S.E. (3) 16.9	FW 1.9				

TABLE 21

INTERCROPPING EXPERIMENTS - MAIZE/BEANS

II WEED CONTROL/FERTILIZER RESPONSE

FUNDONG 1985

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	5533	6067	6267	6000	23867
F ₂	6733	6600	7000	6933	27266
Weeding Totals	12266	12667	13267	12933	51133

S.E. (1) 543 F Ratio: F 9.8** CV (%) 13
 S.E. (2) 384 W 0.6
 S.E. (3) 272 FW 0.3

b) MAIZE: Yield of shelled grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	2467	2940	2733	2927	11067
F ₂	3367	2947	3340	3147	12801
Weeding Totals	5834	5887	6073	6074	23868

S.E. (1) 327 F Ratio: F 7.0* CV (%) 17
 S.E. (2) 231 W 0.1
 S.E. (3) 164 FW 1.5

c) MAIZE: Number of Cobs produced ('000/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	25.2	28.0	26.5	25.6	105.3
F_2	29.2	28.9	28.8	28.5	115.4
Weeding Totals	54.4	56.9	55.3	54.1	220.7
S.E. (1) 2.0	F Ratio: F 6.2*				CV (%) 12
S.E. (2) 1.4	W 0.4				
S.E. (3) 1.0	FW 0.4				

d) MAIZE: Stand count at harvest ('000/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	23.1	22.9	23.1	23.5	92.6
F_2	23.5	23.3	23.6	23.2	93.6
Weeding Totals	46.6	46.2	46.7	46.7	186.2
S.E. (1) 1.1	F Ratio: F 0.2				CV (%) 8
S.E. (2) 0.8	W 0.03				
S.E. (3) 0.6	FW 0.1				

e) BEANS: Yield of Pods (kg/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	183	393	330	343	1249
F_2	137	380	363	367	1247
Weeding Totals	320	773	693	710	2496
S.E. (1) 99	F Ratio: F 0.001				CV (%) 25
S.E. (2) 70	W 17.3**				
S.E. (3) 49	FW 0.5				

f) BEANS: Stand count at harvest ('000/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	47.9	56.1	64.3	60.1	228.4
F_2	38.0	64.8	62.7	54.9	230.4
Weeding Totals	85.9	120.9	127.0	125.0	458.8

S.E. (1) 4.6 F Ratio: F 0.1 CV (%) 13

S.E. (2) 3.3

W 17.8**

S.E. (3) 2.3

FW 3.1*

g) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	224.5	297.6	270.7	288.0	1080.8
F_2	286.3	296.0	323.9	309.5	1215.7
Weeding Totals	510.8	593.6	594.6	597.5	2296.5

S.E. (1) 29.1 F Ratio: F 5.4* CV (%) 16

S.E. (2) 20.5

W 2.1

S.E. (3) 14.5

FW 1.0

TABLE 22

INTERCROPPING EXPERIMENTS - MAIZE/BEANS

II WEED CONTROL/FERTILIZER RESPONSE

Grain Yields (kg/ha.) and Value of Production ('000 CFA/ha) - 1985

Treatment	MBIYEH			DZENG			SANTA			FUNDONG (1)		
	M	B	Value	M	B	Value	M	B	Value	M	B	Value
W0 F1	733	50	59.6	243			227	192	51.5	2467	183	224.5
W0 F2	593	53	49.7	453			453	192	69.1	3367	137	286.3
W1 F1	720	130	68.1	1344	n.a	n.a.	1440	293	163.9	2940	393	297.6
W1 F2	747	120	68.7	1159			1547	293	172.0	2947	380	296.0
W2 F1	1107	133	96.3	1820			1853	300	197.2	2733	330	270.7
W2 F2	1367	253	129.3	1601			2927	304	281.6	3340	363	323.9
W3 F1	960	197	92.9	1312			2700	233	251.2	2927	343	288.0
W3 F2	1207	230	115.2	1687			2180	311	224.8	3147	367	309.5
S.E.	251	51	20.3	261			364	52	33.8	327	99	29.1

(1) Bean Pod Yield: indicative value applied to pods instead of shelled beans.

TABLE 23

INTERCROPPING EXPERIMENTS - MAIZE/BEANS

II WEED CONTROL/FERTILIZER RESPONSE

MBIYEH 1986

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	2533	5000	5200	5067	17800
F ₂	3800	4400	3933	4400	16533
Weeding Totals	6333	9400	9133	9467	34333
S.E. (1)	615	F Ratio:		F 1.1	CV (%) 23
S.E. (2)	435			W 6.0**	
S.E. (3)	307			FW 3.2*	

b) MAIZE: Yield of shelled grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	1393	2780	3007	2700	9880
F ₂	1980	2567	1967	2367	8881
Weeding Totals	3373	5347	4974	5067	18761
S.E. (1)	350	F Ratio:		F 2.0	CV (%) 24
S.E. (2)	247			W 6.5**	
S.E. (3)	175			FW 3.6*	

c) MAIZE: Number of Cobs produced ('000/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	20.7	26.5	29.5	27.7	104.4
F_2	23.9	26.4	23.6	26.5	100.4
Weeding Totals	44.6	52.9	53.1	54.2	204.8
S.E. (1)	3.2	F Ratio:		F 0.4	CV (%) 20
S.E. (2)	2.2		W 2.0		
S.E. (3)	1.6		FW 1.4		

d) MAIZE: Stand count at harvest ('000/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	20.9	17.9	21.5	21.2	81.5
F_2	20.0	18.1	19.1	16.8	74.0
Weeding Totals	40.9	36.0	40.6	38.0	155.5
S.E. (1)	2.4	F Ratio:		F 2.5	CV (%) 19
S.E. (2)	1.7		W 1.0		
S.E. (3)	1.2		FW 0.7		

c) BEANS: Yield of shelled beans (kg/ha)

	W_0	W_1	W_2	W_3	Fertilizer Totals
F_1	1067	1467	1467	1600	5601
F_2	1133	1400	1600	1400	5533
Weeding Totals	2200	2867	3067	3000	11135
S.E. (1)	101	F Ratio:		F 0.1	CV (%) 12
S.E. (2)	72		W 15.4**		
S.E. (3)	51		FW 2.1		

f) BEANS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	69.3	64.7	68.5	77.9	280.4
F ₂	63.5	66.4	70.5	57.9	258.3
Weeding Totals	132.8	131.1	139.0	135.8	538.7

S.E. (1) 5.6

F Ratio: F 3.9

CV (%) 13

S.E. (2) 4.0

W 0.4

S.E. (3) 2.8

FW 3.4*

g) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	276.8	374.5	391.3	384.5	1427.1
F ₂	277.3	351.5	330.8	336.5	1296.1
Weeding Totals	554.1	726.0	722.1	721.0	2723.2

S.E. (1) 34.0

F Ratio: F 1.4

CV (%) 16

S.E. (2) 24.0

W 10.4**

S.E. (3) 17.0

FW 2.1

TABLE 24

INTERCROPPING EXPERIMENTS - MAIZE/BEANS

II WEED CONTROL/FERTILIZER RESPONSE

DZENG 1986

a) MAIZE: Yield of cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	2867	5400	5467	4667	18401
F ₂	4200	5733	4933	6600	21466
Weeding Totals	7067	11133	10400	11267	39867
S.E. (1) 757	F Ratio: F 4.2*				CV (%) 24
S.E. (2) 536	W 6.7**				
S.E. (3) 379	FW 2.1				

b) MAIZE: Yield of shelled grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	1220	2513	2467	1960	8160
F ₂	1933	2520	2247	2873	9573
Weeding Totals	3153	5033	4714	4833	17733
S.E. (1) 322	F Ratio: F 4.8*				CV (%) 23
S.E. (2) 227	W 7.2**				
S.E. (3) 161	FW 2.9				

c) MAIZE: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	23.7	26.8	26.9	27.2	104.6
F ₂	26.3	27.3	27.3	27.1	108.0
Weeding Totals	50.0	54.1	54.2	54.3	212.6
S.E. (1) 1.4	F Ratio: F 1.5				CV (%) 8
S.E. (2) 1.0	W 2.4				
S.E. (3) 0.7	FW 0.7				

d) BEANS: Yield of shelled Grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	220	493	520	627	1860
F ₂	320	587	520	620	2047
Weeding Totals	540	1080	1040	1247	3907
S.E. (1)	133	F Ratio: F		0.4	CV (%) 43
S.E. (2)	94	W		5.2**	
S.E. (3)	67	FW		0.2	

e) BEANS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	34.9	58.3	65.2	63.3	221.7
F ₂	37.2	63.9	61.1	66.8	229.0
Weeding Totals	72.1	122.2	126.3	130.1	450.7
S.E. (1)	5.1	F Ratio: F		0.5	CV (%) 14
S.E. (2)	3.6	W		28.3**	
S.E. (3)	2.6	FW		0.7	

f) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	139.7	293.2	292.5	258.9	984.3
F ₂	217.6	305.3	271.7	340.4	1135.0
Weeding Totals	357.3	598.5	564.2	599.3	2119.3
S.E. (1)	39.6	F Ratio: F		3.6	CV (%) 24
S.E. (2)	28.0	W		8.6**	
S.E. (3)	19.8	FW		1.6	

TABLE 25

INTERCROPPING EXPERIMENTS - MAIZE/BEANS

II WEED CONTROL/FERTILIZER RESPONSE

SANTA 1986

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	1245	3528	4625	4903	14301
F ₂	1999	4205	4025	4473	14702
Weeding Totals	3244	7733	8650	9376	29003

S.E. (1) 520

F Ratio:

F

0.1

CV (%) 23

S.E. (2) 368

W

28.0**

S.E. (3) 260

FW

1.9

b) MAIZE: Yield of shelled grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	771	2129	2696	3013	8609
F ₂	1236	2617	2311	2672	8836
Weeding Totals	2007	4746	5007	5685	17445

S.E. (1) 342

F Ratio:

F

0.1

CV (%) 25

S.E. (2) 242

W

22.4**

S.E. (3) 171

FW

2.0

c) MAIZE: Number of cobs produced ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	14.5	23.3	25.3	27.9	91.0
F ₂	17.6	24.1	25.3	27.9	94.9
Weeding Totals	32.1	47.4	50.6	55.8	185.9
S.E. (1) 2.1	F Ratio: F 0.9				CV (%) 14
S.E. (2) 1.5	W 24.4**				
S.E. (3) 1.0	FW 0.5				

d) MAIZE: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	23.9	25.1	25.6	25.7	100.3
F ₂	25.2	25.5	25.9	26.3	102.9
Weeding Totals	49.1	50.6	51.5	52.0	203.2
S.E. (1) 0.7	F Ratio: F 3.1				CV (%) 5
S.E. (2) 0.5	W 3.2*				
S.E. (3) 0.4	FW 0.4				

e) BEANS: Yield of shelled beans (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	167	260	287	333	1047
F ₂	193	240	180	213	826
Weeding Totals	360	500	467	546	1873
S.E. (1) 51	F Ratio: F 4.7*				CV (%) 34
S.E. (2) 36	W 2.5				
S.E. (3) 25	FW 1.9				

f) BEANS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	34.7	56.8	53.9	56.9	202.3
F ₂	40.8	51.1	45.2	44.0	181.1
Weeding Totals	75.5	107.9	99.1	100.9	383.4
S.E. (1)	6.7	F Ratio:		F 2.4	CV (%) 22
S.E. (2)	4.7			W 4.5*	
S.E. (3)	3.3			FW 1.5	

g) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	89.7	220.0	260.5	293.6	863.8
F ₂	130.5	245.7	212.1	245.3	833.6
Weeding Totals	220.2	465.7	472.6	538.9	1697.4
S.E. (1)	32.8	F Ratio:		F 0.2	CV (%) 24
S.E. (2)	23.2			W 18.2**	
S.E. (3)	16.4			FW 2.1	

TABLE 26

INTERCROPPING EXPERIMENTS - MAIZE/BEANS

II WEED CONTROL/FERTILIZER RESPONSE

FUNDONG 1986

a) MAIZE: Yield of Cobs (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	6667	6867	7067	7467	28068
F ₂	6133	6733	7400	7000	27266
Weeding Totals	12800	13600	14467	14467	55334

S.E. (1) 491

F Ratio:

F 0.7

CV (%) 11

S.E. (2) 347

W 2.7

S.E. (3) 245

FW 0.7

b) MAIZE: Yield of shelled grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	3040	3193	3233	3027	12493
F ₂	2780	3000	3073	3420	12273
Weeding Totals	5820	6193	6306	6447	24766

S.E. (1) 300

F Ratio:

F 0.1

CV (%) 15

S.E. (2) 212

W 0.8

S.E. (3) 150

FW 1.0

c) MAIZE: Number of cobs produced ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	31.6	30.3	30.9	30.8	123.6
F ₂	28.4	29.9	32.3	29.7	120.3
Weeding Totals	60.0	60.2	63.2	60.5	243.9

S.E. (1) 1.4 F Ratio: F 1.5

S.E. (2) 1.0 W 1.2

S.E. (3) 0.7 FW 1.9

CV (%) 7

d) MAIZE: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	26.3	24.7	25.7	26.5	103.2
F ₂	26.0	25.9	25.9	26.4	104.2
Weeding Totals	52.3	50.6	51.6	52.9	207.4

S.E. (1) 0.6 F Ratio: F 0.5

S.E. (2) 0.5 W 2.5

S.E. (3) 0.3 FW 1.1

CV (%) 4

e) BEANS: Yield of shelled grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	60	147	167	133	507
F ₂	40	153	200	133	526
Weeding Totals	100	300	367	266	1033

S.E. (1) 23 F Ratio: F 0.2

S.E. (2) 16 W 25.0**

S.E. (3) 11 FW 0.9

CV (%) 28

f) BEANS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	29.9	56.7	53.3	61.6	201.5
F ₂	31.5	58.1	62.8	60.5	212.9
Weeding Totals	61.4	114.8	116.1	122.1	414.4

S.E. (1) 3.2

F Ratio: F 3.2

CV (%) 10

S.E. (2) 2.3

W 78.2**

S.E. (3) 1.6

FW 2.0

g) TOTAL VALUE OF PRODUCTION ('000 CFA/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	248.0	274.9	281.5	259.5	1063.9
F ₂	224.3	261.1	274.8	290.1	1050.3
Weeding Totals	472.3	536.0	556.3	549.6	2214.2

S.E. (1) 23.6

F Ratio: F 0.1

CV (%) 14

S.E. (2) 16.7

W 2.6

S.E. (3) 11.8

FW 1.0

WINTERCROPPING EXPERIMENTS - MAIZE/BEANS

III. WEED CONTROL/FERTILIZER RESPONSE

Grain Yields (kg/ha) and Value of Production ('000 CFA/ha) ... 1986

Treatment	MBIYEHI			DZENG			SANTA			FUNDONG		
	M	B	Value	M	B	Value	M	B	Value	M	B	Value
W0 F1	1393	1067	276.8	1220	220	139.7	771	167	89.7	3040	60	248.0
W0 F2	1980	1133	277.3	1933	320	217.6	1236	193	130.5	2780	40	224.3
W1 F1	2780	1467	374.5	2513	493	293.2	2129	260	220.0	3193	147	274.9
W1 F2	2567	1400	351.5	2520	587	305.3	2617	240	245.7	3000	153	261.1
W2 F1	3007	1467	391.3	2467	520	292.5	2696	287	260.5	3233	167	281.5
W2 F2	1967	1600	330.8	2247	520	271.7	2311	180	212.1	3073	200	274.8
W3 F1	2700	1600	304.5	1960	627	258.9	3013	333	293.6	3027	133	259.5
W3 F2	2367	1400	336.5	2873	620	340.4	2672	213	245.3	3420	133	290.1
S.E.	350	101	34.0	322	133	39.6	342	51	32.8	300	23	23.6

FUNDONG TDC - 1985

Experiment data are given in Tables 21 and 22.

