BEAN RESEARCH COMMODITY TEAM

RESEARCH STAFF, 1989/90

A. SENIOR STAFF

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H.R. Mloza-Banda	Agronomist (on study leave)
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B. SUPPORT STAFF

P. Kambewa	Graduate student (Social Sciences)
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C.J.B. Kapunda	Senior Technician/Technical Officer (Lunyangwa)
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FORWARD

The Bean Program is given the mandate to conduct and coordinate all bean research in Malawi. This Program is under the custody of the Head of Crop Production Department and Principal of Bunda College of Agriculture, University of Malawi. During 1989/90 season the Program continued receiving excellent support from both. It is with deep regret that the Program registers the loss of late Dr S S Chiyenda, who was Head of Crop Production Department at Bunda College. May his soul rest in peace.

Generally the 1989/90 cropping season was not normal. Rains started a little late but ceased early leading to large losses in yield especially of local maize varieties. Beans were not as much affected because most of them were approaching maturity by that time. Rains returned and persisted for about the whole month of April causing moulding and decay of whatever little was produced. However, one could not help noticing that it was yet another successful cropping season for bean research in that a lot of data was collected as you will note while going through our report. SADCC/CIAT gave the Bean Program USD 11,705.05 to hold the "Bean Research Methods Training Course" between 20 and 31 August, 1990. One can only hope that the Bean Program now has better qualified research assistants that can improve conduction of experiments and data acquisition for many years to come. The program also sent two members of Adaptive Research Section for a short course on beans in Arusha, Tanzania.

The year 1990 experienced significant additions of effort into bean research in Malawi. The Bean/Cowpea Project changed U.S. lead institutions from Michigan State University to University of California, Davis (UCD) with Dr Paul Gepts as the US Principal Investigator. Drs Steven Temple (a breeder previously with CIAT) and Robert Gilbertson (pathologist) are Co-US Principal Investigators. Dr Anne Ferguson another Co-US Investigator, and the Socio-Cultural component remain to be coordinated at Michigan State University as part of the Malawi-UCD Bean Cowpea CRSP Project. This team and our team jointly prepared a research proposal for extension of the Project from FY 92 to 97. The other addition is the support by Rockefeller Foundation. Proposals were prepared for various legumes (including beans), pathology and utilization of legumes into an all-embracing Food Legume Improvement Project with support of a little over USD 330,000 for two years from Rockefeller Foundation. This work is jointly conducted by Bunda College and Chitedze Research Station. The Bean Project requested for over USD 60,000 over two years. The last but very important addition is the establishment of the substation of SADCC/CIAT Regional Bean Program at Bunda College of Agriculture. The long-awaited breeder has now been identified (Dr V.D. Aggarwal) and cleared by Government to come and get established here. We have indicated that as for Malawi the SADCC/CIAT Bean Breeder will follow the research guidelines as laid down by the Bean Program at Bunda. However, he will also be working for all other countries in SADCC. All these three projects are going to significantly stregthen bean research in this country.

I wish to personally thank the Principal of Bunda College (Professor B.B. Chimphamba) and the Chief Agricultural Research Officer for the encouragement they continually offered to our Program. The support of the Dean, the Head of Crop Production Department, the Registrar and the Bursar at Bunda College of Agriculture and the National Research Coordinator (Legumes and Oilseeds) is greatly acknowledged. The financial assistance from Bean/Cowpea CRSP Project, Rockefeller Foundation, SADCC/CIAT, CIARA-Israel, and RPC among many others is most appreciated. Lastly but most important I hold in high esteem the cooperation, collaboration and assistance of all colleagues in the Bean Program and all Program Staff. May I wish you all a successful 1990/91 cropping season!

Dr A B C Mkandawire
COORDINATOR OF BEAN PRAGRAM AND HOST COUNTRY
INVESTIGATOR OF BEAN/COWPEA PROJECT

EXECUTIVE SUMMARY

During 1989/90 the National Bean Variety Trial was placed at Sokola, Chitipa; Ng'onga Extension Planning Area (Rumphi); Lunyangwa, Mzuzu; Champhira Extension Planning Area, Mzimba; Bunda, Lilongwe; Dedza Hills, Dedza; and Matapwata Extension Planning area, Thyolo. Twelve genotypes comprising introductions, landrace selections, hybrid materials, and a released variety (Nasaka) as a check, were included. Seed yields were generally significantly different among genotypes except at Champhira and Sokola (Misuku). And in general, yields were higher than those obtained last year. The genotypes 21-5, A286, A344, and 25-2x8x7 had significantly higher yields than 5-2, 25-2, and the check (Nasaka) at Dedza. At Lunyangwa significantly higher yields were obtained from A286, A344, 29xP692, Phalombe and Nasaka. A344 and A286 had significantly higher yields than the rest of lines at Matapwata (Thyolo). These lines also showed marked resistance to diseases. Data seems to clearly indicate the superiority of these CIAT lines. The Bean Program wishes to find out if these could be preferred by some farmers. The other alternative would be that of using these genotypes in crosses for disease resistance. The trial will be repeated in 1990/91 cropping season.

Selection for disease resistance on the segregating F3 population from crosses initiated in 1987 commenced in 1989/90. In those crosses some parental lines were the CIAT genotypes discussed above. These selections were done through the Initial Screening Trials of the Breeding Scheme. Unfortunately, entries for Thyolo and Dedza were planted late and were subsequently lost. However, 50 test lines have been selected to enter into a Preliminary Variety Trial for further evaluation.

The Adaptation Trial is a component of the Breeding Scheme. It is comprised of introduced materials that have shown promise for a number of attributes and so members of the Bean Program contribute their materials. Significant yield differences were observed in the trial

at Bunda. The highest yield was obtained from A286 and the lowest from Coco ala Creme. The local entries, Nasaka and 25-2, gave close to average yield but were far outyielded by A286. The results indicate that there is a wide range of adaptation variation among entries at Bunda and selections could be made from these entries. One observation from the data is that the top three yielders: A286, A344 and BAT 477 are small-seeded, a character that most of the smallscale farmers in Malawi rarely like. However, G05434, which yielded higher than the two local entries is large-seeded and may offer more flexibility on acceptability. The same would be true for Perry Marrow. The genotypes A286, A344 and BAT 477 also showed resistance to ALS, CBB, BCMV and WB.

Ten isolates of <u>Phaeisariosis griseola</u> from different bean growing areas of the country were grown on Potato Dextrose Agar (PDA) and inoculated on a set of differential varieties. The reaction of these differential varieties to the ten isolates shows that the pathogen is highly variable. This supports our earlier results (1988/89) and confirms the need for developing bean varieties that possess general rather than specific resistance. The existence of this pathogenic variability reinforces the need for collecting more isolates from the different bean growing areas to ascertain the extent of the variability. The results also indicated that PI 167399, Coco ala Creme and G05434 were resistant to all the ten isolates. G05434 had smaller lesions when infected by all ten isolates while Evolutie had the largest lesions when infected by the same.

An experiment was conducted to determine the effects of nitrogen fertilizer application on the uptake of nitrogen by both the maize and beans in an intercropping system. Two contrasting bean varieties in terms of growth habit: Nasaka (dwarf) and Kanzama (a climber), were grown in sole stands or intercropped with NSCM 41 maize hybrid under four N-fertilizer levels: 0, 40, 80 and 120 kg N/ha. There were significant maize grain yield differences among N-fertilizer rates and between cropping systems. Maize/climbing bean system gave the highest maize yield. In both cropping systems maize yields increased with each increment of nitrogen applied. The content of nitrogen differed significantly between bean varieties with the climber having greater rates of uptake of N. Bean yields increased significantly only upon increasing nitrogen application to 40 kg N/ha over none except in the monoculture stand of Nasaka.

The effect of phosphorus on biological nitrogen fixation was investigated in an experiment with three bean varieties, viz: Nasaka, P402, and 13-3; three phosphorus fertilizer rates, viz: 0, 25, 50 kg P205/ha; and inoculation with MG 366 or no inoculation. There were no significant interactions in mean number of effective nodules due to the effect of P fertilizer, bean variety, or inoculation. However, inoculated beans applied with 25kg P205/ha showed significantly more effective nodules over the control. Effective nodulation was highest where beans were applied with 50 kg P205/ha and inoculated with MG 366. The bean variety P402 showed superiority over Nasaka and 13-3 in nodulating ability. The mean seed yields increased with P application. P402 gave the highest response to inoculation and produced highest yields.

Two experiments were conducted during 1989390 to determine the response of bean genotypes to moisture-stress at two stages of growth. One experiment was at Kasinthula Agricultural Research Station in the Shire Valley (200m above sea level) and the other was at Bunda College of Agriculture (1119m above sea level) during the off-season under irrigation. At Kasinthula the time taken by beans to reach flowering did not differ among moisture regimes. However, the time to end of flowering was significantly reduced when drought was imposed during pod-filling. The size of canopy was significantly reduced by moisture-stress at flower ng. The number of pods per plant were significantly reduced by moisture-stress at both flowering and pod-filling stages. However, 100-seed weight was significantly reduced only by moisture-stress at pod-filling. Seed yields were significantly reduced by moisture-stress at both flowering and pod-filling. The reduction at the former stage was a result of reduction in number of pods/plant whereas the reduction at the latter stage was a result of reduction in 100-seed weight. Under well-watered conditions the best yielding (100 kg/ha) genotypes were: Sapelekedwa, Diacol Calima, BAT 1387, BAT 1386, C-20, Domino, A286, Nasaka, Umvoti, A344 and PVA 781. When drought was imposed at flowering the best genotype was Domino. When drought was imposed at pod-filling the best yielding genotypes were Sapelekedwa, A268, A286, and 8-7. At Bunda drought did not seem to have been well-imposed because there were no significant seed yield reductions due to drounght. Drought at flowering reduced the number of days to physiological maturity, leaf area index and canopy height of beans. Due to better canopy characteristics and yielding ability as seen above seven genotypes were selected for further evaluation, viz: 25-2x8-7, Sapelekedwa, 2-10, 25-2, 8-7, 6-1 and 5-2.

A social survey was conducted in the Southern Region (Thyolo) during 1989390 cropping season. This survey demonstrated that beans are an important food as well as cash crop and it ranks first as a crop providing most income for most households. The farmers face constraints to bean production caused by factors such as diseases, pests, drought, lack of seed, lack of preferred varieties, lack of extension support and lack of land. Farmers indicated preference for bush beans other than climbers and among the bush types they preferred Chimbamba (a red kidney) and Kaulesi (greyish) for their culinary aspects, marketability and tolerance to diseases. Other aspects of the survey indicated that the majority of households were headed by women probably because their husbands were gone into the commercial Blantyre/Limbe areas and that land is in real short supply. And because beans are produced mainly for the market apart from providing food in a subsitence economy farmers grew much fewer mixtures in the area as opposed to the Northern and Central regions.

In 1989/90 cropping season a pilot On-Farm Trial was conducted in the Lilongwe Rural Development Project (Extension Planning Area 12, Section 1) of LADD at Kampini. Five farmers were issued with seed of (each) Sapelekedwa (bush red kidney), Nasaka (bush khakhi kidney), 8-7 (purple kidney), 5-2 (olive green medium roundish Nyauzembe), and 25-2x8-7 (white kidney). Farmers grew these beans following the recommendations of the Bean Program and were monitored throughout the season. The highest yield was obtained from the farmer who grew Sapelekedwa (900 kg/ha). This could represent a substantial increase over the general average of 300 kg/ha and comes closer to the government requirement of at least 1000 kg/ha. The Bean Program has therefore multiplied some seed of released varieties which is currently being harvested for distribution to smallholder farmers for further increase.

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BIOLOGICAL COMPONENT

I. NATIONAL BEAN VARIETY TRIAL.

The objectives of the National Bean Variety Trial are:

A. To test improved germplasm in different regions and provide continuous feedback to the bean breeders regarding the performance of all newly developed materials and further characteristics which need genetic improvement; and

B. To select and provide superior germplasm to be considered for release for on-farm testing in different areas. Within the bean breeding scheme recently adopted, the advanced variety Trial preceeds the National Bean Variety Trial and the latter benefits from lines selected from the former.

During 1989/90 this trial was placed at Sokola in Misuku Hills (Chitipa), Ng'onga Extension Planning Area (Rumphi), Lunyangwa (Mzuzu), Champhira Extension Planning Area (Mzimba), Bunda (Lilongwe), Dedza Hills (Dedza) and at Matapwata Extension Planning Area (Thyolo). Twelve genotypes comprising introductions, landrace selections, hybrid materials, and a released variety (Nasaka) as a check, were included. Three replicates were used at each site. Each gross plot comprised of 4 rows each 5m long. Ridges were spaced 0.91m apart. Climbers were spaced at 15cm intra-row whereas non-climbers were spaced at 10cm. The nett plot for harvest was $7.28/m^2$.

Seed yields (kg/ha) were generally significantly different among genotypes except at Champhira and Misuku (Tables 1-6). Generally the yields were higher than in 1988/89. 21-5, A286, A344, and 25-2 x 8-7, had significantly higher yields than 5-2, 25-2 and the check (Nasaka) at Dedza (Table 3). A similar response was observed for number of seeds/pod. Analysis for seed size indicated that all genotypes had larger seed classed than A286 and A344, which had 24 and 27g/100 seeds. At Lunyangwa significantly higher seed yields were obtained from A286, A344, 20xP602, Phalombe and Ia.aka. A286 and A344 were higher yielding possibly due to the signi cantly more pods/plant and seeds/pod that they produce (Table 4). More pods are produced probably due to a larger plant height. A3 4, A286 had significantly higher yields than the rest of lines at pod (Table 6). Data seems to quite clearly indicate the superior ty of the CIAT genotypes A286 and A344. Those promising from the Malawian germplasm are 2-10 x 8-7, 25-2 x 8-7, 8-7 and Phalombe. Malawians prefer large-seeded kidney beans and so direct release of 286 and A344 is not considered. However, the Bean Program may cons der using these as parents to improve yields of released varieties and upcoming bean lines. The lines A286 and A344 also showed a marked level of resistance to the major diseases, (Tables 1-6) except Floury Leafspot at Lunyangwa (Table 4) and Web Blight at Misuku (Table 5).

Table 1. National Bean Variety Trial (Bunda)

Genotype	100-seed wt (g)	Seed yield kg/ha	ALS	CBB	Rust	WB
				Scores (1-9)		
Nasaka	38.7e	766	5.5	4.7	2.7	7.5
21-5	33.4e	828	4.5	2.5	4.0	4.0
5-2 (Nyauzembe)	29.1f	856	5.2	3.5	3.7	4.2
A286	19.7h	1400	2.5	2.7	1.0	2.7
A344	22.5g	1336	2.7	2.2	1.5	2.7
29 x P692	42.5b	1008	5.5	3.5	3.0	5.2
2-10 x 8-7	32.3e	702	4.7	3.0	2.7	4.2
25-2 x 8-7	36.3d	1058	5.5	3.2	3.2	3.5
8-7	33.1e	1001	5.2	3.5	3.2	4.2
P692	46.2a	977	5.5	3.0	2.7	4.2
25-2	43.7b	834	5.7	3.5	3.7	4.7
Phalombe	38.9c	1051	6.0	3.5	2.7	5.5
Mean	34.7	988				
CV(%)	3.55	23.77				
Significance	***	***				

Means followed by the same letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test.

ALS = Angular Leaf spot
CBB = Common Bacterial Blight
WB = Web Blight

Table 2. National Bean Variety Trial (Champhira)

Genotype	#Seeds/pod	100 seed Wt	Seed yield (kg/ha)	ALS	Rust	Scab
				(Scores 1-9)		
Nasaka	4.0	50.6a	1273	2.3	1.7	1.5
21-5	4.3	42.0cd	1350	1.8	1.7	1.5
5-2 (Nyauzembe)	4.5	35.2e	1916	1.7	2.3	2.5
A286	6.0	22.5f	1766	1.0	1.0	1.0
A344	5.3	23.3f	1810	1.0	1.0	1.0
29 x P692	4.0	49.2ab	1570	2.0	2.2	1.5
2-10 x 8-7	4.5	40.3d	1843	2.0	1.7	1.7
25-2 x 8-7	4.0	40.4d	1119	2.0	2.0	2.0
8-7	3.7	41.4cd	1725	1.8	1.5	1.7
P692	4.0	51.5a	1832	2.2	2.0	1.3
25-2	4.3	45.1bc	1519	2.2	2.2	2.5
Phalombe	3.9	42.0cd	1178	2.3	1.2	1.7
Mean	4.4	40.3	1575			
CV (%)	9.69	6.06	22.82			
Significance	***	***	NS			

Means followed by the same letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test.

ALS = Angular Leafspot

Table 3. National Bean Variety Trial (Dedza)

Genotype	#Seeds/Pod	100 Seed Wt	Seed yield (kg/ha)	ALS	FLS	ASC
				(Scores 1-9)		
Nasaka	4.0cde	48.0cd	1305d	4.2	2.8	2.3
21-5	5.3a	45.1def	3220a	2.3	1.7	1.0
5-2 (Nyauzembe)	4.3bcd	38.8g	1486cd	2.3	1.7	2.5
A286	5.3ab	24.2h	2714ab	1.0	1.0	1.0
A344	5.0ab	27.0h	2630ab	1.0	1.0	1.0
29 x P692	3.3e	54.6b	1873bcd	3.0	2.7	1.3
2-10 x 8-7	3.5e	44.8def	3240bc	3.2	1.7	1.3
25-2 x 8-7	4.7abc	41.9fg	2648ab	3.0	2.0	1.7
8-7	3.3e	44.9ef	2327bc	2.3	1.7	1.5
P692	3.7de	58.1a	1935bcd	3.7	2.7	1.0
25-2	4.0cde	50.2c	1516cd	3.7	3.0	2.8
Phalombe	4.0cde	46.5de	1964bcd	4.0	2.0	2.8
Mean	4.2	43.6	2155			
CV (%)	9.45	4.45	21.21			
Significance	***	***	***			

Mean followed by the same letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test.

ALS = Angular Leafspot

FLS = Floury Leafspot

ASC = Ascochyta Blight

Table 4. National Bean Variety Trial (Lunyangwa)

Genotype	Pods/plant	Seeds/pod	Height (cm)	Seed-Wt (100)	Yield (kg/ha)	ALS	Rust	FLS
Nasako	7.7cd	4.7bc	29.7c	45.1a	961abc	8.7	4.3	5.3
21-5 (Nyanzembe)	10.7b	5.0	77.3a	39.3bc	875bc	7.7	3.0	5.0
A286	15.7a	6.7a	81.3a	22.3e	1424a	2.0	1.7	8.0
A344	14.0a	6.3a	65.3ab	24.4e	1140abc	3.3	1.3	5.3
29 x P692	9.3bc	4.0cd	35.0c	46.4a	985abc	7.7	6.0	6.3
2-10 x 8-7	9.3bc	4.7bc	66.7ab	35.8cd	810bc	8.7	3.7	5.0
25-2 x 8-7	11.0b	4.7	72.3a	42.5ab	938bc	7.7	4.7	4.7
8-7	10.7b	3.7d	53.0b	36.1cd	1122abc	8.7	4.3	5.0
P692	10.3bc	4.7bc	33.3c	45.4a	1227ab	8.0	3.7	6.0
25-2	6.0d	4.7bc	25.7c	46.9a	669c	8.3	6.0	3.3
Phalombe	9.0bc	4.3cd	35.0c	42.7ab	1044abc	8.7	5.7	4.3
Mean	10.4	4.8	53.4	38.2	1003			
CV (%)	14.08	9.92	16.22	7.40	24.57			
Significance	***	***	***	***	0.07			

Disease Scored 9 March, 1990.

Means followed by the same letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test.

ALS = Angular Leafspot

FLS = Floury Leafspot

Table 5. National Bean Variety Trial (Misuku)

Genotype	100-Seed Wt (grams)	Seed yied (kg/ha)	ALS	WB
Nasaka	41.0ab	453	9.0	1.0
21-5	34.5bcd	444	4.7	3.0
5-2 (Nyauzembe)	29.8de	478	4.3	2.0
A286	24.5ef	448	1.0	5.3
A344	18.9f	475	1.0	5.3
29 x P692	39.5abc	327	6.7	1.0
2-10 x 8-7	35.4bcd	302	6.3	2.3
25-2 x 8-7	35.5bcd	367	5.0	2.7
8-7	32.0cd	297	7.0	2.1
P692	45.5a	536	6.7	1.0
25-2	38.8abc	398	7.7	1.0
Phalombe	34.7bcd	448	7.0	1.0
Mean	34.2	414		
CV (%)	11.81	28.94		
Significance	***	NS		

Means followed by the same letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test.

ALS = Angular Leafspot

WB = Web Blight

Table 6. National Bean Variety Trial (Thyolo)

Genotype	#Seeds/pod	100 Seed Wt	Seed yield (kg/ha)	Disease scores (1-9) at Flowering			Podding		
				ALS	SCAB	WB	ALS	SCAB	WB
Nasaka	4.0def	34.2abc	871	5.00	4.67	5.00	6.00	5.66	5.33
21-5	4.3cde	22.3f	375de	2.67	2.67	3.33	5.67	4.00	4.33
5-2 (Nyauzembe)	5.0bc	26.6e	933b	5.00	4.33	5.66	4.67	4.33	5.67
A286	6.0a	18.3g	1625a	1.00	1.00	2.66	1.00	1.00	3.33
A344	5.7	21.4fg	1795a	1.00	1.00	3.66	1.00	1.00	3.67
29 x P692	4.7cd	30.8cd	281e	4.00	3.66	3.33	5.66	3.33	3.33
2-10 x 8-7	3.3f	34.7ab	481de	3.00	3.00	4.66	5.00	3.00	4.66
25-2 x 8-7	4.7cd	26.3e	297	4.33	5.33	5.66	5.66	5.33	5.66
8-7	3.7ef	29.2de	586cde	4.66	3.00	2.66	6.67	4.00	4.00
P692	3.3f	31.4bcd	472de	6.33	3.00	4.66	7.33	4.00	4.66
25-2	4.7cd	36.4a	658bcd	5.6	4.00	5.00	7.00	4.33	4.66
Phalombe	4.0def	27.8de	5[illegible]cde	5.33	4.00	5.66	7.00	4.00	6.00
Mean	4.4	28.3	746						
CV (%)	10.30	7.27	24.50						
Significance	***	***	***						

Means followed by the same letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test

ALS = Angular Leafspot

WB = Web Blight

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I. NATIONAL BEAN VARIETY TRIAL SECOND SEASON PLANTING

These genotypes were again planted towards the end of the rainy season (March) at Matapwata (Thyolo). Yields were generally lower from this crop than the ealier planted trial. Seed yields (kg/ha) were highly significantly different among genotype. 25-2 was the highest uielding genotype, followed by A286, 8-7, 29 x P692 and 25-2 x 8-7. Most of the genotypes which had produced high yields in the rain-fed crop did not do very well in the late-planted crop. It would appear that these are not ideal for relay cropping. The bulk of the bean crop in Thyolo is produced as a relay crop (after maize). As mentioned earlier farmers prefer kidney beans having large seed size. 25-2 and 29 x P692 have large seed size while 8-7 and 25-2 x 8-7 have medium size seed. The CIAT line (A286) has small seed size (Table 6b), seed size differed highly significantly among genotypes. With the exception of the CIAT lines, all genotypes had seed sizes belonging to medium and large size categories. The following genotypes had higher seed size in the late-planted crop than the early planted crop: Nasaka, 29 x P692, 8-7, 25-2, Phalombe, 21-5 and 25-2 x 8-7 (Table 6b).

Genotypes also differed greatly in the number of seeds per 10 pods. Generally this was lower in the late planted crop.

II. THE RESPONSE OF SIX BEAN GENOTYPES TO INTERCROPPING WITH THREE MAIZE VARIETIES

The objective of this trial was to evaluate some promising landrace selections and introductions under an intercropping system with three contrastring maize varieties (a hybrid, a composite and a local) in different bean growing areas of Malawi. The trial was

Table 6b. National Bean Variety Trial (Thyolo)
(Late planted crop)

Genotype	100 Seed Wt (g)	# of seeds (per 10 pods)	Yield (kg/ha)
Nasaka	40.1b	39.7bcd	209.2
21-5	30.1d	40.7bcd	268.3
5-2 (Nyauzembe)	29.3d	35.7bcd	296.3
A286	18.0e	54.0a	476.3
A344	20.2e	43.9b	275.2
29 x P692	44.7a	31.7d	348.3
2-10 x 8-7	34.2c	42.0bc	284.4
25-2 x 8-7	34.1c	41.0bcd	306.6
8-7	35.4c	31.7d	423.1
P692	39.8b	33.0cd	241.1
25-2	42.4ab	39.9bcd	616.8
Phalombe	41.4b	34.0cd	197.6
Mean	34.1	38.9	328.6
CV (%)	4.73	12.43	27.39
Significance	***	***	***

Means followed by the letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test.

carried out at Bunda (Lilongwe), Champhira (Mzimba), Dedza Hills (Dedza) and at Ng'onga (Rumphi). The experimental design was randomised complete block, with three replicates. Gross plot size was 4 ridges each 10m long. Nett plot size was 14.4 sq. meter. The ridges were 0.9m apart. Maize was planted at 0.9m between stations, 3 seeds per station. Beans were planted at 0.15m from both sides of the maize station and 3 seeds per station.

There were no significant differences in seed yield of beans among treatments at Champhira, Dedza Hills and Ng'onga. However at Bunda there were significant differences in bean yields among treatments. At all locations 8-7 was the highest yielding genotype closely followed by 21-5, G218, 12-4, and 6-5. Generally bean yields were lower when intercropped with local maize, especially at Dedza Hills. Bean yields were generally low at Bunda. The number of seeds per pod differed highly significantly among treatments at Dedza Hills and Ng'onga, and differed very highly significantly among treatments at Champhira. There were very high significant differences in seed size among treatments at Bunda, Champhira, Dedza Hills and Ng'onga (Tables 7-11). The local bean had the largest seed size at Champhira, Dedza and Bunda, closely followed by 12-4, 8-7 and 21-5. Ng'onga had the lowest seed size for all bean genotypes (Tables 7-11).

Malawians grow beans mainly under mixed cropping with maize and they prefer large seeded kidney beans, 8-7, 12-4 and 21-5 are ideal for the Malawian farmers because they yield highly in mixtures with maize and also have a medium seed size (25-39g/100 seed). Beans yields were lower than last year's yields at Bunda anc Ng'onga but were higher at Dedza Hills. There were very highly significant differences among treatments in maize yield, seed size, grains/row and rows/cob at Bunda (Table 8).

Table 7. Six bean genotypes intercropped with three maize varieties (beans, Bunda).

Treatment Combination	100-Seed Wt (g)	Seed yield (kg/ha)
Local + local bean	38.4abc	142a-e
Local + 5-2	30.0def	91de
Local + 21-5	35.8b-e	140a-e
Local + 8-7	33.6b-f	137a-e
Local + 12-4	39.7ab	120bcde
Local + 6-5	23.1ghi	187abc
Local + G218	29.5ef	118bcde
UCA + Local bean	43.1a	140a-e
UCA + 5-2	31.3def	125b-e
UCA + 21-5	32.1c-f	194ab
UCA + 8-7	35.2b-e	145a-e
UCA + 12-4	36.9a-d	223a
UCA + 6-5	[illegible]	179abcd
UCA + G218	28.4fg	164abcd
MH12 + Local bean	35.9b-e	144a-e
MH12 + 5-2	30.7def	110bcde
MH12 + 21-5	34.0b-f	66e
MH12 + 8-7	33.2b-f	149a-e
MH12 + 12-4	36.9a-d	122b-e
MH12 + 6-5	21.7i	100cde
MH12 + G218	28-0fgh	116b-e
Mean	32.3	139
CV (%)	10.89	32.66
significance	***	***

Means followed by the same letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test.

Table 8. Six bean genotype intercropped with three maize varieties (maize, Bunda)

Treatment combination	Rows/ cob	Grains row	100-Seed weight	Yield (kg/ha)
Local + Local bean	8.5	32	36.6	1366
Local + 5-2	8.4	29	31.5	1323
Local + 21-5	8.3	29	35.5	1161
Local +8-7	8.4	31	31.7	1314
Local + 12-4	8.4	32	33.7	1530
Local + 6-5	8.8	28	37.9	1168
Local + G218	8.3	29	31.7	1276
UCA + Local bean	11.9	32	25.4	2054
UCA + 5-2	12.8	38	23.9	2103
UCA + 21-5	12.1	34	26.8	1150
UCA + 8-7	12.4	34	24.5	
UCA + 12-4	12.3	33	25.5	1819
UCA + 6-5	11.5	31	23.6	2400
UCA + G218	11.7	33	22.4	1173
MH12 + Local bean	10.8	36	29.3	3467
MH12 + 5-2	10.9	33	26.6	1942
MH12 + 21-5	10.4	38	31.6	1855
MH12 + 8-7	10.3	40	30.9	1917
MH12 + 12-4	10.3	40	29.8	2585
MH + 6-5	10.4	36	30.3	1960
MH12 + G218	10.9	36	27.5	
Mean	10.4	33	29.4	1788
CV (%)	5.24	8.6	10.50	29.87
Significance	***	***	***	***

Table 9. Six bean genotypes intercropped with three maize varieties (beans, Champhira).

Treament Combination	100-Seed Wt (g)	Seeds/pods	Pod length (cm)	Yield (kg/ha)
Local + Local maize	38.0	4	11.3	543
5-2 + Local maize	39.7	4	11.9	310
21-5 + Local maize	39.4	4	11.7	106
8-7 + Local maize	35.7	3	8.4	455
12-4 + Local	34.9	3	14.3	193
6-5 + Local maize	35.2	3	9.5	281
G218 + Local maize	39.0	4	11.6	289
UCA + Local	38.4	4	11.2	529
UCA + 5-2	40.0	4	11.3	530
UCA + 21-5	39.5	4	11.3	435
UCA + 8-7	40.0	5	11.4	560
UCA + 12-4	41.9	4	11.5	828
UCA + 6-5	41.9	4	12.6	659
UCA + G218	42.9	5	12.1	267
MH12 + Local	42.7	4	12.0	291
MH12 + 5-2	21.1	5	9.1	863
MH12 + 21-5	22.9	5	10.3	217
MH12 + 8-7	22.2	6	10.3	471
MH12 + 12-4	31.5	5	11.2	824
MH12 + 6-5	30.9	4	9.7	460
MH12 + G218	38.8	5	10.2	671
Mean	35.6	4	11.1	466
CV (%)	5.49	12.00	12.24	60.91
Significance	***	***	***	0.066

Table 10. Six bean genotypes intercropped with three maize varieties (beans, Dedza Hills)

Treatment Combination	100-Seed Wt (g)	Seeds/pod	Yield (kg/ha)
Local + Local maize	43.1	5	755
Local + UCA	41.2	4	708
Local + MH12	40.2	3	1098
5-2 + Local maize	30.6	3	468
5-2 + UCA	31.5	4	992
5-2 + MH12	29.3	4	887
21-5 + Local maize	37.0	4	975
21-5 + UCA	36.1	4	1126
21-5 + MH12	37.0	6	1159
8-7 + Local maize	35.7	4	1053
8-7 + UCA	36.0	4	1154
8-7 + MH12	34.0	4	1144
12-4 + Local maize	40.1	5	741
12-4 + UCA	[illegible]	4	1041
12-4 + MH12	39.7	4	1000
6-5 + Local maize	22.0	6	987
6-5 + UCA	26.2	4	1158
6-5 + MH12	25.3	5	820
G218 + Local maize	27.8	4	477
G218 + UCA	32.4	4	1052
G218 + MH12	29.4	4	1191
Mean	34.0	4	952
CV (%)	12.52	16.96	34.07
significance	***	***	NS

Table 11. Six bean genotypes intercropped with three maize varieties (beans, Ng'onga).