The pattern of observed responses at Fundong differed from that of the other three experiment sites. Where no weeding was done, the higher rate of fertilizer under F₂ increased maize cob and grain yields as the result of more cobs being produced. Stand counts were not affected. Weed control did not in itself influence any of the maize parameters recorded, although F₂ treatments at the higher levels of weed control gave better yields than F₁W₀.

Beans showed a marked response to having 'some' weeding, yields under W₁ - W₃ averaging an approximately 120 per cent increase over W₀. Comparison of Tables 21(e) and (f) shows this to have derived partly from an improved stand count and partly from increased yield per plant following the removal of early weed competition.

The only clear effect in overall value was the result of the fertilizer response in maize in unweeded plots.

Much of the Fundong TDC had been recently cultivated prior to its incorporation under the Adaptive Research Programme. The resultant lower weed population is reflected in the reduced impact of weed control in this experiment.

FUNDONG TDC - 1986

Experiment data are given in Tables 26 and 27.

None of the maize parameters recorded showed any measurable response to the treatments under test.

Beans could not be influenced by the third occasion of weeding which was due immediately before taking the bean harvest. However, bean yields were increased by both the first and second weedings. The increase under W₁ resulted mainly from an improved stand survival, combined with a small increase in individual plant yield. The latter seems to have made the more important contribution to the yield increase seen under the W₂ regimes.

The measurable differences in bean yield were not sufficient to generate marked treatment effects in terms of overall value of the maize/bean association.

Since good yield levels were obtained, (especially for maize, averaging approximately 3 tonnes grain/ha), and coefficients of variation were well within acceptable limits for all parameters, the lack of observed effects would seem not to relate to any inherent deficiency in the experiment. Rather the outcome suggests that little weeding was necessary at this site (although on balance benefit was probably gained from the first weeding) and that the levels of fertilizer applied were not sufficient to generate any major change in weed populations which might subsequently have influenced yields.

2.3.3. Timing of a Single Weeding

This experiment, a Randomized Block in 4 Replications was conducted on four sites in both 1985 and 1986, having also been grown on three of the sites in the 1984 season. It was designed to determine the optimum time for a single weeding with respect to the yields of the associated crops and their combined value of production. Results from the experiment in 1985 and 1986 are given in Table 28.

Coefficients of variation were rather high for yield parameters, although overall yields were much improved at Mbiyeh and Dzeng in 1986, and uniformly high at Fundong.

Few of the eight experiments under examination showed any effect of the weeding treatments on the maize parameters recorded. Cob and grain yields were best at Santa in 1986 if weeded 4 weeks after planting and it was clear that delaying weeding until after 10 weeks considerably reduced yields. 1986 grain yields from Dzeng showed that similarly good results were obtained with weeding during the first 8 weeks but that yields fell after that, with weeding after 10 weeks again giving much lower yields. Bean data showed a more widespread response to the treatments in 1986, but yield and stand count differences were only seen at Fundong in 1985. Stand counts at Fundong were highest with weeding in the first 8 weeks after planting, as were the resultant yields. Further delay in the time of weeding caused a sharp decline in yield related to reduced stand survival presumably following greater competition from weeds.

TABLE 28

INTERCROPPING EXPERIMENTS - MAIZE/BEANS

III TIMING OF A SINGLE WEEDING

a) MAIZE: Yield of Cobs (kg/ha)

	MBIYEH		DZENG		SANTA		FUNDONG	
	1985	1986	1985	1986	1985	1986	1985	1986
SINGLE WEEDING AT:								
2 weeks	2333	3667	787	5533	2073	1963	6960	6833
4 weeks	2667	3420	873	4867	2113	2825	6000	7167
6 weeks	1750	4500	1293	6000	2727	2383	7400	7753
8 weeks	2250	2920	1587	4733	3060	2107	7420	6920
10 weeks	3083	2253	1873	4333	2607	1960	6520	7000
12 weeks	2750	3833	1207	2667	2433	1190	7367	6753
S.E. of Difference	633	854	352	1030	570	356	750	321
S.E.	448	604	249	728	403	252	530	227
C.V. (%)	36	35	39	31	32	24	15	6
F Ratio	1.1	1.7	2.8	2.5	0.9	4.6**	1.2	2.6

b) MAIZE: Yield of Shelled Grain (kg/ha)

SINGLE WEEDING AT:

2 weeks	973	1567	273	2287	1113	1167	3660	3173
4 weeks	1207	1500	240	1940	1140	1617	2833	3160
6 weeks	633	1920	427	2273	1460	1365	3873	3553
8 weeks	967	1227	553	2020	1787	1270	3807	3087
10 weeks	1293	967	700	1687	1433	1167	3073	2953
12 weeks	853	1840	400	993	1327	662	3920	3073
S.E. of Difference	273	388	156	387	364	229	493	234
S.E.	193	274	111	273	257	162	348	165
C.V. (%)	39	36	51	29	37	27	20	10
F Ratio	1.5	1.7	2.4	3.1*	0.9	3.8*	1.7	1.5

c) MAIZE: Stand Count at Harvest ('000/ha)

	MBIYEH		DZENG		SANTA		FUNDONG	
	1985	1986	1985	1986	1985	1986	1985	1986
SINGLE WEEDING AT:								
2 weeks	25.8	24.2	17.5	26.7	25.7	24.8	22.5	25.8
4 weeks	26.0	22.8	18.6	26.3	26.0	24.8	20.7	25.2
6 weeks	24.8	25.7	20.6	25.8	25.8	24.3	23.2	25.7
8 weeks	26.0	22.3	19.2	26.0	25.5	24.3	24.0	25.3
10 weeks	26.5	23.0	20.1	25.0	25.7	22.8	22.7	25.5
12 weeks	25.0	25.5	15.5	25.2	26.2	24.3	23.3	25.3
S.E. of Difference	1.2	1.8	4.6	1.5	0.5	1.3	1.5	0.7
S.E.	0.9	1.3	3.3	1.0	0.4	0.9	1.0	0.5
C.V. (%)	7	11	18	8	3	7	9	4
F Ratio	0.5	1.3	1.3	0.4	0.5	0.7	1.2	0.2

d) MAIZE: Number of Cobs at Harvest ('000/ha)

SINGLE WEEDING AT:								
2 weeks	21.5	25.7			19.7	19.3	29.7	30.7
4 weeks	24.3	24.7			21.2	22.8	27.5	30.7
6 weeks	17.0	30.0	n.a.	n.a.	22.8	21.0	31.2	31.2
8 weeks	21.0	21.2			22.5	19.5	30.7	29.7
10 weeks	24.7	18.7			21.2	19.0	26.3	31.5
12 weeks	24.5	29.2			23.2	16.5	31.0	29.2
S.E. of Difference	3.8	5.0			2.3	1.9	2.3	1.4
S.E.	2.7	3.5			1.6	1.4	1.6	1.0
C.V. (%)	24	28			15	14	11	7
F Ratio	1.2	1.6			0.7	2.4	1.6	0.8

e) BEANS: Yield of dry beans (kg/ha)

	MBIYEH		DZENG		SANTA		FUNDONG	
	1985	1986	1985	1986	1985	1986	1985	1986
SINGLE WEEDING AT:								
2 weeks	208	927	220	287	367	260	327	260
4 weeks	192	593	253	287	267	173	327	233
6 weeks	158	453	200	287	267	173	317	240
8 weeks	117	320	147	140	280	133	283	207
10 weeks	283	327	220	53	267	113	203	140
12 weeks	133	253	120	40	300	120	130	107
S.E. of Difference	66	154	94	67	49	34	27	31
S.E.	47	109	67	48	35	24	19	22
C.V. (%)	51	46	69	53	24	30	15	22
F Ratio	1.7	5.3**	0.6	6.2**	1.2	5.0**	17.1**	7.4**

f) BEANS: Stand Count at Harvest ('000/ha)

SINGLE WEEDING AT:								
2 weeks	51.8	69.8		34.0	77.3	110.5	57.1	68.7
4 weeks	54.7	76.7		32.0	69.5	130.5	57.2	64.0
6 weeks	44.8	69.2	n.a.	43.8	64.5	106.0	61.7	65.3
8 weeks	47.3	73.8		31.0	75.0	114.8	58.7	66.0
10 weeks	57.7	66.0		15.5	80.7	83.0	50.9	57.3
12 weeks	46.3	62.0		9.5	62.2	75.2	38.0	60.7
S.E. of Difference	7.0	3.9		6.7	10.5	15.0	5.0	6.1
S.E.	4.9	2.7		4.8	7.4	10.6	3.5	4.3
C.V. (%)	20	8		35	21	21	13	14
F Ratio	1.1	3.7*		7.1**	1.0	3.8*	6.0**	0.9

g) Total Value of Production ('000 CFA/ha)

	MBIYEH		DZENG		SANTA		FUNDONG	
	1985	1986	1985	1986	1985	1986	1985	1986
2 weeks	95.3	222.3	53.2	246.2	150.5	136.0	399.2	228.0
4 weeks	110.7	178.7	53.7	214.3	135.8	156.0	335.0	287.2
6 weeks	64.8	192.5	64.7	244.7	160.3	136.5	413.2	319.2
8 weeks	84.3	126.7	69.3	203.2	188.8	121.8	396.3	277.2
10 weeks	127.3	108.5	92.2	111.5	158.7	111.0	311.2	254.8
12 weeks	78.0	163.7	46.8	96.7	156.2	72.5	351.0	259.0
S.E. of Difference	25.3	41.0	21.0	49.7	35.3	20.8	37.5	21.9
S.E.	17.9	29.0	14.9	35.2	24.9	14.7	26.5	15.5
C.V. (%)	38	35	47	38	31	24	14	11
F Ratio	1.6	2.1	1.2	3.5*	0.5	3.8*	2.4	2.3

(1)

h) Yield rankings in individual experiments - 1985/1986

Treatment (2)	Maize Grain Yield								Bean Yield								CFA Value of Production							
	MB		DZ		ST		FU		MB		DZ		ST		FU		MB		DZ		ST		FU	
	85	86	85	86	85	86	85	86	85	86	85	86	85	86	85	86	85	86	85	86	85	86	85	86
2 weeks	3	3	5	1	6	4=	4	2	2	1	2=	1=	1	1	1=	1	3	1	5	1	5	3	2	6
4 weeks	2	4	6	4	5	1	6	3	3	2	1	1=	4=	2=	1=	3	2	3	4	3	6	1	5	2
6 weeks	6	1	3	2	2	2	2	1	4	3	4	1=	4=	2=	3=	2	6	2	3	2	2	2	1	1
8 weeks	4	5	2	3	1	3	3	4	6	5	5	4	3	4	4	4	4	5	2	4	1	4	3	3
10 weeks	1	6	1	5	3	4=	5	6	1	4	2=	5	4=	6	5	5	1	6	1	5	3	5	6	5
12 weeks	5	2	4	6	4	6	1	5	5	6	6	6	2	5	6	6	5	4	6	6	4	6	4	4

i) Accumulated ranking scores (3)

Treatment (2)	Value	
	Maize	Beans
2 weeks	28	10
4 weeks	31	17
6 weeks	19	23
8 weeks	25	35
10 weeks	31	32
12 weeks	33	42

Notes: (1) Ranking of the yields/value of production from highest (1) to lowest (6).

(2) A single weeding after the number of weeks shown.

(3) The sum of treatment rankings for each parameter in Table 28 (h).

Yield differences in beans were noted on all four sites in 1986, and the highest yields came with weeding during the first 6 weeks. Improved stand counts with the earlier times of weeding contributed to the observed yield increases at Mbiyeh, Dzeng and Santa, but at Fundong the effect was almost entirely the result of improved yields from individual plants rather than an increase in their number. This again suggests that the weed population was low at Fundong and insufficient to cause any major effect on bean plant survival through strong competition, but still able to affect the vigour of bean growth and hence yields.

Data converted to a total value gave measurable responses in line with the pattern for maize grain yield with advantages from weeding at 6 weeks (Dzeng) and 4 weeks (Santa).

Table 28 (h) ranks the six times of weed control with respect to the grain yields produced at each site and the value of total production. By accumulating these rankings into a total score for each parameter - Table 28 (i) - it becomes clear that the most effective time to carry out a single weeding was 6 weeks after sowing to maximize maize yields and the overall value of the association. This also allowed a good bean result, although weeding within the first month from planting consistently gave the best bean yields. Nevertheless, by accepting a slight reduction in yields of the bean component by weeding at 6 weeks, maximum overall benefit could be achieved.

2.4. INTERCROPPING EXPERIMENTS - MAIZE/BEANS/COCOYAMS

With the start of field operations at the low-altitude TDC at Widikum (450m) from January 1986, a third series of intercropping experiments examined the relationships of the crops in a maize/beans/cocoyams association. The series comprised an assessment of

- weed control and fertilizer response
- the optimum timing of a single weeding
- the effects of manipulating planting arrangements and plant populations.

Inclusion of cocoyams is a reflection of the importance of this root crop in the lower elevation areas of Momo Division to be served by the Widikum TDC.

The experiments involved the area's recommended maize variety (Ekona White) but used local planting material of beans and cocoyams.

Since this was the first year of experimentation at Widikum, results must be considered only as indicative. More definitive interpretation will only be possible after further seasons' investigations.

2.4.1. Weed Control and Fertilizer Response

The experiment contained eight treatments comprising all the combinations of four levels of weed control and two levels of fertilizer (NPK, 20:10:10) application; a 4 x 2 Factorial design in five replications.

Based on previous observations of cocoyam cultivation at other TDC sites, the 'standard' planting arrangement was adopted with cocoyams spaced 60 cm apart in a row on the crown of the ridge flanked by a single row of maize to one side and a double row of beans to the other. The resultant maize population was the standard currently recommended for intercropped maize.

Results from this first season of the experiment are given in Tables 29 and 30. The format of presentation follows that of intercrop experiments on the other TDCs.

Maize grain yields showed a positive response to being weeded once and also to the treatment involving three weedings. Yield levels under the W₂ regime were not markedly higher than those under W₁. The timing of the third weeding (12 weeks after sowing) would therefore seem to be the critical factor rather than the number of weedings involved.