Treatment Combination	100-Seed Wt (g)	Seeds/pod	Yield (kg/ha)
Local + Local maize	26.2	4	285
5-2 + Local maize	26.0	4	372
21-5 + Local maize	26.9	4	242
8-7 + Local maize	30.1	4	339
12-4 + Local maize	28.9	4	471
6-5 + Local maize	24.4	6	288
G218 + Local maize	29.1	4	397
Local + UCA	25.4	4	284
5-2 + UCA	27.1	4	478
21-5 + UCA	31.9	4	519
8-7 + UCA	29.0	4	567
12-4 + UCA	33.9	5	427
6-5 + UCA	25.4	4	519
G218 + UCA	28.3	4	374
Local + MH12	28.2	4	338
5-2 + MH12	25.1	4	458
21-5 + MH12	31.7	4	552
8-7 + MH12	31.3	4	564
12-4 + MH12	31.7	4	439
6-5 MH12	24.6	5	430
G218 + MH12	28.4	4	426
Mean	28.3	4	420
CV (%)	7.93	13.13	29.65
Significance	***	***	0.06

39301

III. DROUGHT RESEARCH

A. INTERGRATED SCREENING FOR HEAT AND DROUGHT TOLERANCE IN COMMON BEAN (Phaseolus vulgaris L):

1. PERFORMANCE OF LINES UNDER TERMINAL DROUGHT STRESS

The objectives of this trial were as follows:

a. To identify and evaluate available dwarf and bush bean germplasm for greater tolerance and adaptability to heat drought stress.

b. To evaluate the suitability of available methodology for the screening of heat and drought tolerance in dwarf and bush bean germplasm.

c. To validate results from the different screening methodologies against actual yields in field trials under stress conditions.

d. To provide information on the developmental and physiological processes enabling greater tolerance and adaptibility to heat and drought tolerance.

Twenty five genotypes comprising introductions, hybrid materials and two released varieties (as check) were entered. The experimental design was randomised complete block, with 3 replicates. Gross plot size was 4 ridges each 5m long. Nett plot size was 2 ridges each 4m long. Inter-row spacing was 0.9m and intra-row spacing was 0.1m.

The genotypes differed highly significantly in yield, seed size, number of seeds per pod and number of pods per plot.

A number of genotypes (introductions) yielded much higher than the released varieties. These were A344, A268, A286, BAT 336, A442, BAT 477, Umvoti and Domino (Table 12). These genotypes have greater tolerance to heat and drought than the Malawian varieties (Nasaka and Sepelekedwa).

Most of the genotypes were susceptible to ALS and Rust. A286, A268, A344, BAT 336 showed resistance to both ALS and Rust (Table 12).

2. PERFORMANCE OF LINES UNDER CONTROLLED DROUGHT STRESS

One experiment was planted at Kasinthula Agricultural Research Station (200m above sea level) on 22 June, 1989. Twenty-five genotypes of beans (none of them being climbers) from the North and South America and Central and Southern Africa (Table 1) were used in a split-plot design with three replications. The mainplots were:

a) adequate irrigation throughout growth cycle

b) drought-stress imposed during flowering;

c) drought-stress imposed during pod-filling.

Drought was imposed by stopping irrigation a week before the start of the respective growth stages. The genoptypes were subplots. Each subplot was composed of 4 ridges (spaced 60cm apart) each 5m long. The beans were planted at a spacing of 10cm apart intra-row. A fertilizer mixture (23:21:0 N:P:K) was applied using the banding method before planting at 200 kg/ha on 20 June. Harvesting was completed on 3 October, 1989. the data collected included phenological characteristics which were obtained with a graduated cross that is placed on the centre of the row and then the width and height of the canopy are easily read from it. Data also included bean seed yield and yield components.

Table 12a. Performance of 25 Genotypes Under Terminal Drought Stress (Bunda)

Variety	Pods/plot	Seeds/10 pods	100 Seed Wt (g)	Yield (kg/ha)	ALS Scores	Rust Scores
Sapelekedwa	516	35	40.1	471	6	4
Calima	398	32	50.5	516	6	4
BAT 1387	542	36	36.9	567	4	5
BAT 125	541	52	24.3	418	4	2
BAT 336	728	52	20.6	717	2	1
BAT 477	758	50	21.0	659	3	1
BAT 1486	489	38	37.0	488	4	5
C-20	916	52	16.5	576	2	2
Domino	839	60	17.8	667	3	1
A268	736	55	24.0	750	2	1
A286	753	5[illegible]	22.5	713	2	1
A442	331	44	30.9	665	2	2
Bonus	332	43	39.2	421	5	6
8-7	449	30	39.0	418	5	4
ICA 21148	497	33	36.5	489	2	4
25-2	318	38	46.8	427	4	7
25-2 x 8-7	476	36	41.8	456	5	4
2-10 x 8-7	371	36	44.1	557	6	5
Nasaka	375	29	43.8	436	6	4
Majuba	366	45	32.4	341	5	4
Umvoti	562	46	30.4	608	4	6
A344	900	49	24.1	811	2	1
PVA 894	429	31	43.4	489	5	4
PVA 781	389	40	47.5	403	4	4
PVA 1095	368	34	48.3	519	6	3
Mean	535	42	34.4	543		
CV (%)	19.43	14.34	5.52	20.78		
significance	***	***	***	***		

ALS = Angular Leafspot

The other experiment was planted at Bunda College of Agriculture (1118m above seal level) in Lilongwe on 6 July 1989. A split-plot design replicated three times was used. Three water regimes represented mainplots, viz:

a) well-watered throughout (WW),

b) drought imposed at stage of flowering (DSF), and

c) drought imposed at stage of pod-filling (DSPF).

Fifteen genotypes, including those used at Ksinthula except 5-2 (medium green), 2-10 (large white kidney), 6-1 (large brown kidney), and 3-13 (small purple), were used as subplots. Each genotype was planted on 4 ridges of 5m in length. Inter-row spacing was 60cm. A fertilizer mixture (20:20:0 N:P:K) was applied at 300 kg/ha. Seeds were planted at 10cm intra-row. Drought at flowering was imposed at 39 days after planting while that at pod-filling was imposed at 61 days after planting. After these stages were complete irrigation resumed. Data collected included meteorological, phenological (flowering pod-filling and maturity stages) physiological (leaf area and biomass) and agronomic (yield and yield components) characteristics. Harvesting was conducted during September and October from $9.6m^2$.

Twenty five genotypes from various parts of the world were grown in an irrigation experiment at Kasinthula Research Station (Table 12b). These genotypes did not differ, across moisture regimes, in time taken to reach flowering (Table 12c). This was because treatments had not been imposed up to a week before flowering. However, the period of time to the end of flowering was significantly reduced when drought was significant reduced when drought was imposed during pod-filling. This probably caused a significant reduction in duration of the flowering period under such moisture-stress conditions (Table 12c). The difference was maintained up to physiological maturity. Growth rates seem to have been reduced by moisture stress at flowering as can be evidenced from significant reduction in both canopy height and width and canopy cover (%) at R6 stage of bean growth and development. The number of pods per plant was significantly reduced by moisture-stress imposed at either flowering or pod-filling stages. The reduction in number of pods when drought was imposed during flowering could have been due to few flowers setting since more probably aborted. However, 100 seed weight was significantly reduced only by moisture-stress at pod-filling. The number of seeds/pod did not differ in bean genotypes across moisture regimes. Seed yields were significantly reduced by moisture-stress at either flowering (70%) or pod-filling (76%) (Table 12c). Both stages seemed to be equally important for moisture-stress to significantly affect seed yields obtained. The reduction at the former stage was probably more a result of reduction in number of pods/plant whereas the reduction at the latter stage was a result of reduction in 100-seed weight.

Under well-watered conditions the best-yielding (100 kg/ha) genotypes were: Sapelekedwa, Diacol Calima, BAT 1387, BAT 1386, C-20, Domino A286, Nasaka, Umvoti, A344 and PVA 781 (data not shown). Nasaka and S[illegible] released varieties in Malawi and they were higher yielding landrace collections. A286 and A344 were best genotypes in terms of disease resistance and yield in the Malawi National Bean Variety Trial in 1990. In these trials Nasks was a check when moisture-stress was imposed at flowering the best genotype was Domino. However, when drought was imposed at pod-filling the best yielding genotype were: Sapelekedwa, A268, A286, and 8-7. Sapelekedwa and 8-7 were determined to be drought tolerant in previous studies and are now being used in the 'Breeding for Drought Tolerance' component of this Subproject.

Drought susceptibility indices were calculated as was done by Fischer and Maurer (1978). Tolerant genotypes at flowering were Sapelekedwa, BAT 125, BAT 336, Domino, A268, 8-7, 25-2 and PVA 894 (Table 12d). When drought was imposed at pod-filling the drought tolerant genotypes were: Sapelekedwa, A442, 8-7, ICA 21148, 25-2 x 8-7, 2-10 x 8-7, A344 and PVA 1095. Genotypes that yielded more under drought (indicated by negative indices, Table 12d) should be studied further before their performance under drought situations could be discussed.

At Bunda College seed yields did not differ among water regimes producing a mean 1425 kg/ha. However, seed yields differed significantly among genotypes. The genotypes 25-2 x 8-7, 5-2, 2-10, 6-1, Sapelekedwa, 8-7, and 25-2 were best yielding (1500 kg/ha) genotypes, in that order (Table 12e). The poorest genotypes across water regimes were BAT 125 and Majuba. Biomass production at R6 did not differ among water regimes. Genotypes however, differed significantly for biomass production at that stage, with 8-7, 25-2 x 8-7, 5-2 and Kaulesi being the best, in that order. Leaf expansion rates were also not significantly different among water regimes. Leaf area index (LAI) was significantly reduced by moisture-stress. The following genotypes: 8-7, Kaulesi, 25-2 x 8-7, and 5-2 had significantly higher LAI than other genotypes. Canopy height was significantly reduced by moisture stress at flowering (R6). The bigger canopies were those from 25-2 x 8-7, 2-10 x 8-7, Kaulesi, and 5-2. However, canopy width at R6 was not significantly different among water regimes (data not shown). Generally, the Malawian genotypes had higher vigour scores than other genotypes probably due to local adaptation. BAT 125 had the least vigour. Drought physiological maturity.

CONCLUSION

Better performance under moisture-stress conditions by Sapelekedwa and 8-7 has been confirmed. These were amongst good genotypes under various moisture-stress environments in 1989. Other genotypes that seem to be good are: BAT 336, Domino, A268, 25-2, and PVA 894 if drought was imposed at flowering and A442, ICA 21148, A344, PVA 1095, 25-2 x 8-7, and 2-10 x 8-7 if drought was imposed at pod-filling. It would seem that the size of plants indicated by canopy characteristics, biomass, LAI, and bean yields under moisture-stress are good indicators of drought tolerant genotpyes. This may only be a result of better root systems for uplifting water than moisture conservation mechanisms under which plant growth is highly minimised.

B. AFRICAN BEAN DROUGHT RESISTANCE NURSERY (ABDREN)

The objective of this trial was to evaluate the performance of promising cultivars identified under drought conditions in Ethiopia and Latin America.

The trial was carried out at Bunda (Lilongwe), using the randomised complete block design. There were 3 replicates. Sixteen genotypes were entered, including a Malawian line as a check. Gross plot size was 4 ridges each 4m long. Nett plot size was 2 ridges each 3m long. Inter-row spacing was 0.9m and intra-row spacing was 0.1m.

There were no significance differences among genotypes in yield and number of pods/plot. However, there were very highly significant differences in seed size. BAT 1198, V8025, G5059, Mexican 142 and Ex Rico 23 were the top 5 high yielding lines. All these had seed sizes of less than 25g (i.e small). One genotype had medium seed size and two (including local check) had large seed size (Table 13).

Table 12b. Twenty-five genotypes used in the drought experiment at Kasintula 1989/90

Genotype	Origin	Colour
Sapelekedwa	Malawi	red
Diacol Calima	colombia	speckled red
BAT 1387	CAIT	speckled red
BAT 125	CIAT	cream
BAT 336	CIAT	cream
BAT 477	CIAT	cream
BAT 1386	CIAT	speckled red
C-20	USA	white
Domino	USA	black
A268	CIAT	cream
A286	CIAT	cream
A442	CIAT	cream
Bonus	RSA	cream
8-7	Malawi	purple
ICA 21148	Colombia	speckled red
25-2	Malawi	white
25-2 x 8-7	Malawi	red
2-10 x 8-7	Malawi	white
Nasaka	Malawi	khakhi
Majuba	RSA	yellow
Umvoti	RSA	cream
A344	CIAT	cream
PVA 894	CIAT	speckled red
PVA 781	CIAT	speckled red
PVA 1095	CIAT	red

CIAT Centro International de Agricultura Tropical

USA United States of America

RSA Republic of South Africa

Table 12c. **The effect of three regimes of moisture-stress on a number of characteristics of twenty-five bean genotypes (1989/90)**

Characteristic	**Water regime**			**Prob.**
	WW	**DSF**	**DSPF**	
Days to full flowering (d)	45.8	45.8	45.3	NS
Days to end of flowering (d)	65.4	65.1	64.2	*
Duration of flowering (d)	25.9	26.0	24.9	**
Days to physiol maturity (d)	77.0	77.4	75.6	*
Canopy cover (%)	78.1	68.7	75.2	*
Canopy height (cm) at R6	47.5	43.0	47.7	**
Canopy width (cm) at R6	47.0	41.9	44.0	*
Number of pods/plant	15.0	13.0	12.6	**
Pod length (cm)	11.1	10.7	10.9	*
Number of seeds/pod	4.92	4.69	4.84	NS
100-seed weight (g)	35.7	36.1	31.3	**
Seed yield (kg/ha)	1000	697	760	*

WW = well-watered;

DSF = drought-stress at flowering;

DSPF = drought-stress at pod-filling.

Table 12d. Drought susceptibility indices (S) of twenty-five genotypes used at Kasinthula (1989/90)

Genotype	S	
	at flowering	at pod-filling
Sapelekedwa	0.707	0.223
Diacol Calima	1.210	0.972
BAT 1387	1.339	2.784
BAT 125	0.706	1.390
BAT 336	0.835	2.215
BAT 477	0.338	0.217
BAT 1386	1.975	2.261
C-20	1.151	2.568
Domino	0.483	1.250
A268	0.349	3.469
A286	1.154	0.425
A442	1.345	0.208
Bonus	1.624	1.542
8-7	0.783	0.699
ICA 21148	1.068	0.449
25-2	0.970	0.998
25-2 x 8-7	1.375	0.378
2-10 x 8-7	1.070	0.828
Nasaka	1.294	1.363
Majuba	1.371	2.261
Umvoti	1.504	1.521
A344	1.014	0.878
PVA 894	0.767	2.024
PVA 781	1.553	2.012
PVA 1095	2.184	0.491

Table 12e. Seed yield (kg/ha) of fifteen bean genotypes grown under various soil moisture regimes at Bunda (1989/90)

Genotype	WW	DSF	DSPF	Mean
25-2 x 8-7	2372	2081	2445	2299a
5-2	1607	1534	1978	1706b
2-10	1796	1500	1730	1675bc
6-1	1878	1813	1317	1669bc
Sapelekedwa	1321	1982	1424	1576bc
8-7	1458	1908	1235	1534bc
25-2	1219	1724	1587	1509bc
BAT 336	1217	1578	1609	1468bc
Kaulesi	1752	1299	1353	1468bc
2-10 x 8-7	1585	1526	1122	1411bc
BAT 85	779	1601	1689	1356bc
Nasaka	1246	1223	1296	1255bc
C-20	1342	1207	966	1172c
BAT 125	969	652	489	703d
Majuba	366	523	835	575d
Mean	1394	1477	1405	1425

WW = Well-watered;
DEF = Drought-stress at flowering;
DSPF = Drought-stress at pod-filling.

Means with the same letter (s) are not significantly different at P = 0.05 using Duncan's Multiple Range Test.

Table 13. Performance of Drought Tolerant lines at Bunda (Lilongwe)

Variety	Pods/plot	100-Seed Wt (g)	Seeds/10 pods	Seed yield (kg/ha)
A152	357	21.7	38	394
EMP 105	198	20.0	35	425
G4830	511	16.4	43	498
G5201	427	17.3	31	471
G5059	332	23.0	40	608
G4446	584	31.6	31	465
V8025	585	19.8	46	675
AND 197	316	45.2	31	279
BAT 477	505	22.0	37	552
BAT 798	369	20.8	50	526
BAT 125	402	21.9	30	350
BAT 1198	438	17.8	32	716
BAT 338-1C	533	17.6	35	486
Ex Rico 23	687	16.2	30	555
Mexican 142	437	16.8	34	561
Sapelekedwa	326	42.3	22	416
Mean	437	23.1	35	498
CV (%)	44.07	5.74	23.34	34.54
Significance	NS	***	***	NS

C. PERFORMANCE OF NONCLIMBING MALAWIAN LANDRACE BEAN GENOTYPES UNDER LIMITED SOIL MOISTURE CONDITIONS

The objectives of this experiment was to evaluate selected landrace genotypes from the Malawian germplasm under drought stress compared to irrigated conditions. Genotypes of known drought tolerance were used as controls.

This experiment was carried out at Bunda (Lilongwe). The experimental design was randomized complete block, with three replicates. Fifteen genotypes were entered including two released varieties and two hybrids. Gross plot size was 4 ridges each 5m long 0.6m apart. Nett plot size was 2 ridges each 4m long. Intra-row spacing was 0.1m.

There were very highly significant differences among genotypes in yield, seed size and number of pods per plot. Three genotypes (6-1, 8-7 and 25-2) outyielded the rest by a very wide margin. These genotypes also had large numbers of pods per plot. These genotypes proved to be very tolerant to drought conditions. BAT 125, Majuba, and BAT 336 showed moderate tolerance to drought (Table 14a). 6-1, 8-7, 25-2 and BAT 125 had seed sizes less than 25g/100 seeds (i.e. small) while Majuba and BAT 336 had seed sizes of 35.0 and 35.1 g/100 seeds (i.e. medium) respectively. The two released varieties (Nasaka and Sapelekedwa) did not perform well under drought conditions, both yielding far below the mean yield (Table 14a). Kaulesi (3-13) had the least tolerance to drought, yielding only 51kg/ha (Table 14a).

When these genotypes were used in an experiment where drought was imposed at different times under irrigated conditions it was observed that drought either at R5 or R7 stages of growth reduced yields significantly (Table 14b). Yield reduction was due to reduction in number of pods/plant if the stress was at R5 and due to reduced 100-seed weight if the stress was at R7. However, genotypic variability was not observed

Table 14a. Performance of non-climbing Malaiwan landrace bean genotypes under limited soil moisture condition (Bunda)

Variety	Pods/plot	100-Seed Wt (g)	Yield (kg/ha)
BAT 336	46	35.1	298
BAT 85	39	37.9	239
BAT 125	50	17.6	349
5-2	45	33.0	276
Majuba	50	35.0	326
C-20	45	36.0	234
Nasaka	41	29.5	239
Sapelekedwa	43	35.8	262
2-10	36	39.6	295
25-2	107	16.0	555
8-7	111	19.4	740
6-1	95	18.6	808
25-2 x 8-7	54	40.8	301
2-10 x 8-7	47	36.0	186
Kaulesi (3-13)	19	22.1	51
Mean	55	30.2	337
CV (%)	56.08	8.99	33.16
Significance	***	***	***

Table 14b. Yield and yield components of ten bean genotypes grown under three moisture regimes

Moisture	Yield (kg/ha)	No. pods/ plant	No. Seeds/ pods	100-Seed Wt. (g)
Well-watered	1798a	14.8a	4.1a	42.6a
Stress at R5	1581b	12.4b	4.2a	42.6a
Stress at R7	1564b	14.2a	4.4a	40.8b
Mean	1648	13.8	4.2	42.0

Means with the same letters along each column are not significantly (P=0.05) different under Duncan's Multiple Range Test.

R5 = Flowering growth stage
R7 = Seedfilling growth stage

Table 14c. Seed yield and yield components of ten bean genotypes grown across three moisture regimes

Genotype	Yield (kg/ha)	No. pods/ plant	No. Seeds/ pods	100-Seed Wt (g)
Nasaka	1686a	10.3bc	4.3	45.7bc
Bwenzilawana	682b	9.7c	4.0	36.0fg
Sapelekedwa	1934a	14.2abc	4.3	47.0ab
2-10	1601a	12.4bc	5.0	46.7bcd
25-2	1930a	10.5bc	4.3	48.9a
8-7	1448a	15.9ab	4.0	39.3e
6-1	1848a	14.8abc	4.0	34.2g
25-2 x 8-7	1844a	14.2ab	4.3	43.8cd
2-10 x 8-7	1887a	18.9a	4.0	42.3d
Kaulesi	1619a	19.0a	4.0	38.1ef
Mean	1648	14.0	4.2	42.0
CV (%)	17.2	22.5	11.4	3.48

Means with the same letters along each column are not significantly (P=0.05) different under Duncan's Multiple Range Test.

Table 14d. Yield and yield components of nine bean genotypes under two moisture regimes.

Genotype	Yield (kg/ha		No. of pods/m^2		No of Seeds/pod	
	RF	ST	RF	ST	RF	ST
Nasaka	1145	670	83.3	51.9	3.80	3.70
Sapelekedwa	983	847	84.8	91.1	3.47	3.20
2-10	1133	811	73.0	72.6	4.30	3.93
25-2	761	437	70.0	54.4	3.20	3.43
8-7	758	677	71.1	87.4	2.90	2.97
6-1	610	425	87.4	50.7	4.00	3.37
25-2 x 8-7	342	270	74.8	47.8	3.33	2.60
2-10 x 8-7	454	334	80.4	66.7	3.13	2.80
Kaulesi	256	247	73.3	52.6	3.83	3.53
Mean	716	524	77.6	63.9	3.55	3.28
SEd (g)	129.5		11.99		0.370	
SEd (g)	49.6		6.34		0.173	
SEd (g x t)	148.9		19.01		0.518	
CV (%)	25.6		20.8		13.2	

RF = Rainfed;
ST = Stressed
g = genotypes
t = treatments

(Table 14c). But when these genotypes were grown under rainfed conditions with plastic placed in furrows to create moisture-stress in stressed plots yields among genotypes varied signifiantly.

39302

IV. ADAPTION OF BEANS TO GROWING SEASON LENGTH IN MALAWI

The objective of this experiment was to identify genotypes of beans from Bunda germplasm that synchronise maturity with the end of the growing season in different agroecological zones. Evaluation was done under both monoculture and inter-cropping systems with maize (NSCM 41). This experiment was carried out at three sites, namely; Ng'onga (Rumphi), Bunda (Lilongwe), and Matapwata (Thyolo). 22 genotypes were entered comprising landrace selections, hydrid materials and two released varieties (Namajengo and Sapelekedwa).

The experimental design was randomised complete block, with two replicates. Gross plot size was 4 ridges each 5m long and 0.9m apart. Nett plot size was 7.28 sq.metre. Intra-row spacing for dwarf and bush genotypes was 0.1m, intra-row spacing for climbing genotypes was 0.15m in monoculture and 4 seeds per hill in intercropping systems. Intra-row spacing for maize was 0.9m apart for seeds were planted per hill and thinned to 3 plants per hill 2 weeks after emergence.

Bean yields differed highly significantly among genotypes under intercropping at Ng'onga but the differences were not significant at Bunda and Matapwata. Under monoculture there were very highly significant differences in yield among geno-types at Ng'onga, while at Matapwata the differences were highly significant. However, the genotypes did not differ in yield at Bunda. Generally, yields were lower under intercropping than monoculture at all sites. A number of genotypes performed very well under both monocropping and intercropping, at more than one site, viz: Sapelekedwa, 8-7, 7-8, 6-1, 5-2, 16-6, 2-10, 11-1. 1-1 yielded the highest under both monoculture and intercroppine at Malapwata only. The hybrids performed well only at Bunda (Tables 15, 17, 19). There were very highly significant differences among genotypes in seed size under intercropping at Ng'onga and Matapwata, but seed size did not differ significantly at Bunda. Under monoculture seed sizes were not significantly different among genotypes at Ng'onga but they were very highly significantly different at Matapwata and significantly different at Bunda. Seed size was generally high at Ng'onga where 17 of the genotypes had seed sizes between 25-39g/100 seeds (medium) and three genotypes had seed sizes ranging between 40.8 and 56.2g/100 seeds (Table 16). The genotypes also differed in number of seeds/pod. The differences were significant at Matapwata and highly significant at Ng'onga. Maize yields did not differ among treatments at Bunda, Ng'onga and Matapwata. Number of rows/cob and number of grains/row did not differ at Bunda and Ng'onga but number of grains/row was very highly significantly different among treatments at Matapwata (Tables 16, 18 and 20).

Table 15. Adaptation of 22 bean genotypes under both monoculture and intercropping with NSCM 41 at Ng'onga, Rumphi.

	Monoculture			Intercropping		
Genotypes	Seeds/pod	100 Seed Wt	Yield	Seed/pod	100 Seed Wt	Yield
1-1	5.0	13.4	788	5.0	19.1	109
2-10	5.0	35.5	816	3.5	38.4	392
16-6	4.0	32.2	1055	4.0	34.5	384
5-2	4.0	30.8	833	3.5	30.6	331
6-1	3.5	39.3	1020	3.5	38.1	369
7-8	3.0	38.7	876	4.0		318
8-7	4.0	33.1	870	3.0	30.9	411
3-13	4.5	31.1	473	4.0	32.7	155
22-2	3.5	40.9	542	3.5	41.5	199
11-1	5.0	37.4	878	5.0	37.6	267
24-6	4.0	29.8	180	3.5	31.2	52
14-5	4.5	56.2	732	5.0	21.2	313
25.2	4.0	40.8	717	4.0	43.7	216
18-10	5.5	29.8	893	5.0	32.8	180
17-1	5.0	35.7	678	4.5	35.7	243
12-4	4.5	37.1	935	4.0	39.2	280
21-5	4.0	31.5	847	4.5	29.3	317
13-3	5.0	38.0	504	4.0	36.1	133
25-2 x 8-7	4.0	36.3	732	3.5	37.1	305
2-10 x 8-7	4.0	36.4	629	4.0	36.7	383
Sapelekedwa	3.5	34.7	871	4.0	40.7	620
Namajengo	5.0	22.5	756	5.0	24.9	281
Mean	4.3	34.6	764	4.1	33.9	284
CV (%)	10.53	35.26	15.83	13.84	8.18	23.45
Significance	**	***	***	***	**	***

Table 16. Performance of NSCM 41 maize when grown with 22 bean genotypes at Ng'onga, Rumphi

Bean genotype grown	#rows/cob	#grains/row	100 Seed Wt (g)	Yield (kg/ha)
1-1	15.0	36.0	34.8	3122
2-10	13.5	37.0	28.9	1474
16-6	13.0	39.5	31.3	2066
5-2	14.5	39.0	31.3	1625
6-1	14.0	40.5	34.2	2338
7-8	14.0	36.0	31.0	1958
8-7	14.0	37.5	35.1	2113
3-13	14.0	37.5	31.7	3213
22-2	13.0	40.0	33.8	2676
11-1	14.0	38.0	32.6	2319
24-6	14.0	39.0	33.9	1573
14-5	13.5	38.5	34.2	2235
25-2	14.0	40.0	33.9	2665
18-10	13.5	43.0	32.4	2504
17-1	12.5	[illegible]	36.4	2019
12-4	15.0	42.5	30.7	1659
21-5	14.0	41.5	29.3	2188
13-3	13.5	38.0	31.9	2324
25-2 x 8-7	13.5	35.0	32.0	2069
2-10 x 8-7	14.5	43.5	34.8	2225
Sapelekedwa	13.5	46.0	37.3	1995
Namajengo	13.5	42.5	34.7	1682
Mean	13.8	39.6	33.0	2183
CV (%)	8.87	10.37	8.65	23.23
Significance	**	***	**	***

Table 17. Adaptation of 22 bean genotypes under both monoculture and intercropping with NSCM 41 maize Malapwata, Thyolo

	Monoculture			Intercropping		
Genotype	Seeds/pod	100 Seed Wt	Yield	Seeds/pod	100 Seed Wt	Yield
1-1	5.1	13.7	768	5.0	24.9	696
2-10	5.0	29.2	509	3.5	34.1	392
16-6	4.1	25.2	453	4.0	30.9	273
5-2	4.0	27.0	484	4.0	30.2	435
6-1	4.1	33.2	305	4.0	36.3	240
7-8	3.5	29.0	400	3.5	38.6	209
8-7	4.0	31.8	323	4.0	36.9	429
3-13	4.5	26.9	618	4.5	31.8	382
22-2	4.0	33.0	253	4.5	29.4	119
11-1	5.0	29.5	732	5.0	36.8	258
246						
14-5	5.0	19.4	421	5.5	22.0	317
25-2	4.5	33.7	364	4.0	38.4	216
18-10	4.5	22.5	352	4.5	27.0	228
17-1	4.5	34.5	530	4.5	38.5	266
12-4	4.0	27.4	602	4.5	33.4	340
21-5	4.5	26.0	543	4.0	30.3	408
13-3	4.5	29.6	235	5.0	36.4	375
25-2 x 8-7	4.5	29.6	387	4.0	31.3	297
2-10 x 8-7	4.5	30.1	217	4.0	37.2	240
Sapelekedwa	4.5	35.4	642	4.0	34.4	257
Namajengo	6.0	17.1	455	5.0	24.2	381
Mean	4.5	27.8	454	4.4	32.3	322
CV (%)	11.82	11.06	27.90	12.87	10.34	45.53
Significance	***	***	***	0.053	***	***

Table 18. Performance of NSCM 41 maize when grown with 22 bran genotypes at Matapwata, Thyolo

Bean genotypes grown with NSCM 41	#rows/cob	#grains/row	100 Seed Wt (g)	Yield (kg/ha)
1-1	14.0	37.5	29.5	3245
2-10	14.2	38.5	29.7	1695
16-6	14.6	35.0	30.9	2256
5-2	13.6	37.0	28.7	2722
6-1	13.4	36.5	31.6	2394
7-8	13.8	39.5	32.4	3173
8-7	14.4	36.0	30.3	3248
3-13	13.2	38.0	29.3	1903
22-2	13.6	33.5	28.2	2094
11-1	14.6	32.0	25.4	2334
24-6	14.0	40.5	28.1	2900
14-5	14.6	37.5	25.9	2522
25-2	15.0	37.0	30.6	3351
18-10	12.8	29.0	31.3	2166
17-1	14.2	39.0	27.7	2450
12-4	14.4	29.5	31.0	2339
21-5	12.2	32.5	30.9	2777
13-3	14.6	32.5	25.7	1753
25-2 x 8-7	13.6	32.0	23.4	1807
2-10 x 8-7	14.0	39.5	29.0	2859
Sapelekedwa	13.6	40.0	31.6	3113
Namajengo	14.8	34.0	28.0	2153
Mean	14.0	35.7	29.0	2512
CV (%)	7.24	6.54	8.44	24.38
Significance	NS	***	NS	NS

Table 19. Adaptation of 22 bean genotypes under both monoculture and intercropping with NSCM 41 maize at Bunda, Lilongwe

	Monoculture		Intercropping	
Genotype	100 Seed Wt	Yield	100 Seed Wt	Yield
1-1	26.3	768.9	27.1	184.8
2-10	32.1	754.5	33.1	42.9
16-6	30.1	355.4	30.3	94.1
5-2	33.6	512.2	34.9	279.7
6-1	36.5	983.9	39.3	105.7
7-8	36.9	330.7	37.6	381.3
8-7	32.4	788.1	32.8	117.9
3-13	36.0	796.9	35.4	163.7
22-2	43.3	567.4	39.8	133.4
11-1	37.1	200.3	38.7	59.7
24-6	38.7	445.5	24.3	134.4
14-5	35.3	551.7	41.9	191.0
25-2	34.3	803.1	37.4	301.1
18-10	37.4	[illegible]	34.7	52.2
17-7	41.7	788.0	38.9	188.9
12-4	35.6	530.5	30.1	181.1
12-5	39.0	729.5	39.2	167.9
13-3	34.4	817.8	37.0	179.3
25-2 x 8-7	33.3	751.8	36.9	318.5
2-10 x 8-7	27.0	1062.4	39.1	179.2
Sapelekedwa	22.7	935.0	31.0	235.6
Namajengo	21.1	1057.0	24.6	141.0
Mean	33.9	685.1	34.7	174.3
CV (%)	14.65	46.24	20.07	74.48
Significance	***	NS	NS	NS

Table 20. Performance of NSCM 41 maize when grown with 22 bran genotypes at Bunda, Lilongwe

Bean genotypes grown with NSCM 41	#rows/cob	#grains/row	Height (cm)	Yield (kg/ha)
1-1	12.5	37.5	227	2400
2-10	12.0	40.5	238	4050
16-6	14.0	38.0	236	3600
5-2	14.0	39.0	206	3600
6-1	12.0	37.5	205	3750
7-8	13.0	38.0	201	3300
8-7	12.0	34.0	216	3750
3-13	13.5	36.5	215	3450
22-2	12.5	35.5	188	3600
11-1	13.5	38.0	219	3750
24-6	13.5	40.0	230	3750
14-5	11.3	36.5	214	3750
25-2	13.5	38.5	199	3150
18-10	13.5	35.5	211	3750
17-1	13.5	37.5	194	3300
12-4	13.5	37.5	220	4500
21-5	14.5	42.0	189	3900
13-3	12.5	41.5	210	3450
25-2 x 8-7	13.0	36.0	196	3000
2-10 x 8-10	13.0	38.0	206	3350
Sapelekedwa	13.0	38.0	197	3300
Namajengo	13.0	38.5	237	3600
Mean	13.0	37.9	212	3582
CV (%)	7.57	10.55	6.94	18.41
significance	NS	NS	**	NS

39303

V. 1. SOUTHERN AFRICAN BEAN IMPROVEMENT NURSERY (SARBEIN) SET 3

The objective of this trial was to evaluate the performance of South African bean lines in different agroecological zones in Malawi.

This trial was carried out at Bunda (Lilongwe), champhira (Mzimba), Dedza, Luyangwa (Mzuzu) and Matapwata (Thyolo). The experimental design was Randomized Complete Block, with three replicates. These were 15 entries (12 South African lines and three Malawian lines).

Gross plot size was 4 ridges each 4m long spaced 0.9m apart. Nett plot size was [illegible].4m sq. Intra-row spacing was 0.1m, 1 plant per station.

There were very highly significant differences in yield among genotypes at Dedza and Matapwata. The differences in yield were significant at Bunda but were not significant at Champhira and Lunyangwa. Several of the Southern African lines did very well at all sites. The best genotype was Carioca 80 which had high yields at all sites except Bunda. BA 1514, PVBZ 1782, PVA 340, PVA 773, PVA 262, PVBZ 1589, PVBZ 1713 and Broad Acres performed well at several sites (Tables 21-26). The Malawian [illegible] below the mean yield at all sites except 5-2 at Dedza and 8-7 at Lunyangwa. Both of these genotypes did quite well at Bunda (Table 21). The highest yields were obtained at Dedza, and the lowest at Matapwata.

Genotypes differed very highly significantly in seeds size at Bunda, Dedza and Thyolo. The differences were highly significant at Champhira A number of Southern African genotypes (PVA 340, PVA 773, PVA 262 and PVA 1267) had large seed size at all sites only 8-7 had large seeds among the Malawian genotypes (Tables 21-26). There were very highly significant differences among the genotypes in the number of seeds/pod at Bunda, Champhira, Lunyangwa and Matapwata. At Dedza the differences were significant. Carioca 80 had the highest number of seeds/pod at all sites, except Bunda (Table 21-26). Genotypes also differed very significantly in plant height and number of nodes. PVBZ 1589 had the greatest height at the two sites. Several Southern African lines showed resistance to ALS and Rust. There were very highly significant differences among the genotypes in their reactions to these two diseases at Champhira (Table 22). Carioca 80, BAT 1514, PVBZ 1589 and PVBZ 1782 showed resistance to both ALS and Rust at Champhira and Lunyangwa (Disease score = 1) (Tables 22 and 25). The rest of the genotypes were susceptible to both diseases. Kaulesi showed resistance only to ALS at these two sites (All genotypes were susceptible to Floury leaf spot (Table 25).

2. SOUTHERN AFRICAN BEAN IMPROVEMENT NURSERY (SARBEIN SET 4)

The objective of this trial was to evaluate the performance of Southern African bean lines in different agroecological zones in Malawi.

The trial was carried out at Bunda (Lilongwe), Champhira (Mzimba), Lunyangwa (Mzuzu) and Matapwata (Thyolo). The experimental design was Randomised Complete Block, with three replicates. There were 15 entriest, 13 of which were Southern African lines and 2 were released varieties and three new lines. Gross plot size was 4 ridges each 4m long spaced 0.9m apart. The nett plot size was 5.4 sq. meters. Intra-row spacing was 0.1m, 1 plant per station.

Bean yields were highly significantly different among genotypes at Bunda. The differences were very highly significant at Matapwata while at Lunyangwa they were not significant. However, the yield differences were not significant at Champhira. Several good Southern African genotypes were Umvoti, Kompasberg, H 7822-C2, PC 222-2-D2, PC 166-C39, and Enselini (Tables 27-31). The Malawian varieties yielded lower than the mean yield at Bunda. The situation was different at Champhira where Sapelekedwa outyielded the 12 Southern African genotypes (Table 29). Nasaka had yields above the mean yields at

Table 21. Performance of South African Bean Genotypes at Bunda, Lilongwe. Sarbein Set 3

Variety	100-seed weight	pods/ plants	seeds/ pod	plant height (cm)	number nodes	Yield kg/ha
Broad Acres	34	19de	5bc	95cd	12	383ab
PVA 340	42	15f	5bc	42h	6	444ab
PVA 773	41	17ef	4c	41h	6	514a
PVA 262	39	20cde	4c	38h	6	396ab
PA 1267	35	21cd	5c	44h	6	377ab
PVA 782	29	9g	4c	43h	6	150b
BAT 1713	19	17def	6a	76ef	11	552a
PVBZ 1589	25	27b	6ab	127a	18	558a
A 442	25	24bc	6a	114ab	13	579a
PVBZ 1782	22	26b	5bc	100bcd	13	613a
BAT 1514	19	34a	6a	48gh	12	642a
Carioca 80	21	20cde	4c	85de	12	464ab
5-2	27	18def	4c	64fg	11	619a
8-7	35	20cde	5c	91de	11	627a
Kaulesi	31	22cde	6a	110abc	13	312ab
Mean	30	21	5	75	10	484
CV (%)	15.97	11.15	10.37	12.74	11.63	34.50
Significance	***	***	***	***	***	*

Table 22. Performance of South African Genotypes at Champhira, Mzimba. Sarbein Set 3.

Variety	Seeds/pod	100-Seed weight (g)	Yield kg/ha	ALS (Scores)	Rust (Scores)
Broad Acres	q4cf	44ab	520	1.2	1.0
PVA 340	3f	50a	527	1.5	1.0
PVA 773	4c-f	38abc	611	2.0	1.0
PVA 262	5b-e	46ab	890	2.0	1.0
PVA 1267	4ef	43ab	502	2.0	1.0
PVA 782	6abc	41ab	575	1.0	1.0
BAT 1713	6abc	20de	634	1.5	1.7
PVBZ 1782	6ab	25cde	626	1.0	1.0
BAT 1514	6abc	36a-d	446	1.0	1.0
Carioca 80	7a	24cde	744	1.0	1.0
5-2	4f-c	19f	309	1.0	1.0
8-7	4d-f	21de	987	1.0	1.0
Kaulesi	4d-f	34a-e	556	1.0	1.0
Mean	5	34	599	1.4	1.1
CV (%)	15.97	24.16	35.86	18.70	16.22
Significant	***	***	***	***	***

ALS = Angular Leafspot

Means followed by the same letter(s) are not significantly (P= 0.05)

Table 23. Performance of South African Genotypes at Dedza. Sarbein Set 3

Variety	Seeds/pod	100-seed wt (g)	Yield kg/ha
Broad Acres	5abc	43a	1720abc
PVA 340	4bc	46a	1197bc
PVA 773	5abc	43a	1697abc
PVA 262	4bc	41a	1676bc
PVA 1267	5abc	44a	1517bc
PVA 782	3c	35b	1690abc
BAT 1713	5abc	18d	1012c
PVBZ 1589	6ab	23cd	1542abc
A442	6ab	27cd	1703abc
BAT 1514	5abc	20d	1559abc
Carioca 80	6a	20d	1768ab
5-2	4bc	36b	2263a
8-7	4bc	36b	1168bc
Kaulesi	4bc	24cd	1217bc
Mean	5	32	1523
CV (%)	18.62	9.07	25.74
significance	*	***	***

Means followed by the same letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test.

Table 24. Performance of South African Bean Genotypes at Lunyangwa, Mzuzu. Sarbein Set 3

Variety	pods/ plant	seeds/ pod	plant height (cm)	pod length (cm)	yield (kg/ha)
Broad Acres	18	5	151	11	997
PVA 340	17	4	44	13	777
PVA 773	14	4	37	12	653
PVA 262	17	4	42	13	687
PVA 1267	12	4	30	13	577
PVA 782	14	5	41	13	617
BAT 1713	27	6	[illegible]	10	600
PVBZ 1589	17	7	114	13	960
A442	17	6	67	12	687
PVBZ 1782	18	5	86	11	610
BAT 1514	28	5	53	11	887
Carioca 80	23	7	82	10	787
5-2	16	4	[illegible]	10	523
8-7	17	4	67	13	820
Kaulesi	15	5	120	11	637
Mean	18	5	69	12	721
CV (%)	26.31	7.83	28.45	6.08	30.93
Significance	**	***	***	***	NS

Table 25. Reaction of South African Bean Genotypes to three bean diseases at Lunyangwa, [illegible]

Variety	Rust	FLS	ALS
Braod Acres	5.3	7.0	1.0
PVA 340	4.3	6.3	7.3
PVA 773	3.0	5.7	7.3
PVA 262	4.7	7.0	7.7
PVA 1267	4.0	5.3	7.3
PVA 782	4.3	6.3	7.3
BAT 1713	1.0	7.3	5.7
PVBZ 1589	1.3	6.7	1.0
A 442	2.7	6.0	3.0
PVBZ 1752	1.0	8.0	1.0
BAT 1514	1.0	8.0	1.0
Carioca 80	1.0	7.3	1.0
5-2	5.3	4.3	9.0
8-7	4.0	[illegible]	7.7
Kaulesi	4.3	7.0	1.0

FLS = Floury leaf spot

ALS = Angular leaf spot

Table 26. Performance of South African Genotypes at Matapwata, Thyolo. Sarbein Set 3

Variety	Seeds/pod	100-Seed Wt (g)	Yield (kg/ha)
Broad Acres	-	-	-
PVA 340	-	21.6	-
PVA 773	4	31.3	147
PVA 262	4	27.3	254
PVA 1267	4	25.7	230
PVA 782	-	--	-
BAT 1713	6	14.9	482
PVBZ 1782	6	20.1	483
A 442	-	-	-
PVBZ 1782	5	19.1	389
BAT 1514	5	17.1	496
Carioca 80	7	19.0	712
5-2	4	19.6	100
8-7	3	19.2	-
Kaulesi	5	19.0	-
Mean	5	21.1	276
CV (%)	13.28	5.22	39.99
Significance	***	***	***

Table 26b. Disease Reaction of South African Genotypes at Sokola in Misuku Hills Chitipa)

Variety	ALS	WB	FB
Broad Acres	1.0	1.7	1.0
PVA 340	6.7	1.0	1.0
PVA 773	3.0	1.0	1.0
PVA 262	4.6	1.0	1.0
PVA 1267	3.0	3.3	3.7
PVA 782	1.0	1.0	1.0
BAT 1713	1.0	3.3	3.3
PVBZ 1589	1.0	2.6	1.3
A 442	1.0	2.0	1.0
PVBZ 1752	1.0	4.0	1.0
BAT 1514	1.0	5.3	2.7
Carioca 80	1.0	6.0	2.7
5-2	1.0	1.0	1.0
8-7	6.3	1.0	1.0
Kaulesi	1.0	[illegible]	1.0

Lunyangwa and Matapwata (Table 30 and 31). Yields were generally high at Champhira and low at Matapwata.

Genotypes differed very highly significantly in seed size at all sites. Seed size was generally high at Champhira, with some lines reaching 52/100 seed (Table 29). The Southern African lines generally had smaller seed sizes than the Malawian varieties. PC 223-4-D1 had seed sizes which were almost the same with those of the Malawian varieties (Tables 27-31). There were very highly significant differences among genotypes in the number of pods/plant, plant height, number of nodes/plant and number of seeds/pod.

All genotypes were susceptible to Floury leaf spot, ALS and Rust. Three Southern African lines (H 7822-C2, Kompasberg and PC 166-C39) showed resistance to ALS (Table 27). Disease scores from one replicate showed that 8 lines were resistant to Ascochyta blight at Bunda. The genotypes differed very highly significantly in their reactions to ALS at Champhira. Generally, all lines showed some resistance (Mean disease score = 1.7). The lines did not differ significantly in their reaction to rust (Table 29).

3. SOUTHERN AFRICAN BEAN IMPROVEMENT NURSERY (SARBEIN) SET 5

The objective of this trial was to evaluate some selected genotypes of bean lines from the Southern African region.

The trial was carried out at Bunda (Lilongwe). The experimental design was Randomized Complete Block, with three replicates. There were 15 entries which included 3 local checks.

Gross plot size was 4 ridges each 4m long 0.9m apart. Nett plot size was 5.4m sq. Intra-row spacing was 0.1m, 1 plant per station.

Table 27. Performance of South African Genotypes at Bunda Lilingwe. Sarbein Set 4.

Variety	Pods/plant	Seeds/pod	Height (cm)	#nodes	100-Seed Wt (g)	Yield (kg/ha)
H 7822 C2	22.6	5.2	86	13.7	13.0	726
PC 222-5-D2	17.8	4.8	41	6.7	21.4	725
PC 222-5-P2	15.1	4.5	36	9.2	22.4	492
Enselini	12.7	5.1	37	6.1	19.4	682
Umvoti	12.3	5.2	37	6.5	16.3	759
Kompasberg	25.3	6.4	57	11.5	11.1	768
PC 166-C-39	23.1	5.9	62	14.2	7.8	743
PC 223-4-D1	19.9	6.5	139	13.7	31.8	581
PC 252-D2	22.1	4.5	111	13.9	32.2	387
PC 256-D1	19.4	4.8	111	11.3	31.4	411
Nasaka	13.1	4.2	40	6.6	38.1	561
Sapelekedwa	12.3	3.9	42	7.7	30.9	602
Type 2 Red	19.4	4.6	98	13.4	33.7	769
Type 2 white	15.1	4.7	121	12.7	29.6	611
Type 1 White	11.4	4.0	[illegible]	[illegible]	32.1	714
Mean	17.4	5.0	71	10.3	24.8	635
CV (%)	14.98	8.75	10.52	17.06	10.78	20.89
Significance	***	***	***	***	***	***

Table 28. Reaction of South African Bean Genotypes to four bean diseases at Bunda, Lilongwe

Variety	FLS	ALS	RUST	ASC
H 7822-C2	6.0	1.0	4.0	6
PC 222-5-C2	4.5	9.0	5.0	1
PC 222-5-P2	3.0	7.5	5.0	3
Kuselini	7.5	4.5	4.5	1
Umvoti	3.5	9.0	6.5	1
Kompasberg	5.0	1.0	2.5	2
PC 166-C39	6.0	1.0	3.0	1
PC 223-4-D1	4.5	6.0	7.0	4
PC 252-D2	4.5	7.5	4.5	4
PC 265-D1	6.5	7.0	3.5	1
Nasaka	3.5	8.0	3.5	1
Sapelekedwa	4.5	8.0	6.0	1
Type 2 Red	4.0	6.5	5.5	1
Type 2 white	3.5	7.0	6.0	1
Type 1 white	4.0	5.5	5.5	3

FLS = Floury Leafspot

ALS = Angular Leafspot

ASC = Aschochyta Blight

* Scores for Replicate One Only.

Table 29. Performance of South African Bean Genotypes at Champhira, Mzimba. Sarbein Set 4.

Variety	Seeds/pod	100-Seed Wt (g)	Yield (kg/ha)	ALS	Rust
H 7822-C2	5.3ab	19.7g	890	1.0	1.3
PC 222-5-B2	5.0abc	33.0f	866	2.0	2.8
PC 222-5-P2	5.0abc	32.5f	793	2.0	1.7
Enselini				1.6	1.4
Umvoti	5.3ab	34.8ef	906	1.6	1.2
Kompasberg	5.7a	15.6h	1108	1.1	1.3
PC 166-C39	5.7a	14.1h	855		3.5
PC 223-4-D1	5.3ab	45.6b	931	2.0	1.8
PC 252-B2	5.0abc	37.6de	889	2.0	2.0
PC 256-D1	5.0abc	42.9bc	790	1.8	1.9
Nasaka	3.7d	52.4a	853	1.7	1.7
Sapelekedwa	4.1cd	43.9b	999		1.4
Type 2 Red	4.0cd	39.3cd	900	1.7	1.7
Type 2 White	4.3bcd	41.7bcd	799	2.1	1.6
Type 1 white	4.0cd	51.8a	867	1.9	1.8
Mean	4.8	36.1	889	1.7	1.8
CV (%)	11.88	6.74	11.57	11.83	36.2
Significance	***	***	NS	***	NS

Means followed by the same letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test.

Table 30. Performance of South African Bean Genotypes at Lunyangwa, Mzuzu. Sarbein Set 4.

Variety	Pods/plant	Seeds/pod	Height (cm	Pod/length (cm)	Yield (kg/ha)
H 7822-C2	12	6	61	8.8	490
PC 222-5-D2	6	5	19	11.7	240
PC 222-5-P2	7	4	46	11.1	290
Enselini	9	6	33	13.0	700
Umvoti	7	5	26	11.4	325
Kompasberg	20	6	52	8.4	640
PC 166-C39	26	5	58	8.6	800
PC 223-4-D1	9	4	95	12.0	315
PC 252-D2	10	5	59	11.0	605
PC 256-D1	7	4	52	12.3	350
Nasaka	4	5	26	13.0	465
Sapelekedwa	7	5	30	13.0	340
Type 2 Red	7	4	69	11.6	165
Type 2 white	7	5	31	12.9	240
Type 1 White	8	5	25	12.7	425
Mean	10	5	45	11.4	426
CV (%)	20.05	8.10	19.70	5.07	37.93
Significance	***	***	***	***	***

Table 31. Performance of South African Bean Genotypes at Matapwata, Thyolo. Sarbein Set 4.

Variety	Seeds/pod	100-Seed Wt (g)	Seed Yield kg/ha
H 7822-C2	5	16.7	561
PC 222-5-B2	5	18.6	405
PC 222-5-P2	5	20.6	83
Enselini	6	19.9	659
Umvoti	5	18.3	602
Kompasberg	6	13.1	197
PC 166-C39	6	13.2	232
PC 223-4-B1	5	18.4	-
PC 252-B2	3	15.0	-
PC 256-B1	5	12.3	-
Nasaka	4	27.4	357
Sapelekedwa	4	21.1	78
Type 2 Red	4	20.9	104
Type 2 white	5	20.2	-
Type 1 white	5	23.5	102
Mean	5	18.6	224
CV (%)	12.80	14.51	50.99
Significance	**	***	***

Genotypes differed very highly significantly in yield, seed size, plant height, number of nodes per plant, and number of pods per plant. A local genotype (Nyauzembe) produced the highest yield, outyielding the top yielding South African genotype by 244 kg/ha. PC 213-C3, Umvoti, Type 2 White, PC 167-C6 and PC 351-19 were the high yielding bean lines. These genotypes had yields greater than the mean yield. They also outyielded the local checks. All these high yielding Southern African lines had small seed size (less than 25g/100 seeds) except Type 2 White which had medium seed size (Table 32).

Generally, all genotypes showed high susceptibility to rust. PC 223-C3 had the least susceptibility to WB, CBB and ALS (Table 33).

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VI. BEAN BREEDING

A. HYBRIDIZATION

PROGRESS

Selection for disease resistance on the segregation F3 population commenced in 1989/90 crop season. The selections were done through the initial Screening Trials. Unfortunately, entries for Thyolo and Dedza were planted late and were subsequently lost due to drought and bean fly (*Ophio...* spp.) in some cases. However, over 50 test lines have been selected to enter into a preliminary trial for further evaluation. All the F4 populations (initial screening entries) have been planted under irrigation at Bunda to advance them to F5 which will be planted in the 1990/91 crop season for further evaluation and selection.

Table 32. Performance of South African Bean Genotypes at Bunda, Lilongwe. Sarbein Set 5.

Variety	Pods/ plant	Seeds/ pod	Plant/ height	Nodes	100-Seed weight	Yield (kg/ha)
Umvoti	17cde	5cd	50f	7f	23.0c	740abd
PC 167-C6	32ab	6a	60ef	12de	14.8e	731abc
PC 213-C3	37a	6ab	114ab	8ab	17.2e	772ab
PC 235-5-6-E3	17cde	5abc	110abc	15cd	33.4a	461b-f
PC 222-5-6-P5	19cde	6ab	103a-d	15bcd	32.6ab	455b-f
PC 238-D2	19cde	6a	92a-d	14cde	29.8b	155f
PC 255-D1	19cde	6ab	89bcd	12de	33.3a	338ef
PC 238-D3	26abc	5bc	99a-b	16bcd	33.5a	507b-e
PC 242-D5	25bcdd	5bc	117a	17bc	32,6ab	366def
PC 315-19	12e	5bc	47f	7f	25.3c	647b-e
PC 222-5-3-P3	27abc	6abc	101a-d	15bcd	32.8ab	448c-f
Nyauzembe	29abc	4d	81de	13de	31.3ab	1016a
8-7	13de	4d	84cde	11e	30.3ab	637be
Type 2 Red	28abc	6ab	101a-d	21a	20.1d	623b-e
Type 2 White	23b-c	5cd	104a-d	16bcd	30.3ab	671bcd
Mean	23	5	90	14	28.2	571
CV (%)	27.39	9.21	15.55	13.50	6.11	28.63

Means followed by the same letter(s) are not significantly (P=0.05) different by Duncan Multiple Range Test.

B. ADAPTATION TRIAL I

Yield data from Table 33 indicate that there were significant differences (P=0.01) for yield. The highest yield was obtained from A286 and the lowest from Coco ala creme. The local entries Nasaka and 25-2 gave close to the average yield but were far outyielded by A286. The results show that there is a wide range of adaptational variation among the entries at Bunda and selections could be made from these entries.

One observation from the data is that the top three yielders: A286, A344, and BAT 477 are small-seeded, a character that most of the small-scale farmers in Malawi rarely like. However, G 05434 which yielded higher than the two local entries is large-seeded and may offer more flexibility on acceptability. The same would be true for Perry Marrow.

Seed size, pod length and seeds per pod showed significant difference (P=0.01). Nasaka and 25-2 came third and second, respectively, to G 05434 for seed size but gave the longest pod length. However, they gave less than the mean average for seeds per pod. A286 and BAT 477 were the only entries that gave the highest number of seeds per pod (5.5 and 5.9, respectively).

The commonest diseases that occurred in the adaptation trial at Bunda College during the 1989/90 crop season were Angular leafspot (ALS) caused by Phaeisariopsis griseola; Common bacteria blight (CBB) caused by Xanthomonas campestris Pv. phaseoli; Bean common mosaic virus (BCMV); Web blight (WB) caused by Rhizoctonia solani and rust caused by Uromyces phaseoli.

Table 33. Performance of adaptation trial entries at Bunda, Lilongwe (1989/90)

Entry	Yield (kg/ha)	Seed size g/100 seeds	Pod length (cm)	Seeds/pod
Evolutie	216cd	21.7	7.6d	4.8b
G 05434	342abc	52.6a	12.1a	3.2e
Mexico 222	227cd	21.8f	8.6cd	4.4bc
BAT 477	417ab	22.9f	10.2b	5.9a
A 286	508a	24.0ef	9.2bc	5.5a
Umvoti	411ab	26.7e	11.4a	4.3bcd
Coco ala creme	72d	38.8d	9.9b	3.6cde
A 344	438ab	25.7e	10.2b	4.3bcd
Perry Marrow	316bc	41.8cd	9.9b	3.8cde
Nasaka	285bc	43.5c	12.5a	3.7cde
25-2	265bc	48.5b	12.5a	3.9cde
Charlevoix	296bc	42.8c	11.9a	3.5e
Mean	316	34.2	10.5	4.2
SE	55.3	0.89	0.37	0.24
LSD (5%)	162	2.62	1.09	0.71
CV (%)	30.2	4.52	6.14	9.84
Significance	**	**	**	**

* = Significant at 0.05
** = Significant at 0.01
NS = Not significant

Note: In a column, means followed by a common letter are not significantly different at P=0.05.

The results in Table 34 show that A286, A344 and BAT 477 gave good resistance to almost all the diseases. Nasaka showed intermediate reaction to most of the diseases.

CONCLUSION

The data presented indicate that there is variation in yield adaptation and disease resistance among the entries tested. Selection for these two characters is therefore possible. One observation is that the entries that were the top three in yield performance were also disease resistant. It is however, premature to draw any meaningful conclusion because the data is from one site and one season.

C. DISEASE RESISTANCE SCREENING

PROGRESS

This research was initiated in 1988 (Ref: Bean progress report 1989).

Objectives:

1. To identify some of the *Phaeisariopsis griseola* variation that exists in Malawi; and

2. To identify sources of resistance to *Phaeisariopsis griseola* in some Malawian bean germplasm.

MATERIALS AND METHODS

Ten isolates of *Phaeisariopsis griseola* (Pg) from different bean growing areas of the country were grown on Potato dextrose agar (PDAO and inoculated on differential varieties. An inoculum density of 100,000 spores per ml of distilled water containing 0.05% v/v Tween 80 (polyoxthelene sorbitan monoeleatte) was sprayed as a fine mist onto upper and lower leaf surface and the entire stem of differentials having two trifoliate leaves. The inoculated differentials were maintained in a saturated mist chamber for 4 days and then taken out. The first disease count was done 10 days after taking the differentials out of the chamber and the second count two weeks later. The plants were rated "+" for susceptibility, "-" for resistance, and "I" for an intermediate reaction.

PATHOGENIC VARIATION

The reaction of the differential varieties to the ten isolates of Pg (Table 35) shows that the pathogen is variable. This supports the results from the 1989/90 study and confirms the need for developing bean varieties that possess general rather than specific resistance. Another strategy would be to develop many varieties each with different reaction to different pathotypes or races, in the way of multilines. The current practice of growing bean mixtures which the majority of the Malawian bean farmers do may play a role as one method of controlling this pathogen.

The existence of this pathogenic variability of Pg reinforces the need for collecting even more isolates from different bean growing areas of the country in order to ascertain the extent of variability of this pathogen. Collection of disease specimens should be a continous process to monitor the shift in variabilty, race frequency or occurrence of new races. Such information is vital for developing a proper breeding strategy and a bean breeding programme.

SOURCES OF RESISTANCE

The results presented in Table 35 indicate that PI 167399, Coco ala Creme and G 05434 were resistant to all the 10 isolates. These differential varieties can be utilized as sources of resistance to this Pg pathogen. G 05434 which gave a resistant reaction to 60% (6 our of 10) of the isolates in the previous study (Ref: Bean Progress Report, 1989) is showing a 100% (10 out of 10) resistant reaction to the isolates in this study. G 05434 evaluation and utilization. PI 167399, which gave a resistant reaction to 50% of the isolates in the previous study is showing a 100% resistant reaction to the isolates in this study and can be another useful source of resistance. However, it is a small-seeded white bean and may be more useful as a donor parent in a breeding programme. Nasaka, a released variety, gave an intermediate reaction to many of the isolates.

The results on lesion sizes (Table 36) show that G 05434 had the smallest lesions when infected by all ten isolates, while Evolutie had the largest lesions when infected by the same. PI 167399 produced small-sized lesions when infected by all but one (Pg7) isolates. Nasaka gave large-sized lesions to many (80%) of the isolates. AB 136 produced medium-sized lesions to all the 10 isolates.

CONCLUSION

The study reveals that there is pathogenic variation for the <u>Phaeisariopsis griseola</u> pathogen in Malawi and that sources of resistance to this pathogen are available. G 05434 is a potential source of resistance and should be further evaluated. However, more disease specimens need to be collected to ascertain the extent of variability and more bean germplasm should be screened to identify more sources of resistance.

Table 34. Disease reaction of adaptation trial entries at Bunda Lilongwe. (1989/90)

Entry	Reaction (Scores 1-9)				
	ALS	CBB	BCMV	WB	RUST
Evolutie	8	2	0	6	5
G 05434	6	6	0	6	4
Mexico 222	5	2	1P	5	6
BAT 477	1	1	2P	3	1
A 286	1	2	0	4	1
Umvoti	1	2	0	4	1
Coco ala Creme	2	1	0	6	5
A 344	1	1	0	3	1
Perry Marrow	3	5	2P	4	3
Nasaka	2	5	0	6	4
25-2	3	3	2P	3	5
Charlevoix	4	7	0	5	3

Reactions were recorded using a scale of 1-9: A "1" rating = absence of symptoms and a "9" rating = extreme susceptibility except for BCMV which has a "0" rating = no observed symptoms (not absence of symptoms), and P rating = number of plants affected.

ALS = Angular Leafspot
CBB = Common Bacterial Blight
BCMV = Bean Common Mosaic Virus
WB = Web Blight

Table 35. Reaction of differential varieties to ten isolates of *Pg*

Differential	Reaction									
Variety	Pg2	Pg6	Pg7	Pg8	Pg9	Pg11	Pg12	Pg13	Pg14	Pg15
Evolutie	1	+	–	1	1	1	–	–	1	1
PI 165426	–	+	+	1	1	1	1	1	1	1
PI 167399	–	–	–	–	–	–	–	–	–	–
Coco ala Creme	–	–	–	–	–	–	–	–	–	–
Perry Marrow	–	1	1	1	–	1	–	–	–	1
C 05434	–	–	–	–	–	–	–	–	–	–
Cornell 49-242	–	1	1	1	1	1	1	1	1	1
AB 136	–	1	1	1	–	1	–	–	1	1
Mexico 222	1	1	1	–	1	1	1	1	1	1
Nasaka	1	1	1	1	1	1	–	–	1	1

"–" = resistant (1–3)

"1" = intermediate (4–6)

"+" = susceptible (7–9)

Table 36. Lesion sizes on differential varieties when inoculated against ten isolates of Pg

Differential	Lesion diameter									
variety	Pg2	Pg6	Pg7	Pg8	Pg9	Pg11	Pg12	Pg13	Pg14	Pg15
Evolutie	L	L	L	L	L	L	L	L	L	L
PI 165426	M	M	L	L	M	L	M	M	M	M
PI 167399	S	S	M	S	S	S	S	S	S	S
Coco ala Creme	S	S	M	S	S	S	M	S	M	M
Perry Marrow	M	M	M	M	S	M	M	M	S	S
G 05434	S	S	S	S	S	S	S	S	S	S
Cornell 49-242	M	L	L	M	M	L	M	M	M	M
AB 136	M	M	M	M	M	M	M	M	M	M
Mexico 222	S	M	M	M	M	M	M	M	M	M
Nasako	L	L	M	L	L	L	M	L	L	L

"S" = small (1.5mm)

"M" = medium (1.5-3mm)

"L"L = large (1-4.5mm or above)

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VII SOIL SCIENCE FOR BEAN PRODUCTION

A. NITROGEN UPTAKE IN MAIZE/BEAN INTERCROPPING AS AFFECTED BY NITROGEN FERTILIZER

Intercropping is a predominant cropping system for the small-scale subsistence farmer and will probably remain so for many years to come. It has been observed that crop yield increases for smallholder farmers practising intercropping system have not been achieved. One of the reasons is that fertilizer technology, expensive though it is, has been developed for monoculture systems of the developed world and there are no recommendations for the intercropping systems.