Table 29 (c) shows that cob number increased when plots were weeded. However, the grain yield increase was proportionately higher than the increase in cob number, indicating that more grain was also produced per cob following release from weed competition. The yield increase from W₂ to W₃ was almost entirely the result of heavier grain weights per cob. There was no measurable effect of the treatments on maize stand count. In contrast to other similar experiments involving beans on the TDCs, bean yields at Widikum were not affected by the treatments imposed. It will be interesting to note if this result is repeated in 1987, since the lack of yield response to early weeding is unusual.

Cocoyams were affected both by the weeding and fertilizer components of the treatments tested. There was no interaction effect, the higher rate of fertilizer giving higher yield values throughout, particularly when associated with two or three occasions of weed control.

TABLE 29
INTERCROPPING EXPERIMENTS - MAIZE/BEANS/COCOYAMS

I. WEED CONTROL/FERTILIZER RESPONSE

WIDIKUM 1986

a) MAIZE: Yield of Cobs (kg/ha).

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	2633	2700	3533	4200	13066
F ₂	2767	4067	4067	4600	15501
Weeding Totals	5400	6767	7600	8800	28567
S.E. (1) 803	F Ratio: F 2.3				CV (%) 36
S.E. (2) 568	W 3.2*				
S.E. (3) 401	FW 0.4				

b) MAIZE: Yield of shelled grain (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	1065	1133	1625	1933	5756
F ₂	1165	1891	1740	2039	6835
Weeding Totals	2230	3024	3365	3972	12591
S.E. (1) 403	F Ratio: F 1.8				CV (%) 41
S.E. (2) 285	W 3.2*				
S.E. (3) 202	FW 0.6				

c) MAIZE: Number of cobs produced ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	15.9	17.7	24.5	25.5	83.6
F ₂	15.2	22.4	26.5	26.7	90.8
Weeding Totals	31.1	40.1	51.0	52.2	174.4
S.E. (1) 4.0	F Ratio: F 0.8				CV (%) 29
S.E. (2) 2.9	W 6.1**				
S.E. (3) 2.0	FW 0.3				

d) MAIZE: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	33.9	31.7	35.2	34.1	134.9
F ₂	29.6	33.5	34.9	31.9	129.9
Weeding Totals	63.5	65.0	70.1	66.0	264.8
S.E. (1)	2.7	F Ratio:		F 0.9	CV (%) 13
S.E. (2)	1.9		W 1.1		
S.E. (3)	1.4		FW 0.9		

e) BEANS: Yield of shelled beans (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	257	250	294	293	1094
F ₂	257	287	215	343	1102
Weeding Totals	514	537	509	636	2196
S.E. (1)	64	F Ratio:		F 0.01	CV (%) 37
S.E. (2)	45		W 0.8		
S.E. (3)	32		FW 0.8		

f) COCOYAMS: Yield of corms (kg/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	1933	3267	2433	3100	10733
F ₂	2100	3833	4133	3967	14033
Weeding Totals	4033	7100	6566	7067	24766
S.E. (1)	626	F Ratio:		F 6.9*	CV (%) 32
S.E. (2)	443		W 5.4**		
S.E. (3)	313		FW 1.1		

g) COCOYAMS: Stand count at harvest ('000/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	7.1	9.5	10.1	10.5	37.2
F ₂	7.3	10.0	10.4	10.7	38.4
Weeding Totals	14.4	19.5	20.5	21.2	75.6

S.E. (1) 0.8 F Ratio: F 0.5 CV (%) 14
 S.E. (2) 0.6 W 13.2**
 S.E. (3) 0.4 FW 0.04

h) TOTAL VALUE OF PRODUCTION: ('000 CFA/ha)

	W ₀	W ₁	W ₂	W ₃	Fertilizer Totals
F ₁	405.5	569.7	538.7	654.4	2168.3
F ₂	437.5	734.8	778.1	779.2	2689.6
Weeding Totals	843.0	1304.5	1276.8	1433.6	4857.9

S.E. (1) 71.4 F Ratio: F 13.3** CV (%) 19
 S.E. (2) 50.5 W 12.9**
 S.E. (3) 35.7 FW 1.0

i) Yield and value rankings

Treatment	Maize	Beans	Cocoyams	Value
W0 F1	8	5=	8	8
W0 F2	6	5=	7	7
W1 F1	7	7	4	5
W1 F2	3	4	3	3
W2 F1	5	2	6	6
W2 F2	4	8	1	2
W3 F1	2	3	5	4
W3 F2	1	1	2	1

TABLE 30

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/COCOYAMSI WEED CONTROL/FERTILIZER RESPONSE

WIDIKUM 1986

Treatment	Grain/Corm Yield (kg/ha)			Total Value Production ('000 CFA/ha)
	Maize	Beans	Cocoyams	
W0 R1	1065	257	1933	405.5
W0 F2	1165	257	2100	437.5
W1 F1	1133	250	3267	569.7
W1 F2	1891	287	3833	734.8
W2 F1	1625	294	2433	538.7
W2 F2	1740	215	4133	738.1
W3 F1	1933	293	3100	654.4
W3 F2	2039	343	3967	779.2
S.E.	403	64	626	71.4

The major yield increase came from the first occasion of weeding, partly due to the improved stand count following weeding, but principally from heavier yields per plant.

Conversion of yield data from the three crops to a total value of production obviously follows quite closely the yield pattern for cocoyams, being by far the heaviest component of the association.

Ranking of the data - Table 29 (i) - further illustrates the apparent advantage gained in this experiment (at this early stage of the Centre's establishment) from an additional later weeding. Further examination of this apparent effect, in association with results from the other intercropping experiments at Widikum, is clearly necessary in the coming seasons.

2.4.2. Timing of a Single Weeding

The experiment was a Randomized Block in 4 Replications, with the treatments being six different times of weed control.

Yield data and the overall values of production from this experiment are given in Table 31.

Treatment differences were only seen in terms of the overall value of production where the best results were from weedings at 4 and 6 weeks. It will be noted that the single weeding at 12 weeks gave a poor result in all the parameters recorded (except cocoyam stand count) and produced the lowest value of overall production.

Taken in conjunction with the outcome of the Weed Control/Fertilizer Response experiment described above, this suggests that weed control as late as 12 weeks may only be beneficial if it also follows an earlier occasion of weeding.

2.4.3. Planting Arrangements/Plant Populations

Figure 3 illustrates the different planting arrangements tested in this experiment which was designed to observe the influence of maize/bean/cocoyam planting configurations on the productivity of the association.

The experiment was laid out as a Randomized Block in 4 Replications. The results, summarized in Table 32, indicate marked treatment effects for all parameters except overall value of production.

TABLE 31

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/COCOYAMS

II TIMING OF A SINGLE WEEDING

WIDIKUM 1986

SINGLE WEEDING AFTER:	MAIZE				BEANS Shelled bean Wt. (kg/ha)	COCOYAMS		VALUE OF PRODUCTION ('000 CFA/ha)
	Yield of Cobs (kg/ha)	Yield of Grain (kg/ha)	No. of cobs ('000/ha)	Stand at harvest ('000/ha)		Harvest Wt. (kg/ha)	Stand at harvest ('000/ha)	
2 weeks	4040	1307	26.3	44.8	250	2540	8.3	544.2
4 weeks	3627	1127	22.2	45.0	319	3127	9.2	654.8
6 weeks	3833	1307	28.3	45.7	243	3420	10.3	646.5
8 weeks	2540	747	20.2	41.2	165	3040	10.5	503.3
10 weeks	2167	613	17.7	46.3	99	2920	10.7	455.7
12 weeks	1753	440	15.2	41.5	162	2707	10.0	416.3
S.E. of Difference	918	381	5.3	3.4	80	683	0.8	81.5
S.E.	649	269	3.7	2.4	57	483	0.6	57.6
C.V. (%)	43	47	35	11	55	33	12	21
F Ratio	2.2	2.4	1.8	0.8	1.9	0.4	2.3	2.9*

The populations achieved at harvest were in line with the differences required by the experiment, indicating that the data may be interpreted in relation to planting configurations.

The total plant population under local planting practice in Treatment 6 was much higher than in the designed arrangements (see Table 33), with the maize numbers even exceeding the recommended population for maize grown as a sole crop. It remains to be confirmed whether the very high populations under Treatment 6 are a true reflection of local practice.

Although the numbers of plants for each component crop were high in Treatment 6, the proportions of cocoyams and beans to the total plant population were similar to those in the other treatments.

The best maize grain yields of 1.34 and 1.26 tonnes/ha were from Arrangements 3 and 5 each of which involved maize populations equivalent to the sole-crop maize recommendation. In each case, maize was planted in two rows with single plants in each "hill" within the row. The same final population derived by retaining two plants per hill, with a wider spacing between hills within the row (Arrangement 4), gave only 0.8 tonnes of grain per hectare. This was similar to the 0.9 t/ha, from a maize population half the size, in treatment 2 which comprised a single row of single plants (representing the current recommended population for inter-cropped maize). Particularly poor yields were obtained from treatment 6 where the high population was clearly detrimental to the maize. With its intermediate population of 32,000/ha, treatment 1 gave very good maize yields and will be referred to again below.

The three treatments with higher stand counts, gave the highest bean yields and as a group they outyielded the remainder of the treatments although they did not differ from each other. Arrangements 4 and 5 each had a bean population of 26,660/ha. However, Arrangement 4 gave the higher yield which may suggest that the planting arrangement of the associated maize crop allowed better light penetration across the ridge profile. Further evidence of the adverse effect of shading is shown by the bean yield in Arrangement 3 where beans were in smaller numbers and also restricted to the central portion of the ridge between both maize rows and the cocoyams.

Cocoyam yields were highest in the local planting of Treatment 6 (4.83 t/ha) and in Treatment 1 (3.63 t/ha) where harvest stand counts were highest.

Treatment 6 gave a 33 per cent yield advantage over Treatment 1 from 74 per cent more plants. In comparison, from only 7 per cent more plants, Treatment 1 itself gave a 31 per cent yield increase over Treatment 3.

Since the yield increase was not equal to or greater than the stand increase, this may suggest that the cocoyam population in Treatment 6 was too high to optimize yield per plant and represented a waste of planting material. Ranking of the yield and value data shows Treatments 1 and 6 to give the best overall performance. However, the poor maize performance in Treatment 6 suggests that Arrangement 1, with its more moderate populations of component crops and row planting, may be preferred since good results were obtained from each crop.

If similar results are obtained over the next few seasons, it may be possible to raise the maize population above the current recommended level for intercropped maize without serious detriment to the other crops, whilst maximizing the overall value of crop production.

FIGURE 3INTERCROPPING EXPERIMENTS - MAIZE/BEANS/COCOYAMSPlanting Arrangements

Plan view of portion of ridge;

o o o o o Beans at 30cms spacing
 x x x x x Maize - see below for spacing
 C C C C Cocoyams at 60cms spacing

-
- | | |
|--|--|
| <p>1.
 C C C C C
 x x x x x
 o o o o o
 o o o o o</p> | <p>4.
 x o x o x o x o x o x
 C C C C C
 x o x o x o x o x o x</p> |
| <p>2.
 C C C C C
 x x x x x
 o o o o o
 o o o o o</p> | <p>5.
 C C C C C
 x x x x x
 x x x x x
 o o o o o</p> |
| <p>3.
 x x x x x
 C o C o C o C o C o C o
 x x x x x</p> | <p>6. Control planted
 according to local
 practice</p> |

1. Single row maize at 20cms spacing
2. Single row maize at 25cms spacing
3. Double row maize at 25cms within row spacing
50cms between rows
4. Double row maize at 50cms within and between rows and two
plants retained per hill
5. Double row maize at 25cms within row spacing
20cms between rows

(A plot comprises 4 ridges each 1.5m wide x 5m long)

TABLE 32

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/COCOYAMS

III PLANTING ARRANGEMENTS/PLANT POPULATIONS

WIDIKUM 1986

a) Summary of recorded data

Treatments (1)	MAIZE				BEANS Shelled bean Wt. (kg/ha.)	COCOYAMS		VALUE OF PRODUCTION ('000 CFA/ha)
	Yield of cobs (kg/ha)	Yield of Grain (kg/ha.)	No. of cobs ('000/ha)	Stand at harvest(1) ('000/ha)		Harvest Wt. (kg/ha)	Stand at harvest ('000/ha)	
1	2833	1047	16.5	31.2	287	3627	11.5	608.5
2	2333	913	14.3	27.2	280	2540	10.7	464.0
3	3627	1340	22.2	50.5	133	2760	10.7	511.8
4	1833	827	13.7	54.5	233	2587	10.5	448.5
5	3460	1260	21.5	54.0	187	2667	10.3	501.8
6	1373	360	9.3	63.5	307	4833	20.0	672.3
S.E. of Difference	365	165	2.2	3.0	36	544	1.3	73.7
S.E.	258	116	1.5	2.1	26	385	0.9	52.1
C.V. (%)	20	24	19	9	22	24	15	20
F Ratio	12.0***	9.1**	10.1**	45.6**	6.9**	5.6**	17.2**	2.8

(1) Being based on mean counts from central portions of each plot
there are minor deviations from the populations as originally designed.

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TABLE 32

b) Yield and value rankings

	Maize	Beans	Cocoyams	Value	Total Score
1	3	2	2	2	9
2	4	3	6	5	18
3	1	6	3	3	13
4	5	4	5	6	20
5	2	5	4	4	15
6	6	1	1	1	9

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TABLE 33

INTERCROPPING EXPERIMENTS - MAIZE/BEANS/COCOYAMS

Theoretical populations expected in planting arrangement experiment

(Treatments 1 - 5 as designed: Treatment 6 from counts at germination)

WIDIKUM 1986

Treatment	Maize	Beans	Cocoyams	Total Plants
1	32.000	44.000	12.000	88.000
2	26.660	44.000	12.000	82.660
3	53.330	13.330	12.000	78.660
4	53.330	26.660	12.000	91.990
5	53.330	26.660	12.000	91.990
6	63.500 ⁽¹⁾	50.000	23.000	136.500

(1) Maize plants remaining at harvest.

3. THE ADAPTIVE RESEARCH PROGRAMME AND ITS ACHIEVEMENTS TO DATE

As a unit of the Provincial Delegation for Agriculture (PDA), the Adaptive Research Programme has several functions :-

- to liaise closely with IRA Stations to ensure that the PDA has access to new research information and improved planting materials.
- to establish priorities for adaptive agronomic research in the North-West Province on which to base the work of the TDCs.
- to examine research information, and through the programme of adaptive research on the TDCs, modify recommendations (where necessary) in the context of overall programme priorities and to suit local farming circumstances.
- to conduct demonstrations of recommended agricultural practices under the Training and Visit approach to extension staff training, to ensure that technical staff have the latest information to pass on to farmers.
- where recommendations involve improved varieties/cultivars, to coordinate their larger-scale production with the Provincial Multiplication Unit.
- to provide feedback from the PDA's extension service to IRA research stations on the effectiveness of existing recommendations and the farmers' needs for further information/planting materials, etc.
- to collaborate with IRA and other agricultural agencies in the development of provincial programmes for improving crop production, within which specific agency responsibilities can be assigned to ensure optimum use of resources in the province and avoid duplication of development efforts.

The following sections discuss the status of the adaptive research programme in relation to these various functions, thereby revealing achievements of the programme since its inception during 1983.

3.1. Access to IRA information and recommended planting materials

Although the formal ratification of a protocol agreement has not yet taken place, the operational links embodied in the Draft Agreement (see Appendix 5) have formed, from the outset of the MIDENO support programme, the basis for cooperation between the PDA, MIDENO Project and IRA.

From the start of the Programme in 1983, the recommended arabica and robusta coffee, and maize varieties were made available by IRA and an increasing range of crops continues to be incorporated into the programme as new materials are developed. The Adaptive Research Programme and Provincial Multiplication Unit now have varieties/Cultivars of cowpeas, soya beans, sweet potatoe, yams, cassava, wheat, citrus and other fruit trees and cocoa, for further testing and/or multiplication. Varieties of Phaseolus beans, and additional soya bean varieties will be tested on TDCs from 1987 with a view to selection of varieties for recommendation in the North West Province (see also sections 3.6 and 3.7 below).

Technical information is frequently shared informally between staff of the programme and IRA scientists, and provided formally through the exchange of published research reports.

3.2. Priorities for Adaptive Agronomic Research

Through discussions with IRA scientists and experienced agricultural extensionists familiar with farmers' problems, and from personal field observations within the province, the major factors limiting crop production were first identified. A number of them may be taken as generally applicable to a wide range of crops (e.g. soil fertility or weeding problems) whilst others adversely affect production of specific crops (e.g. the producer price for arabica coffee).

Limiting factors may conveniently be divided into "external factors", outside the direct control of farmers (e.g. farm input availability, pricing policies, availability of farm to market roads, etc), and "internal factors" over which farmers may be expected to exert some degree of control (e.g. cultivation systems, crop management practices, on-farm processing techniques etc). The MIDENO Project as a whole, in association with its implementing agencies, is involved in alleviating external constraints through discussion, development and modification of the policies controlling the provision of Government support to the agricultural sector. The adaptive research programme, itself one element of Government support through MIDENO, concentrates on the "internal" factors influencing production and examines agricultural techniques through which farmers could themselves improve crop production and farm productivity in a sustainable fashion.

Research priorities were established in relation to the various categories of "internal" limiting factors identified, together with the need to provide improved planting materials. Formulated into programme guidelines (see Appendix 7) these priorities have governed field activities to date, although it is recognised that the programme will evolve and priorities change as agricultural development progresses.

Soil conservation was identified as a crucial area on which to concentrate research efforts, both in terms of the physical characteristics of the soil and its nutrient status. A number of traditionally practised farming techniques lead to reduced fertility and/or severe erosion losses. As a means of partially recouping lost productive capacity after several years' cropping, land has traditionally been returned to an extended period of bush fallow. With the various increasing pressures on crop land the bush fallow periods are becoming shorter and less efficient.

Under a true "bush fallow" system, early herbaceous re-growth is ultimately replaced by more woody and deep-rooted bush and tree species, which, over a period of years recycle nutrients from lower soil horizons to layers nearer the surface. In this manner, nutrients are once again made available in the rooting zone of crops in the subsequent cycle of cultivation.

With the shortening of fallow periods, now occurring as the pressures on farm land increase, insufficient time elapses to allow the bush species to develop and the nutrient recycling process cannot occur. Rather, the early heavy growth of herbaceous species may tend to further deplete the nutrients in the surface soil layers, thereby having a detrimental effect on subsequent crop yields rather than the positive effect intended.

Clearly if the land's productive capacity is to be maintained during increasingly continuous cropping, farming must involve cultivation techniques which allow replenishment of nutrients as a substitute for the no-longer feasible bush fallow.

Much of the Adaptive Research Programme is designed to investigate and demonstrate the several ways of achieving improvements in soil characteristics, including the use of cattle manure, compost, green manures, crop-residue incorporation, and a range of agro-forestry techniques.

The dramatic impact on maize yields obtained at Nyen and Nkwen TDCs through the addition of compost was reported earlier (see Technical Report No. 1). Following the incorporation of cattle manure to soils at Dzeng TDC in 1985, the negligible maize grain yields obtained in the 1984 season have been raised to an average of some 3.5 tonnes per hectare (see Table 1 above) in just two seasons.

Whilst not all farmers will either have access to or interest in the full range of technical possibilities, their adoption of the principle of incorporation of organic matter, from whatever source, is to be strongly encouraged following the demonstrable benefits which can be obtained.

Still with a view to removing/reducing internal constraints on production, and within the framework of the urgent need for adoption of soil conserving farming methods, a second area of priority is to examine cultivation requirements of crops in the context of farming systems in the Province. Since over 90 per cent of farmers in the Province are estimated⁽¹⁾ to sow their land to a mixed association of crops, the adaptive research programme also investigates ways to increase productivity of the crops in association rather than concentrating only on their performance as individual crops.

On the basis of these priority areas, three major categories of investigation have been established on the TDCs.

- 1) Examination of the degree of adaptation expressed by available improved crop varieties, to the environments represented by the TDCs.
- 2) Examination of the effects of a range of crop management practices on the productivity of crop associations.
- 3) Examination of crop and crop association performance in relation to the maintenance and improvement of productive capacity of farmland.

In many cases (e.g. following experiments, rotation observations), investigations in categories 2 and 3 are conducted simultaneously in combined experiments or observation plots.

(1) Testing and Liaison Unit; IRA Bambui (1983) An Agro-Socio-Economic Survey of farmers in the North West Province, Cameroon.

(See Appendix B for a summary of the investigations underway). Some modifications are to be made to the programme from 1987 since a number of the short-term variety and crop association experiments have produced, following up to three years testing, the information they were designed to provide and may now be discontinued (see Section II).

The coffee intercropping experiments are designed to observe the potential for continued intercropping (after the coffee has begun to yield) through modification to the coffee spacing or planting arrangement. Clearly results will only be available in the longer term.

3.3. Modification to recommendations on the basis of adaptive research results

Experiment results are discussed in detail in Section II. In summary, the following modifications may be proposed for farmer recommendations, and for future research efforts.

1. MLC should be phased out as the recommended maize variety for farming areas above 1800m and replaced by newly multiplied stock of "High Altitude Local."
- 2) Once the NCRE programme has developed appropriate varieties for these altitudes, a short-list of potential releases should be tested on the appropriate TDCs (Mbiyen and Dzong).
- 3) Following identification of the best of these potential varieties, the one chosen should be multiplied to replace "High Altitude Local."
- 4) Consideration should be given to replace COCOA by EKONA WHITE as the recommended variety for mid-altitude Momo Division - principally in agricultural post areas under Mbengwi Central in altitudes up to 1200 cm.
- 5) In view of its relatively low yield compared with other available varieties, BACOA need only be promoted if there is a specific farmer requirement for an early, yellow grained variety, (BACOA being the only current variety with these characteristics).
- 6) Larger scale observation plots should be established on appropriate TDCs of the best planting configurations and crop maintenance techniques now identified for the maize/beans/groundnuts and maize/beans associations.

For maize/beans/groundnuts this would involve :-

Plot 1

- Two rows of maize 20 cm apart, with 25 cm between single maize plants along the rows. This is equivalent to a maize population of 53,300 per hectare.

- Beans in single rows to each side of the maize, with 30 cm between stands giving a bean population of approximately 21,000 per hectare.
- Groundnuts in single rows to the 'outside' of the beans with 20 cm between stands, giving a population of approximately 32,000 per hectare.
- Fertilizer application at the recommended rate of 4 bags 20:10:10 per hectare (however see also Section IV).
- Weeding at 6 weeks after planting with a second weeding approximately 4 weeks later if the general level of weed growth requires.

Plot 2

The currently recommended maize population (approximately 25,000 per hectare), achieved by planting a single central row of maize with single plants 25 cm apart flanked by a row of beans with a row of groundnuts to the outside of the beans as in Plot 1 and maintained as in Plot 1.

For maize/beans the observation would involve :-

- A single central row of maize with single plant spaced 20 cm apart giving a final population 33,000 per hectare.
- Two rows of beans to each side of the maize, spaced 30 cm apart and giving a population of 64,000 per hectare.
- Fertilizer application at the recommended rate of 4 bags 20:10:10 per hectare (but see also Section IV).
- Weeding at 4 - 6 weeks (Santa/Fundong) and again at about 8 weeks (Mbiyeh and Dzeng).

With the increased adoption of the use of fertilizer on maize in an intercropped situation, the experiments indicate the need for added emphasis on weed control, especially in the first 6 - 8 weeks after planting. This is particularly important in the crop associations since the stimulus to weed growth of the added fertilizer, provided for the maize, was shown on several sites to have an adverse effect on associated legume crops.

3.4. Demonstration of recommended practices

Establishment of the TDCs started in 1983 and was phased to not only provide an increasing range of adaptive research facilities but also allow demonstrations of recommended practices to be set up in advance of the posting of extension staff following their 3-months induction training.

Trained VEWs are now working in all but two sub-divisions of the Province, and seven TDCs are carrying demonstrations in support of their continuing in-service training needs. VEWs report to their respective centres on a regular monthly basis, for training in topics related to the cropping calendar in their work area.⁽¹⁾

(The remaining two centres - Babungo and Widikum - will begin their in-service training responsibilities during 1987. A tenth TDC to be established under the Wum Area Development Authority in 1987 will supplement the training facilities for Menchum Division which are currently confined to the Fundong TDC.

Appendix 6 lists the topics currently covered by farmer recommendations. The demonstrations carried are widening in scope as further information is developed and the TDCs' capacity to expand their operations increases.

Training under the system is provided by the TDC senior staff, supplemented by senior extension staff, Provincial Delegate for Agriculture technicians or IRA Bambui Scientists as necessary.

3.5. Multiplication programmes

From the outset of the Programme, multiplication of improved planting materials has concentrated on maize and arabica coffee, crops for which recommended varieties were already available.

As the impact of the extension effort of VEWs has spread, so the demand for recommended seed maize and 'Java' arabica seedlings has increased. In the case of arabica coffee, the central nurseries (several of which are run by TDCs) and the individual or group nurseries raised by farmers under the technical guidance of VEWs, have kept pace with the demand for seedlings. Recommended planting materials of robusta coffee and cocoa from IRA Pemambi Kang and oil palm from PAMOL, have also been brought into the nursery programme in support of extension activities in the lower altitude zone of the Province. This tree crop multiplication is coordinated by the Tree Crop Section of the Extension Service at the PDA.

(1) See publications of the Extension and Training Component of the MIDENO/PDA support programme for further details.

In the case of seed maize, two multiplication farms have been established in the Province under Adaptive Research Programme coordination, to ensure the production of adequate quantities of recommended varieties. High altitude varieties are produced at Santa Estate (Mezam Division) and low altitude varieties at Modelle (Menchum Division). Areas cultivated are now 31 ha and 13 ha respectively, the areas having been expanded gradually as anticipated demand increased. For the 1986 crop season 35.62 tonnes of high altitude seed maize and 6.735 tonnes of low altitude varieties were sold to some 8471 farmers assuming one package per farmer, representing a planted area of approximately 4236 hectares (see Appendix 10)

Distribution of the seed to the level of Cooperative Primary Society was coordinated by each season by the Adaptive Research Section. Following the establishment of the Farm Support Service under NWCA, coordination of supply will be under FSS control from 1987 distribution season onwards.

Through the development of close collaboration with IRA Stations improved varieties of other crops have been brought to the Province. In the first instance these have been multiplied on a limited scale, principally on the TDCs to provide the Centres with sources of the materials for further local observation. These stocks provide the basis from which larger scale multiplication for supply to farmers will be developed (see also Section IV below).

3.6. Information feedback to research

The following examples illustrate important areas where field observations by various agricultural staff and agencies have provided the impetus for further research investigations.

The establishment of the NCRE's programme for the development of a high altitude maize variety follows from field observation of the limited yield of available varieties under higher altitude environments with extended growing seasons.

Although the maize variety CUCA has yielded well at medium elevations, it has on occasion proved susceptible to lodging on exposed sites due to its tallness and the height of ear development. In addition, it is a rather leafy variety increasing the shading of other crops with which it is associated under farm conditions. In view of these observed drawbacks, IRA is attempting to produce shorter varieties, and to introduce the "liguleless" gene to produce a more erect leaf-type which would permit improved light penetration to the lower crop canopies in a mixed cropping situation.

The results of a number of the crop association experiments reported here, would support the need for minimizing mutual shading, by manipulating planting arrangements. If this were to be coupled with the use of the new morphological types of maize mentioned above, considerable benefits to the productivity of the associations would possibly be gained.

The lack of recommended varieties of grain legumes for the province is a continuing problem. Two cowpea varieties and one soya bean variety have recently been received for observation. Following the expressed need for a wider range of soya bean and Phaseolus bean varieties, IRA Dschang and IRA Foubot will be collaborating with the Adaptive Research Programme, to conduct variety/fertilizer trials on TDCs from 1987.

Observations on the range of Solanum potato production systems operating in the North West Province, suggest that different dormancy characteristics are needed in the varieties to be recommended to match the varying lengths of "off-season" in different parts of the Province during which seed is retained for the next cycle of planting. IRA Bambui, as the national centre for Solanum Potato research coordination, could make a valuable contribution to improving potato production through selection of varieties which, in addition to other desirable characters, fit into these different systems of production. Collaboration between the Adaptive Research Programme, Extension Service and IRA Bambui is now underway in this connection (see also 3.7 below).

Through the TDCs an excellent channel now exists for the flow of such information/observations to research. Following their frequent meetings with farmers, VEWs now have a regular monthly opportunity to discuss identified farmers problems with senior TDC staff who in turn are in close contact with IRA both directly and through the Adaptive Research Section of the PDA. Particularly close ties are maintained with the TLU of IRA Bambui through its collaboration with the extension staff for the establishment of the TLU network of on-farm trials, and also through joint experimentation at the level of the TDCs.

3.7. Provincial programmes of support for specific crops

The programmes are aimed at those crops which have to date received relatively little research attention or extension support in the Province.

The object is to ensure the coordination of the efforts of various support agencies in the Province in promoting production of specific crops by developments in a number of disciplines, including plant breeding, agronomic research, extension, crop processing and storage, and marketing. Where the potential exists for liaison with other appropriate agricultural agencies for such coordinated crop programmes, areas of responsibility within the overall programme have been assigned to each organisation. In the case of maize for example, variety development and applied agronomic research are done by IRA, adaptive research by the PDA programme and on-farm testing/economic assessment by TLU of IRA Bambui. Extension of recommendations is the prerogative of the Extension Service. Provincial programmes have also been established for Solanum potatoes and wheat (see Appendix 9), aspects of which are now being implemented by the relevant agencies. The establishment of IRA experiments on TDCs to select varieties of soya and Phaseolus beans for the Province represents the beginning of a similar approach in support of grain legume production. The soya bean programme is further ahead in that production recommendations accompanying the currently available variety (SJ 239) are linked to programmes of training ⁱⁿ methods of preparing and cooking soya beans, conducted through the Department of Community Development and the Women's Programme of the PAFSAT oxen-farming project under the PDA.