This experiment focussed on the effects of N-fertilizer application on the uptake of nitrogen by both the maize and beans in an intercropping system. Two bean varieties of contrasting growth habits were used, viz: Nasaka (253/1), a dwarf variety and Kanzama (97/1), a climber with a single maize variety (NSCM 41). A factorial experiment in a randomized complete block design with three replications was used. Sole and intercropping systems using four levels of nitrogen: 0, 40, 80, and 120 kg n/ha were investigated. The N-source was calcium ammonium nitrate (CAN).

Nitrogen concentration in 4-week old maize plants was not significantly different between nitrogen fertilizer rates and among cropping system (Table 37). This could have meant that there was already enough nitrogen in the soil to sustain seedling establishment. There were significnat maize grain yield differences among N-fertilizer rates and among cropping systems (Table 38). Maize/climbing bean system gave the highest maize yield. In all cropping systems maize yields increased with each increment of nitrogen fertilizer application.

Table 37. Effects of nitrogen fertilization and cropping systems on % N in 4-week old maize plants

N-rate (kg/ha)	CROPPING SYSTEM Sole maize	Maize+Climber	Maize+dwarf	Mean
0	2.15	2.35	1.98	2.16
40	2.72	2.04	2.80	2.52
80	1.81	2.64	2.05	2.17
120	2.39	2.79	2.07	2.42
Mean	2.27	2.46	2.22	2.32

CV (%) = 17.4

SE (cropping system = 0.11

SE (nitrogen rates) = 0.13

Table 38. Effects of N-fertilizer application and cropping systems on maize grain yield (kg/ha)

N-rate (kg/ha)	CROPPING SYSTEM Sole maize	Maize+Climber	Maize+dwarf	Mean
0	619	544	243	469
40	1274	1063	957	1098
80	1308	1441	1025	1258
120	1591	1916	1209	1572
Mean	1198	1241	859	1099

CV (%) = 36.5

SE (Nitrogen rates) = 134

SE (Cropping system) = 116

LSD (0.01) = 533

LSD (0.01) = 340

However, yields were generally lower than expected. Generally, there was an increase in nitrogen content of the maize grain as fertilizer rates increased from none to either 40 or 80 kg N/ha. And there was another increase if additional nitrogen was applied (Table 39). The nitrogen content of maize grain in pure stand and that from maize grown with a climber was not different although nitrogen content decreased significantly if the maize was grown with a dwarf bean variety.

The content of nitrogen in biomass at 4 weeks of bean plants' growth were not significantly different among fertilizer levels and among cropping systems (Table 40). However, the content of nitrogen different significantly between bean varieties with the climber having had greater rates of N-uptake. Bean seed yields were increased only by increased nitrogen fertilizer application (Table 41) as was also reflected by the seed nitrogen content (Table 42).

B. EFFECT OF APPLIED PHOSPHORUS ON BIOLOGICAL NITROGEN FIXATION IN BEANS

Nitrogen is the major limiting factor for crop production in many developing countries. This is due to the fact that soil organic nitrogen gets drained continually from the soil. The cost and restricted availability of artificial nitrogenous fertilizers make it difficult for smallholder farmers to use fertilizers. However, the utilization of biological nitrogen fixation (BNF) technology could economically provide a cheap source of N for crop production.

This experiment was conducted in order to determine the effect of applied phosphorus fertilizer on BNF in beans and to study the effect of inoculation on BNF. A three factor factorial experiment in a randomized complete block

Table 39. Influence of N-fertilizer application and cropping systems on maize grain nitrogen (kg/ha)

N-rate (kg/ha)	CROPPING SYSTEM Sole maize	Maize+climber	Maize+dwarf	Mean
0	8.5	8.5	4.0	7.0
40	17.2	14.6	11.3	14.4
80	16.8	19.8	11.1	15.9
120	23.1	27.3	19.4	23.3
Mean	16.4	17.6	11.4	15.0

CV (%) = 37.1

SE (Nitrogen rates) = 1.87

SE (Cropping systems) = 1.62

LSD (0.01) = 7.47

LSD (0.05) = 4.76

Table 40. Influence of N-fertilizer application cropping systems, and bean varieties on % N in 4-week old bean plants (%N).

Variety	N-rate (kg/ha)	CROPPING SYSTEM Monoculture	Intercropping	Mean
Kanzama	0	2.88	2.79	2.84
(Climber)	40	3.33	3.08	3.21
	80	3.52	2.62	3.07
	120	3.48	3.66	3.58
Mean		3.30	3.04	3.17
Nasaka	0	2.89	2.46	2.68
(Dwarf)	40	2.20	2.34	2.27
	80	2.84	2.79	2.77
	120	2.49	2.78	2.64
Mean		2.61	2.57	2.59

CV (%) = 19.6

SE (Vrieties) = 0.11

SE (N-rates) = 0.16

SE (Cropping systems) = 0.11

Table 41. Effects of N-fertilizer application, cropping systems, and bean varieties on bean seed yield (kg/ha)

Variety	N-rate (kg/ha)	CROPPING SYSTEMS Monoculture	Intercropping	Mean
Kanzama	0	180	164	172
(Climber)	40	269	252	260
	80	214	182	198
	120	251	231	241
Mean		228	207	218
Nasaka	0	195	105	150
(Dwarf)	40	204	257	230
	80	220	202	211
Mean		221	200	210

CV(%) = 42.7

SE (Varieties) = 18.7

SE (N-rates) = 26.4

SE (Cropping systems) = 18.7

Table 42. Nitrogen (kg N/ha) in bean seed as influenced by N-fertilizer application, cropping systems, and bean varieties.

Variety	N-rate (kg/ha)	CROPPING SYSTEM Monoculture	Intercropping	Mean
Kanzama	0	6.17	5.43	5.80
(Climber)	40	9.87	6.47	8.17
	80	10.9	8.97	9.95
	120	12.6	10.6	11.6
Mean		9.89	7.86	8.88
Nasaka	0	7.37	2.97	5.17
(Dwarf)	40	8.77	10.2	9.47
	80	8.77	7.80	8.28
	120	10.2	8.43	9.33

CV (%) = 42.2

SE (N-rates) = 0.97

SE (Cropping systems) = 0.68

SE (Varieties) = 0.68

design was laid out. Three bean varieties, viz: 253/1, P402, and 13-3; three P fertilizer rates, viz: 0, 25, and 50 kg P205/ha and Rhizobium inoculation with (MG 366) or none were the factors used.

There were no significant differences in mean number of effective nodules due to the effect of P fertilizer, bean variety, or inoculation (Table 43). However, inoculated beans applied with 25 kg and 50 kg P205/ha showed significantly more effective nodules over the control. Effective nodulation was highest where beans were applied with 50 kg P205/ha and inoculated with MG 366. The bean variety P402 showed superiority over varieties Nasaka (253/1) and 13-3. Application of P fertilizer to inoculated beans may significantly increase effective nodulation thereby increasing rate of N fixation. The amount of N fixed biologically by flowering was not different among treatments. However, the highest mean N yield was obtained when 50 kg P205/ha was applied to the inoculated beans (data not shown). There was a significant increase in %N fixed at flowering from no inoculation in comparison with inoculated treatment (Table 44). It may be possible then to increase %N by flowering time if inoculation is done . P402 and 13-3 were superior to Nasaka in this regard.

Seed yields were not significantly different among treatments (Table 45). However, the mean seed yield increased with phosphorus application. P402 gave the highest response to inoculation and produced highest seed yields. From the foregoing, it may be possible to increase biological nitrogen fixation in beans through inoculation with an effective strain and by application of fertilizer phosphorus. These experiments need to be continued using more effective strains to verify results.

Table 43. Effect of bean varieties, phosphorus fertilizer rates and inoculation on number of effective nodules/plant

Phosphorus (kg P_2O_5/ha)	Inoculation	Variety			Mean
		Nasaka	P402	13-3	
0	0	35	42	38	38
	MG 366	39	44	39	41
25	0	42	45	39	42
	MG 366	46	50	42	46
50	0	40	50	39	43
	MG 366	48	51	44	48
Mean	0	39	46	39	41
	MG 366	44	48	42	45

CV (%) = 9.4

SE = 2.3

Table 44. The effect of varieties, phosphorus fertilizer rates, and inoculation on %N fixed by flowering time.

Phosphorus (kg P_2O_5/ha	Inoculation	Variety			Mean
		Nasaka	P402	13-3	
0	0	2.5	2.7	2.8	2.7
	MG 366	2.5	3.1	3.1	2.9
25	0	2.2	2.7	2.6	2.5
	MG 366	2.5	3.0	3.0	2.8
50	0	2.6	2.8	2.8	2.7
	MG 366	3.1	3.0	2.3	3.0
Mean	0	2.4	2.7	2.7	2.6
	MG 366	2.7	3.0	3.0	2.9

CV (%) = 16.81

SE = 0.027

Table 45. The effects of varieties, phosphorus rates and inoculation on bean seed yield (kg/ha)

Phosphorus (kg P2-5/ha)	Inoculation	Varieties Nasaka	P402	13-3	Mean
0	0	451	769	477	566
	MG 366	467	943	720	710
25	0	426	959	516	634
	MG 366	520	1200	712	811
50	0	473	943	[illegible]	649
	MG 366	590	1035	657	761
Mean	0	450	890	508	616
	MG 366	526	1059	969	761

SOCIO-CULTURAL COMPONENT

I. PRELIMINARY ON-FARM RESEARCH

During the 1989/90 cropping season the Bean Programme responded to a request for some better bean varieties than those locally grown by farmers from the vicinity of Bunda College of Agriculture. As a result 25kg of seed was distributed among five (5) farmers in Lilongwe Rural Devlopment Project EPA 12 section one (1) headquartered at Kampini, about 20km from Bunda. Each of five farmers from three villages, namely: Mkaka, Kambalanje, and Nambaya were given 5kg of either Sapelekedwa (Mr Benjamin Gwengwe, Kambalanje), Nasaka (Mr Sedraki Chabenda, Kambalanje), 8-7 (Mrs Christina Fositala, Mkaka), 5-2 (Nyauzembe) (Mrs Bete Kachamba, Mkaka), and 25-2 x 8-7 (Mr Mageza Mkhwinthi, Nambaya). Sapelekedwa is a short vine large red-kidney. Nasaka is a short vine khakhi-kidney. 8-7 is a bush medium purple-kidney. Nyauzembe is medium to small olive-green roundish seed. And 25-2 x 8-7 is a bush large white-kidney. Two farmers, viz: Mr Gwengwe and Mr Chabenda, planted in pure stands whereas the others planted within 10 days of planting their maize in intercropping. The villages which were selected for this effort were some of those selected for the [illegible] Lilongwe Bean Survey which involved nine (9) villages in EPAs 11 and 12. This area is under Traditional Authority Chiseka. The main objectives were to:

a) arouse farmers' interest and to make them aware of the bean varieties being produced by the National Bean Programme at Bunda in order to facilitate technology adoption,

b) provide justification for close and more extension services on smallholder bean production, and

c) recommend credit and extension packages on bean production to smallholder farmers as is done with groundnuts and maize.

The results obtained were spectacular. Mr Gwengwe, who grew Sapelekedwa, obtained bean yield equivalent to 900 kg/ha. Others like Mr Chabenda and Mrs Kositaza obtained just slightly less than that. Those that grew Nyauzembe and white (25-2 x 8-7) Type II obtained almost half of that obtained with Sapelekedwa. This may have a number of connotations. The first is that yields of beans can be improved in the country. The mean bean yields are about 300 kg/ha considering the amounts and areas involved in bean production. The yield of 900 kg/ha is substantially far in the right direction although still short of the Government aim of 1500 kg/ha. The second connotation, which follows from the first, is that we still have to keep looking for better varieties. Sapelekedwa, which did the best in this study, was one of the only six (6) varieties released by the National Bean Programme in this country. Nyauzembe, 8-7, and 25-2 x 8-7 are newer identifications from the local germplasm and hybrid. These studies need to continue in o der to confirm the high performance of Sapelekedwa against these newer genotypes. And the Breeding Programme has to continue, in the meantime, to search for better genotypes. And an off-spin to the effort here has been a Seed Multiplication Scheme that has just started. At least a tonne each of Sapelekedwa and Nasaka (released varieties) have been produced in the dry season of 1990 at the Bunda Farm. This crop was inspected adequately in the field by the Seed Technology Unit. The seed has been treated with actellic (a storage chemical) and will immediately be distributed to the Rural Development Projects (RDPs) of ADDs that are actively growing beans i.e., Karonga ADD (Chitipa RDP), Mzuzu ADD (Henga Valley RDP), Kasungu ADD (Nthisi/Dowa RDP), Lilongwe ADD (Dedza Hills RDP), and Blantyre ADD (shire Highlands RDP). Seed availability (of good varieties) seems to be a real bottleneck in bean production in the country. A third connotat on is that the short vine varieties performed better than the indeterminate bush/climber varieties. It was also observed that the five farmers found the beans they grew very palatable. This was shown by the fact that farmers consumed most of their bean produce by the end of the trials.

One of the problems observed was that associated with Extension. Extension workers seemed not to have information handy to take across to the bean farmers. And so we had to attend to the farmers ourselves. It is hoped that as this effort will be continued in this area the link between researchers and extension workers will be strengthened. The National Bean Programme has produced a booklet of 'Recommendations for Bean Production in Malawi' and we hope that this will come in handy for extension workers that will be involved with bean seed production and the other ordinary bean farmers.

Some of the recommendations were that:

a) This On-Farm Research has to be continued and should be better planned in future but perhaps involving the Adaptive Research Section of the Ministry of Agriculture;

b) The number of visits by members of the National Bean Programme has to be increased; and

c) The Department of Agriculture needs to ensure that extension staff is on the ground before rains start to avoid the obvious confusion that arises if extension staff are moved out and into an area with which they are unfamiliar.

In this case, an extension worker was removed at the beginning of the rains but was still not replaced by the end of the rains.

II. BEAN PRODUCTION PRACTICES AND BOTTLENECKS AMONG SMALLHOLDER FARMERS IN MALAWI

INTRODUCTION

Malawi's agricultural performance since independence has been commended by donor agencies such as the The World Bank as one of the most successful in sub-Saharan Africa. Indeed, in the 1970's Malawi was a front-runner in integrated rural development projects in the region. The agricultural sector in Malawi is bimodal in that it involves the estate sector and the smallholder sector. The estate sector has been the main basis for the country's expansion of export production. Main crops grown by the estate sector are: flue-cured and burley tobaccos, tea, sugar, and coffee. The small-holder sector is composed of largely small farmers who constitute about 88% of the population. These supply the bulk of the country's food requirements as well as providing some surplus for expert. Apart from growing maize, the smallholder farmers also grow cash crops such as dark-western tobacco, cotton, tea, sugarcane, and, more recently, burley tobacco.

The government's emphasis on developing agriculture in general and the smallholder sector in particular has enabled the country to achieve a status of self-sufficiency in food such that in early 1980's Malawi was a net exporter of maize. Although Malawi has achieved self-sufficiency in food at national level, there is growing evidence suggesting that household food insecurity is prevalent in the country. Indeed even in years of good harvest some households are neither able to produce nor purchase enough food to meet their requirements. This is reflected in high levels of malnutrition, high child mortality rate and depletion of food stock before the next season among most households.

Apart from maize, beans are a next important food crop in most areas in Malawi among smallholder farmers. They are also an important cash crop. The importance of beans as a relatively cheap source of protein is well recognised throughout the country. For instance, in intitutions such as boarding primary schools, day and boarding secondary schools, hospitals, prisons and even among refugees, beans are usually a prominent part of the diet. This crop is mainly produced by smallholder farmers who benefit from the crop twofold: as a source of food and as a source of income. Just as is the case with other crops, the growing of beans at smallholder level is not without constraints. This study, therefore, set out to examine bean production practices and bottlenecks among smallholder farmers in Malawi: a case study of smallholder farmers in Blantyre ADD.

So far, the Bean/Cowpea CRSP has carried out surveys in the Central and Northern Regions of Malawi with a view to understanding various cultivation systems and practices and also to undertanding their determinants.

STUDY OBJECTIVES

This study is part of an on-going study of farming systems, bean production and use practices, designed to assist the National Bean Programme in developing improved bean varieties for smallholders. According, the purpose of the study were to gather information on the farming household and its broader social and economic context and information on farming practices especially as they relate to beans and other legumes.

In the survey, special attention was given to the following:

1. Nature of farming systems in the area which includes crops and cropping patterns during different seasons, animals kept on farms, soil types and rainfall patterns.

   The study also gathered information on the cropping calendar, and use of hired labour. Attempts were made to identify major problems and contraints associated with the farming systems of the area. Special attention was also paid to the role of beans in the farming systems with reference to:-

- Various bean varieties farmers in the area grow and why they maintain them;
- Major problems faced by farmers in growing beans;
- Farmers' awareness of bean pests and measures taken for intervention;
- Advice the extension staff give to farmers regarding bean production.

2. Social and economic structure of the area.

- Inheritance pattern among the people in the area;
- Method of land acquisition;
- Landholding sizes per household;
- Strategies farmers have developed to supplement their farming activities;
- Food security status of the households and strategies employed to achieve food security;
- Relationship between the farmers and the surrounding estates;
- Number of female-headed households among the farming population.

3. Farmers' clubs and income generating activities.

- Determine credit groups in the area or other sources of credit to farmers;
- Collect information on the role of farmers' clubs;
- Investigate income generating activities especially among women.

4. Extension service.

- Discuss how the block system is working;
- Find out whether farmers find extension advice useful;
- Amount of block meeting attendance.

METHODOLOGY

The survey was conducted in Blantyre Shire Highlands Rural Development Division of Blantyre Agricultural Development Division. The Project has seven EPAs and it covers the following districts: Blantyre, Thyolo, Chiradzulu, and Mulanje. The survey was conducted in Matapwata Extension Planning Area which is in Thyolo district in March-April, 1990.

Two strategies were employed in this study. A questionnaire to gather quantitative type of socio-economic and agronomic data was administered to three hundred respondents. The respondents were chosen randomly from 42 villages. There was, however, purposive sampling of female-headed households. Farmers' lists that are kept at the EPA were used in our sampling. The 42 villages were chosen from five sections (See Table 50 below).

Table 50. Sample households by sections

Section No.	Villages No.	Households No.	Interviewed	% Sampled
Chingazi	9	2824	94	3
Muonekera	9	1028	34	3
Nansadi	9	2400	79	3
Sharpe	8	1006	33	3
Phepheni	7	1800	60	3
Total Mean	42	9058	300	3

The questionnaire was divided into two parts. Part one covered general demographic and agricultural information. Part two covered bean production and use. In most cases, both the household head and spouse were present for the interview. The household head was the main respondent for Part One of the questionnaire. Part Two was only answered by bean-growing households and in such cases the women were main respondents since in this area, as documented for the North and Central Regions, women are the major growers of beans in the household.

Quantitative information was also collected through informal discussions with key informants in the area who included the following:

1. Farmers with a good understanding of bean production;
2. Extension workers;
3. ADMARC (Agricultural Development and Marketing Corporation) staff;
4. Village headmen and other local leaders.

BEAN CULTIVATION PRACTICES IN MALAWI

The common bean, Phaselus vulgaris L., is second only to groundnuts in grain legume production in Malawi. It provides a cheap source of protein for the majority of the people in the country. The existance of beans in the farming systems has led to the evolution of various production practices in an attempt by farmers to best use the available resources.

In Matapawata EPA the following are the major crops produced: maize, beans, groundnuts, pigeon peas, cowpeas, garden peas, yams, chillies, sorghum, soybeans, cassava, and sweet potatoes. The most common vegetables produced are cabbage, chinese cabbage, rape, turnips, onions, and tomatoes. The are is also favourable for fruit-growing. The most commonly grown fruits are avocado pears, mangoes, lemons, oranges, tangerines, guavas, peaches, and pineapples. Most of this produce is sold in Blantyre city.

In this diverse cropping system beans are one of the most important crops as shown in Table 51 and 52 below:

Table 51. Crops that provide most food for the family.

Crops	Household head											
	Male				Female				Total			
	Rank 1		Rank 2		Rank 1		Rank 2		Rank 1		Rank 2	
	No.	%	No.	%	No.	%	No	%	No	%	No.	%
L. maize	176	93	4	2	90	94	–	–	266	94	4	1
H. maize	13	7	3	2	2	4	4	5	15	5	7	3
Beans	–	–	141	78	–	–	69	79	–	–	210	74
Others	–	–	32	18	–	–	14	16	2	1	62	22
Total	189	100	180	100	92	100	87	100	283	100	283	100

L. maize = local maize

H. maize = hybrid maize

Table 52. Crops that provide most income for the household

Crops	Household					
	Rank 1		Rank 2		Rank 3	
	No.	%	No.	%	No.	%
Beans	146	52	49	33	–	–
Local maize	52	18	47	31	5	100
Hybrid maize	23	8	3	2	–	–
Others	27	10	52	34	–	–
Not applicable	35	12	–	–	–	–
Total	283	100	151	100	5	100

Other crops that provide income are groundnuts, chillies, cassava, potatoes, cowpeas, pigeon peas, finger millet, sorghum, sugarcane, chickpeas, bananas, tomatoes, and garden peas. Apart from crop husbandry, farmers in this area also keep animals such as cattle, goats, chickens, doves, guinea pigs, rabbits, ducks, and bees. The area is within the Blantyre milkshed and has about 203 dairy farmers who produce about 13,000 litres of milk per month on average.

The land situation among smallholder farmers in Matapwata

Landholdings in the country are generally small. Malawi is one of the most densely populated countries in Africa and this couples with the fact that the majority of the people are in the rural areas engaged in agriculture puts a lot of pressure on land. The 1980/81 National Sample Survey of Agriculture estimated that at national level, the mean landholding size per household was 1.17ha. This was a drop from the average size of 1.54ha in 1968/69. Amongst all ADDs in the country, Blantyre ADD has the lowest average landholding size of 0.88ha.

Historically, most land in Matapwata area was owned by a European settler who had a tobacco and a tea estate. After attaining independence in 1964 government bought this land and through the District Commissioner distributed it to the people. It is, therefore, not surprising that unlike in other areas, chiefs in this area are not as important or a prominent source of land for households.

The number of bean varieties grown

Farmers in this area plant a number of bean varieties (components) on a single farm as shown in Table 53 below.

Table 53. Number of components planted on a single farm

Components	Households		Cumulative
	No.	%	%
1	77	27	27
2	124	44	71
3	47	17	88
4	25	9	97
5	6	2	99
6	3	1	100
Total	282	100	100

The average number of components grown per farm is 2.17. Other surveys in Northern and Central Regions have indicated that number of components grown on a single farm range from 5 to 21. Farmers who grew three components or less said they did so due to lack of seed. The farmers who grew more than three components indicated that the intention was to avert failure of the new components and also due to differences in taste. Most farmers will choose components because of their preceived attributes. For instance, one component may be liked because it cooks fast yet it is nor high-yielding. Kachitosi (chicken droppings), for instance, may be favoured because it is high-yielding yet it has poor culinary qualities. Table 54 shows reasons for preference for various bean varieties in Matapwata EPA.

Table 54. Reasons for preferring some varieties.

Reason	Household head					
	Male		Female		Total	
	No.	%	No.	%	No.	%
Tastes good	50	27	30	32	80	28
Cooks fast	36	19	20	21	56	20
Highly marketable	34	18	10	10	44	15
High yielding	22	12	11	12	33	12
Early maturity	8	4	8	8	16	6
Others	37	20	16	17	53	19
Total	187	100	95	100	282	100

More male-headed households (18%) favoured highly marketable as compared to female-headed households (10%). This suggests that more male-headed households are involved in selling beans than are female-headed households. Fifty-one percent of the male-headed households indicated that they sell most of their beans as compared to 44% for female-headed households. On the other hand, 43% of the female-headed households indicated that they eat most of their beans as compared to 33% of the male headed households. It seems, therefore, that more female-headed households give the nutritional needs of their household. Sixty-seven percent of the respondents indicated that they sell beans as dry beans. Consumption at household level, however, revealed a different picture. Only 11% of the respondents consumed beans in their dry seed form (Tables 55 and 56 below). Many people ate fresh shelled or snap beans. A small fraction (12%) consumed fresh leaves.

Table 55. Form in which most of the beans are sold

Form	Household head					
	Male		Female		Total	
	No.	%	No.	%	No.	%
Dry beans	124	68	82	65	206	67
Fresh beans	15	8	13	10	28	9
Snap beans	9	5	10	8	19	6
Leaves	5	3	5	4	10	3
Do not know	1	-	2	2	3	1
Not applicable	29	16	14	11	43	14
Total	183	100	126	100	309	100

Table 56. Form in which most beans are consumed

Form	Household head					
	Male		Female		Total	
	No.	%	No.	%	NO.	%
Dry beans	252	45	96	33	348	41
Fresh beans	177	31	92	32	269	32
Snap beans	99	18	65	23	164	19
Leaves	33	6	35	12	68	8
Total	561	100	288	100	849	100

The number of households selling bean leaves is less than the number of households consuming the same. People in this area, in contrast to those from other areas in Malawi, do not like to pluck leaves because the practice reduces yields. Households, therefore, just produce enough [illegible]. About 78% of the households sold their beans at the local market, Goliati. Some private traters buy directly from the farmers in the surrounding villages. Only 11% of the households indicated that they sell to ADMARC. Although only 4% indicated that they sell at city markets, it is likely that most of the beans sold at the local market, handled by entrepreneurs or ADMARC eventually find their way to towns and cities.

In this study the total number of components that farmers planted in the various farms was 13. Some of these were grown by very few farmers whereas others were grown by most farmers. Table 57 indicates those components that respondents liked the most.

Table 57. Components most liked in Matapwata EPA.

Component	Household					
	Male		Female		Total	
	No.	%	No.	%	No.	%
Chimbamba	89	47	49	52	138	49
Kaulesi	48	26	19	20	67	24
Nanyati	24	13	10	10	34	12
Kayera	9	5	2	2	8	3
Others	4	2	4	4	8	3
No preference	13	7	11	12	24	8
Total	187	100	95	100	282	100

Chimbamba = large red-kidney (determinate)

Kaulesi = medium khakhi with purple sparkles (climber)

Nanyati = large creamish with brown spots (climber)

Kayera = large white-kidney (determinate)

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RECOMENDATIONS FOR BEAN PRODUCTION IN MALAWI

1. INTRODUCTION

A. IMPORTANCE

The common beans, *Phaseolus vulgaris* L., also known by various names as dry beans, kidney beans, ration beans, sugar beans, french beans, haricot beans, garden beans, snap beans, string beans, bush beans, pole beans or *nyemba*, are one of the most important food grain legume crops in Malawi being second only to groundnuts in total production among the grain legume crops.

As food, beans provide high percentage of protein compared with maize, rice or cassava. Green pods and green shelled seeds are also good sources of vitamins A and C. In addition to the protein supply, beans are also a good source of energy providing comparable values of calories of maize flour, milled rice or cassava flour. They provide about 1.5 to 4.5 times more energy than bread and potato (*Solanum tuberosum*), respectively. In addition to providing subsistence needs, surplus beans can be sold because there is high demand for domestic use and there is good export market for it .

B. UTILIZATION

The beans most commonly eaten in Malawi are the dry beans. These are the red, white, speckled or tan large seeded (40-50 grams/100 seeds); kidney shaped seeds, which after cooking look like small chunks of meat, are preferred. There are several ways of preparing bean dishes in Malawi. The commonest one in home, boarding schools, colleges, farming estates and most institutions where a large number of people are fed communally, is to soak the seeds in water for a few hours and discarding the water afterwards. The purpose of soaking is to accelerate cooking, and secondarily to reduce flatulence (generation of gas in the digestive system). Salt, pepper, cooking oil, tomato and other ingredients may be added according to taste to the bean mixture and cooked. This "ndiwo" is served with ufa or rice. The seed coat is sometimes removed after soaking, and the beans are boiled till soft. They are mashed with a special stick or laddle to form "chipere". Beans are also boiled together with maize from which the pericarp has been removed to produce a popular dish called "ngata". Beans are cooked with bananas to produce a dish known as "mbaranga". Beans may also be cooked in the pods, "makata", and eaten with no accompanying porridge. Bean flour is also a constituent of

"Likuni phala" which is used for weaning children and for children under five.

The green immature pods, "zitheba", are commonly eaten as relish. Young and tender leaves are also boiled, and groundnut flour may be added to taste ("khwanya"). Any 'surplus' leaves are dried and stored for future use as "mfutso". In areas where bean production is low or at the time of the year when the supply is low, beans, cowpeas (*Vigna unguiculata* L.) and pigeon peas (*Cajanus cajan* L.) can be cooked together either for the bean flavor and/or to stretch their supply. Other bean dishes are: baked brown beans with bacon joint, brown beans in oil, beans flitters, fried bean balls and mock meat loaf.

C. TYPES OF BEANS

1. Growth habit

On the basis of growth habit, beans are divided into:
a. dwarf, bush or determinate:
b. semi-climbing, indeterminate;
c. climbing, indeterminate.

The dwarf varieties are short, erect with about 10 nodes and do not need support when planted. The main stem terminates in an inflorescence. Maturity is about 90-100 days after planting.

The semi-climbing varieties have their main stem longer than their branches. They are weak climbers and can grow longer than the dwarf. The climbing varieties are the commonest types in Malawi where they are grown in mixed stand with cereals, notably maize. These varieties have relatively long thin stems with long internodes , few branches. Because of their weak stem, they normally grown with support, a cereal, so as to increase seed yield and quality. Because the support or stake exposes the leaves to better to better light utilization and the pods are raised above the ground to reduce spoilage from microbial growth.

Unlike the dwarf, the last node is vegetative and growth period for the crop can last up to 120 days.

2. USES:

Beans can also be classified into types based on uses. These are :
A. dry beans
B. canning beans
C. seed

Dry beans are the commonest type in Malawi. These are medium-to-large sized kidney , round, oval, or oblong shaped beans which range in colour from red or white to speckled.

They are usually harvested when the pods are fully dry; the dry seeds are cooked. The pods are parchment (fibrous) and dehisce on both seems when dry. The second type is canning beans. These are white and roundish in shape and are grown for their dry seed which are canned. Because of the stringent seed quality requirements, especially for colour and splits production under irrigation is prefer to rain-fed crop. ADMARC's canning factory, Mulanje peak, cans these beans in tomato sauce.

The third type, seed beans , also known as french beans are usually eaten green because their pods are tender. The pods do not split open when dry and has thick fleshy pods when green with relatively small seeds. Sometimes seed beans can be canned. At the moment the production of seed beans is aimed at producing seeds for export so that the seeds can be grown for green beans overseas.

2. RAIN-FED CROP

A. <u>LAND PREPARATION AND TYPE OF SEEDBED</u>

Beans can be planted on ridges 91cm apart or on flat. Land should be prepared before the rains since it might be difficult to get into the field after the rains have started.

B. <u>VARIETIES</u>

1. <u>Dwarf (bush or determinate) varieties</u>

a.	Nasaka (253/1)	- tan seed coat colour kidney-shaped.
b.	Bwenzilawana (373)	- yellow seed coat, roundish.
c.	Kamtsilo(499/1)	- blue seed coat colour kidney-shaped.
d	Sapelekedwa (600/1)	- red seed coat colour, kidney-shaped.

2. Climbing (pole or indeterminate) varieties

The national seed compony of Malawi Limited also sells the following varieties:

a. Kanzama (97/1) - red seed coat colour, roundish.
b. Namajengo (336) - red seed coat colour, roundish.

The above varieties can be purchased from ADMARC in Karonga ADD, Mzuzu ADD, Kasungu ADD, Lilongwe ADD, and Blantyre ADD. They can also be purchased from other seed dealers.

C. SEED RATE

1. Dwarf varieties
80-90 kg/ha

2. Climbing varieties
75-90 kg/ha

D. TIME OF PLANTING

Plant at such a time that the beans mature in dry weather. The dwarf and climbing beans take about 90-100 and 100-110 days, respectively, to mature. Suggested time of planting for the Southern Region is about late December to mid-January while in the Central Region, about early January to late January.