5.7. Provincial programmes of animal husbandry

The programmes are aimed at those crops which have the most potential for relatively little research, extension or extension support in the Province.

4. FUTURE PROGRAMME PRIORITIES

The important development priorities with respect to agriculture in the Province have not changed since the start of the adaptive research programme. The major approaches involved in the present programme could therefore usefully be continued, although changes will be necessary in the detail of work within each major category.

The basic concept of the TDCs as dual purpose, research and training facilities has already been shown to be of value. What remains is to ensure a continued improvement in the efficiency with which these two roles are performed, and to ensure that the content of the programme of research and training remain relevant to the major agricultural development priorities and potentials which are identified.

In terms of the efficiency of the TDCs operations, added emphasis should be given to development of the management and teaching skills of the TDC Managers, and the standard of control over data collection and recording on the parts of the Managers and Trials Supervisors.

The coordinating role of the Adaptive Research Programme at the PDA is vital to the control of the content of the work done on the TDCs not only to ensure that TDC resources are used for the major work priorities of the centre, but to design these work priorities in line with provincial programmes which will involve close liaison with an increasing range of collaborating agencies.

As further recommendations and technologies develop, it is anticipated that the demonstration role of the TDCs would be proportionately increased. It will not be feasible for all farmers to adopt a given recommended practice for technical reasons (e.g. the topographical and ecological limitations to the spread of oxen farming), or financial reasons (e.g. the cost of equipment, storage structures etc). What is important is for the TDCs to demonstrate a wide range of recommended farming activities and technologies (involved in land preparation, crop production, processing and storage) and for the senior staff to be aware of existing credit lines.

During their training sessions, VFWs will then become increasingly familiar with the possibilities which exist. They can then go on to guide their individual contact farmers and farmer groups, to identify what is feasible for them and how they may best use their available resources.

At the same time they are able to advise the farmer of how to gain access to more costly technology through the various provincial credit programmes. This aspect of the VEWs role may be expected to increase as farmers who have adopted the basis recommendations now being promoted, ask the question "what else can I do?" One important aspect of the TDCs will be to have the capacity to provide the extension staff with an appropriate range of additional possibilities which will have a positive effect in relation to one or more of the limiting factors mentioned in Section III above. With respect to the detail of adaptive research for the future and the technical content of TDC programmes, the following areas could usefully be emphasized.

1. Soil Conservation

The TDCs should continue to demonstrate sustainable farming, treating the centre as a single unit with its associated soil conservation problems to be tackled through combinations of control of water movement across the site; establishment of contour bands; contour cultivation; planting of perennial crops along contour lines; incorporation of organic matter during land preparation; and where appropriate using mulching; green manure crops etc. Adoption of these principles has already improved soil stability, soil structure (and hence resistance to erosion and improved nutrient retention capacity) and soil fertility on the earlier - established TDCs.

There are indications that incorporation of organic matter may be especially valuable at higher elevations where high rainfall on shallow, acidic soils (many of which have been subject to repeated effects of burning) has created particularly severe soil problems. (1)

Of particular interest in relation to the soil problems will be the long-term performance of crops in the recently established Alley Cropping plots. Results from use of this system in the humid tropics have been impressive (2), and the relevance of this approach to the situation of increased erosion, declining fertility and shorter fallow periods in the Province is clear.

(1) See also results of PAISAT on-farm observations 1986.

(2) Alley Cropping : A Stable Alternative to Shifting Cultivation.

International Institute for Agronomic Research, Ibadan, Nigeria.

Observation plots have been established on seven TDCs to date using the leguminous shrub Tephrosia for the hedgerows.

The feasibility of using other shrubs should be explored. However, the use of Tephrosia (in alley cropping and the other soil-related investigations) has a number of advantages. Firstly, it is a plant known by many farmers in the province to be beneficial to soil fertility. Recent soils research⁽¹⁾ has shown much higher levels of the major plant nutrients in soils under Tephrosia (including phosphorous, the lack of which is limiting crop growth on many (acidic) soils in the Province.

Secondly, Tephrosia grows well in a wide range of altitudes and soil types (c.f. Leucaena spp., commonly used in this system at lower elevations and on less acidic soils).

Thirdly, the bush will ratoon, although it remains to be seen how long this can be maintained before re-planting becomes necessary.

The first advantage is especially important in an extension sense in that the alley cropping can be portrayed to farmers as a modification of existing farming practice rather than an entirely new concept.

A further advantage of the system may prove to be the possibility of reducing/eliminating the need for soil tillage (having protected from erosion risk on unridged land by planting the hedges and reduced the need for start of season weed removal by using trimmings from the hedges as mulch). Much remains to be learned of how best to adapt this technique to conditions and farming system in the Province, but the apparent potential is considerable.

The following experiments, rotations and soil fertility maintenance elements of TDC programmes should continue as part of an integrated approach to developing appropriate methods for alleviating soil problems and land preparation difficulties.

2. Provision of Improved Planting Materials

The provision of improved planting materials is a continuous process. The Adaptive Research Programme should continue to acquire, and if necessary further test, varieties developed by the various IRA stations. The approach of short-list testing and observation on the TDCs prior to issue to farmers has already been established.

(1) B. Schimpf (1986) Probleme der Bodenfruchtbarkeit bei der Einführung eines ökologisch angepassten, permanenten Anbausystems mittlerer Ertragslage in der Nordwestprovinz Kameruns Universität Göttingen, F.R.G. (P49).

It is anticipated that the range of crops handled by the Provincial Multiplication Unit farms at Santa and Modelle will increase.

Obvious directions for Santa are to include soya and Phaseolus beans once varieties become available. At Modelle the first stage of establishing robusta coffee propagation to satisfy the provincial robusta cutting requirements by 1992 has already taken place. Mother bushes of IRA-recommended clones will be planted out in 1987. Considerable effort is still needed to ensure the satisfactory build-up of this programme.

Recent advances in root crop multiplication techniques provide an opportunity for a major impact on root crop multiplication in the Province. The rapid multiplication methods for (especially) cassava and yams should be established on TDCs (and perhaps also at Multiplication Farms) to provide large quantities of the improved IRA varieties to farmers, without the previously attendant problems of coping with very heavy and bulky materials. Staff of the PDA who recently attended a root crops seminar sponsored by IITA and IRA Ekona, have access to the appropriate information, which is also under preparation for publication as a technical reference document.

Particularly for maize and the grain legumes, it will be important to examine the yield potential of the new varieties being introduced in the context of a crop association, bearing in mind the potential problems of mutual shading and competitive interaction of components seen in the TDC experiments to date.

Budding and grafting techniques could usefully be demonstrated on the TDCs to encourage uptake of improved quality fruit trees.

3. Experiments with crop associations

See also discussions under Section II.

Although farmers currently grow the majority of their crops in mixed associations, future adoption of alternative farming methods (e.g. oxen farming, alley cropping) could provide an opportunity to encourage separation of the crops (possibly facilitating crop care and reducing adverse competitive effect). However, it is not currently known if such separation would give a yield advantage over mixed cropping. This is an area where the adaptive research programme could potentially have a major impact in future through anticipating the need for answers to new series of questions which are likely to be brought to extension staff as farming systems and available technologies change.

For example, the use of animal or motorized power for cultivation allows an opportunity to cultivate a larger parcel of land (indeed their use is more feasible on larger parcels of land). This in turn permits a different set of cropping system options to be considered, one of which could be the separation of crops, perhaps to facilitate establishment of a rotation system.

Clearly there are many uncertainties in this area, such as the likely future trend in land tenure systems, development of appropriate mechanical cultivators etc. However, research should where possible create new opportunities for farmers, and anticipate their future needs, as well as being in a position to respond to their current problems. In this connection, investigation of the comparative benefits of mixed associations as against pure stands warrants urgent attention.

4. Expansion of the "Provincial Programme" approach

Already operating for maize, Solanum potatoes, wheat and soya beans, the coordinated programme approach is a valuable means of maximising the use of development resources in the Province, particularly in support of new initiatives. Consideration should be given to expanding this approach to other crops, and to farming systems developments (e.g. the establishment of soil conservation pilot schemes, oxen farming etc).

In the case of "systems", the areas of responsibility might be divided into; research into techniques, equipment etc; cost/benefit analyses of adoption of the practice; provision of extension support; assistance in identification of market outlets for increased production; training requirement etc.

5. Testing of small tools and equipment

As with the testing of the AAPICA oil palm screw press, the section could increase the emphasis on making available small tools and equipment at TDCs for demonstration to VEWs in the context of ensuring their greater familiarity with available technology (e.g. hand operated maize shelling machines; rolling injection planter; groundnut decorticator etc). Stimulation of interest in such machines could lead to the need for added credit lines in the first instance. It would also add to the expansion of rural industry in the longer term for machine repairs and maintenance. Expansion of this aspect may take off more easily if a technician with a particular specialisation and interest in farm tools and equipment was to be made available at the PDA.

TDC SITE CHARACTERISTICSSANTA

Planting programme established March 1983

Altitude 1650m

Mid-high altitude zone: Major crops include :

- Maize, beans, arabica coffee, Solanum potatoes.
- Potential for wheat, vegetables, alley cropping, oxen farming.

Area available - 15.5ha

Area cultivated - 6ha (+ fuelwood plantation)

Major agricultural problems associated with :

- relatively poor soil structure and need for major soil conservation measures.
- low fertility of acid soils (bracken indicator); indications of trace element deficiencies especially on coffee.
- marked diurnal temperature range (especially affecting coffee growth)
- extended growing season due to low (soil) temperatures.
- soil borne pests - (mole cricket).

NKWEN

Planting programme established March 1983

Altitude 1200m

Mid-altitude zone: Major crops include:

- maize, beans, groundnuts, arabica coffee, yams.
- potential for soya beans and cassava, and for increasing cowpeas, sweet potatoes, vegetables, alley cropping and oxen farming.

Area available - 7.5 ha

Area cultivated - 5 ha

Major agricultural problems associated with :

- soil conservation requirements
- low fertility status
- heavy Imperata infestation in earlier stages of site development

NYEN

Planting programme established March 1983. (Sang site from 1985)

Altitude 1200m

Mid-altitude zone (although climate, and plant disease spectrum more typical of lower elevations in the forest zone). Major crops include :

- maize, beans, arabica coffee, groundnuts, cocoyams,
- potential for cowpeas, soya beans, yams, cassava, sweet potatoes, vegetables, alley cropping.

Area available (2 sections)- 5ha

Area cultivated - 4 ha (+ fuelwood plantation)

Major agricultural problems associated with :

- poor soil structure and attendant fertility problems
- high pest/disease incidence (associated with higher relative humidity)

DZENG

Planting programme established March 1984

Altitude 2000m

High altitude zone: Major crops include

- maize, beans, Solanum potatoes.
- potential for tea, arabica coffee (with specialized care), wheat, vegetables, oxen farming.

Area available - 11 ha

Area cultivated - 6 ha

Major agricultural problems associated with :

- severely leached and acid soils (bracken indicator)
- soil adversely affected by repeated 'ankara' burning in the past.
- major soil erosion risk
- soils with virtually no organic matter
- very low levels of soil fertility
- very long growing season associated with low temperatures, high rainfall and little sunshine.
- extremely low night temperatures in dry season with occasional ground frosts (problem for especially perennial crops, and dry-season vegetables).
- severe soil borne pest problems (cutworms and crickets).

MBIYEH

Planting programme established March 1984

Altitude 1900m

High altitude zone. Major crops include

- maize, beans, arabica coffee,
- potential for Solanum potatoes, wheat, oxen farming, alley cropping (?)

Area available 15 ha

Area cultivated 4 ha (+ fuelwood plantation)

Major agricultural problems associated with :

- highly leached, acid soils
- poor soil structure and generally low soil fertility.

- very long growing season, associated with long, cool rainy season (see Appendix 2)
- severe soil pest problems, especially on newly opened land after fallow (cutworms, crickets).

FUNDONG

Planting programme established June 1984

Altitude 1500m

Mid-high altitude zone: Major crops include

- maize, beans, arabica coffee, Solanum potatoes
- potential for cowpeas, soya beans, sweet potatoes, yams, citrus, vegetables.. Oxen farming, alley cropping.

Area available 8 ha

Area cultivated 4 ha (+ fuelwood plantation)

Major agricultural problems associated with :

- very high soil erosion risk on steeply sloping land in very high rainfall area (major control measures required).
- only moderate soil fertility level.

BABUNGO

Planting programme established June 1985

Altitude 1100m

Mid-altitude zone

Site on generally rather fertile colluvial soils

Major crops include :

- maize, beans, groundnuts, cassava, arabica coffee (although in transition area to environment suitable for robusta), yams, sweet potatoes, cocoyams.

- potential for cowpeas, soya beans, vegetables, citrus.

Alley cropping likely to be of major interest in view of rapid growth of Lephrosia hedgerows in this environment.

Oxen farming potential.

Area available 20 ha

Area cultivated 4 ha (+ fuelwood plantation)

Major agricultural problems associated with :

- soil erosion control requirements
- heavy weed growth
- soil borne pests (maize rootworm, crickets)

OKU-NONI

Planting programme established March 1986

Altitude 1400m

Mid-altitude zone

Generally fertile area with low soil erosion risk, although protective measures still needed.

Major crops include :

- maize, beans, arabica coffee, sweet potatoes, groundnuts (?)
- potential for cowpeas, soya beans, yams, vegetables, citrus.

Major alley cropping and oxen farming potential.

Area available 10 ha

Area cultivated 2 ha

Major agricultural problems associated with :

- heavy weed growth
- need to improve soil structure

WIDIKUM

Planting programme established March 1986

Altitude 450m

Low altitude, forest zone with moderately fertile forest soils.

Major crops include :

- robusta coffee, oil palm, cocoa, maize, cocoyams, beans.
- potential for cowpeas, soya beans, citrus (?) yams, sweet potatoes cassava.