E. FERTILIZERS.

In the absence of soil test results the following can be used:

1. TYPE
Use compound fertilizer 20-20-0 (N-P205-K20) Beans fix very little amount of nitrogen hence nitrogen is needed for reasonable yields.

2. RATE

Apply 200-300 kg/ha of 20-20-0 or 23:21:0

3. METHOD OF APPLICATION

Band fertilizer in a groove on ridges and plant about 10cm away from the band. If planted on the flat, band on flat and plant 10cm also from the fertilizer band.

4. TIME OF APPLICATION
Just before planting. Only the basal application is needed because beans are a short seasoned crop and it is not economical to side dress with nitrogen execept perhaps under irrigation.

F. **PLANT POPULATION AND SPACING**

1. DWARF BEANS

a. Ridges

Plant about 222,000 plants/ha. This is achieved by planting two rows of beans on ridges which are made 91cm apart.The distance between the row should be about 30cm apart. The fertilizer is banded between both rows and coverd. The distance between plants within each row is 10cm. Plant one seed per station. Fill gaps (supply) within one week after emergence.

b. Flat

The same population as for ridges. However, the seed should be planted in rows 45cm apart. The distance between plants within the row should be 5cm apart. If it is machine planted, the planter should be calibrated to deliver about one seed every 5cm. The seed row should be about 10cm from the fertilizer band.

2. **CLIMBING BEANS**

a. Ridges

Plant population is about 73,000 plants/ha. This can be achieved by planting on ridges 91cm apart and 15cm between plants on the ridge. Plant single row per ridge.After applying fertilizer on the ridge,it is covered and seeds are planted on top of the ridge over fertilizer band. It is, therefore,essential to ensure that the fertilizer is at least 5-7cm below the seed.

b. Flat

Plant in rows randing from 60cm to 91cm apart. The choice depending on the tractor drawn implement avalabie.Closer distance between rows are prefered since they yield more and control weeds more effecietly because plants grow and cover the distance between rows much more rapidly. The distance between plants within rows can be adjusted to achieve a plant population ranging from 73,000 to 111,000 plants/ha.

C. SUPPORT FOR CLIMBING BEANS

This is not economic on a commercial scale although results have shown that both seed yield and quality are reduced by as much as 50% when climbing bean plants are not provided with support. The reduction in seed yield of unstaked bean is becauce of poor leaf exposure to sunlight Poor seed quality is attributed to pods resting on the soil where water and soil splashing on them increase microbial growth on and inside the pod and the seed.

H. DISEASES

The commonest bean disease in Malawi is halo blight, a bacterial disease. This can be controlled by spraying with a fungicide called copper oxychloride. The chemical is available from shell chemical in Blantyre and Lilongwe.

The chemical should be sprayed at the rate of 4.5g of commercial product per one litre of water and sprayed on the crop to run off.Effective control is achieved by spraying at two weekly intervals. Anthracnose, Angular leafspot, and web blight are other diseases.These can be conrolled by the use of daconil at 3.5g of commercial products in one litre of water.Spray to run off at two-weekly intervals.

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Spray to run off at two weekly intervals.

I. INSECT PESTS

Most insect pests are leaf beetles. Use dipterex 95% S.P. at the rate of 1.5g of commercial product per one of water and spray as needed.

J. WEED CONTROL

1. Hand weeding (with hoe)

Weed two to three times depending upon the weed situation. No banking after pod set because this raises the height of the ridge bringing the soil too close to the pod or even at times touching the pod resulting in low quality seeds.

2. CHEMICAL WEED CONTROL

Use Lasso or dual at three litres of commercial product per hectare.

NOTE:

Trial have shown that weed control during the first 30 days or so is very ciucial in bean production.Delay in weed control until after this time seems to be a waste of time since yield reduction from weed competition after this time cannot be compensated for from the late weeding.

Harvest in mid-morning.Pods harversting too early in the morning are rather wet from dew and may rot if not properly dried. If harversting is too late in the day,the pods dehisce (split open) easily resulting in low yield from seed loss. The seeds are difficult to pick after the pods have shattered.

L. SHELLING

Seeds meant for planting are better shelled by hand so as to prevent splitting when the pod are hit or flogged with sticks. Seed resulting from such shelling procedure usually have cracked coats, and sometimes split cotyledon that lead to loss of seed viability.

Seed meant for food can be shelled mechanically with an appropriate sheller driven by tractor or manually operated. When shelling is by hand or with a sheller, shelling is simplified by first of all drying the pods in the sun. Pods so treated split open quite thus increasing the rate of shelling.

M. STORAGE

Beans are easily attacked by weevils even before they are harvested especially if harvesting is delayed.Therefore, proper storage after shelling is rather important. Use actellic dust at the rate of 115-120g per 100kg of clean and sorted seeds. For small quantity meant for seed (planting) beans can be stored in ash, tobacco dust or use cooking oil such as covo (if there is enough to spare from cooking). Rub the oil on the seed thoroughly using about 200-250 cc per 100kg of seed.

N. MIXED CROPPING BEANS WITH MAIZE

Mixed cropping, which is the system of growing 2 or more crops on the same piece of land during the same cropping season,is the commonest system of growing beans in Malawi especially by the small farmer who produces the bulk of the crop in the country. This system is characterised by intensive land use and maximization of scarce resources. It is not a primitive or a haphazard system as it was once thought; rather the agronomic management of crops grown in mixed stand is much more complex than that of a monocrop.Farmers over the years have realised that while the yield of a minor crop in the mixture might be reduced.The total seed yield of all crops are usually greater than when the crops had been grown in pure stand. This may explain why this cropping system is still so popular among the smallholders despite the fact that research has concentrated efforts on the growing of crops in pure rather than in mixed stands.

1. Dwarf beans

Dwarf beans can be planted on the same ridge with maize. If maize is planted on ridges which are 91cm apart and there are three maize plants per station where the stations are 91cm apart; it is possible to plant two bean rows on the same ridge as the maize. The planting population, the spacing and the arrangement is the same as described above for a pure crop of beans. Where maize has been planted on the flat, it is possible to plant beans in between the two rows of maize. Here beans should be planted about 5-6m apart in a single row between two maize rows.

2. Climbing beans

These can also be planted on the same ridge a maize. If there are three maize plants/station, plant four to six bean seed on the same station as the maize crop. This is designed to ensure that the beans can be trained on the maize plants.

If maize are planted at one plant per station, plant two to three bean seeds on the same station as the maize plant. Again, the beans should be trained on the maize plant. You will note that we are fewer bean plants/station than would be expected. The reason is that increase plant competition and therefore reduce maize yield.

In planting either dwarf of climbing beans with maize on the same ridge, no additional fertilizer is needed for the bean crop. Both crops use the same type; and the rate of fertilizer, no additional land is required.

Also note that the bean yield when planted together with maize will be about 15-50% lower than would be expected when beans are grown as a pure crop. This should be borne in mind. However, as long as the yield of maize remains the same the bean is a bonus crop.

O. PLANTING BEANS AFTER TOBACCO

In areas where flue-cured or burley tobacco is dry planted early, it is possible to grow a crop of dwarf beans after the tobacco stems have been uprooted,provided there will be enough rainfall for a reasonable yield of a bean crop.Where the basal fertilizer has been banded for the tobacco crop, the ridges on which the tobacco were growing can be built up and beans planted as described above for a pure stand of dwarf beans.There may be no need to apply additional fertilizer.

Where fertilizer has been localized,i.e. where the fertilizer has been applied using dollop method both for the basal and the side dressing of nitrogen, then plant the beans on the same station as where the tobacco plant was.Of course, it will be necessary to loosen the soil around the station and weed the entire field before planting.In this situation about 4-5 bean seeds can be planted per station about 45-55cm apart depending upon the type of tobacco. It should be noted, however, that there might be nematode attacking the bean crop following the tobacco crop.The degree to which the bean yield will be reduced by such a double cropping system is being investigated.

Excepting in areas where there is prolonged rainfall or where the planting is after tobacco since climbing beans take longer time to mature than the dwarf type with respect to the quality of seeds, observation have shown that higher quality seeds are produced after a tobacco crop matures under drier weather and less disease resulting from water and soil splashing on pods.

III. ON RESIDUAL MOISTURE ON IRRIGATION SCHEMES

There are about 16 irrigated settlement schemes in Malawi occupying about 4147 hectares; and there is further planned expansion of 64,000 hectares. Some of these schemes have no facilities or irrigation during the dry season and so only one crop of rice is produced. Results of trials have shown that beans can be grown on some of these schemes successfully on residual moisture. Below are tentative recommendations for growing beans as a rotational crop under residual moisture between two rice crops.

A. LAND PREPARATION

This seems to be the most crucial aspect of growing beans on residual moisture. After rice harvest, the land should be ploughed or dug up with hoe and soil clods broken into a good seedbed. The land should be allowed to "rest" for about 7-10 days before planting. At this time moisture content will not be too high for seed germination. Plant on flat.

B. VARIETIES

The varieties recommended for rain-fed crop can also be used. If planting is late, only the dwarf varieties that have a shorther growing period should be planted.

C. SEED RATE

1. Dwarf varieties

   40-50 Kg/ha

2. Climbing varieties

   33-45 Kg/ha

This seed rate is half what is recomended for rainfed crop because there is need to reduce competition for moisture.

D. PLANTING TIME

Plant at such a time that bean crop can be harvested before it is time to prepare land for the subsequent rice crop. Anytime from the middle of the of May to the middle of June is recommended.

E. FERTILIZER

In the absence of soil test results, the following recommendations can be used.

1. Type Used 20-20-0 or 23:21:0 (N:P2O5:K2O) Beans are poor nitrogen fixers and so may not meet their own nitrogen needs from fixation.

2. Rate 200-300 Kg/ha

3. Method of application

   Band fertilizers in grooves and plant about 10cm away from the fertilizer band.

4. Time of application
   Apply before or at planting.

F. PLANT POPULATION AND SPACING

1. Dwarf beans

Plant on flat with rows 45cm apart at 20cm between plants on the row. This will give about 111,000 plants/ha which is about half what is recommended for rain-fed crop. The reduction in the plant population to reduce competition for moisture.

2. Climbing beans

Plant on flat with rows 45cm apart and at 30cm between plants on the row. The population is half that which is recommended for rain-fed crop because there is need to avoid competition for moisture.

G. DISEASE

The recommendations are as for rain-fed crop. It must be noted that the incedence of disease is very much reduced when beans are planted on residual moisture. This is probably because there is no water splashing the soil on to the plant.

H. INSECT PESTS

The most troublesome pests of beans under irrigation are aphids. Aphids can be controlled by spraying one of the following insecticides:

1. Rogor 40% EC at 1.2ml/litre of water
2. Diazinon 60% EC at 0.8ml/litre of water
3. Malathion 50% EC at 1.9ml/litre of water
4. Menazon 70% WP at 1.0g/litre of water

I. WEED CONTROL

Recommendation are as for rain -fed crop.

J. HARVEST, SHELLING AND STORAGE

Recommendation are as for rain-fed crop.

K. MIXED CROPPING

The growing of maize and beans on residual moisture is feasible provided the growing period of maize crop does not interfer with rice production. Where maize and beans can be grown in association, recommendations for rain-fed crop should be used.

L. SEED QUALITY

Experiments have shown that higher quality seeds are obtained from seeds produced under irrigation (residual moisture) than rain-fed crop. The difference in quality is attributed to the absence of water splashing soil and pathogen on the crop and the relatively cooler condition under which the crop is grown where disease spread is much reduced.

IV. IRRIGATED CROP

Bean crop is not irrigated in Malawi. The crop is normally grown under rain-fed condition and recently attempts have been made to grow it under residual moisture following a rice crop. However, because of the need to diversify crop production, beans may serve as a short seasoned "wintered" rotational crop between the two rice crops. Efforts were made a few years ago to encourage small-holders to grow beans under irrigation at the British Irrigated Rice Project now Dwangwa Sugar Corporation.

Results of experiments conducted at Bunda college, Kasinthula Agricultural Research Station, Makhanga Agricultural Reseanch Station and at Domasi show promising results but water management is still a problem.

A. LAND PREPARATION

The rice crop during the normal cropping season should be ploughed or dug up with hoes about the end of April to the middle of May when the rice crop has been harvested.

Beans can be planted on ridges, beds or on flat depending on the irrigation facilities, soil type and planting technique. If flood irrigation is used, ridges should be 60-91 apart, preferably 91cm apart. Ridges closer than 60cm increase lodging problem because of erosion. If sprinkler irrigation will be used, planting can be done on flat with 45cm between rows. On medium textured beans can be grown on corrugated ridges.

B. VARIETIES

See recommended dwarf varieties under irrigation. Climbers are not recommended because of reduction of yield and quality since the pods will be resting on wet soil.

C. SEED RATE

100-120 KG/HA

The above recommendations are for the dwarf varieties listed above. The seed rate is higher under irrigation than under rain-fed condition because by increasing the seed rate, plant population can be increased to take advantage of the available moisture and hence increase seed yield.

3. Rust

Bean rust is caused by a fungus Uromyces appendiculatus. This usually infect leaves and pods and hardly stems. Symptoms white slightly raised spot. These spots later develop as brown raised pustules with a ring of yellow leaf around the pustules. Later the entire leaf may turn yellow, than brown and falls off from the plant. Canning bean varieties are more susceptible than most dry bean varieties.

Rust can be controlled by dusting plants at 7-10 days interval with sulphur. Daconil, Dithane M-22, Maneb, Plantvax or Manconeb can be used.

The fungus is not seed-borne so. chemical seed control has no value. Cultural control measures include the use of crop rotation and removal of infected plannt material from field, reduce infection especially during pre-flowering to flowering stages of crops development.

4. Anthracnose

This is caused by a fungus Collectotrichum lindemuthianum. The organism can infect leaves, pops and stems. Leaf symptoms are usually brown lesions along veins and veinlets which are more conspicuous on the lower than the upper leaf surface. Pods infection are sunken lesions brown to black in colour. Chemical control include the use of Du-Ter, Zineb, Maneb and benomyl. Cultural control measures include two or three years crop rotation, the removal of infected debris and the use of resistant varieties.

5. Halo Blight

see section on rain -fed crop.

1. Insects

1. cut worms

These attack the crop erratically and hence difficult to predict. Control measures include the use of baits which are applied in the late afternoon near the plant.Use bait in the mixture of:

1,000 grmmes of saw dust or maize flour
120 cc of molasses or substitute
40 grammes of trichlorfon
The above bait is also effective against crickets and millipedes.

D. TIME OF PLANTING

The crop should be planted between mid May and mid-June along the lakeshore and areas of similar weather; or even as late as the end of July in the plateau areas where temperatures are still low even at the end of July. It should be noted that canning beans are much more sensitive to low temperature than dry beans. This should be considered when deciding the time to plant the canning beans.

E. FERTILIZER

It is advisable to test soils before applying fertilizer. However, where this is not possible. General recommendations is given below.

1. TYPES

20-20-0 (N-P2O5-K2O) Plus Sulphate of Ammonia.

2. RATES

Use 300-400 kg/ha of 20-20-0 (N-P205-K2O) plus 150-200kg/ha of sulphate of ammonia

Higher rates are recommended for beans under irrigated than under rain-fed crop because under the latter condition the use of water is controlled with respect to timing and amount to the use and the need to exploit the availability of water in order to increase seed yield.

F. PLANT POPULATION AND SPACING

1. Ridges

Plant about 222,000 300-000 plant /ha.This is achieved by planting two rows per ridge.The top of the ridge is flattened hand in between both rows. The distance between plants is about 10cm and 7.5cm.Plant one seed per station. Fill gaps within seven days from emergence.

The planting of beans on water line is not recommeded because with flood irrigation, most of the soil erodes.The results in serious lodging problems with pods in mud and water in the furrow.

2. Flat

The same population as for ridges. However, seeds should be planted on rows 45cm apart with spacing of 3.5 to 5.0cm between plants in row. Plant one seed per station. Fill gaps (supply) within seven days after emergence. If the crop is machine planted, calibrate planter to deliver one seed every 3.5 to 5.0cm.

G. **WATER MANAGEMENT**

1. General aspects

Water management i.e. when and how much water to apply is one of the most important aspects of bean production under irrigation. The field where flood irrigation is used should be furrowed uniformily so that water will not stand in the furrows and they should be deep enough to prevent flooding and to keep pods out of the water. The bean plant is relatively shallow-rooted and has an effective depth of water withdrawal of about 91cm. It is, therefore, essential that planting should start with a full moisture profile.

Two to three days before planting, fields should be irrigated with about 100mm of water. This is known as "pre-planting irrigation". This is to ensure that there is to not too much water around the seed at planting and seeding emergence as beans cannot withstand "wet feet". The first irrigation after the pre-planting one should be applied before the plants are under moisture stress. Too liberal and frequent irrigation result in excessive vegetative growth and yield reduction. Proper irrigation management, therefore, is to irrigate infrequently.

2. Amount frequency

The number of irrigations and the amount of water needed at each irrigation depend partly on the season, and the type and depth of soil and partly on the amount of organic matter in the soil and the slope of the land. It has been shown that the ratio of evapotranspiration to open-pan evaporation (Et/Eo) over the life of the crop is 0.72 with an Et/Eo ratio of 0.91 about three weeks from planting which coincides with the period of maximum ground cover. Where evaporation pan is available, irrigation frequency and rate should be based on Et/Eo factors.

In the absence of information on the consumptive water use, it is recommended to irrigate four times in addition to the pre-planting irrigation of 100mm with 50-65mm each time as follows:

Pre-planting,
Two to three weeks after planting,
Begining of flowering or just before flowring,
Begining of pod filling, and
Begining of pod maturation.

The pre-planting irrigation is to ensure that the plant starts with a full moisture profile for rapid and uniform emergence. Irrigation at two to three weeks after planting is for adequete development before flowering. Irrigation at the begining of flowering or just before flowering increases the number of pods/plant. A good supply of water at the beginning of of pod fill increases the number of seeds/pod and seed weight. The last irrigation is intended to hasten the filling and maturity of the last pods that were set.

Excessive applications waste water and in some places may cause excessive vegetative growth, production of secondary set of flowers that may produce very small or sometimes seedless pods delay maturity and reduce seed yield. At each irrigation time, water should be allowed to run only as long as is necessary to wet the soil to capacity in yhe root zone. In fields of long ridges and where there is not much slope crops ridges should be made at convinient intervals.Otherwise the upper end is likely to be flooded before the lower end is wet enough.

3. Time of irrigation

a. Flood irrigation

No definite time. Irrigation can be done to fit with normal farm operations. However, irrigating too early in the morning or too late in the evening will lower soil temperature which could slow the rate of crop's growth and developement. Higher seed quality are produced underfllod than sprinkler because of the spread of disease spread with the latter.

b. Sprinkler irrigation

The use of sprinkler irrigation has been reported to increase the spread of diseases by droplet splash. One alternative of overcoming the problem of disease spread resulting from the use of sprinkler is to irrigate at night if this can be fitted into the normal farming operation. Leaves are normally wet at night from dew and once the leaves are allowed to dry during the day, the risk of disease spread can be reduced.Irrigation at night might seem to contradict the reason for not irrigating early in the morning or late in the evening in the case of flood irrigation. The time of sprinkler irrigation is based, therefore, on a choice between disease spread and reduce growth rate which may prolong the duration of crop's growth without necessarily causing reduction in seed yield and quality.

H. DISEASES

1. Rhizoctonia root rot

1. Rhizoctonia root rot is caused by a fungus *Rhizoctonia solani*. The symptoms of the disease are red lesions on the lower part of the stem and the roots. The plant becomes chlorotic and stunted. The pathogen can be transmitted through irrigation water, aerially disseminated sclerotia or spores, and infected seeds. The fungus may be internally or externally seed borne.Control measures include the use of fungicides such as benomyl, thiram, zineb, captan, vitavax or busan. The use of cultural control measures include crop rotation by planting beans after maize, wheat or oats. Avoidance of excessive moisture can also reduce infection and spread.

2. Southern blight

Southern blight also know as crow root or sclerotium root rot is caused by a fungus *Sclerotium rolfsii*. Plant symptoms appear as dark-brown water soaked lessions on the stem or hypocotyl just below the soil line. Foliage symptoms consist of yellowing of leaves and defoliation in the upper branch leaves. Pods that touch soil may become infected and rot.

Control with chemicals include the use of PCNB (pentachloronitrobenzene) difolatan 4F, or Captafol. Cultural practices that can reduce southern blight include the use of disease resistant varieties, wide plant spacing or to follow maize or sorghum with beans.

2. Bean fly

Bean fly or bean stem maggot is caused by three species of *Ophiomyia*. This is the major pest of beans in Malawi and heavy infestation can result in complete loss of the crop.

Damage by bean fly is caused by the larvae which tunnel within the plant tissue.This begins in the leaves then extends down the mid rub and into the stem. The larvae pupate on the stem at ground level with black to brown colour cigar-shaped pupae. These invade the vascular bundle and causing demage which restrict nutrient and photosynthate translocation.Susceptible plant's leaves turn yellow and plant dies, resistant plants produce aerial roots above the would.Chemical control methods include the use of aldrin 40% WP at the rate of 28 grammes of commercial product per 405 Kilogrammes of seed as dust.

3.Wire grubs

These are a problem especially if beans are grown after a pasture crop.

Chemical control include the use of Carbofuran. land preparation is a cultural control method.

J. ENVIRONMENTAL DISORDES

1. LOW TEMPERATURE

Beans, especially canning bean varieties, are rather sensitive to low soil temperatures (10-15C).Leaves of susceptible seedlings turn yellow and fall off before the first trifoliate leaves emerge.

Susceptible cultivars should be planted when the soil temperature is higher than 15C.

2. SUN SCALD

Sun scald or light injury may affect leaves,stems or pods.This condition is caused by intense by heat followed by high humidty and cloudy weather. There also appear to be some association with heavy application of fertilizer.

Affected plant parts show lesions which can be mistaken for bacterial blight. But such lesions have no bacterial exudates. There are no resistant varieties.

39309

FOOD LEGUME IMPROVEMENT PROJECT

BEANS (*Phaseolus vulgaris* L.)

A PROPOSAL PREPARED BY:

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PREPARED FOR SUBMISSION TO:

The Rockefeller Foundation
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BEAN PROJECT PROPOSAL

1. OVERALL OBJECTIVE

The national objective is to achieve potential yields of all grain legumes including beans (MOA, 1988/89). Operational objectives as laid down by the ministry are:- a). to promote the bulking of improved seed; b). to promote mixed cropping in all areas; c). to encourage pure stands where land is sufficient; d). to encourage farmers to keep enough supplies for consumption; e). to promote double and/or relay cropping in areas with a long growing season; and f). to promote recommended cultural practices. The specific objectives of this proposal are:-

a). To initiate and develop a comprehensive seed multiplication and distribution scheme in Malawi;
b). To generate information about performance and acceptability of improved bean varieties under on-farm conditions using minus-one designs; and to increase farmers' awareness of the improved bean varieties by use of demonstration plots;
c). To develop fertilizer recommendations under maize/bean intercropping systems;
d). To expand areas of bean production by introducing heat tolerant bean genotypes into Lower Shire and Lakeshore areas of Malawi;
e). To screen bean accessions for tolerance to Beanfly and Bean beetle under field conditions and Bruchid under storage conditions and also to screen for resistance to Anthracnose and Angular leafspot diseases of beans to determine cheaper avenues to intervention in an integrated pest management program; and
f). To support operational costs of the National Bean Programme.

2. REVIEW OF BEAN RESEARCH AND PRODUCTION IN MALAWI

In Malawi beans (*Phaseolus vulgaris* L.) are an important food legume because they form the basis of the protein component of diets inasmuch as they are commonly consumed with *nsima*. Beans are also the commonest crop found growing with maize (*Zea mays* L.), sorghum (*Sorghum bicolor* L.), and cassava (*Manihot utilissima* L.). Research on beans in Malawi is the mandate of the National Bean Programme located in the Crop Production Department of Bunda College of Agriculture within the University of Malawi. This National Bean Programme was initiated in 1969 with two objectives, viz: a). To produce varieties that are high yielding, disease resistant, insect pest tolerant and acceptable to consumers, and b). To conduct trials both under rainfed and irrigated conditions so as to provide recommendations for the production of beans. During that first year local bean types were collected from all parts of the country. This formed the basis of our National Bean Germplasm as the source of materials for breeding programmes. The Research and Publications Committee of the University provided some limited funding to the National Bean Programme. Results of the first decade of the programme included: a). Germplasm evaluation and the release of six varieties, viz: Nasaka (253/1), Sapelekedwa (600/1), Bwenzilawana (373), Kamtsilo (499/1), Kanzama (97/1), and Namajengo (336). The first four are dwarf and the last two are of climbing growth habit. These were released to the National Seed Company of Malawi (NSCM) in 1979 for multiplication and marketing.

Other results culminated in the following recommendations: a). Beans should be planted at such a time that they are harvested at the beginning of the dry season; b). Beans should be planted on ridges spaced 0.9 m apart in two rows (20-30 cm apart) per ridge and 10 cm apart along the row to achieve optimum plant populations; c). Fertilizer mixture 20:20:0 should be applied at a rate of 200-300 kg/ha depending on the nutrient status of the soil.

However, the Research and Publications Committee could no longer support this on-going research. Fortunately, in 1982 our National Bean Programme joined hands with Michigan State University on a Bean/Cowpea Collaborative Research Support Project. The first phase of this project aimed at quantifying the genetic diversity that currently exists in the Malawian bean germplasm, its generation, and how it is maintained either biologically or socio-economically. During 1983 a new bean collection was conducted. Now there are about 4,000 accessions in the germplasm bank at Bunda. Experiments showed that genetic diversity was large between locations than within farms although bean colours, shapes or sizes may have differed (Martin and Adams, 1987a). And the small amount of outcrossing (10%) that occurs in bean populations generated a myriad of bean types that had varying colours, shapes, and sizes (Martin and Adams, 1987b). Socio-economic data suggested that deliberate mixing by farmers occurs as an insurance policy against changing ecological (and maybe biological) variables in the field and in storage and cooking quality and culinary attributes (Ferguson, 1987; Barnes-McConnell, 1989). Other results indicated that bean mixtures have more yield stability than most pure genotypes (Ayeh, 1988).

In 1988 the Bean/Cowpea CRSP Project was extended for another three (3) years. The new and second phase of the project is aimed at helping Malawi develop improved varieties. Support is given to germplasm evaluation for physical and biological stresses and constraints. This project also aims at understanding the co-existence of disease pathogens of Anthracnose (Colletotrichum lindemuthianum) and Angular leafspot (Phaeisariopsis griseola) within either the small- and large-seeded bean types or mixtures of these. This will help both the U.S. and Malawi formulate a strategy for development of disease-resistant bean varieties.

Smallscale agricultural production has been the mainstay of the Malawian economy over the past, as evidenced by its approx. 50% contribution to GDP in 1985 (EPD, 1986/87), and this may remain so for some years to come. Quantities of bean production are difficult to estimate because much of the crop is consumed on-farm. However, apart from groundnut, which is regarded as a cash legume crop, beans provide the country with some foreign exchange which in 1983 was estimated MK million 9.643 (NSO, 1986). ADMARC are the major exporter of both dry and baked beans whereas Rab Processors and Sales Services also participate in exporting dry beans. Total production of pulses was estimated at 60,806 tonnes in 1988 (The Smallholder Crop Estimates Committee). In that year about 7,600 tonnes worth about MK million 3.2 of pulses were purchased by ADMARC (ADMARC, 1989). In 1982/83 an estimated 114,000 ha was used for bean production as compared to 135,000 ha for groundnuts in that same season (Mwandemere, 1986).

3. GOVERNMENT STRATEGY

Since pulses are a cheap but important source of protein, government aims at increasing production for local consumption to improve nutritional status. The average yields of beans are 200 kg/ha and 600 kg/ha in intercropping and pure stands, respectively. The national aim is improvement of average yield to 1,500 kg/ha under pure stands and 500 kg/ha in intercropping. Yield improvement towards potential yield production can be achieved through improvement of varieties and use of recommended cultural practices. Government strategy includes exploitation of the potential of agroecologically suitable areas for various varieties and promotion of appropriate farming systems.

4. PRIOR OR ON-GOING ASSISTANCE

As a National Programme we are obligated to deal with national needs. Unfortunately, donors often fund initiatives that are of more importance to their national or regional needs which may sometimes be unrelated to the host country's needs. For the Food Legume Project we have identified areas of research that are currently not funded but they are vital to the establishment of a viable bean production system in

Malawi. The Title XII Bean/Cowpea CRSP Project supports evaluation of germplasm to strengthen varietal development. It also funds research on the co-existence of disease pathogens with large- or small-seed types. SADCC/CIAT Regional Bean Programme is providing limited support to the regional sub-projects on screening for drought tolerance, screening for Angular leafspot resistance, and screening for nitrogen fixation in beans. GIARA (Israel) is providing additional support in screening for drought tolerance in beans. SARCCUS is providing limited support for our participation in the Southern African Regional Bean Improvement Nurseries (SARBEIN). Funding requested for this proposal provides for consolidation of research efforts to better address problems of the Malawian smallscale farmer and this project will, therefore, play a central role in the Malawi National Bean Programme.

5. INSTITUTIONAL FRAMEWORK FOR BEAN INDUSTRY IN MALAWI

Beans have been under the smallscale agricultural production in Malawi for a little over 300 years. Most of the beans produced are landraces that have been adapted, after introduction mainly from the Andean centre of origin, by the Portuguese and the Spaniards, into what is now referred to as a centre of domestication (Eastern Africa). Unfortunately, active bean research in the country started only 20 years ago and during that time some of the local landraces were released as varieties. This was about ten years ago but those varieties can now hardly be found in farmers' fields. The main theme of this proposal is the question, 'Why has there been very little adoption of the varieties released ten years ago?' This proposal addresses areas that may eventually provide far-reaching solutions so that the released varieties can spread among bean farmers if not obtain information which will help prevent earlier problems as the Programme produces newer high yielding and disease and pest resistant varieties.

The small-scale farmer is responsible for bean production as well as its consumption and so will fully participate in the proposed on-farm research. Government personnel in close touch with the farmer are the Department of Agriculture (DOA) extensionists. This project will, therefore, form close liaison with that department in all its Agricultural Development Divisions. The National Bean Programme is part and parcel of the Department of Agricultural Research (DAR). As a result it will draw on expertise of the Seed Technology Unit, the Inspectorate, the Soil Laboratory and other services from the Adaptive Research Team, all of whom are within the Department.

6. PROJECT JUSTIFICATION

A. SEED MULTIPLICATION AND DISTRIBUTION

It has been mentioned elsewhere that the first varieties ever produced in Malawi were landrace selections which were released in 1979. These varieties have not been adequately adopted by farmers. One of the causes of lack of adoption is inaccessibilty to and lack of seed. Certainly, other factors will be elucidated by the On-Farm Research component of this proposal. The lack of seed could be due to the reluctance of the National Seed Company of Malawi to produce the seed of the six varieties due most likely to the unprofitable nature of such an undertaking. Beans are largely a self-pollinated crop and as such farmers maintain their seed from one year to another resulting in low market activity. Another factor is that such seed would be priced higher than farmers can afford. Again, seed companies are comfortable producing one, two or three varieties. Certainly, not one variety (e.g. Canadian Wonder, the only one produced by NSCM for export) would be good for the entire country.