Area available 8 ha

Area cultivated 0.5 ha

Major agricultural problems associated with :

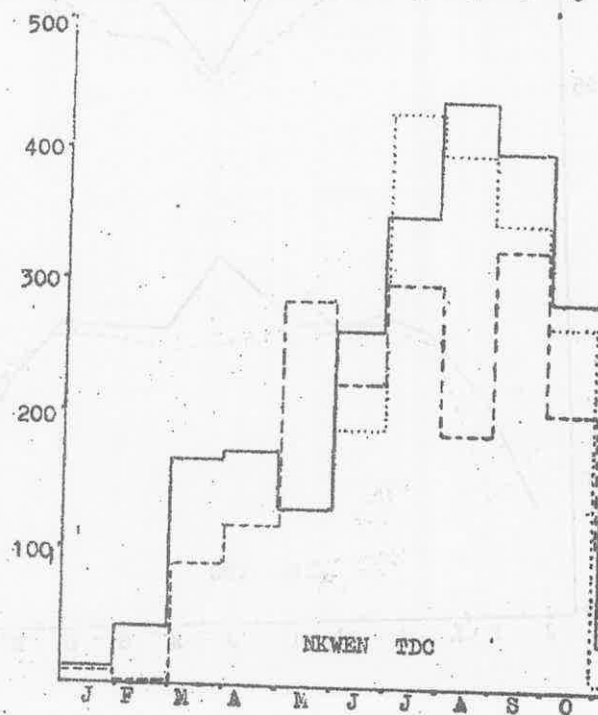
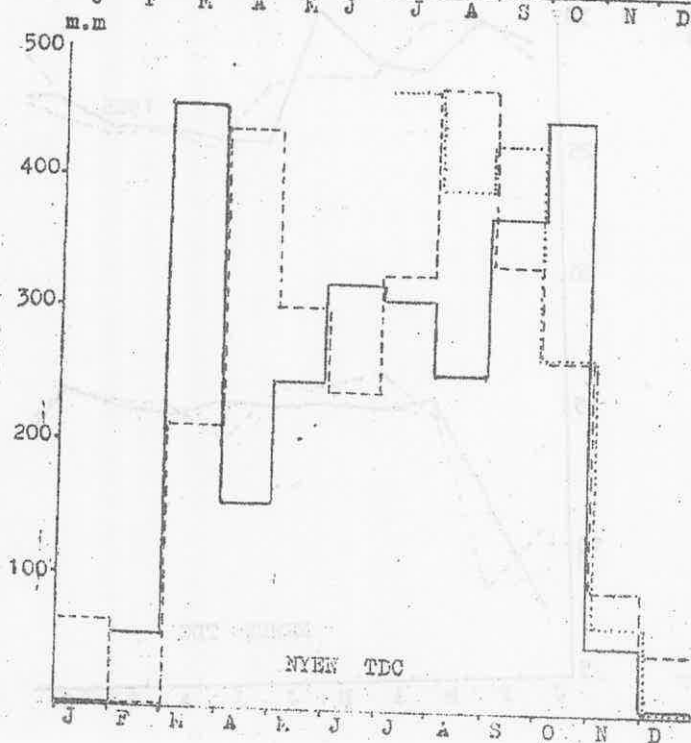
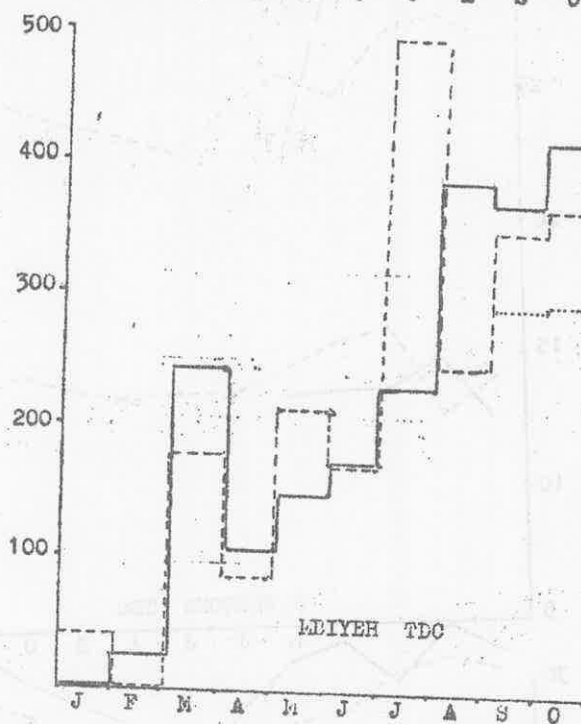
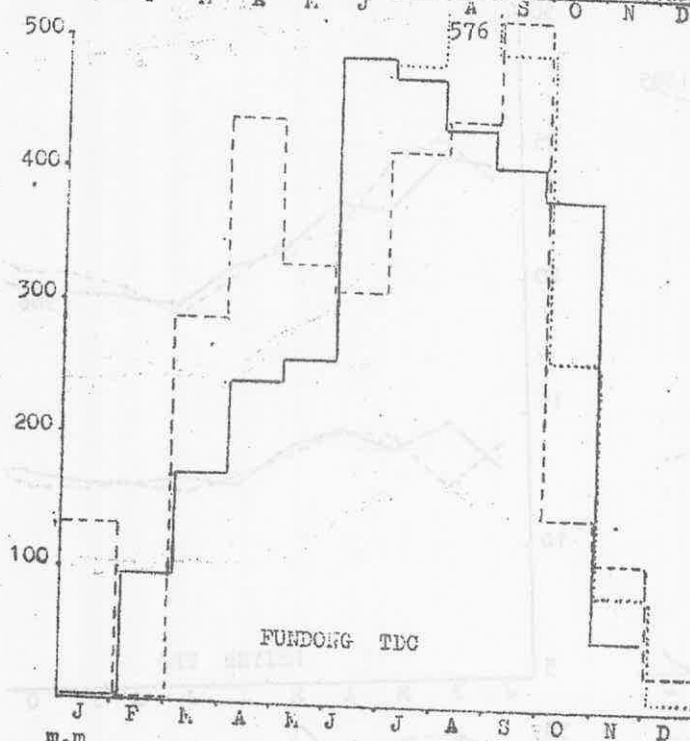
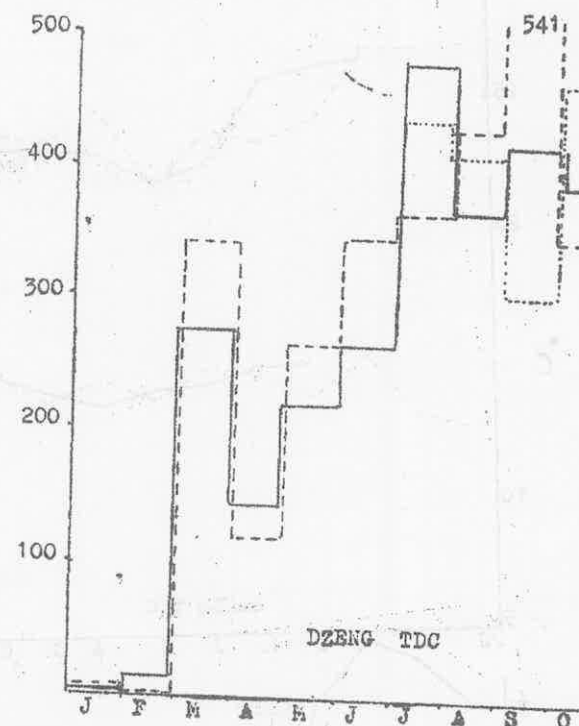
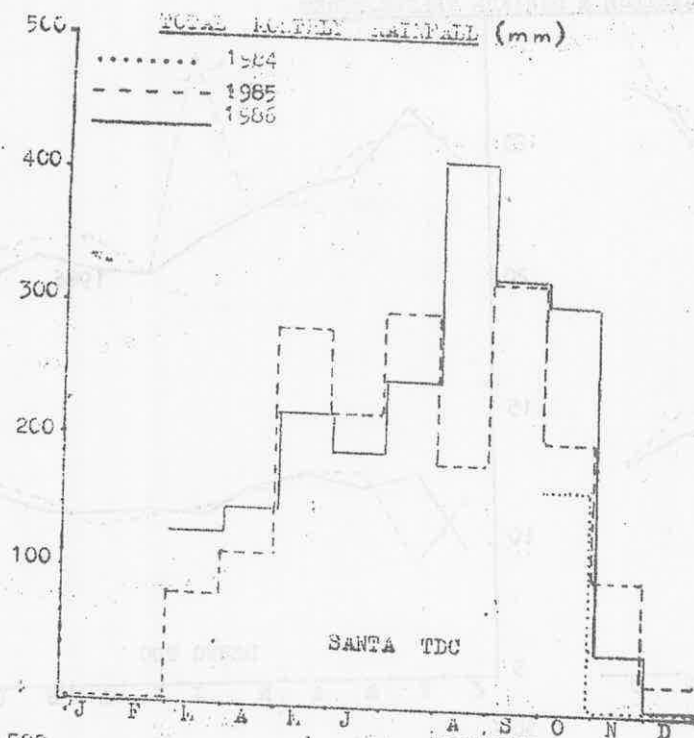
- rapid rate of weed growth
- high pest/disease incidence in this humid zone.

APPENDIX 2

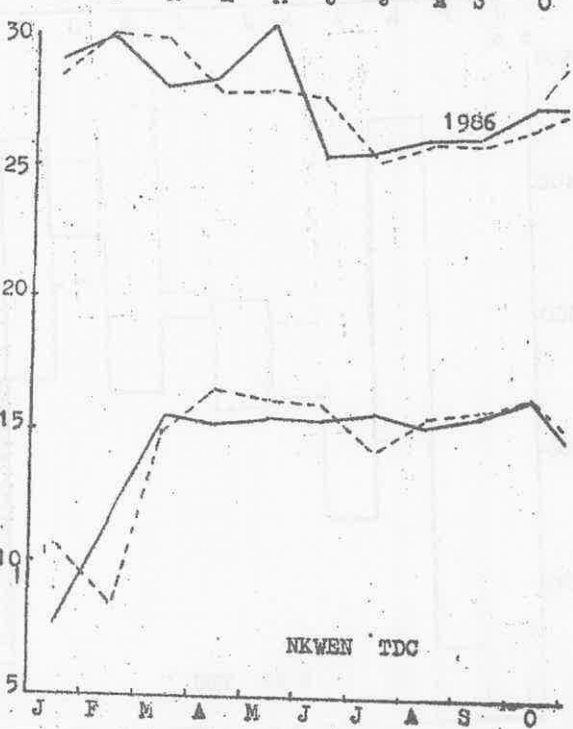
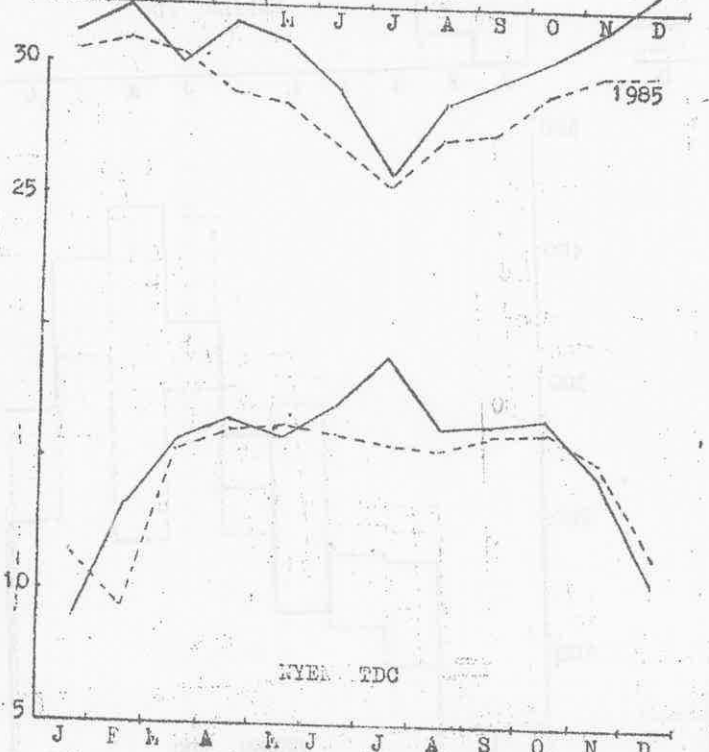
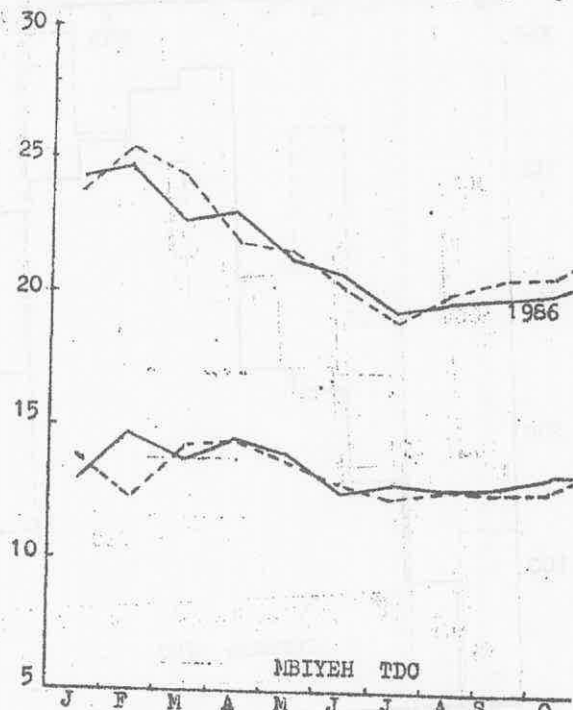
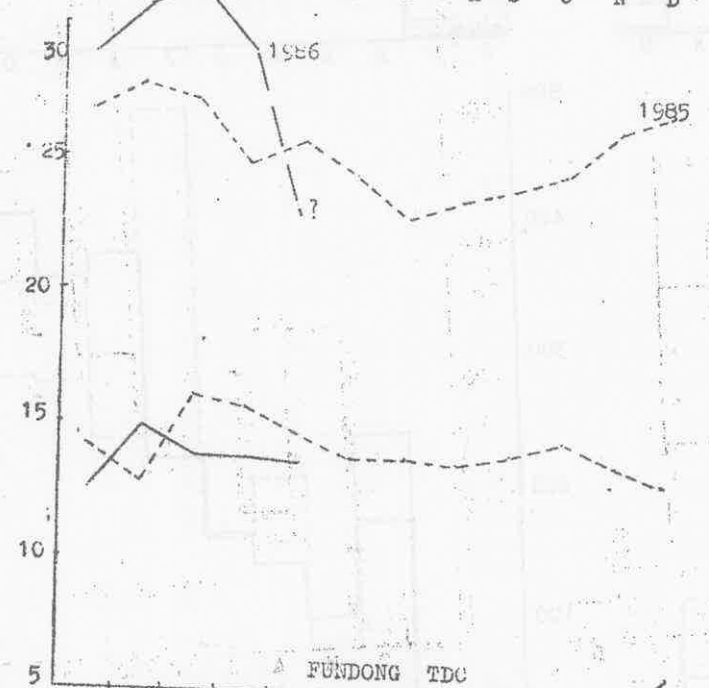
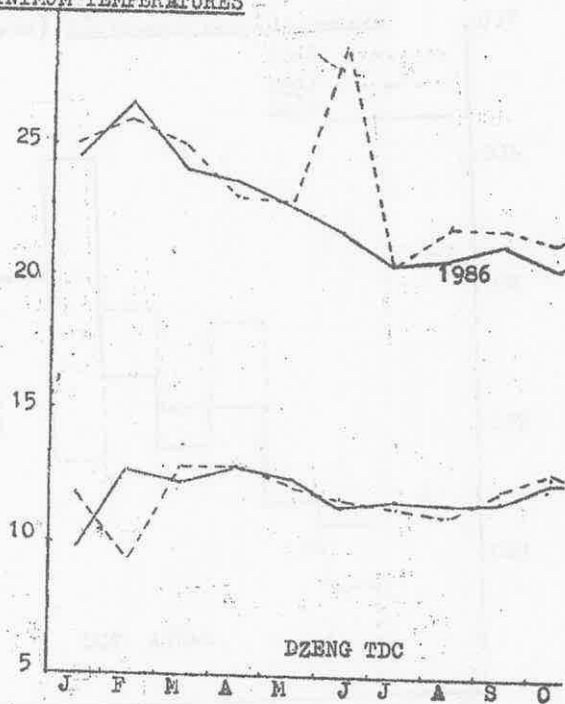
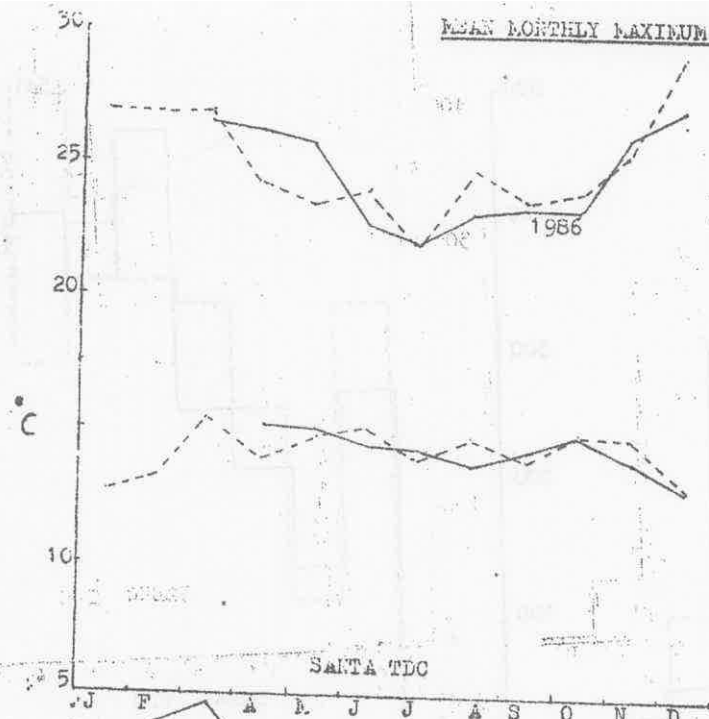
TDC RAINFALL

&

MAXIMUM/MINIMUM TEMPERATURES



MEAN MONTHLY MAXIMUM & MINIMUM TEMPERATURES



APPENDIX 3

DERIVATION OF CROP VALUES

In their regular monthly reports to the Provincial Delegation for Agriculture, field extension staff indicate the current market prices for major crops in their work areas.