In an attempt to overcome this problem we intend to initiate a seed multiplication and distribution scheme. This scheme will follow closely the Smallholder Seed Multiplication Scheme that was developed by the Ministry of Agriculture (Sibale and Mtambo, 1988). In such an undertaking the National Bean Programme will produce about five (5) tonnes of basic seed under irrigation at the Bunda College Farm during the dry season. Under such conditions disease-free seed is easily produced. The seed will be planted in June, 1990 and will be harvested in October,1990. During that time five farmers in each of the ADDs will be identified especially in the active bean growing areas of Chitipa, Rumphi, Mzimba, Dowa, Lilongwe, Dedza, Chiradzulu, Namwera, and Thyolo districts. After harvest in October/November the basic seed will be distributed to the ADDs during November/December starting with the Southern region going up northwards. Each district will receive 500kg of seed which will be divided among 5 farmers per district, i.e. each farmer will receive 100kg for multiplication. We wish to purchase back the seed on behalf of the ADDs at the prevailing price per kg of seed produced. For this we intend to establish a Seed Revolving Fund. The project may supply fertilizer if need be but its cost will finally be deducted from farmer revenues. In the second year we anticipate an increase in the number of participating farmers. As far as possible the ADDs will take charge of this system. The areas where these farmers will be growing the seed will act as nuclei for adoption and spread of the varieties. As a result we intend to use these as demontration plots for other farmers to come and familiarise themselves with our varieties. It is also intended that rural sociologists and socio-economists will base their studies on the nuclei formed across the country to monitor [illegible] adoption and the changing socio-economic status expected of both the nuclei farmers (multipliers of seed) and subsequent seed beneficiaries (the rest of the farmers growing the recommended varieties). Ferguson and Sprecher, 1989a and Ferguson and Sprecher, 1989b have developed a strategy based on our experience with beans in Malawi in the studies conducted by the Bean/Cowpea Project. This system will be tried in this project and it aims at improving the components of mixtures that farmers produce instead of producing a 'once for all variety' in traditional breeding. As a result we expect farmers to incorporate the improved varieties in the bean mixtures that they have kept all along.

B. CROPPING SYSTEMS

Palaniappan (1985) has defined cropping system as 'the yearly sequence and spatial arrangement of crops or of crops and fallow on a given area of a farm and their interaction with farm resources, other farm enterprises, and available technology which determine their make up.' Intercropping is a cropping system that has been variously described as the simultaneous growing of two or more crops in the same field during the same growing season (Willey, 1979).

Intercropping is the predominant cropping system in the tropical regions of the world (Willey, 1979). Maize is the staple food crop in most tropical countries apart from other cereal staples like sorghum, millets and rice in some countries. Farmers have traditionally produced the maize under various intercropping systems with other crops, notably food legumes. Beans are probably the predominant of the food legumes that are grown with the maize in Malawi and indeed in Africa and Latin America. In Malawi 94% of all cultivated hectarage was sown to mixtures of crops (Malawi Government, 1970). And 99% of all food legume production in Malawi was in various forms of intercropping with other crops, mostly maize. It is important to note that traditionally these systems were used virtually without the application of artificial fertilizers. In most developing countries food crops are grown in marginal areas, and Malawi being no exception, whereas cash crops are grown in the more fertile areas. With greater need for increased food production careful attention needs to be given to the nutrition of crops under traditional cropping systems.

The National Maize Improvement Programme at Chitedze Research Station is re-orienting itself towards production of more acceptable flint maize hybrid varieties. There is a need to start work on mineral nutrient uptake in maize and beans intercropping systems in marginal areas. There are presently no recommendations on fertilizer application in intercropping systems. This work will be the beginning of the development of recommendations in that regard. This is a prerequisite to production of new high yielding varieties of beans that are compatible with the upcoming maize varieties and we hope this will foster rapid acceptance of both crops. Intercropping trials investigating avenues to higher crop productivity with minimal fertilizer inputs will be conducted in a number of marginal areas in the bean-growing areas of Malawi.

C. ON-FARM RESEARCH

The National Bean Programme in Malawi conducts research at six locations, viz: Misuku Hills, Chitipa; Ng'onga, Rumphi; Champhira, Mzimba; Bunda, Lilongwe; Dedza Hills, Dedza; and Matapwata, Thyolo. These six locations are on government land which is rather unrepresentative of farmers' fields. As mentioned elsewhere bean production is mostly on marginal areas. It is very likely that research done on these six sites could be applicable to the large commercial farmers but probably presents very little bearing on small-farmers' conditions. Forming recommendations on such results may be misleading and probably totally unacceptable to small-scale farmers. As a result before the varieties are released they need to be tested on small-scale farmers' fields and conditions (farmer-managed).

On-Farm Research is a problem-oriented approach to agricultural research that begins by diagnosing the conditions, practices, and problems of particular groups of farmers. Once the problems are identified, a research program is designed to address them. A key part of any such program is conducting experiments on farmers' fields under farmers' conditions and management. Those experiments are then evaluated using criteria that are important to farmers, and the results are used to make recommendations.

On-Farm Research (OFR) is a set of procedures for adaptive research whose purpose is to develop recommendations for representative groups of farmers (referred to as recommendation domain). Farmers participate in identifying priorities, managing experimentation, and evaluating results. Procedures that will be followed include: a). Diagnosis, b). Planning, c). Experimentation, d). Assessment, and e). Recommendation and diffusion (Tripp and Woolley, 1989).

D. DROUGHT/HEAT TOLERANCE

Beans are a crop that serve as a cheap protein source for rural small-scale farmers who usually can not afford animal protein. Even in Lakeshore areas and the Lower Shire Valley where people have an alternative protein source (fish) beans are becoming more popular because of the declining fish catches most of which is sent to urban markets. Unfortunately, beans are susceptible to both drought or moisture-stress and heat stress. In the lakeshore areas it is mostly the heat that limits bean production but in the Lower Shire it is probably both drought and heat. This project aims at expanding bean production to areas mentioned above. Experiments conducted in the past season indicate the possibility of growing beans in Chikwawa (Lower Shire). This project will, therefore, link up with the SADCC/CIAT Drought Sub-Project that aims at screening bean germplasm for tolerance to heat and drought and then develop varieties of beans that would be high yielding under moisture- and heat-stress conditions. The GIARA Germany/Israel/Malawi Drought Project is assisting in understanding the morphological and physiological processes that confer tolerance to both heat and drought stress. This project will use materials coming from these other studies and conduct varietal adaptation trials in Chikwawa and Nsanje areas as well as along the lake shore in Salima, Nkhota-kota, Nkhata-Bay and Karonga on residual moisture that was used in rice production.

E. PATHOLOGICAL/ENTOMOLOGICAL/BREEDING RESEARCH

Pests and diseases are perhaps the single most important constraint in bean production in Malawi. Among insect pests of [illegible] are Beanfly (*Ophiomyia* spp.) and Bean beetle (*Ootheca* spp.) whereas in storage the Bruchid is a serious storage pest. There are three species of *Ophiomyia*, *O. phaseoli* (Tyon); *O. spencerella* (Greathead); and *O. centrosematis* (de Meij) and they are all known to attack beans in Africa. This project aims at screening the Malawian germplasm for resistance against the species that will be found to be prevalent in our bean-growing areas, studying population dynamics of the predominant beanfly species, and later breeding high-yielding preferred bean varieties with resistance to this pest. Also this project aims at screening germplasm for resistance to Bean beetle *Ootheca mutabilis*, studying the population dynamics of the pest and later breeding varieties with combined resistance against both pests. A link will be established with the new SADCC/CIAT Sub-Project on 'Breeding for beanfly resistance in beans' located in Tanzania. The bruchids *Zabrotes subfasciatus* and

Acanthoscelides obtectus are the most destructive pest of stored beans. Not long ago all bean cultivars were susceptible. CIAT now has some bruchid resistant varieties of beans. Arcelin, a seed protein discovered in wild beans has insecticidal effect on bean bruchids. Four forms of arcelin have been identified; these are Arcelin-1, Arcelin-2, Arcelin-3 and Arcelin-4. Bean lines with different arcelin forms will be obtained from CIAT and will be evaluated through field and storage infestations. Results from the trials to be conducted will provide basis for a breeding strategy for stable resistance against bruchids using different arcelin forms. Unfortunately, the preferred types here are large red kidney beans unlike those preferred in south America. There may be a need to transfer resistance genes into our preferred types. There is a SADCC/CIAT Sub-Project on 'Breeding for bruchid resistance in beans' located in Zimbabwe. This project will link up with the Zimbabwean bruchid project to strengthen efforts at combating this serious pest for small-scale farmers' stored beans.

The major diseases of beans are Anthracnose (*Colletotrichum lindemuthianum*) and Angular leafspot (*Phaeisariopsis griseola*). Anthracnose is the most widespread and destructive disease of beans. Severe infestations may result in a total loss of the crop. Angular leafspot appears in the field by about the middle of the growing season. The bean pathological work forms a significant part of the Bean/Cowpea CRSP Project. It has been observed that beans from the meso-American (Mexican) centre of origin (characterized by small seed size) are resistant to a certain range of races of both the above pathogenswhereas those beans from the Andean centre of origin (characterized by large seeds) are resistant to the other range of races of the two pathogens. The aim is to study the co-existence described and develop a strategy to producing high-yielding bean genotypes that are resistant to both ranges of races of each pathogen. Another approach, which the Food Legume Improvement Project will explore, is that of disease management by growing bean mixtures so that the resistant varieties slow the rate of spread of the two diseases in the field. The same scientists working on the Bean/Cowpea CRSP Project will conduct this research as part of this project.

7. PROJECT STRATEGY

The basic question being addressed in this proposal is that of low adoption of bean varieties and to set the stage for improvement. The aims of the project are to foster adoption of released varieties and test the performance and acceptance of varieties shortly to be released and to carefully address farmer problems as newer varieties are being bred.

a. Seed multiplication and distribution
This project aims at installing a more feasible and self-sustaining machinery for seed production for the small farmer. The scheme has already been in operation in groundnut seed production. Using this system cheaper seed can be easily obtained by the farmers. The seed production fields will also serve as demonstration plots and we hope to use these to bring more awareness about the existence of high yielding bean varieties.

b. Cropping systems
There is need for clear understanding of the systems of production and their ramifications under small-scale environment. A great deal of research has been done on intercropping but, of prime importance, there are currently no fertilizer recommendations that increase yields of both or more crops under such systems. This project will conduct experiments using different levels of major nutrients and varieties of maize and beans and nutrient uptake and yields will be obtained to aid in formulation of the fertilization scheme to be recommended. Experimental sites will be long-term so that effects of long-term fertilization schemes can be evaluated.

c. On-farm research
Surveys will be administered in consultation with the SADCC/CIAT Cropping Systems Agronomist and the Adaptive Research Team in which farmer problems will be prioritized. One of the problems expected to rank highly is lack of good varieties. If that indeed is a factor then farmers will be asked to choose bean lines they prefer from a number of promising lines from our Programme. There will be five farmers in each of the following districts depending on their priority for varieties: Chitipa, Rumphi, Mzimba, Dowa, Lilongwe, Dedza, Chiradzulu, Thyolo and Namwera. Farmers will be asked to grow their own local types of beans in a plot next to one in which the improved variety will be grown. This is said to be a minus-one design.

The Adaptive Research Team has been contacted for participation and they have indicated their willingness to take part. The SADCC/CIAT Regional Programme will be conducting a course on On-Farm Agronomy Research and Socio-economics of bean production to be held in Arusha, Tanzania early 1990. Opportunity has been given to two scientists from Adaptive Research to attend on our behalf since they will be involved in this research. The Cropping Systems Agronomist will visit our National Programme to provide guidance on this aspect of research and his trip will be funded by the SADCC/CIAT Regional Bean Programme.

d. Heat/drought tolerance
Experiments are underway to screen bean varieties and lines of preferred types for tolerance to heat and drought. This project will take this further by conducting varietal adaptation trials in areas normally too hot for bean production.

e. Pathological/entomological/breeding research
Most of the work in this area will be conducted by the Pathology/Entomology Sub-Project of the Food Legume Project. However, the Bean Sub-Project aims at screening the Malawian germplasm for types that are tolerant to the two most destructive insects, viz: beanfly and bean beetle in the field and the bruchids in storage. Experiments will also be conducted to screen the Malawian germplasm for resistance to the two most prevalent diseases of beans, viz: anthracnose and angular leafspot. A breeding program will then be initiated for combined insect and disease resistance in an integrated pest management (IPM) program.

f. Support of the National Bean Programme
This project will provide operational costs of some of the routine activities of the Bean Programme. This includes funding the breeding activities, i.e. Preliminary Variety Trial, the Intermediate Variety Trial, and the National Variety Trial before selected genotypes are tested on-farm. The project will also support evaluation of germplasm; help renovate the seedstore; and support activities of replication of our germplasm. The project will purchase a vehicle for Bunda to be used by other sub-projects as well. It will purchase a photocopier and a computer for data analysis and word processing for the National Bean Programme. The project will also support activities of the Adaptive Research Team on the on-farm trials.

8. PROJECT IMPLEMENTATION

a. Staff
The Project will be coordinated by the Coordinator of the National Bean Programme and HCPI of the Bean/Cowpea CRSP Project based at Bunda College of Agriculture,

University of Malawi. The coordinator will be assisted by the Bean Team comprised of a breeder, a pathologist, an entomologist, two soil scientists, an agronomist, a food scientist, and a socio-economist.

b. Duration and estimated starting date
The project will commence June 1, 1990 and will initially be for a period of two years.

c. Project funding
This project proposal is being submitted to the Rockefeller Foundation to consider funding for the entire duration. No matching funds will be expected from the Malawi Government. However, all items acquired by the project will remain the property of the Government of Malawi/Bunda College of Agriculture (National Bean Programme) upon expiry of the said project.

d. Reporting
Reporting of the progress being made by the project will be done after every six months and these will be submitted to both the Rockefeller Foundation and the Malawi Government.

e. Additional funding
It is important to view the proposed work in this project as a preliminary phase. Depending on the success in achieving the objectives of the preliminary phase, additional funds may be sought to consolidate the achievements of the preliminary phase.

9. EXPECTED DEVELOPMENT IMPACT

a. Increase in food self-sufficiency through increased production by greatr adoption of more productive bean varieties and through expansion of production area;

b. Improve bean production in intercropping system through use of articulated fertilizer recommendations for that system;

c. Development of new bean varieties that are tolerant to prevalent insects and diseases both in the field and in storage;

d. Diversify crop production by farmers;

e. Improve soil fertility;

f. Impart necessary skills and knowledge to Malawian scientists who will ensure the sustainability and further development of the sub-project;

g. Strengthen the Malawi National Bean Programme;

h. Improve socio-economic status of target beneficiaries;

The target beneficiaries of this sub-project are the smallholder farmers as well as estate growers.

10. ESTIMATED BUDGET

The following budget caters for work proposed in the project. The project activities which need funding are:-

a). Seed multiplication including fertilizer, seed revolving fund, seed crop inspection and certification activities by the Seed Technology Unit at Chitedze Research Station;

b). Cropping systems including maize seed and varios fertilizers as sources of major nutrients being varied and sample analysis at Chitedze Research Station;

c). On-farm research to be conducted with assistance from Adaptive Research Section;

d). Heat/drought tolerance for varietal adaptation trials in terms of fertilizer and labour;

e). Pathological/entomological/breeding research to develop resistant varieties for fertilizer, laboratory and greenhouse supplies, and labour.

f). One four wheel twin cab pick-up to service transportation needs under four sub-projects at Bunda, fuel and subsistence for bean work and limited office equipment for the National Bean Programme.

BUDGET (US $)

	Item	1990	1991
1.	Project vehicle (Bunda)	25,000	-
2.	Seed store renovation	10,000	-
3.	Photocopier	8,000	-
4.	Computer	6,000	-
5.	Fertilizers	2,000	2,000
6.	Fuel and subsistence	7,000	7,000
7.	Sample analysis	2,000	2,000
8.	Seed multiplication	5,000	5,000
9.	On-Farm Research	4,000	5,000
10.	Pathology/entomology/breeding	4,000	8,000
11.	Stationery	2,500	2,500
12.	Vehicle maintenance/insurance	4,000	5,000
13.	Operating costs (labour)	4,500	4,500
	Total	84,000	41,000

Bean Research and Production Needs In Malawi

Report of Brainstorming Meeting of Bean Commodity Team and Adaptive Research Programme

Facilitated by

R.L. Tinsley

Foreword

With the Rockefeller Foundation funding research and extension in bean production (*Phaseolus vulgaris*) as part of the Grain Legumes Improvement Project, the Bean Commodity Team Leader requested a select group of individuals involved with bean research and extension to participate in a brainstorming meeting to determine the needs of the Bean component of the Grain Legume Improvement Project. The meeting was held at Bunda College on 9 and 10 April 1990. Over the two day period the group reviewed the following general topics:

1. What is currently known about bean production in Malawi;

2. What is desired for bean production in Malawi;

3. Additional information that is needed to get from what is currently known to what is desired;

4. How this information should be acquired; and

5. Who should be responsible for getting the needed information.

This report is a literary summary of this meeting with the intention of providing a smooth narrative of the problem rather than minutes of the meeting. It is hoped this will provide a more readable and useful product. It is the responsibility and intention of the facilitator to provide an accurate account of the meeting's discussions, free of any personal biases, but with supplemental information that may have come to his attention subsequent to the meeting or would assist in illustrating the concerns expressed, and other information clearly derived from the discussions.

Bean Research and Production Needs in Malawi

Executive Summary

During a brainstorming meeting between the Bean Commodity Team, the Adaptive Research Programme, and Extension it was recognized that:

1. Beans were produced under three main systems which include:

    a. Intercropped with maize,
    b. Relayed or mid season pure stand, and
    c. Winter beans in dimba areas.

2. The availability of seed was a major concern, but the specifics of the problem are not well understood.

3. There was a need to have greater farmer involvement in variety development, particularly in determining cooking quality, taste and digestibility.

4. Technology development for increasing yields per hectare needs to concentrate on the intercropping and mid-season planting bean production systems.

5. Expansion of bean production areas need to consider sequential cropping on the flu-cured tobacco estates, intercropping into atooned sugarcane, and as a winter crop in the irrigation schemes in place of winter rice.

Bean Research and Production Needs In Malawi

R.L. Tinsley, Facilitator [1]

Bean Production In Malawi

Types of Bean Production

Bean production in Malawi can generally be classified into three types:

1. **Intercropped into the Main Maize Crop:** These beans are planted either between the maize stations or on the maize stations. They can either be climbing beans, dwarf beans, or a mixture. The crop is planted early in the cropping season. The production of intercropped beans covers the greatest acreage of bean production. It is usually grown in conjunction with local maize and limited inputs, rather than hybrid or composite maize with higher level of inputs. One reason for this is hypothesized to be that as the level of inputs increases the vigor of the maize increases and the degree of shading on the beans will also increase resulting in lower yield potential. As the lower canopy and earlier maturing of the intercrop combination, the beans are subject to intensive shading and thus yields are low, usually only 200 - 300 kg/ha. It is really more of a bonus crop requiring little additional effort beyond that already committed to the maize. It is also a relatively risky crop, when compared to the other bean production methods, with frequent failure due to excess moisture resulting in pods rotting or seed discoloration, or insect damage. Most of this crop is used for subsistence purposes on the farms where it is produced, although small amounts will be marketed either because of surplus or to meet immediate cash needs.

2. **Mid-season or Relay Cropped Beans:** This is probably the highest yielding system of bean production, both because it is grown essentially as a pure stand crop, and matures during the early dry season when there is less hazards from diseases and pest. It does suffer some drought stress late in its growing period as the effects of the dry season become apparent. These beans are planted anywhere from January through to March depending on location in the country and local rainfall pattern. They are planted either on land

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1. Attending the meeting were A.B.C. Mkandawire, W. Msuku, J. Bokosi, W.C.C. Mughogho, G.M. Bulla, S. Mughogho, J. Nyasulu, O.T. Edje, A. Ferguson. R.L. Tinsley served as a non-participating facilitator.

not previously planted or relayed into the maize when the maize is at or near physiological maturity and is really only drying in the field. When relayed into maize frequently most of the lower leaves are stripped to allow more light penetration. The area is however somewhat limited and thus the total production is less than from the intercropped beans. This crop tends to be more of a commercial crop with a larger percent being marketed.

3. **Winter Dimba Beans:** This is really a very limited production system that relies on residual moisture or relatively isolated unreliable showers or very limited highly local irrigation from intermittent streams. It is grown mostly in dimbas which constitute only a very small percent of cropping areas in most part of the country. As a dimba crop it often competes with the dry season grazing of cattle. A major area of winter beans would be the rainfed rice tracks of Salima RDP. The crop is planted from March to June and harvested from June to August. Because of the very limited area and the eventual drought stress the crops normally suffers, yields are not high and the total output not a substantial percent of the country's production. The exception to this may be the winter beans in the rainfed rice tracks such as in Salima where the yields are some of the highest in the Country.

Most of the bean crop is considered to be a subsistence relish crop. However, that which is marketed tends to be marketed more through the private traders, who are offering more favorable prices, than ADMARC. The marketing through private traders is making it difficult for the MOA (depending almost exclusively on ADMARC for production figures) to keep track of bean production. Also, by not going through ADMARC there is little or no seed retained in the area for planting the next crop. It is thought that much of the crop is actually marketed within a relatively short distance from the point of production, as estates purchase beans for in-kind payments to their workers.

Major Production Areas

There are ten RDP in which beans are an important commercial crop. Nine of them were discussed in the meeting; the tenth recognized subsequently. The nine discussed, in their order of importance, are:

1. Dedza Hills RDP of Lilongwe ADD,
2. Thyolo-Mulanje RDPs of Blantyre ADD,
3. Ntchisi RDP of Kasungu ADD,
4. Rumphi North Mzimba RDP of Mzuzu ADD,
5. Chitipa RDP of Karonga ADD,
6. Dowa West RDP of Kasungu ADD,

7. South Mzimba RDP of Mzuzu ADD,
8. Namwera RDP of Liwonde ADD, and
9. Ntcheu RDP of Lilongwe ADD.

The one not discussed, but probably equally important is Salima RDP in Salima ADD.

Intercropping is important in Dedza Hills, Ntchisi, Rumphi North Mzimba, Dowa West, South Mzimba, Namwera, and Ntcheu. The relay planting is important in Thyolo-Mulanje, Ntchisi, and Chitipa. The winter crop is important in Salima and scattered over the rest of the country depending on the availability of dimbas.

Seed Problems

One of the problems with bean production appears to be the availability of seed and utilization of released varieties. It seems the farmers are not accepting the varieties recommended by the Commodity Team such as Nasaka. Part of this is associated with the National Seed Company concentrating on producing Canadian Wonder for a seed export market. When grown locally Canadian Wonder is thought to be highly susceptible to numerous diseases. In addition to the lack of improved variety seed in the market, the cost of new seed from NSCM is considered to be too high for smallholder farmers. Farmers thus prefer to obtain seed from local markets.

Farmers also prefer to grow mixtures of different varieties rather than pure varieties. This could be out of necessity of what is available or associated with risk avoidance, as different varieties will perform better in any given season. When the crop is used mostly for subsistence needs the farmers have several quality factors they take into consideration in seed selection that is not necessarily consistent with breeders improvement criteria.

Bean Production Needs for Malawi

Self-Sufficiency

The major objective for bean production is for the country to be self sufficient. At present it is thought that the country is not self sufficient, although accurate data is difficult to find that will substantiate this hypothesis. The most substantial indirect information indicates that there is an embargo on the export of beans. Because of the dominance of private traders dealing with beans, the flow through ADMARC does not provide a reliable estimate of production to determine the amount of short fall or surplus. The information available indicated an unrealistic low per capita consumption of only 4 kg per year.

The increase in production towards self sufficiency could best be accomplished by increasing the yield per hectare. For smallholder production this would in turn imply increasing the yield of the intercropped beans, as this is the greatest acreage grown. The other alternative for increasing production is to increase the area planted to beans in general.

Increasing Yields Per Hectare

The need to increase yield per hectare is associated with determining the differences between research yields and farmer yields, and then determining to what extent the difference is a result of the different resource bases on which the farmer and researcher are operating, or to what extent it is a technology problem. With the limited seed supply there appears a need to look at varieties that will provide relatively high yields when planted at low density. This might imply looking at longer maturing varieties with more vegetative growth prior to initiating their reproductive stages. Other alternatives would be to try and increase the use of relay cropping with mid-season planting. This may imply looking at the newly released early maturing composite maize varieties for their potential for allowing an earlier planting of a relayed bean crop. Also, it may require concentrating on early maturing varieties that will mature before the dry season becomes too advanced.

The two suggestions above appear to be contradictory in that one advocates longer maturing varieties while the second early maturity. What may really be needed is some survey work to get a better understanding on the bean management practices of the farmers with idea of developing some research strategies to indicate how to proceed and determine if more than one strategy is needed. Given the need for similar seed to be available for the different bean production systems, it may be necessary to have a single compromise strategy that maximizes none of the systems but optimizes production from all systems. Included in a survey of farmers needs should be some index of percent recommended varieties, like Nasaka, that are part of the farmers seed mixture.

Expansion of Area

The other alternatives would be to expand the area grown to beans. Such expansion may have to be concentrated in the estate sector. The most seriously considered possibility was the flu-cured tobacco estates. They operate on a consolidated management rather than tenant management as with burley tobacco. Also, the flu-cured tobacco is harvested with the stalks removed from the fields in time for the mid-season planting. In addition estate managers should have a vested interested in bean production since they are already providing beans to their laborers. Thus if the flu-cured tobacco estates started producing beans, most of the production may not enter the market. It would, however, relieve pressure on the demand. The main problem would be the conflict with the tobacco work in the sheds. The managers may not be willing to divert labour away from assuring the best quality of tobacco to bean production.

Another possibility would be winter planting into the sugarcane ratoons. For the crop that is cut during this period this would again be possible. There is normally two or three months before the ratoon crop reaches canopy closure. There are other areas in the world where beans and other short season legume are regularly intercropped with sugarcane. As with the tobacco estates the sugar estates have a vested interested in bean production as a saving in what they have to provide their workers. Again working with beans intercropped into sugarcane, particularly at harvest could be fairly labourious and managers may have more productive work for laborers.

A third possibility for increasing the area grown to beans is as a winter crop in the rice irrigation schemes. However, the land under the organized irrigation schemes is highly limited totaling around 3000 hectares nationwide. In addition there is some potential areas in the self-help irrigation schemes. The irrigation schemes are smallholder operations and beans would be as a cash crop for smallholders. The schemes are designed for two crops of irrigated rice each year. However, growing two crops is not a comfortable fit with the current medium maturity varieties, and many schemes really do not have sufficient water for two rice crops. Thus there is interest in alternative crops for the winter (cool, dry) season. Beans are a crop that can physically be grown during this period. However, there are other commodities looking at winter cropping in the irrigation schemes. Thus there could be some conflict of interest in which the farmer's will opt for the crop with greatest economic return. It is quite possible for several crops to be produced in the winter season depending on local economics, as well as position within the irrigation scheme associated with water availability.

Finally, there could be some possibility of increasing the amounts of beans being grown in the areas already producing beans. This would imply increasing the area devoted to intercropped beans, or the amount of mid-season relayed beans. One concern in doing this would be understanding what crops, if any, beans would be substituting for, and in the overall government agricultural production needs, is this substitution desirable.

Seed Availability

One major concern with bean production is the availability of seed to smallholder farmers. It appears as a well accepted problem, but not well identified and without any real knowledge of the specifics. There appears more speculation on what the causes and possible solutions are than concrete facts. Some of the thoughts on the subject are:

1. At the farm level, it is suspected that farmers are selling a large percent of their beans shortly after harvest in order to meet immediate cash needs, with the hope that funds from other sources will be available to buy seed when time for next planting arrives. Short range economics of this nature is common in smallholder farming communities. However, if most members of the community are operating on short term economics, the availability of seed when planting comes can be critically short. There is a real need for more information on bean seed availability within smallholder farm communities, to see the extent short range economics is hindering seed supplies, or whether there are some farmers within the community with sufficient surplus to sell seed to their neighbors at reasonable prices.

2. One result of farmers selling their beans and later buying locally available beans for seed, is the farmers' loss control on the varieties being grown. The farmers have little choice but to accept any variety mixture available, although it is expected that farmers do have a fairly good ability to identify seed and relate it to variety characteristics. There is a need to evaluate the farmers' mixtures to see what percent can be attributed to improved germplasm.

3. Given the possible involuntary nature of the seed mixtures the farmers use, it may be necessary to ascertain if farmers are really interested in mixtures as hypothesized, and if so what type of mixtures they want. If they are interested in mixtures how should the mixtures be formulated to meet various local needs. The need for mixtures implies a need to test and increase several different varieties simultaneously.

4. Commercial seed production does not appear to be serving the needs of smallholders. The National Seed Company is concentrating on producing and marketing Canadian Wonder as an export seed crop. The price of this commercial seed is considered too high for most smallholders. The returns over locally available seed do not justify the additional cost. The Commodity Team is more interested in promoting Nasaka among some five released varieties, and does not appear able to get the National Seed Company interested in producing seed for these varieties. The result is the Commodity Team

and the ADDs are left with the task of seed multiplication and distribution. They can do this to a limited extent, but it is not in their mandate and funding does not allow them to produce or distribute sufficient seed to meet the demand. There is a potential for contracting seed production by smallholder, but the potential to sell at higher prices to private traders is likely to compromise the effort. It might also be possible to contract with estate growers or farmers in the rice schemes. The real problem here may be the marketing has not fully stabilized after the liberalization that allowed private traders to compete with ADMARC in buying beans. The institutional setup of ADMARC does not allow its buyers to make decisions on the spot, while private traders have the flexibility to make quick decisions. This flexibility in market decision making gives private traders a competitive edge over ADMARC. With regards to seed availability here are also some real administrative issues that need to be sorted out at relatively high levels in the Ministry related to encouraging the National Seed Company and the Bean Commodity Team to work together in variety development and seed multiplication.

Farmers Involvement in Variety Development

There are some major differences between what researchers are screening for and what the farmers seek in the varieties they choose to grow and consume. The failure to consider farmers' desires, particularly when it involves a primary subsistence crop contributes to the low acceptance of resulting varieties. The bean variety improvement priority system emphasizes:

1. Yield potential,
2. Disease and pest resistance/tolerance,
3. Cooking quality (time),
4. Maturity time,
5. Farming system compatibility,
6. Appearance and seed characteristics, and
7. Market requirements.

The farmers, at least those surveyed in Dedza Hills [2], selection criteria priorities are:

1. Yield,
2. Taste,
3. Cooking quality (time and seed consistency),
4. Markets requirements,

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[2]. Ferguson, A.E. and S. Sprecher. 1987 Women and Plant Genetic Diversity: The Case of Beans in Central Region of Malawi. Bean/Cowpea CRSP. Michigan State University, E. Lansing, Michigan 48824-1035

5. Maturity time,
6. Digestibility,
7. Disease and pest resistance/tolerance, and
8. Environmental stress to both wet and dry conditions.

In addition to these characteristics associated with production and grain quality, the farmers are also concerned with the potential for fresh snap beans, and bean leaves as relish. The differences between the two lists is not necessarily incompatible. It can reasonably be easily rectified. Some items may be interrelated. For example seed size and colour could be associated with taste and cooking time. If similar taste and cooking time were found in a bean of a different color, farmers would most likely easily adjust. The differences in the two lists is important in indicating the need to have some farmer review incorporated into the variety development process. As the breeders narrow their potential lines to 15 - 20 entries used in the National Bean Variety Trial, farmers or preferably farmer's wives preference evaluation should be conducted. This could be a relatively simple study of having a group of farmers or wives cook and sample different lines and render their opinions.

There is probably a need to continue to conduct surveys that include questions on farmers' preferences for beans as there could be some variation in preferences between different regions of the country. However, it must be recognized that researchers have access to a broader range of materials particularly concerning such things as pest and disease resistance than the farmers and thus can provide the farmers with a wider choice upon which to select potential varieties.

Farmer Involvement in Technology Development

As with the need for farmers to be involved at some point in variety development, farmers should also be involved in other aspects of bean technology development. This not only implies doing on-farm testing of potential ideas, but also not trying to make too detailed recommendations. Provide the farmers with some broad ideas, and allow them to "fine tune" the concepts to suit their circumstances. Farmers usually will make some minor modification to technical innovations. The farmer may also have some operational constraints that hinder complete adoption. Labour shortages could interfere with time of planting, and limited seed supply may reduce the number of stations or seed used per station. Excessive detailed technology development and recommendations can actually become a manner of "trivial pursuit" in which the returns to the research do not justify the cost.