Average 1986 village market prices for the Divisions appropriate to each TDC were calculated, for the months of harvesting the crops concerned.

The average prices were then applied to appropriate yield data from the intercropping experiments.

Harvesting was carried out on the TDCs as follows in 1986.

	Beans	Maize	Groundnuts	Cocoyams
Nkwen	June (175)	August (100)	August (299)	
Nyen	June (193)	August (118)	August (167)	
Babungo	June (175)	Aug/Sept (90)	August (299)	
Oku-Noni	June (126)	Aug/Sept (100)	Aug/Sept (n.a.)	
Widikum	June (193)	August (120)	-	September (118)
Fundong	June (175)	September (78)	-	
Santa	June (175)	September (78)	-	
Dzeng	July (126)	Sept/Oct (92)	-	
Mbiyeh	June (117)	October (73)	-	

The average market prices (CFA) applied to TDC yield data are indicated in brackets. (Due to lack of local price information, Mezam Division prices were applied to yield data from Fundong).

APPENDIX 4

SUMMARY OF EXPERIMENTAL DESIGNS

EXPERIMENT	DESIGN	Number of Replications	Number of Treatments	Plot size (M ²)
Maize Var 1	Randomised Block	5	4	20
Maize Var 2	"	5	6	20
Maize Var 3	"	5	4	20
<u>Maize/Beans/Groundnuts</u>				
I Weed/Fertilizer	"	5	8	30
II Timing of weeding	"	4	6	30
III Improved varieties	"	4	8	22.5
IV Planting Arrangements	"	4	6	30
<u>Maize/Beans</u>				
I Planting Arrangements	"	4	6	30
II Weed/Fertilizer	"	5	8	30
III Timing of weeding	"	4	6	30
<u>Maize/Beans/Cocoyams</u>				
I Weed/Fertilizer	"	5	8	30
II Timing of weeding	"	4	6	30
III Planting Arrangements	"	4	6	30

APPENDIX 5

EXTRACTS FROM PROPOSED PROTOCOL AGREEMENT - MIDENO/PDA/IRA

The extracts given below indicate areas of cooperation/coordination proposed to ensure a combined approach to research, extension and on farm activities:

"MIDENO/PDA, and IRA (TLU) shall meet formally at least once a year for discussions to agree upon their respective technical programmes and areas for cooperation and formulation of recommendation packages for farmers.

The PEM Division of MIDENO shall liaise with the TLU of IRA in order to take advantage of their respective capabilities and experience in the planning and implementation of surveys. Such liaison will :-

- Help in defining the technical content of the TLU and Agricultural Research Programmes.
- Assist PEM in its role within MIDENO to provide support data for planning future agricultural activities, and examining the effectiveness of existing programmes.

The IRA staff shall be available as subject matter specialists to :-

- Contribute to extension training programmes
- Collaborate with senior TDC staff to find solutions to technical agronomic problems.
- Train senior TDC staff in specified research techniques
- Advise as necessary in seed production and technology.

In areas where the T & V system is already operational, IRA shall establish its on-farm experimentation programme through PDA/MIDENO. The Extension/Training and Adaptive Research Sections of the PDA shall assist IRA in the supervision and management of on-farm experiments. The TDCs would conduct selected experiments with IRA on the basis of recommendations made at the technical meetings.

Liaison with other IRA stations as well as IRA Bambui shall cover :

- Provision of improved planting materials either by special agreement or under existing MINAGRI/MESRES agreements.
- Access to technical information/advice concerning crops of concern to PDA/MIDENO but which are not covered by IRA Bambui.

TECHNICAL RECOMMENDATIONS/TDC DEMONSTRATIONS

1. Arabica Coffee

- (a) Pre-germination of coffee seeds.
- (b) Coffee nursery management
- (c) Planting coffee in the field
- (d) Field maintenance of coffee
- (e) Control of Coffee Berry Disease
- (f) Harvesting and on-farm pulping of arabica coffee.

2. Recommendations on Improved Crop Production Practices - covering all aspects from land preparation to harvesting - have been developed for each of the following crops :

Maize, Yams, Rice, Soya Beans, Cassava, sweet Potatoes, Oil Palm.

3. Production Handbooks summarizing the ecology and uses of crops in addition to their management requirements have been produced for :
Rice, Oil Palm, Cocoa.

4. Crop Storage

- a) How to store grain in bags, with Actellic Powder
 - b) How to store grain in bamboo boxes with Actellic Powder.
 - c) How to use the Ferro Concrete Silo
 - d) Code of good storage practices for any improved storage method
 - e) Storage of ware potatoes.
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ADAPTIVE RESEARCH PROGRAMME

I INTRODUCTION

The programme is primarily designed to meet the following objectives of adaptive research under MIDENO:-

1. To develop, through a series of experiments, recommendation packages for the cultivation of the major crops in the areas served by the TDC's.
2. To design and conduct experiments on the major crops to solve problems experienced in crop production by (especially) the small-scale farmers, i.e. a major emphasis will be placed on overcoming limiting factors known to exist in the field.
3. Where recommendation packages exist (for crops common in the area of the TDC), or where such packages are developed through (1) and (2) above, to demonstrate such recommendations to extension staff (principally) and visiting farmers.
4. To develop and demonstrate as appropriate, techniques of post-harvest crop storage and/or processing.

Detailed programme design therefore requires identification of the major factors considered to be limiting production now, or which are likely to reduce production potential over the longer term. The experimental programme is concerned with those limiting factors over which the farmer can exercise some control through methods/techniques applied at farm level, as opposed to external factors outside direct farmer control such as national and international pricing policies.

II FACTORS LIMITING PRODUCTION

1. Low productive potential of planting material available to/used by the farmer.
2. Soil fertility levels - involving one or a combination of the following:
 - effects of soil erosion on soil fertility and structure
 - crop sequences
 - fallowing systems/cropping intensity
3. Weed control practices
4. Incidence of pests and diseases (relates closely to (1) above)
5. Effects of plant population on yield per unit area
6. Labour constraints for carrying out essential farm operations.
7. Systems of crop storage/processing

III PROGRAMME CONTENT

1. The programme for each TDC will be divided into three main areas:-

- a) Experiments - data recorded from these will be subjected to statistical analysis.
- b) Observation Plots - data will be recorded as a source of supplementary information, but will not be subjected to statistical analysis.
- c) Demonstrations - primarily to provide teaching aids to extension staff and, to a lesser extent, farmers. Data will be recorded but (as in (b) above) will have no statistical validity

2. Given that the majority of farmers grow their crops in a number of crop associations, investigations of the factors outlined under (II) above, will be carried out with particular reference to crop associations in an effort to increase the productivity of the associations. However, investigations/observations on single crops will also be carried out where this is considered appropriate.

3.

3. The population of N. Province is increasing rapidly. As a result there is an increasing pressure on arable land, particularly in the main cropping areas of the province. This land pressure is having a number of important effects:

- (i) it is causing the extension of crop farming on to land which is marginal (at best) for crop production and where the dangers of soil erosion and reduction in soil fertility are very much increased.
- (ii) in many parts of the province there is no longer new, unused land to move into. As a result it is becoming necessary for farmers to cultivate the same piece of land for longer periods with shorter fallows than was done under the traditional shifting cultivation system. Increased use of the land, together with the techniques involved in crop production (e.g. orientation of ridges, ankara etc) are threatening to reduce the long-term productivity of the land in many areas. at the very time when the demand for food production from the same land is rising rapidly.

A major consideration in the design of the Adaptive Research Programme is the need to develop methods of maintaining/increasing soil fertility and minimizing the risks of soil erosion in an effort to maximize long-term productivity.

The fact that crops are commonly grown in association in the province increases the number of options available for achieving these objectives within the context of farmers' existing circumstances. Rather than introducing totally alien practices, there is therefore considerable scope for tackling crop production problems through manipulation, or restructuring of current farming practices. Hopefully this will increase the acceptability and rate of adoption of any new proposals.

4. Although the programmes of all the TDC's will operate within these general principles, details of the programmes will differ from site to site in accordance with differences in environment and the crops grown within the vicinity of the Centres. Details of the programmes on each site are presented later.

Major areas of activity will include:-

1. Collection and testing of improved planting materials.
(Preliminary multiplication may be necessary to provide sufficient planting material for experimentation.)
2. Collection and observation of species for inclusion in fallowing/soil conservation programmes.
3. Experiments to investigate the agronomic aspects of a number of major crop associations (involving different associations at higher and lower elevations).
4. Experiments to determine the possibilities for reducing the land fallowing period. (Involving also the use of the late rains for a second growing period.
5. Observations relating to soil conservation and soil fertility maintenance (including rotations; bund construction; modified planting patterns etc.)
6. Examination of crop drying/processing/storage techniques.
7. Demonstration of agronomic techniques/recommendation packages.
(This part of the programme will provide the technical basis of the Training and Visit system for the field extension staff.)

5. A major labour requirement in the farming calendar is for land preparation. Much of the farm land of the province does not lend itself to either mechanized land preparation or the use of animal traction. The Adaptive Research Programme will seek ways of easing the difficulties of land preparation. Investigation of the use of green manuring and occupation of the land through the 'second cycle' may help in this effort since land will be kept open for longer and perhaps thereby reduce the difficulties of cultivation by hand methods at the beginning of the following main season.

APPENDIX 8

TDC EXPERIMENTS, OBSERVATIONS
AND DEMONSTRATIONS

EXPERIMENTS 1987

	MBIYEH	SANTA	DZENG	FUNDONG	NYEN	NKWEN	BABUNGO	OKU-NONI	WIDIKUM
Maize Variety 1									
Maize Variety 2					X		X	X	
Maize Variety 3									X
M/B/G 1							X	X	
M/B/G 2							X	X	
M/B/G 4							X	X	
M/B 1									
M/B 2									
M/B 3									
M/B/C 1									X
M/B/C 2									X
M/B/C 3									X
Fallowing 1					X	X	X	X	
Fallowing 2	X	X	X	X	X	X	X	X	
Coffee 1	X	X	X	X	X	X	X	X	
Coffee 2	X	X	X	X	X	X	X	X	
<u>IRA experiments</u>									
Wheat 1	X	X	X						} IRA BAMBUI (Dr. Kikafunda) (prepare in June/July)
Wheat 2	X	X	X						
Wheat 3	X	X	X						
Soya bean varieties	X			X	X				IRA DSCHANG
Phaseolus varieties	X			X	X				IRA FOUMBOT
High altitude maize breeding trial	X								IRA BAMBUI (Dr. Everett)
TLU "on farm"		X	X			X			IRA BAMBUI (Dr. McHugh).

Demonstrations and observations should be set up with seed of recommended varieties for the area of the TDC in question i.e. as follows for maize:

MBIYEH	-	MLC	BABUNGO	-	COCA
DZENG	-	MLC	FUNDONG	-	COCA
SANTA	-	COCA	NYEN	-	EKONA WHITE
NKWEN	-	COCA	WIDIKUM	-	EKONA WHITE
OKU-NONI	-	COCA	WUM	-	EKONA WHITE

TDC FIELD DEMONSTRATIONS AND OBSERVATIONS - 1987.

	MBIYEH	SANTA	DZENG	FUNDONG	NYEN	NKWEN	BABUNGO	OKU-NONI	WIDIKUM	WUM
<u>DEMONSTRATIONS</u>										
Maize (NPK)	X	X	X	X	X	X	X	X		X
Maize/beans (NPK)	X	X	X	X	X	X	X	X		X
Maize/beans (ridge size)	X	X	X	X	X	X	X	X		X
Coffee	X	X	X	X	X	X	X	X	(1)	X
<u>OBSERVATIONS</u>										
Rotation I	X	X	X	X						
Rotation II	X	X	X	X						
Rotation III					X ⁽²⁾	X	X	X		
Rotation IV									X	
Soil Fertility maintenance	X	X	X	X	X	X	X	X	X	X
Coffee planting arrangements	X	X	X	X	X	X	X	X		
Alley cropping	X	X	X	X	X	X	X			
Soya bean Variety/Fertilizer		X	X			X				
Phaseolus Variety/Fertilizer		X	X			X				
<u>NURSERIES</u>	D ⁽³⁾	S	D	S	S ⁽⁴⁾	S	S	S	S	

(1) robusta coffee

(2) 1 at each site: Nyen and Sang

(3) D = Demonstration nursery only

S = Supply nursery (in addition to acting as a demonstration)

(4) Two nurseries: at Nyen and Sang sites.

THE SUPPORT OF WHEAT FARMING IN THE NORTH WEST PROVINCE.-

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I.C. WALTON, Dr. J. Kikafunda - Twine, F. Rauch.

Introduction :

There is currently no comprehensive agricultural programme in the North-West Province to support improved/increased wheat production in the area. IRA does have a nationally based research programme directed largely at Northern Provinces of Cameroon. IRA Bambui has maintained a small screening programme since 1974, supported by wheat agronomy experiments at its Upper Farm (See IRA Annual Report).