Sustainability

One advantage of beans as with other legumes is their ability to fix atmospheric nitrogen and thus provide a more sustainable agricultural base than a system without legumes. Unfortunately Phaseolus beans are not really a very good nitrogen fixer. It is possible to take advantage of some of the nitrogen fixing potential by incorporating the crop residues rather than burning them as is the common practice in Malawi. The incorporation of residues could be either directly, which may require considerable labour, or indirectly via grazing animals. Running the residue through a ruminant probably does not substantially reduce the quality, or reduce the potential increase in soil organic matter. Over 90% of crop residues decompose within a couple weeks so there is very little remaining to improve organic matter or soil tilth, most of this decomposition comes from the cellulose or hemicellulose which ruminants can use for energy. The animal might just as easily use this for its energy supply.

Other than incorporating residues, it may be possible to include an early green manure crop prior to planting a mid season bean crop in February or March. The best crop for green manure may be one of the Crotalarias. It may also have a positive effect on witchweed control as Crotalaria is considered a catch crop that will stimulate the germination of the witchweed seed without hosting it.

Another possibility would be to combine with Agro-Forestry and the use of Acacia Albida within the system. It does not appear that beans are adversely affected by Acacia Albida as groundnuts are.

What ever work on sustainability that will be done will take an extensive and complex field trial programme that would, at least initially, have to be concentrated on experiment stations rather than on-farm. The minimum time requirement would be 5 years.

Bean Improvement Programme

Entities Involved

In Malawi there are three entities actively involved in bean research. The most important is the Bean Commodity Team. It is located at Bunda College and conducts its field trials on the college farm as well as different research and on-farm location around the country. While most members of the Commodity Team are biological scientists, the commodity team has the part time assistance from social scientists. Also, as faculty members of Bunda College the Commodity Team members have teaching responsibilities in addition to their Bean research. They normally do not have other research responsibilities.

The second entity is the Adaptive Research Programme. It operates through Adaptive Research Teams (ARTs) seconded to all the ADDs and has been actively involved in bean research in those ADDs and RDPs in which beans is an important commodity. The ARTs consist of both biological and social scientists and undertake a variety of on-farm studies. The ARTs working through the ADDs have a well established support system with field staff at the RDP and extension field assistance already working with the programme. The ARTs have responsibilities for all major crops in their ADDs.

The third research entity is the maize commodity team. It is involved in research on maize bean intercropping studies, as part of a broader effort associated with maize production.

In addition to the research workers, the extension programme is active in promoting bean production throughout the different ADDs.

Work Programme

<u>**Seed Availability:**</u> Given the concerns on the magnitude of the problem, the limited amount of soil knowledge, and the difficulty in developing acceptable solutions, addressing the problems of seed availability in all its various facets is probably the most important task of the Bean Production effort. This will require a major social science input just to define the nature of the problem and develop alternative solutions. Once the problem is clearly understood, it most likely will require some effort to work with the different entities involved in facilitating the linkages needed to resolve the problem.

<u>**Variety Development:**</u> The variety development work is one of the major efforts of the Bean Commodity Team work at Bunda. The initial screening process is well established. The real need is to add a component of farmer evaluation when the material is ready for inclusion in the National Bean Variety Trials for multi-location testing. The farmer evaluation needs to include both production criteria and cooking/taste criteria. Also, at the time lines are considered for the National Variety Trial they should be tested intercropped into maize.

Another concern of the variety development work, would be the rather complicated evaluation of variety mixtures. If this is what the farmer prefers to plant, then it follows that there is a need to develop methods for evaluating mixtures.

<u>Other Technology Development:</u> The other technology development efforts by the Commodity Team need to take a closer look at increasing the yield of intercropped beans; and the mid-season planted beans, both in pure stand and relayed. The mid-season planted beans appears to have the biggest potential of major increases in production, particularly if they can replace some of the very late planted maize with virtually no yield potential. Work is also needed on the dimba production particularly when combined with local irrigation. Some of this work might be done in the rainfed rice track of Salima RDP, or even the rice irrigation schemes. Finally there is a need to begin looking at the sustainability issues related to bean production.

<u>On-Farm Evaluations:</u> On-farm evaluation needs to be a coordinated joint effort between the Bean Commodity Team and the Adaptive Research Programme. It is really taking information developed by the Commodity Team that is of interest to the ADDs and evaluating them on-farm. Included in these efforts would be varieties nearing release, production technology such as different intercropping and relay cropping ideas, as well as sustainability and consumption needs.

<u>On-Farm Assessment:</u> It is always important to assess the on-farm bean production practices and needs. This is currently being done through the Commodity Team and the Bean/Cowpea CRSP. They are mostly looking at farmer preferences and production practices and the acceptance and rejection of technology. The effort would benefit by involving the ARP in the design of local studies for additional ideas for inclusion in the surveys and take advantage of the ARP's well established support system in the ADDs. Other on-farm assessment concerns would include marketing, and cash flow requirements that appear to interfere with farmers' ability to retain their own seed.

<u>Maize Commodity Efforts:</u> The maize commodity team in recognizing the importance of maize intercropping combinations are conducting experiments with beans and other crops commonly intercropped with maize in Malawi. These experiments include studies on the suitability of maize genotypes for intercropping with beans; density of beans in a maize bean intercrop; nitrogen and phosphorus fertilizer responses in maize bean intercrops, and a survey of maize production in LADD and KADD including the extent the maize is intercropped with various legumes. These studies all appear clearly within the maize commodity team mandate, and appropriate and complimentary to the bean programme except for the bean density study. The bean density study appears more in the mandate of the Bean Commodity Team and a duplication previous efforts by both the bean commodity team and the Adaptive Research Teams in LADD and KADD.

Encouragement of Estates Bean Production: To follow up on the prospects for increasing bean production in either the flu-cured tobacco estates or sugar estates it would be necessary to contact Dr. Chipala of the Kasungu Flu-Cured Tobacco Authority and the General Manager of the Sugar Estates in Dwangwa and Nchalo.

Summary

The two days of discussion highlighted several areas of need in developing a Bean Production Improvement Programme. The most critical need appeared to be an evaluation of seed availability and the use of new seed varieties within existing mixtures. Other ideas included intensifying the maize-bean intercropping and mid-season plantings. Also considered was the growing of beans on the flu-cured tobacco estates and relayed into sugarcane ratoons. There was concern about possible duplication of effort with the Maize Commodity Team's work on spatial arrangements of maize bean intercrops.

FY 92-97 BEAN/COWPEA CRSP
FIVE-YEAR PROJECT EXTENSION PROPOSAL--PART I A

1. <u>Name and Address of Lead Institution</u>

a. FY 89-92 — University of California
Davis, CA 95616-8515

b. FY 92-97 — No change

2. <u>Name and Address of Principal Investigator</u>

a. FY 89-92 — Paul Gepts
Department of Agronomy and Range Science
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Davis, CA 95616-8515
Voice: (916) 752-[illegible]43, (916) 752-1703
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b. FY 92-97 — No change

3. <u>Names and Addresses of Other Participating Institutions and Co-Investigators</u>

a. U.S.:

1) FY 89-92 — S. Temple
Department of Agronomy and Range Science
University of California
Davis, CA 95616-8515

R. Gilbertson
Department of Plant Pathology
University of California
Davis, CA 95616

A. Ferguson
Women-in-Development Program
Bean/Cowpea CRSP
200 Center for International Programs
Michigan State University
East Lansing, Michigan 48824

2) FY 92-97 — No change

b. HC:

1) FY 89-92 — A. Mkandawire
Crop Production Department
Bunda College of Agriculture
P.O. Box 219
Lilongwe
Malawi

R. Mkandawire
Bunda College of Agriculture
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Lilongwe
Malawi

4. Proposed Title of Research

Improvement of bean production in Malawi through the development of genetically diverse cultivars with durable disease and pest resistance

5. Funding Requested for FY 92-97		Amount to be Contributed:	
Budget 1: US $	926,874	U.S.: US $	177,742
Budget 2:	1,075,547		
Budget 3:	1,602,363	HC:	245,122

6. Lead Institution Approvals

	Department or Unit Head	Institutional Representative
Name:	D. Nielsen	B. Webster
Title:	Department Chair	Associate Vice-Chancellor Research
Address:	Dept. of Agronomy & Range Science, University of California, Davis, CA 95616	Office of Research University of California Davis, CA 95616
Signature:		

39311

Malawi/University of California, Davis/Gepts

FY 92-97 BEAN/COWPEA CRSP

FIVE-YEAR PROJECT EXTENSION PROPOSAL

PART I. B. Summary of Past Goals and Accomplishments during FY 81-92 in US and HC

1. Project Rationale:

This project, which started as a collaboration between Michigan State University (MSU) and Bunda College (BC) in Malawi and continues as a collaboration between the University of California at Davis (UCD) as lead institution, MSU, and BC, has as central theme the study of genetic diversity in common bean. An understanding of the distribution patterns of genetic diversity is an important element in the production of improved cultivars, because it allows breeders to identify sources of genetic diversity and to determine how the genetic relatedness between parents affects the breeding success of their progeny.

Prior to the early 1980s, our understanding of the patterns in beans was very limited and had been based exclusively on the study of morphological variation. With the introduction of electrophoretic techniques in the 80s, substantial advances were made by research teams at the University of Wisconsin (e.g., Gepts et al. 1986), Michigan State University (Bean/Cowpea CRSP project with Malawi: e.g., Sprecher 1989), and the University of California, Davis (e.g., Koenig and Gepts 1989), in our understanding of the genetic diversity of common bean, specifically with regard to the influence of domestication on genetic diversity and speciation on intraspecific gene flow. On one hand, these studies have elicited additional questions that can have important practical applications (e.g., co-evolution) and on the other hand, the point has been reached where this knowledge can be applied to breeding programs.

Beans in Malawi constitute an excellent model for the study of genetic diversity and its utilization in breeding programs: 1) Malawian bean fields exhibit high levels of morphological and phenological diversity allowing us to examine how these different phenotypes can complement each other within the same field in order to provide cultivars with more stable production; 2) within the same field, it is possible to find both Mesoamerican and Andean domesticates, allowing us to examine the relationships between the two groups and to identify potential (rare) recombinants; 3) the presence of Mesoamerican and Andean host genotypes in the same growing region allows us to test of co-evolution, i.e. that bean pathogens exhibit a similar arrangement of genetic diversity into Mesoamerican and Andean pathotypes. Recombination of Mesoamerican and Andean resistance genes into the same genotype may lead to a more stable ("sustainable") resistance; and 4) the need to maintain the current genetic heterogeneity of Malawian bean cultivars creates a challenge to develop breeding methods that will maintain this heterogeneity instead of leading to pure lines as is the case with traditional methods.

Because of the importance of bean common mosaic potyvirus in

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Malawi and the emerging problem of necrosis-inducing strains of BCMV in the US, a major effort on molecular characterization of a necrosis-inducing strain, either NL-3 or NL-5, containing all the recognized virulence genes for the virus, and of the type strain, which contains the minimal pathogenicity functions for the virus, will be conducted. It is anticipated that the results generated from this effort will provide basic information on the virulence factors of this virus and on the level of genetic diversity between these strains; they will also provide valuable DNA probes that will be used as tools to study the epidemiology of BCMV in Malawi and other regions.

Concurrently with the more basic research on co-evolution, reproductive isolation, and BCMV resistance and virulence in common bean, this project will establish in Malawi a fully operational bean breeding program capable of releasing improved bean cultivars to help that country reach self-sufficiency in bean supply.

2. Previous Year's Objectives:

2.a. Research: Biological Component:

1) Discover genetic, agronomic, and socio-cultural forces that account for the persistent pattern of bean landrace diversity in Malawi.

2) Distill from the findings and experiences in Malawi a set of principles concerning the acceptance criteria that must be met in attempts to introduce improved cultivars or populations.

3) Agronomic evaluation of bean component lines: yield, growth habit, phenology, resistance to biotic and abiotic stresses.

4) Evaluation of germplasm for resistance to anthracnose and angular leafspot; examination of the co-evolution hypothesis between host and pathogen.

Social Component:

1) Examination of bean cultivation and use practices by small-scale farmers in the different regions of Malawi, focusing especially on the integral role of farm women in bean evaluation, production, use and acceptance.

2) Identification of preferred seed types and reasons for their preference in the three regions of Malawi.

3) Study of farmer perception and management of bean diseases.

4) Together with biological scientists, initial development of a plant improvement strategy that maintains diversity and meets farmers' needs.

2.b. Training:

Provide educational and training opportunities for Malawian and US scientists and students.

2.c. Anticipated Impact:

Through an understanding of the processes involved in generating and maintaining genetic diversity in beans, improved genetic conservation and breeding practices can be developed. Training of HC scientists will lead to the formation of a multidisciplinary, integrated commodity team for Malawi.

3. Major Accomplishments:

3.a. Research: Biological Component

1) The genetic structure of Malawian landraces was elucidated using multivariate analyses on morpho-agronomic traits.

2) The agronomic performance of mixtures was studied in comparison with that of pure lines.

3) Allozyme, seed protein, and mtDNA variability of Malawian germplasm was determined.

4) The relative importance of drought and high temperature as abiotic stresses was investigated.

5) The racial variability of *Colletotrichum lindemuthianum*, the pathogen causing anthracnose, was studied.

6) Indigenous and introduced germplasm was screened for its agronomic value: yield, disease and pest resistance, nodulation ability, and drought.

7) The behavior and performance of bean lines intercropped with maize was studied.

8) Through multiple-site testing, a local Malawian line was identified as superior.

9) Single spore isolations of angular leafspot and seed harvest of the corresponding host plant was completed in the Southern region.

Social Component

1) A two-year longitudinal study of woman's roles in bean production and use in Northern Malawi was carried out. This information provides baseline data allowing us to monitor impacts

in the future.

2) Smaller surveys of bean production and use were carried out in the Central and Southern regions of Malawi. This information can also be used a s baseline data.

3) The central role farmers play in maintaining genetic diversity in beans and the importance of diversity in their cropping and household food provisioning strategies were described for the three regions of Malawi. These studies indicate that social as well as biological processes account for the kind and amount of genetic diversity present in Malawian beans.

4) Information was gathered from farmers in the three regions of Malawi which permits targeting of seed types for improvement purposes. This information indicates that seed size and color pattern serve as markers for traits such as early maturity, yield, fast cooking time, and palatability which farmers prize. These traits are as important to maintain as the seed colors and sizes that are used to mark them.

5) A bean breeding strategy, called "component breeding," was developed as a means of maintaining diversity and meeting smallholder needs.

3.b. Training:

Host country: 2 PhDs (A.B.C. Mkandawire: Crop & Soil Science, MSU; M. Mafuleka: Food Technology, MSU), 2 MS (H. Mlozabanda and J. Bokosi: Crop & Soil Science, MSU)

US: 2 PhDs (S. Sprecher and M. Khairallah: Crop & Soil Science, MSU), 1 MS (G. Martin: Crop & Soil Science, MSU)

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3.c. <u>Actual Impact</u>:

1) The ground work is laid for a strong bean commodity research team at Bunda College, which has the mandate for bean research in Malawi. Prior to the CRSP project, bean research was carried out largely by expatriates. The CRSP supported the training of Malawian researchers obtaining Ph.D. and M.S. degrees in the US who have recently returned to Bunda College and have initiated an expanded bean improvement program. As this effort has been under way for only two years, there are no impacts on farmers as yet.

2) The Project gave Mzuzu Agricultural Development Division about 2 tonnes of seed of a released variety (Nasaka). Last year, ADMARC purchased about 10 tonnes of this seed from smallholder farmers multiplying it. This year, ADMARC has purchased 26 tonnes of Nasaka from these seed multipliers.

PART I. C. <u>Five-year (FY 92-97) Project Extension Goals</u>

1. <u>Research</u>: 1.1. HC: **BIOLOGICAL SCIENCES: The overall goal will be to establish an expanded breeding program that will produce improved bean cultivars adapted to the cropping systems used by Malawi's smallholder farmers.**

Although valuable results have been obtained from the evaluation of local germplasm, sustained progress in genetic improvement will require a permanent (i.e. year in, year out) breeding program with supporting activities such as parental selection, hybridization, and evaluation and testing for the major constraints across the various bean producing regions and cropping systems of the country. This will be achieved in collaboration with U.S. scientists and will be combined with training of host country scientists.

Objective 1: *Collection, maintenance, and evaluation of Malawian bean germplasm*

A national bean genetic resources program will be established that will maintain and evaluate existing bean germplasm in the country. Germplasm evaluation will be done in conjunction with the progeny evaluation of the breeding program. Establishment of this program will include training and installation of short-term storage facilities.

Objective 2: *Improve current varieties through incorporation of multiple disease and pest resistance*

The six released varieties and breeding lines will be improved for their resistance to the major diseases and pests through crosses with appropriate sources of resistance. Diseases include principally angular leafspot, anthracnose, and bean common mosaic virus (BCMV) and pests include bean fly (*Ophiomyia* spp.) and bruchids (*Zabrotes* spp.).

Objective 3: *Conduct on-farm research to determine superiority of above materials*

The new materials obtained from research above will need to be tested on farmer's fields against earlier varieties to show superiority of these materials against diseases, pests, moisture stress, and poor soils.

Malawi/University of California, Davis/Gepts

SOCIAL SCIENCES: **The overall goal is to assist in developing the bean breeding program, on the applied side, and to investigate farmer management of bean diseases and the relationship of landholding size, land tenure, and agricultural production system with human nutritional status, on the basic side.**

Objective 1: *Assist in the expansion of the national bean breeding program*

Social scientists will contribute to the development of this program - in collaboration with the Agricultural Extension Service - by developing 1) participatory research techniques in on-station research; 2) an on-farm testing system at various stages of the bean improvement process; and 2) a system of seed multiplication and release of improved bean materials (populations, component lines, etc.).

Objective 2: *Study practices adopted by farmers to manage bean diseases*

In conjunction with the biological work on host/pathogen co-evolution, the study of farmer perception and management of bean diseases will be continued.

Objective 3: *Investigate the interrelationship of landholding size, land tenure arrangements, soil degradation, and maize/bean cropping practices as it affects human nutritional status in different regions of Malawi*

Malawi/University of California, Davis/Gepts

1.2. US: **BIOLOGICAL SCIENCES: The overall goal will be to bolster the establishment of the Malawian bean breeding program, on the applied side, and to investigate the concepts of co-evolution and reproductive isolation, on the basic side.**

Objective 1: *Provide technical support for the expansion of the Malawian bean breeding program*

The US component will provide assistance in the following areas: 1) Germplasm management; 2) Disease and pest resistance evaluations; 3) Early and late generation selections and testing; 4) Multilocation trials; and 5) On-farm trials.

Objective 2a: *Examine host-ALS pathogen co-evolution patterns to establish durable disease resistance*

This objective will build on work currently under way. Experiments will culminate in an evaluation of the co-evolution hypothesis through an assessment of the diversity of host and pathogen for molecular markers and for resistance/virulence genes. Host resistances and pathogen strains identified in this study will be used in the breeding program to incorporate ALS resistance in superior cultivars.

Objective 2b: *Detection and molecular characterization of common mosaic potyviruses*

The prevalence of BCMV (particularly its necrosis-inducing strains) in Malawi bean seed lots will be determined. Molecular probes to distinguish the various necrosis-inducing strains will be identified. Results of these studies will be used to determine a strategy to incorporate BCMV resistance into improved Malawian bean cultivars.

Objective 3: *Identify and overcome the reproductive isolation mechanisms separating Mesoamerican and Andean genotypes*
This objective aims at understanding the speciation mechanisms operating within *Phaseolus vulgaris* (i.e. the barriers to gene flow between Mesoamerican and Andean genotypes) and identifying strategies to overcome them in order to further broaden the genetic basis of bean cultivars.

SOCIAL SCIENCES: Research by the US social scientist will be carried out in Malawi in collaboration with social scientists at Bunda College (see Objective 1-3 under HC). Some data analysis and write-up will be done at the US institution.

2. Training: 2.1. HC: **Education of PhD-level plant breeder, entomologist, and social scientist**

During FY 81-92, the Malawi project has provided advanced education to several individuals who are now members of the Bean Team at Bunda College. In order to establish a team with a broad range of expertise, team members were educated in distinct yet complementary areas such as crop physiology, plant pathology, and food science. One areas that needs to be strengthened further is plant breeding. Currently, Mr. J. Bokosi is undergoing PhD training in plant breeding; however, given the diversity of bean types to be improved and the numerous constraints to bean production, a second PhD level breeder needs to be trained.

Insect pests represent serious yield limitations in both

California and Malawi. This project will seek to educate an entomologist who will study bean fly (*Ophiomyia* spp.) and develop screening techniques in support of the breeding program. Bean fly is an important pest in Africa and after his/her graduation this person will provide significant expertise as an entomologist in general and a bean fly specialist in particular to Bunda College, other CRSP projects in Africa, and national programs.

To date, no social scientist has been trained at the PhD level by CRSP although social science is an integral part of the project and of the Malawian National Bean Improvement Program. As Bunda College has currently only one sociologist on its staff, there is an urgent need to identify a Malawian for training in an applied sociology or anthropology program.

2.2. US: **Education of PhD level plant pathologist**

One of the major constraints to bean production in Malawi (and numerous other bean growing regions) appear to be diseases such as angular leafspot and anthracnose. This project will educate a plant pathologist in the various aspects related to characterization and control of these diseases, in particular, and bean diseases, in general.

3. Anticipated Impact on HC Populations, especially Small-scale Farmers and Women

By its very nature, this proposal aims at improving the living conditions of small-scale farmers and especially women who are often responsible for a large part of the farming decisions and operations. This proposal will seek to establish the appropriate breeding methodology to improve the yield capacity and stability of the existing varietal mixtures currently grown by small-scale farmers.

PART I. D. Anticipated Contributions

1. Bean/Cowpea CRSP Global Plan

This project will contribute to the Global Plan in the following areas:

a) Plant response limitations: General patterns of genetic diversity in the primary gene pool of common bean are now fairly well-known. This project will build on this knowledge to provide solutions to the gene transfer problems identified within the primary gene pool. This will, in turn, facilitate the broadening of the genetic basis of bean cultivars and reduce their genetic vulnerability. The development of bean improvement strategies that maintain or enhance genetic diversity will be relevant to farmers in many areas of the world where beans are planted in mixed variety stands.

b) Limitations due to disease: Work on the co-evolution hypothesis will determine whether different gene pools contain different genes for resistance and if they do, whether a combination of these genes provides a more stable (sustainable) resistance against pathogens. Work on BCMV will lead to molecular probes in rapid squash and dot blot tests to detect the virus and facilitate BCMV resistance breeding.

c) Multidisciplinary research methodology: Inclusion of social scientists and farmers at various stages of the bean breeding program can serve as a model to be used elsewhere in the region.

d) Seed dissemination: The development of a system to make an array of bean seed available to farmers in the three regions of Malawi may serve as a useful model in other areas of the world where seed multiplication and dissemination are constraints to bean improvement.

c) Education, training, and research capability: A PhD (in Plant Breeding) will be trained and a breeding program capable of developing improved cultivars will be put in place. A PhD in applied sociology or anthropology will be trained to take part in the plant breeding and improvement program.

2. US Bean Research:

The individual commercial types of the US bean crop (e.g., pintos, navies, etc.) are fairly narrowly based genetically. This project will help determine how the existing genetic base can be broadened and how the resistance of cultivars can be made more durable, thus limiting the turnover of defeated resistance genes, the need to introduce additional resistance genes, and the application of pesticides. Work on BCMV will allow a continuation of research in this area and expansion into the biotechnology field. Few bean researchers are currently involved in insect pest-related research in the US. This project will train an individual in this research.

Malawi/University of California, Davis/Gepts

FY 92-97 BEAN/COWPEA CRSP

FIVE-YEAR PROJECT EXTENSION PROPOSAL

PART II. WORKPLAN

A. RESEARCH OBJECTIVES:

1. Specific objectives and methods:

1.1. FY 92: 1.1.1. HC: **BIOLOGICAL SCIENCES:**

Objective 1: Person in charge: Alex Mkandawire
Development of improved bean cultivars

1. Collection, maintenance, and evaluation of Malawi bean germplasm. Collection of accessions not currently included in the collection will be pursued. Procedures to regenerate, store, assess germination, and document accessions will be established. Funds for training of a technician at UCD or at CIAT will be sought.

2. Continue crossing program started during FY90-91 between preferred Malawian lines and sources of disease and pest resistance.

3. Establish artificially inoculated or infested disease and pest nurseries for resistance screening. Nurseries for screening for resistance against the major diseases (ALS, ANTH) and pest (bean fly) will be established by artificial inoculation or infestation. Materials to be evaluated will include Malawian bean germplasm, other potential disease and pest resistance donors, and if applicable early generations from crosses made during FY90-91.

4. Establish selection nurseries for early generation resulting from crosses made during FY90-91.

5. Conduct on-farm trials of varieties released by CRSP during FY89-9[illegible].

Objective 2a: Person in charge: Alex Mkandawire
Bean-ALS co-evolution

1. A small plot will be established in or more locations in Malawi where one or two Mesoamerican and Andean bean types will be planted and *Phaeoisariopsis griseola* isolates recovered from these plants. These isolates will be examined as described in US Objective 2a to determine if certain *Phaeoisariopsis griseola* subpopulations are selected for on these genotypes.

2. Cross-inoculations. The inoculations of various Mesoamerican and Andean genotypes collected during FY 89-91 with the corresponding strains will be continued (see US Biological Sciences Objective 2a).

Objective 2b: Person in charge: Alex Mkandawire
BCMV characterization
Bean seed lots will be collected and observations made on the

incidence of BCMV in bean fields of the northern, central, and southern regions of Malawi.

SOCIAL SCIENCES: All research will be undertaken in Malawi, although some data will be analyzed and written up at the US institution.

Objective 1: Persons in charge: R. Mkandawire, A. Ferguson
Assist with the development of an expanded bean breeding and improvement program at Bunda College

1. Determine the range of variation acceptable within the seed types that have been selected for improvement purposes by carrying out a survey of farmer opinions and by using participatory research methods (for example, group consultation methods). Using the same methods, determine if the farmers will accept novel seed types.
2. As new varieties are tested on station, develop a system whereby farmers are brought to the research station to observe and evaluate early generation materials. This will require developing methods to select farmers and to record their comments and evaluations in a way that is useful to plant scientists. Efforts will be made to carry out some of these evaluation activities during farmers' field days at the college.
3. Work with the Agricultural Development Districts (ADDs) to select farmers to take part in bean seed multiplication and to develop a system of dissemination of these bean varieties.

Objective 2: Persons in charge: R. Mkandawire, A. Ferguson
Continue research on farmer perceptions and management of common bean diseases

1.1.2. US: **BIOLOGICAL SCIENCES:**

Objective 1: Persons in charge: S. Temple, R. Gilbertson, P. Gepts
Support for the expansion of the Malawian bean breeding program
Assistance will be provided in the following areas (see HC Biological Sciences Objective 1):

1. Germplasm collection maintenance and evaluation
2. Artificially inoculated or infested nurseries
3. Crosses between preferred components and sources of disease and pest resistance

Objective 2a: Person in charge: R. Gilbertson, P. Gepts
Evaluation of the genetic variability among isolates of the angular leafspot pathogen by restriction fragment length polymorphism and testing the hypothesis of coevolution of the pathogen on Mesoamerican and Andean bean types
It is expected that in FY 90-91 suitable DNA probes will have been generated that allow for determination of the level of variability among isolates of the angular leafspot pathogen,

Phaeoisariopsis griseola. Continued effort will be devoted to finding probes that contain repeated elements in the ALS genome because of the potential for such probes to reveal polymorphisms; this will be done by evaluating hybridization of various probes to known quantities of total genomic DNA. DNA probes containing a repeated sequence from other fungi will also be evaluated.
It is anticipated that in FY 90-91 a collection of ALS isolates from Mesoamerican and Andean bean types from the southern, central, and northern bean growing regions of Malawi will have been completed. During FY 92, RFLP analysis of these isolates will be conducted. A limited number of ALS isolates from Central and South America will be obtained from Dr. M. Pastor Corrales at CIAT and a similar RFLP analysis will be conducted on these isolates. A phylogenetic tree will be generated to group isolates and reveal relationships among them. Similar analyses will be performed on host plants using phaseolin, isozymes, and RFLPs.
Selected ALS isolates from Malawi that were isolated from Mesoamerican and Andean genotypes will be tested for pathogenicity on a selected group of Mesoamerican and Andean genotypes from Malawi and other locations (presumably Central and South America).
We will use the results generated in the above studies to identify sources of resistance to ALS that can be used in a breeding program in Malawi to generate improved lines possessing broad spectrum resistance to ALS.

Objective 2b: Person in charge: R. Gilbertson
Detection and molecular characterization of bean common mosaic virus potyvirus strains associated with Malawian bean genotypes
In collaboration with Dr. Gaylord Mink at Prosser, WA, selected seed lots from Malawi will be tested for the presence of potyviruses and necrosis-inducing strains of BCMV. This will be done using serological methods developed by Dr. Mink and will employ poly/mono clonal antisera. The prevalence of BCMV in such seed lots will be determined as well as the predominant strains, particularly the necrosis-inducing strains (NL-3, NL-5, NL-8). The need for incorporating BCMV resistance into Malawian landraces will be evaluated.

Objective 3: Person in charge: P. Gepts
Determine whether the reproductive isolation separating Mesoamerican and Andean genotypes in F_2 and subsequent generations is due at least in part to distorted segregation as suggested by preliminary results of Koenig and Gepts (1989) and identify crosses that are not subject to segregation distortion.
A set of 20 Mesoamerican and Andean cultivated genotypes from Malawi will be crossed and F_2 segregation of phaseolin and allozyme markers will be analyzed according to Koenig and Gepts (1989). These genotypes will include preferred component lines, newly released lines, and sources of disease and pest resistance. Genotypes have already been characterized for morphological and biochemical markers (Singh et al. 1990a and b). Allozymes will be

those revealing polymorphisms between specific parents involved in the population, such as RBCS, SKDH, ME, MDH1, DIAP, LAP, NAG, and MUE. Deviations from expected segregation ratios will be evaluated by goodness-of-fit tests. F_1 plants of crosses exhibiting distorted segregations will be backcrossed reciprocally to both parents to determine whether segregation distortion is induced by male or female gametes or both. BC_1F_1 generations will be analyzed in the same way as the F_2 generations.

1.2. FY 93-97: 1.2.1. HC: **BIOLOGICAL SCIENCES**

Objective 1: Person in charge: A. Mkandawire
Development of improved bean cultivars
In addition to the activities described for FY 92, the following objectives will be pursued:
1. Early and late generation selection and testing; on-station component will be carried out in part with social scientist to investigate participatory research techniques
2. Multi-location testing of superior advanced lines
3. On-farm trial in collaboration with social and extension scientists
4. Seed multiplication and dissemination in collaboration with social and extension scientists

Objective 2a: Person in charge: A. Mkandawire
Bean-ALS co-evolution
The small plot co-evolution experiments will be continued but depending on the results of FY 92, the experimental design may be modified (e.g., plot size, number of genotypes, artificial inoculation with mixture of strains, etc.).

Objective 2b: Person in charge: A. Mkandawire
BCMV characterization
Based on the prevalence of BCMV in Malawian bean seed lots and the perceived importance of BCMV in Malawi, the need for incorporating BCMV resistance into Malawian landraces will be evaluated. Potential sources of resistance will be identified that will be used in the breeding program in Malawi. If necrosis-inducing strains are prevalent, emphasis will be placed on incorporation of non-specific resistance genes (*bc-u*) and/or strain-specific resistance genes (*bc-1* to *bc-3*).

Objective 3: Persons in charge: A. Mkandawire
Reproductive isolation in Phaseolus vulgaris
Correlation between breeding behavior and intensity of segregation distortion or differential developmental pattern (in collaboration with P. Gepts)

SOCIAL SCIENCES

Objective 1: Persons in charge: R. Mkandawire, A. Ferguson
Assist the bean breeding and improvement program at Bunda College
The work described under 1.1.1. will be continued, the emphasis depending on the stage of materials in the breeding program. We anticipate that as the program develops over the years our emphasis will shift more toward on-farm testing coordinated with the Adaptive Research Unit. It will also include increasingly seed handling, multiplication, and dissemination as well as project impact.