Following the small-scale introduction of wheat to some high altitude parts of Bui and Donga-Mantung Divisions from 1975, a number of farmers in these localities have now become involved in wheat production. In addition, with the recent expansion of WADA's oxen-farming programme in these same areas, the opportunity has been taken to include wheat within their farming system, and the farmers concerned have already shown a keen interest in the crop's potential.

Although no formal study or survey of the marketing potential for wheat has yet been made, it seems clear that a considerable market exists, at least in the urban areas of the province and almost certainly elsewhere in the country. (See notes of Dr. J. Ayuk-Takem: IRA/AOB/241/358 of January, 1984). Further assessment of this potential, together with an indication of the likely costs of production (a farm budget) for wheat, would be of value in helping to determine the degree of future emphasis to be placed on wheat in the province.

Nevertheless, and in anticipation of the generation of such information, a number of coordinated and complementary programmes are suggested below which would not only allow a start to be made on providing support to existing wheat farmers, but would also be a first stage in developing longer-term assistance to allow an expansion of wheat cultivation in the Province.

Suggested responsibilities of IRA, WADA oxen farming programme, and MIDENO/PDA as agricultural support agencies in the area, are outlined below. The proposals are given on the assumption that they should complement and support each other in the context of an overall provincial wheat programme.

Guidelines for a provincial wheat programme :

In developing a wheat support programme for the province it is considered that there is a need to :-

- a) provide technical support to existing wheat farmers through the oxen-farming and PDA extension programmes.
- b) identify wheat varieties with increased production potential for the North West Province.
- c) continue applied and adaptive agronomic research to support an expansion of wheat production in appropriate areas of the Province if this is seen to be justified on the basis of market availability and examination of farm budgets.

3. Proposed programme content :

3.1. 1985 crop season onwards within existing field programmes and budgets.

3.1.1. Investigations of wheat agronomy in association with oxen farming to include: timing of planting, weed control requirements, fertilizer application, spacing/seed rates.

The investigations would be done in the form of a series of observation plots on the farms of a small number of carefully chosen oxen farmers in Bui and Donga/Mantung Division.

Consideration would be given to the practicalities of crop establishment and maintenance within the oxen-farming system (adaptability to draught animal cultivation methods; suitability for incorporation in mixed cropping systems etc.)

The programme would be under the supervision of the oxen-farming adviser of WDA.

3.1.2. Examination of the potentials for incorporation of wheat in the mixed crop associations of the wheat growing areas.

Observations to be made on TDC's at Dzeng (Bui) and Mbiyeh (Donga/Mantung).

The programme would be supervised under the Adaptive Research Section of MIDRO/EDA.

3.1.3. Identification of wheat varieties with improved production potential.

a) Comparison of the performance of "elite varieties" with that of seed material currently available to farmers.

- a number of varieties have been under investigation for some time at IRA Bambui. Whilst these cannot at this stage be considered "recommended" varieties they represent a likely source for providing a recommended variety/varieties to farmers.

For the sake of convenient identification only of this group of materials, they are here referred to as "elites", being further along in the screening process (to be described below) than other available materials.

- growth and yield performances will be assessed in an experiment carried at 3 locations in 1985. Upper Farm, Bambui; TDC Dzeng and TDC Mbiyeh.

Note: the early screening of potential recommended varieties be confined to IRA research stations and TDC's to ensure that no seed is released/available to farmers prematurely.

b) Screening of imported varieties selected by CIMMYT for their potential adaptability to the altitudes of wheat areas of the North West Province.

- some 13 varieties have been imported from CIMMYT, Mexico through GTZ and the WADA oxen-farming programme. Initial performance assessment will be made to compare them with both the "elites" and farmers' seed.
 - the experiment will be conducted at IRA Upper Farm Dzeng and Mbizah TDC's under IRA supervision. Selected promising varieties would then be included in further tests on TDC's and later farmers' plots prior to multiplication/release of any recommended variety.
- c) Initial screening of the large numbers of varieties/lines included in CIMMYT's national screening trials in Cameroon.
- this is an IRA responsibility which would lead to identification of new material for inclusion in the later stages of screening described above.
- 3.1.4. Development of initial agronomic recommendations for inclusion in the information made available to extension staff (PDA's Village Extension Workers and oxen farming staff) who will be in contact with existing wheat farmers.
- IRA would provide the basic information available to date to Adaptive Research and Extension. The recommendations would be refined/added to as further investigations are conducted (see also note 3.1 below).
- 3.15. Establishment of demonstrations (from crop production - crop storage). Following the development of the recommendations, the adaptive research section and oxen farming programmes would establish demonstrations of the use of recommended practices. TDC demonstrations would be incorporated in the Training and visit programme for VBW's.
- Local seed would be used in the first instance until a recommended variety can be made available.
- Again the demonstrations will be modified as necessary in line with developments in research and recommendation package design.
- 3.1.6. Estimation of a farm budget for wheat production using information available to TLU; information made available through involvement with oxen-farmers and others already cultivating wheat. the estimation would involve consultation between PEM and TLU.
- 3.1.7. Examination of marketing potential
PEM Division; Food Marketing Officer of MIDENO/PDA.
- 3.2. Possible long-term investigations :
- 3.2.1. Expansion of experimentation (as opposed to observation) with agronomic aspects of wheat cultivation
applied research programme - IRA
adaptive research programme - TDC's
- 3.2.2. Testing and Liaison Unit (TLU) of IRA to establish a farm programme for wheat in a similar manner to its existing programmes for other cereals
- 3.2.3. Investigation of potentials for wheat production in additional localities if markets deemed to warrant an expansion of wheat production (e.g. Fundong, Oku-Noni TDC's to serve/encourage wheat production in the areas served by the TDC's.

3.2.4. Intensification of screening programme for North West Province under IRA under a full time wheat specialist.

Such intensification/expansion of wheat-related research activities would take place in the context of a nationally agreed increased emphasis on wheat production from the North West, following demonstration in the short term of production potentials.

It is conceivable that a large proportion of such expansion would be in association with oxen-farming. It would therefore be necessary to consider mechanisms for the provision of credit lines to supply oxen and associated cultivation equipment to farmers to a greater degree than is currently feasible under the GTZ/WADA programme.

JULY, 1985.

THE ESTABLISHMENT OF A COMPREHENSIVE AGRICULTURAL PROGRAMME
IN SUPPORT OF POTATO PRODUCTION IN THE NORTH WEST PROVINCE

1. INTRODUCTION

- 1.1. Potato production is well established in many of the highland areas of the North West Province and is based on plant material introductions which began in the 1940's. The cultivars now grown express a wide range of characteristics and appear to be well adapted to the environmental conditions and production systems of the province.
- 1.2. Potatoes have been given relatively little attention by agricultural institutions in the area, although some work has recently been done on ware potato storage in order to give a market price advantage to those producers who are then able to sell stored crops outside the peak production period.⁽¹⁾
- 1.3. Potato support programmes were not emphasised in the original design of the MIDENO programme. However, the importance of potato production in certain areas and the considerable potential which exists for increased production, suggests that agricultural extension staff should be in a position to provide technical assistance to potato farmers.
- 1.4. Based on the results of investigations under the FAO programme, ware potato storage recommendations have been produced by MIDENO/PDA and are now incorporated in the extension programmes for the potato zones of the province. 8 demonstration stores have been constructed (and a further 15 are planned) to assist the extension effort.
- 1.5. Following a series of meetings and field tours in 1984 and early 1985 involving MIDENO/PDA, IRA and visiting specialists from the International Potato Centre in Peru (C.I.P.), preliminary plans had been discussed for a comprehensive and coordinated approach to supporting potato production through the various agricultural agencies in the province. The feasibility of such an approach was greatly increased through the recent appointment by IRA of a potato research coordinator for Cameroon based at IRA, Bamun.
- 1.6. Links with C.I.P. (both on the part of MIDENO/PDA and IRA) have been strengthened in the fields of research, extension and training in relation to production systems, opening up further possibilities for the generation of increased potato production in the province. The IRA research coordinator together with two of the PDA's Trial and Demonstration Centre Managers attended a short training course in Senegal, on tropical potato production, in March 1985.

(1) FAO Food Loss Reduction Programme: 1979 to 1981.

1.7 As a result of their increased liaison, IRA and CIP are together working on plans to link national research programmes in Cameroon with the international based research of CIP, and to station CIP personnel in Cameroon to support the national research effort. (See Appendix)

1.8. Within the context of the activities and plans described above, the request made by the PDA (1925/236/S.9/PDA/NW/305 of 28th May 1985) for a proposal concerning a comprehensive approach to increasing potato production in the province is particularly appropriate.

The IRA potato research coordinator is currently drawing up a listing of research priorities on a national basis. Within this programme (See Dr. Foncho's paper) opportunities exist (many of which are already being exploited through MIDENO/PDA programmes) for close coordination between CIP, IRA and MIDENO/PDA to develop applied and adaptive research, extension and training programmes directed specifically at farmers of the North West Province.

1.9. Current and possible future responsibilities of the various institutions in relation to potato support programmes are discussed below.

2. UNDERLYING ASSUMPTIONS OF PROGRAMME DESIGN

2.1. The following are the underlying assumptions on which the present potato activities are based, and which are likely to guide future developments:

- three major potato production systems are operating in the province, with minor local variations on these main themes.

- improvements can be made in the production potential of planting material available to farmers.

- improvements can be made on the storage systems used for seed and ware potatoes.

- there is a need to assist producers/producer groups with the construction of appropriate storage structures throughout the provision of demonstration stores and a credit line for store construction.

- further markets for increased potato production need to be identified and the possibility of local processing of surplus / e.g. into crisps) to be investigated

- further technical training of agricultural personnel of several levels in aspects of potato production and storage would be an advantage,

3. PROGRAMME CONTENT

3.1. Further description of the potato production systems operating in the Province in order to generate development objectives relevant to each of the different systems. (e.g. the growing period, dormancy and storage characteristics required of cultivars will differ for the different production systems. Support (e.g. planting materials; technical information etc) will therefore vary from area to area in accordance with the systems. The descriptions could be compiled by PEM/TLU/Adaptive Research using information from surveys and knowledge of field staff who are now familiar with the production systems operating in their areas. Local development objectives (system specific objectives) could then be established between MIDENO/PDA and IRA.

3.2. Establishment of a system for screening clonal materials with a view to identification of high yielding cultivars suitable for the range of production systems described under 3.1. above,

Initial screening would be under the supervision of IRA with field performance assessed on IRA land. Following identification of potentially useful cultivars land on TDC's could be made available for further selection work.

The PDA programme would therefore be providing assistance in terms facilities for: field screening for disease tolerance, growth and yield performance. screening in storage structures for adaptation to storage/dormancy requirements in production systems of the province. (Storage structures on TDC's could therefore serve dual purposes of demonstration and also provide a means for IRA to conduct storage experiments.)

Screening would include collections of local cultivars as well as imported clonal material. If breeding work was to be done in the future, this would be an IRA responsibility. Potentially useful clones would move onto TDC's only at a later stage in the selection programme of field testing.

Note: Any planting materials made available to agricultural institutions in the province (e.g. through MIDENO, MIDEVIV, WADA, Agricultural Schools etc) must pass through the IRA screening programme to ensure that cultivars are not passed on/available to farmers prematurely.

3.3. Testing of storage structures

- a) modifications/refinements to recommended ware potato storage structures and the associated storage technology (e.g. selection of produce for storage; produce treatment etc).
- b) development/testing of diffused light storage structures and systems for seed potatoes.

the support programme would involve IRA/Adaptive Research and the FAO Food Loss Prevention Programme (1). Facilities for the work would be made available both at IRA Bambui and on TDC's in potato areas.

A ware storage structure is already in use at Santa TDC which will be available for some of the screening work described in 3.2. above from the 1985 main crop harvest period onwards (July)

- 3.4. Development of recommendations for potato production/storage to be incorporated in the Training and Visit system and field programmes of VEW's in potato growing areas.

Initially the recommendations relate to 'local' cultivars already available to farmers and concern:

- cultivation practices
- selection of seed material - in the field
- post harvest
- storage systems for seed and ware potatoes

Recommendations will be refined/added to as technical developments occur or improved cultivars become available.

Note: a limited package of information on cultivation practices is already in use, together with a comprehensive programme for ware potato storage in the PDA's extension programme.

- 3.5. Establishment of a credit line to assist farmers/farmer groups to construct (especially) ware potato storage facilities. This is already envisaged under the MIDENO assistance programme. Demonstration stores have been constructed in several potato areas, and proposals for credit line establishment submitted to the Project Manager and Credit Adviser for consideration.

It has also been strongly suggested to FAO that an element be included in their forthcoming project to provide credit funds; the argument being that the benefits of the technology already developed or to be developed under the project, would be inaccessible to many producers unless credit could be provided for store construction.

- 3.6. Multiplication would initially be a very small scale to ensure the availability of clonal material for the IRA/Adaptive Research screening programme. Once potentially useful clones have been identified, the scale of multiplication (on a Provincial Seed Farm, IRA Upper Farm or TDC's) would gradually increase to allow wider scale testing of "elite" materials.

Larger scale multiplication to supply interested farmers will only be done once recommended cultivars have been identified for the specific production systems. This could involve growing for seed by selected farmers.

- 3.7 Marketing of increases production at the time of peak harvest or after a period of storage is an issue for urgent attention given the observed fluctuations in price of potatoes even at present levels of production. Sale price advantages have already been gained by women's groups which have adopted the recently introduced storage recommendations through sales outside the normal harvest period. It is considered by MIDENO/PDA that with more widespread adoption of improved storage technology and the increased overall production to be derived from the programme components outlined above, there will be an increasing need to assist producers/producer groups in contacting potential markets - both internal Cameroon markets and export markets.

Such potato marketing issues are to be covered by the Food Crop Marketing officer to be appointed under the MIDENO programme from July 1985.

I.C. Walton
Adaptive Research Agronomist
MIDENO/PDA
4th July, 1985

Footnote

Ref. Note (1) on P4 above

Following extensive discussions and site visits with PDA/MIDENO personnel, proposals have been developed by P.A.O. for a continuation to FAO assistance to Food Loss Prevention within the context of the current PDA/MIDENO extension and adaptive research programmes. A final project design is expected from FAO with a view to the project starting from December 1985.

APPENDIX 10

SUMMARY OF 1986 SEED MAIZE DISTRIBUTION

(Weight of seed in kg)

VARIETY	VEW's (1) Extension Programme	Credit (2) Programme	Union Direct Sales	TDC's Expts.	Other (3)	Total
1) Mid/High Altitude						
COA	13,145	8,970	2,250	150	490	25,005
MLC	8,535	1,160	-	150	845	10,690
BACOA	125	-	-	125	100	350
2) Low Altitude						
EKONA WHITE	3,405	375	750	75	445	5,050
EKONA YELLOW	960	-	500	75	300	1,835
	26,170	10,505	3,500	575	2,180	42,930

Notes.

- (1) Issued in accordance with VEW's listed requirements
- (2) Issued in accordance with FONADER listed requirements
- (3) Supplied to: Young Farmers Programme; WADA; oxen farming programme; Bafut VCP.