Objective 2: Persons in charge: R. Mkandawire, A. Ferguson
Continue the investigations of farmers' perceptions of management of bean diseases related to host-pathogen coevolution research

Objective 3: Persons in charge: R. Mkandawire, A. Ferguson
Initiate the study of the relationship among cropping practices, soil degradation, landholding size, and tenure arrangements

1.2.2. US: BIOLOGICAL SCIENCES

Objective 1: Person in charge: S. Temple, R. Gilbertson, P. Gepts
Support for the expansion of the Malawian bean breeding program
Assistance will be provided in the areas mentioned for FY 92 and in addition for the multilocation evaluations.

Objective 2a: Person in charge: R. Gilbertson
Continue evaluation of the variability of Phaeoisariopsis griseola
Results obtained in FY 92 will be evaluated in light of the coevolution hypothesis. RFLP analyses on pathogen and phaseolin and isozyme analyses will be continued as needed. Cross-inoculations will be continued when necessary.

Objective 2b: Person in charge: R. Gilbertson
Molecular characterization of bean common mosaic virus potyvirus strains associated with Malawian bean genotypes
The present serological test cannot distinguish among necrosis-inducing strains. Thus, we will initiate attempts to characterize BCMV strains at the molecular level, with the goal of developing nucleic acid probes that can be used to differentiate necrosis-inducing strains and that can be used to study the epidemiology of these strains. Initial efforts will be focused on the NL-3 strain and full or partial cDNA clones will be produced of this strain. These clones, or selected subclones, will be evaluated as potential probes and rapid squash and dot blot hybridization methods evaluated for application of these probes.

Objective 3: Person in charge: P. Gepts
Pursue the investigations on reproductive isolation within the common bean species
Investigations will include identification of alternative mechanisms of reproductive isolation such as differential developmental patterns of gene expression (e.g., different methylation patterns) and in depth studies of segregation distortion (mechanism, developmental stage, genetic control). The presence and magnitude of segregation distortion and differential developmental patterns will be correlated with the breeding behavior of the populations as determined in HC.

2. Project Logistics:

2.1. Field sites: 2.1.1. HC: **BIOLOGICAL SCIENCES**

Bunda College serves as the major site for bean research. It is comprised of a field of about six ha of land. The Bean Programme also operates across the country the following sites (in addition to Bunda, Lilongwe): Misuku Hills (Chitipa), Ng'onga (Rumphi), Lunyangwa (Mzuzu), Champhira (Mzimba), Dedza Hills (Dedza), Matapwata (Thyolo), Kasinthula (Chikwawa), and Lifuwu (Salima).

SOCIAL SCIENCES

All research will be undertaken in Malawi. Some data analysis and write-up will take place at Michigan State University. The survey of the degree of seed coat variation acceptable to farmers will be carried out in the North, Central, and Southern Regions and will involve a small purposive sample of farmers. On-station research involving farmers will take place at Bunda College. On farm, farmer-managed trials of improved materials will be coordinated with the Adaptive Research Unit of the Ministry of Agriculture. If possible, a location in the Central Region, such as Dedza Hills, close to Bunda College, will be the site where these tests are initiated. Research on means of seed dissemination by smallholders will be coordinated with Bunda College collaborators and the Ministry of Agriculture. Specific Agricultural Development Districts cannot be identified at this point.

2.1.2. US: **BIOLOGICAL SCIENCES**

The field sites proposed for the extension are those currently in operation. They consist of:
Agronomy farm: within biking distance from the central campus; is routinely used for the bean breeding program and has all the necessary specialized equipment to conduct field research: planters, harvesters, etc, with the assistance of permanent personnel.

Plant Pathology farm: the Plant Pathology department has a large farm on close proximity to the Davis campus (within walking or biking distance). A full-time crew is available to assist in planting and other agronomic needs; all necessary equipment for filed work is available.
UC Field Stations: The UC system operates a series of field stations whose locations cover a broad range of ecological and production environments from temperate to subtropical and assure that we can screen for almost any type of biotic and abiotic stress under natural or artificially manipulated field conditions.

2.2. Resources: 2.2.1. HC:

Human Resources: **Biological Sciences**: The Malawian national Bean Programme includes scientists of the Crop Production Department and other Departments of the University of Malawi. This is the single largest crop commodity team working on a single crop within the research system in Malawi. This team is aided by technicians of every member on the team in the areas of breeding, pathology, agronomy, soils, and sociology.

Social sciences: A full-time technician for the social sciences will be hired to carry out data entering and analysis and to provide other support services, such as assisting with the participatory research strategy. In addition, Bunda College students will be hired as research assistants for the proposed social science surveys. Part-time secretarial support for report and questionnaire preparation, duplicating, etc. will be needed. As noted under training, an applied sociologist or anthropologist is needed to work with the bean research team at Bunda College as there is only one sociologist at the college now.

Laboratory: Central buildings include a field laboratory in which samples are processed after harvest. Another building houses oven driers for drying and grinding plant samples. Fertilizers, chemicals, and other materials are kept in a separate storage room. Bean germplasm is stored under regulated temperature.

2.2.2. US

Human Resources: **Biological Sciences**: The food legume improvement program in the Department of Agronomy and Range Science at UC-Davis benefits from the assistance of Mr. D. Helms, Staff Research Associate, who is in charge of the overall day-to-day management of the breeding program, and of Mr. J. Small, who is responsible for disease resistance testing. The program also receives the assistance from scientists in other disciplines to rear nematodes, insects, and pathogens to screen for resistance. Dr. R. Gilbertson has a half-time technician, who will devote some of his time to this project.

Social Sciences: The proposed research depends on having an applied anthropologist or sociologist skilled in working with biological scientists as a US co-PI. A student helper will be necessary for the data entry and analysis carried out at the US institution.

Laboratory: *P. Gepts and S. Temple*: equipped to run molecular markers (RFLPs, allozymes, seed proteins) and ELISA tests: power supplies, electrophoresis equipment, sap extractor, freezers (-80 °C, -20° C), refrigerators, table-top ultracentrifuge, centrifuge, microcentrifuges, spectrophotometer, balances, pH meter, water baths, 37 °C incubator, incubator-shakers, vacuum oven, gel dryer, concentrator, dark room, computer (386/20; 150 Mb HD). Departmental equipment includes ultracentrifuge and scintillation counter.

R.L. Gilbertson: fully equipped laboratory for traditional and molecular studies on plant pathogenic fungi, bacteria, and viruses. This includes electrophoresis equipment, power supplies, photographic system, laminar flow hood, preparative centrifuge, microcentrifuges, water baths, incubators, speedvac system, microscopes, -20 °C freezer, refrigerators, spectrophotometer, and controlled temperature plant growth chambers, IBM-compatible microcomputer. The following large equipment items are readily accessible in the department: ultracentrifuge, scintillation counter, -70 °C freezer, lyophilizer, X-ray film developer, and PCR apparatus. On the campus mainframe, the extensive program package of the University of Wisconsin Genetics Computer Group is available for DNA sequence analysis.

2.3. Distribution of research activities:

2.3.1. HC: **Biological Sciences**:
Most activities will take place at Bunda College. Multisite testing and on-farm trials will take place in the northern, central, and southern bean-growing regions of Malawi.

Social Sciences:
As noted above, the primary research site for the social sciences portion of the project will be located in Malawi. Data analysis will be carried out in the US and Malawi. The US and the HC social scientists will collaborate in implementing the research agenda. The US social scientist will spend a minimum of 1 month a year in Malawi to facilitate collaboration. The HC researcher will take primary responsibility for HC Social Science Objective 1 while the US researcher will focus principally on the survey research.

2.3.2. US: **Biological Sciences**:
Activities taking place at UC Davis include: 1) Laboratory: Molecular diversity of host and ALS pathogen; Isolation of DNA probes for BCMV detection; 2) Greenhouse: BCMV typing of Malawi

lines; crossing; cross-inoculations with ALS pathogen; 3) Field: Observation trials on Malawi material (only after prior quarantine in greenhouse)

Social Sciences:

Some data analysis and write-up will take place at the US institution (MSU).

3. Expected Outcomes:

3.1. FY 92: 3.1.1. HC: **Biological Sciences**:

1) Operational artificially inoculated and infested disease and pest nurseries
2) Improved management of Malawi bean germplasm collection; catalogue of collection with passport data and evaluation results
3) Better knowledge of the agronomic value of CRSP released varieties following on-farm trials.

Social Sciences (includes US contribution):

1) Survey results on the range of variation acceptable in seed types will be completed, the data analyzed and ready for use in the breeding program.
2) Preliminary descriptions of farmer bean disease perception and management practices will be available to biological and other scientists planning disease management strategies.
3) Participatory research involving on-station and on-farm trials of new bean varieties will be under way.

3.1.2. US: **Biological Sciences**:

1) Preliminary data regarding the co-evolution hypothesis between bean host and ALS pathogen
2) Data on incidence of BCMV in Malawi
3) Data on incidence of segregation distortion in Mesoamerican x Andean crosses from Malawi
4) Journal articles on BCMV incidence and segregation distortion

3.2. FY 93-97: 3.2.1. HC: **Biological Sciences**:

1) Expanded multidisciplinary bean breeding program
2) Improved breeding lines
3) New bean varieties
4) Organized on-farm research
5) Organized bean seed multiplication and distribution scheme
6) Breeding strategies to maintain diversity within bean cultivars.

Social Sciences (includes US contribution):

The principal aim of the social science research is to contribute to the development of a strong bean breeding and improvement program by devising ways for farmers to gain a voice in the research and evaluation process. This strategy should help insure

higher adoption rates of project varieties, technologies, and techniques. These participatory methods can also be applied to agricultural research in the US. On-farm trials and surveys will allow us: 1) measure the adoption rate of new releases by farmers; 2) examine the effect of these new releases on productivity of bean fields and on the welfare of small-scale farmer.
Social scientists will publish scholarly articles which broadly consider social and economic constraints to agricultural production and how these can be addressed in Malawi.

3.2.2. US: **Biological Sciences:**

1) Understanding of the reproductive isolation mechanisms separating Mesoamerican and Andean genotypes in Malawi and strategies to overcome them; journal articles
2) Probes to identify the various necrosis-inducing strains of BCMV
3) Reliable data on the presence/absence of co-evolution between bean host and ALS pathogen based on laboratory and field data
4) Sources of resistance to BCMV and ALS for use in breeding programs

B. TRAINING PROGRAM

1. US students: **Biological Sciences**: A PhD level student in plant pathology will be trained at UC Davis. This person may perform part of his/her thesis in Malawi. A postdoctoral fellow will further his/her education in genetic diversity and speciation mechanisms at the molecular level.

Social Sciences: None anticipated.

2. HC students: **Biological Sciences**: A plant breeder and an entomologist will be trained at UC Davis at the PhD level. Part of his/her thesis can be carried out in Malawi. A MS level student in biological science will be trained at Bunda College.

Social Sciences: We anticipate training one applied anthropologist or sociologist to the PhD level in either the US or Britain. This person will work closely with the bean commodity research team at Bunda College upon his/her return, thus helping institutionalize the participatory research strategy. A MS student in social science will be trained at Bunda College.

3. Other developing country students: None anticipated on CRSP funds. A student from Colombia has been identified whoa has interest in obtaining a PhD on the coevolution project. It is anticipated that this student will work in some capacity on angular leafspot, common bacterial blight, or BCMV.

4. Other training efforts: Training in computer and data analysis techniques will be provided to graduate students and technicians at Bunda College. Also, one HC technician will be trained in participatory research methods and another HC technician in management of the germplasm collection. Funding will be sought (from Rockefeller?) for the training of one technician in genetic resources at UCD or CIAT.

5. Expected outcomes:
5.1. FY 92: Degree training, whether for MS or PhD, requires more than one year. Hence, see next paragraph.

5.2. FY 93-97: 5.2.1. HC: While bean research is now well institutionalized at Bunda College, gaps in the program remain. During the FY 92-97 extension period, these will be addressed by training another plant breeder, a sociologist/anthropologist and by providing technicians with short courses.

5.2.2. US, other developing countries: It is expected that the students in training at UC Davis will have completed their PhD training.

C. PROJECT INTEGRATION (for biological and social sciences)

1. HC: 1.1. Within Malawi, close ties exist between CRSP project researchers and the Maize Commodity Research Team, the Adaptive Research Unit and Extension in the Ministry of Agriculture.
1.2. Linkages have been established with the Rockefeller Foundation, Southern Africa Office, located in Lilongwe. Funding for bean research has been obtained from the Rockefeller Foundation and we are currently seeking funding to support student training at Bunda College and abroad.
1.3. Ties are also being established with various church groups and NGOs which may assist with bean seed dissemination.
1.4. Project researchers, including US PIs, will continue to collaborate closely with CRSP researchers at Sokoine University in Tanzania (see below under 3.).
1.5. Project researchers, including US PIs, will work closely with the regional CIAT/SADCC program headquartered in Arusha, Tanzania.

2. Other [illegible]:
A. Mkandawire *With Tanzania* (Bean/Cowpea CRSP): Breeding for disease resistance; seed multiplication, and distribution; collaborators: M. Silbernagel, J. Teri.

With Mexico (Bean/Cowpea CRSP): Breeding for drought tolerance; collaborators: J. Kelly, J. Acosta.
With SADCC/CIAT (Regional Bean Programme, Arusha, Tanzania); Bean yield improvement in SADCC region; collaborators:

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D.J. Allen, O.T. Edje, K. Ampofo (SIDA)
With Hebrew University, Rehovot, Israel: Heat and drought tolerance in common bean; collaborators: J. Kigel, S. Schwartz, F. Bangerth (Hohenheim).

P. Gepts: *With Mexico* (Universidad Nacional Autónoma de México): Molecular, cultural, and ecological markers of genetic diversity in *Phaseolus coccineus*; collaborators: R. Bye, A. Delgado *et al.*; funding: AID (PSTC)
With CIAT: 1) Study of the patterns of genetic diversity in *Phaseolus vulgaris* using molecular and agronomic traits; collaborators: S. Singh and W. Roca; funding: CIAT, AID (PSTC). 2) Establishment of an integrated genetic linkage map for *Phaseolus vulgaris*; collaborator: S. Singh; funding: UCD
With IBPGR (International Board for Plant Genetic Resources): Molecular markers in *Phaseolus vulgaris* and *Vigna unguiculata*; collaborator: D. Debouck; funding: IBPGR

R. Gilbertson: *With the Dominican Republic* (and the Univ. of Nebraska): Development and application of a plasmid DNA probe for detection of *Xanthomonas campestris* pv. *phaseoli* in bean seed and from bacteria recovered in or on bean plants. Collaborators: G. Gadoy, J.R. Steadman, A.K. Vidaver et al.; funding : USAID Bean/Cowpea CRSP

S.R. Temple: With CIAT: Regular exchange of information and germplasm. Five hundred germplasm bank and experimental lines evaluated in 1986 and 1989, 40 of which have been used subsequently in crosses. Utilization of parents with root knot nematode resistance to incorporate resistance into California varieties.
Other IARCs: Evaluation of germplasm from IITA and ICARDA in LISA cropping systems research and utilization as parents for improvement of cowpeas and chickpeas. In addition, S. Temple's program supports a Mexican national (A. Dutton) to work on *Lygus* screening beginning June 1990.

3. US:
R. Gilbertson: Molecular characterization of bean common mosaic virus and development of DNA probes for identification of virulence genes in the pathogen and application of probes to epidemiological studies. This will interface with and continue work by Dr. M. Silbernagel at USDA/Washington State University and in Tanzania. This will involve close collaboration with Dr. G. Mink at Washington State Univ. (Prosser), who uses serological methods for detecting BCMV; collaborators: G. Mink and M. Silbernagel; funding: USAID Bean/Cowpea CRSP.

D. PROJECT BUDGET REQUEST

BEAN/COWPEA CRSP
ESTIMATED BUDGET REQUEST
Flat Line at FY 91 Level

	Estimated Budget Request Year 1		Estimated Budget Request Year 2		Estimated Budget Request Year 3		Estimated Budget Request Year 4		Estimated Budget Request Year 5		Total Five-Year Budget Request	
	US	HC	US	HC	US	HC	US	HC	US	HC	US	HC
1. Personnel	31,900	14,000	32,690	14,700	34,045	15,435	34,975	16,207	35,745	17,017	169,355	77,359
2. Equipment and facilities	0	15,000	0	15,000	0	5,000	0	0	0	0	0	35,000
3. Travel and P/D	20,000	19,000	20,000	18,000	18,750	24,000	17,000	24,000	17,000	23,000	92,750	108,000
4. Materials and supplies	10,677	6,000	9,011	5,500	8,995	6,000	8,739	9,500	5,773	9,000	43,195	36,000
5. Training costs	14,000	20,000	14,700	21,000	15,435	22,050	16,207	23,153	17,017	24,311	77,359	110,514
6. Other direct costs	1,000	500	1,000	500	1,000	1,000	1,000	1,000	2,000	1,000	6,000	4,000
7. TOTAL DIRECT COSTS	77,577	74,500	77,401	74,700	78,225	73,485	77,921	73,860	77,535	74,328	388,750	370,[illegible]
8. Indirect costs	33,298	0	33,274	0	33,665	0	33,594	0	33,511	0	167,342	0
9. TOTAL DIRECT AND INDIRECT COSTS	110,875	74,500	110,675	74,700	111,890	73,485	111,515	73,860	111,046	74,328	556,001	370,873
10. TOTAL REQUEST	185,375		185,375		185,375		185,375		185,374		926,874	
11. University Contribution	26,107	44,361	27,412	46,579	28,783	48,908	30,222	51,353	31,733	53,921	144,257	245,122

BEAN/COWPEA CRSP
ESTIMATED BUDGET REQUEST
Flat Line at FY 91 Level (UCD and MSU subdivision in each US column)

	Estimated Budget Request Year 1		Estimated Budget Request Year 2		Estimated Budget Request Year 3		Estimated Budget Request Year 4		Estimated Budget Request Year 5		Total Five-Year Budget Request	
	US	HC	US	HC	US	HC	US	HC	US	HC	US	HC
1. Personnel	25,900	14,000	27,190	14,700	28,545	15,435	29,975	16,207	31,745	17,017	143,355	77,359
	6,000		5,500		5,500		5,000		4,000	0	26,000	
2. Equipment and facilities	0	15,000	0	15,000	0	5,000	0	0	0	0	0	35,000
3. Travel and P/D	8,000	19,000	8,000	18,000	8,000	24,000	8,000	24,000	8,000	23,000	40,000	108,000
	12,000		12,000		10,750		9,000		9,000		52,750	
4. Materials and supplies	1,000	6,000	1,000	5,500	1,000	6,000	1,000	9,500	1,000	9,000	5,000	36,000
	9,677		8,011		7,995		7,739		4,773		38,195	
5. Training: UCD, HC	14,000	20,000	14,700	21,000	15,435	22,050	16,207	23,153	17,017	24,311	77,359	110,514
6. Other direct costs	250	500	250	500	250	1,000	250	1,000	500	1,000	1,500	4,000
	750		750		750		750		1,500		4,500	
7. TOTAL DIRECT COSTS	35,150	74,500	36,440	74,700	37,795	73,485	39,225	73,860	41,245	74,328	189,855	370,873
	42,427		40,961		40,430		38,696		36,290		121,445	
8. Indirect costs	15,818	0	16,398	0	17,008	0	17,651	0	18,560	0	85,435	0
	17,480		16,876		16,657		15,943		14,951		81,907	
9. TOTAL DIRECT AND INDIRECT COSTS	50,968	74,500	52,838	74,700	54,803	73,485	56,876	73,860	59,805	74,328	275,290	370,873
	59,907		57,837		57,087		54,639		51,241		280,711	

10. TOTAL REQUEST	185,375		185,375		185,.75		185.375		185,374		926,874	
11. University Contribution	0	44,361	0	46,579	0	48,908	0	51,.53	0	53,921	0	245,122
	26,107		27,412	0	28,783	0	30,222	0	31,733	0	144,257	

BEAN/COWPEA CRSP
ESTIMATED BUDGET REQUEST
FY 91 Level Plus 5 Percent Per Year

	Estimated Budget Request Year 1		Estimated Budget Request Year 2		Estimated Budget Request Year 3		Estimated Budget Request Year 4		Estimated Budget Request Year 5		Total Five-Year Budget Request	
	US	HC	US	HC	US	HC	US	HC	US	HC	US	HC
1. Personnel	31,900	14,000	33,190	15,000	34,545	15,750	35,975	16,[illegible]8	38,245	17,365	173,855	78,653
2. Equipment and facilities	0	15,000	0	19,000	0	0	0	0	0	0	0	34,000
3. Travel and P/D	22,000	19,000	21,500	20,000	23,000	26,000	23,000	27,000	24,000	28,000	113,500	120,000
4. Materials and supplies	10,928	7,000	11,465	7,500	12,907	9,000	13,859	9,500	13,374	10,500	62,533	43,500
5. Training costs	14,000	20,000	14,700	21,000	15,435	33,076	16,207	34,730	17,017	36,467	77,359	145,27 3
6. Other direct costs	3,500	2,000	3,000	2,000	3,500	3,000	4,750	3,500	5,500	4,000	20,250	1[illegible],500
7. TOTAL DIRECT COSTS	82,328	77,000	83,855	84,500	89,387	86,826	93,791	91,268	98,136	96,332	448.412	4[illegible]6,841
8. Indirect costs	35,321	0	36,019	0	38,387	0	40,265	0	42,132	0	192,124	0
9. TOTAL DIRECT AND INDIRECT COSTS	117,649	77,000	119,874	84,500	127,774	86,826	134,056	91,268	140,268	96,332	639,621	435,926
10. TOTAL REQUEST	194,649		204,374		214,600		225,324		236,600		1,075,547	
11. University Contribution	26,107	44,361	27,412	46,579	28,783	48,908	30,222	51,353	31,733	53,921	144,257	245,122

BEAN/COWPEA CRSP
ESTIMATED BUDGET REQUEST
FY 91 Level Plus 5 Per Cent [MSU(top) and UCD (bottom) subdivision in each US column]

	Estimated Budget Request Year 1		Estimated Budget Request Year 2		Estimated Budget Request Year 3		Estimated Budget Request Year 4		Estimated Budget Request Year 5		Total Five-Year Budget Request	
	US	HC	US	HC	US	HC	US	HC	US	HC	US	HC
1. Personnel	25,900	14,000	27,190	15,000	28,545	15,750	29,975	16,538	31,745	17,365	143,355	78,653
	6,000		6,000		6,000		6,000		6,500	0	30,500	
2. Equipment and facilities	0	15,000	0	19,000	0	0	0	0	0	0	0	34,000
3. Travel and P/D	9,000	19,000	9,000	20,000	10,000	26,000	10,000	27,000	10,500	28,000	48,500	120,000
	13,000		12,500		13,000		13,000		13,500		65,000	
4. Materials and supplies	1,000	7,000	1,500	7,500	1,500	9,000	1,500	9,500	1,000	10,500	6,500	43,500
	9,928		9,965		11,407		12,359		12,374		56,033	
5. Training: UCD, HC	14,000	20,000	14,700	21,000	15,435	33,076	16,207	34,730	17,017	36,467	77,359	14[illegible]73
6. Other direct costs	1,000	2,000	1,000	2,000	1,000	3,000	1,250	3,500	1,500	4,000	5,750	14[illegible]00
	2,500		2,000		2,500		3,500		4,000		14,500	
7. TOTAL DIRECT COSTS	36,900	77,000	38,690	84,500	41,045	86,826	42,725	91,268	44,745	96,332	204,105	435,926
	45,428		45,165		48,342		51,066		53,391		166,033	
8. Indirect costs	16,605	0	17,411	0	18,470	0	19,226	0	20,135	0	91,847	0
	18,716		18,608		19,917		21,039		21,997		100,277	
9. TOTAL DIRECT AND INDIRECT COSTS	53,505	77,000	56,101	84,500	59,515	86,826	61,951	91,268	64,880	96,332	295,952	435,926
	64,144		63,773		68,259		72,105		75,388		343,669	

10. TOTAL REQUEST	194,649		204,374		214,600		225,324		236,600		1,075,547	
11. University Contribution	0	44,361	0	46,579	0	48,908	0	51,353	0	53,921	0	245,122
	26,107		27,412	0	28,783	0	30,222	0	31,733	0	144,257	

BEAN/COWPEA CRSP
ESTIMATED BUDGET REQUEST
FY 91 Level Plus 5 Percent Per Year Plus Need

	Estimated Budget Request Year 1		Estimated Budget Request Year 2		Estimated Budget Request Year 3		Estimated Budget Request Year 4		Estimated Budget Request Year 5		Total Five-Yea[r] Budget Reque[st]	
	US	HC	US	HC	US	HC	US	HC	US	HC	US	H[C]
1. Personnel	69,900	1[illegible] 000	73,090	16,800	76,440	17,640	79,965	18,52[illegible]	83,934	19,448	383,329	88,[illegible]0
2. Equipment and facilities	0	29,000	0	27,000	0	0	0	40.00	0	3,000	0	99,[illegible]
3. Travel and P/D	22,000	2[illegible],000	28,500	20,000	29,500	26,000	29,500	27,000	30,000	31,000	139,500	127[illegible]00
4. Materials and supplies	12,000	10,000	13,500	10,500	14,500	11,000	15,500	11,500	17,000	12,000	72,500	55,[illegible]00
5. Training costs	14,000	40,000	14,700	42,000	15,435	[illegible],100	16,207	46,305	17,017	48,620	77,359	221[illegible]25
6. Other direct costs	3,500	5,000	3,500	5,000	3,500	5,000	4,750	5,000	5,500	5,000	20,750	25[illegible]00
7. TOTAL DIRECT COSTS	121,400	123,000	133,290	121,300	139,375	103,740	145,922	148,327	153,451	119,068	694,353	61[illegible]50
8. Indirect costs	51,419	0	56,386	0	58,982	0	61,743	0	64,960	0	293,490	
9. TOTAL DIRECT AND INDIRECT COSTS	172,819	123,000	189,676	121,300	198,357	103,740	207,665	148,327	218,411	119,068	986,928	615,[illegible]5
10. TOTAL REQUEST	295,819		310,976		302,097		355,992		337,479		1,602,363	
11. University Contribution	32,167	44,361	33,775	46,579	35,464	48,908	37,237	51,353	39,099	53,921	177,742	245,122

BEAN/COWPEA CRSP
ESTIMATED BUDGET REQUEST
FY 91 Level Plus 5 Per Cent Plus Need [MSU(top) and UCD (bottom) subdivision in each US column]

	Estimated Budget Request Year 1		Estimated Budget Request Year 2		Estimated Budget Request Year 3		Estimated Budget Request Year 4		Estimated Budget Request Year 5		Total Five-Year Budget Request	
	US	HC	US	HC	US	HC	US	HC	US	HC	US	HC
1. Personnel	25,900	16,000	27,190	16,800	28,545	17,640	29,975	18,522	31,745	19,448	143,355	88,410
	44,000		45,900		47,895		49,990		52,189	0	239,974	
2. Equipment and facilities	0	29,000	0	27,000	0	0	0	40,000	0	3,000	0	99,000
3. Travel and P/D	9,000	23,000	9,000	20,000	10,000	26,000	10,000	27,000	10,500	31,000	48,500	127,000
	13,000		19,500		19,500		19,500		19,500		91,000	
4. Materials and supplies	1,000	10,000	1,500	10,500	1,500	11,000	1,500	11,500	2,000	12,000	7,500	55,000
	11,000		12,000		13,000		14,000		15,000		65,000	
5. Training: UCD, HC	14,000	40,000	14,700	42,000	15,435	44,100	16,207	46,305	17,017	48,620	77,359	221,025
6. Other direct costs	1,000	5,000	1,000	5,000	1,000	5,000	1,250	5,000	1,500	5,000	5,750	25,000
	2,500		2,500		2,500		3,500		4,000		15,000	
7. TOTAL DIRECT COSTS	36,900	123,000	38,690	121,300	41,045	103,740	42,725	148,327	45,745	119,068	205,105	615,435
	84,500		94,600		98,330		103,197		107,706		410,974	
8. Indirect costs	16,605	0	17,411	0	18,470	0	19,226	0	20,585	0	92,297	0
	34,814		38,975		40,512		42,517		44,375		201,193	
9. TOTAL DIRECT AND INDIRECT COSTS	53,505	123,000	56,101	121,300	59,515	103,740	61,951	148,327	66,330	119,068	297,402	615,435
	119,314		133,575		138,842		145,714		152,081		689,526	

10. TOTAL REQUEST	295,819		310,976		302,097		355,992		337,479		1,602,363	
11. University Contribution	0	44,361	0	46,579	0	48,908	0	51,353	0	53,921	0	245,122
	32,167		33,775	0	35,464	0	37,237	0	39,099	0	177,742	

Malawi/University of California, Davis/Gepts

BUDGET JUSTIFICATION

Budget 3 represents what we think is necessary to be able to achieve the objectives of the project. In the following paragraphs, we review our needs in the respective areas:

1. <u>Personnel</u>: US: UCD: 1 postdoctoral fellow to investigate the reproductive isolation mechanisms separating Mesoamerican and Andean genotypes; this area requires with a certain level of research experience at the molecular level and it would be highly unlikely to find a graduate student able to pursue this type of research. Cost is $ 30,000 + 26 % benefits.

MSU: 50 % salary + benefits of US Co-PI A. Ferguson. Because most of her research takes place in Malawi, a substantial part of her salary currently imputed to the US part of the project should actually be attributed to the HC part.

HC: Salaries for two technicians, one for the biological sciences and the other for the social sciences.

2. <u>Equipment and facilities</u>:
US: No equipment is requested for the US component. The project will use existing facilities and equipment. This has not actually been included in the US contribution because it is hard to put a monetary value on the fraction contributed to CRSP.

HC: The list of equipment requested is detailed in Part III. B.
To further the plant pathology part of the project, a modest laboratory needs to be set up that can perform isolations and produce inoculum. We have added glassware to this equipment list because of the large amount of money for this initial purchase. A backpack sprayer is needed for the artificial inoculations of the evaluation and breeding nurseries. Two greenhouses will be used for inoculations with various pathogens: anthracnose, angular leafspot, BCMV. A camera is needed to document the various aspects of the work and its progress.
Three motorcycles (2 for Biological Sciences and one for Social Sciences) are requested to complement the project vehicle (when researchers or technicians need to take data in various experiments). Computers and printers will supplement or replace the existing computer at the end of its useful life. We anticipate we will need to replace the current four-wheel-drive vehicle after 5 years of service because of the unfavorable road conditions.

3. <u>Travel and per diem</u>:
US: MSU: For one person, a round trip between US and Malawi cost approximately $ 5,000 to which some $ 1,000 has to be added for expenses and per diems. We anticipate trips of Co-PIs S. Temple and R. Gilbertson each year once. To minimize costs, US PI P. Gepts will alternate his trips to Malawi with HC PI A.

Mkandawire's trips to the US. In the third and fifth year, graduate students from Davis will carry out part of their thesis in Malawi.

HC: There will be extensive travelling in Malawi both for the Biological and the Social Sciences components. In addition, HC PI A. Mkandawire and Co-PI R. Mkandawire will alternate their trips to US. The first year and fifth year, two students in the biological sciences will take a one-way trip to the US and back to Malawi, respectively. The third and fifth year, a graduate student in the social sciences will take a one-way trip to the US or Britain and back to Malawi, respectively.

4. <u>Training costs</u>:
US: One graduate research assistantship in plant pathology for which in-state tuition is assumed.
HC: Two graduate research assistantships (in plant breeding, entomology) for which out-of-state tuition is assumed.

5. <u>Other direct costs</u>:
These include photocopying costs, telecommunications (phone, fax), computer use, greenhouse use, and publications. Mostly because of the latter, these costs are expected to go up towards the end of the grant period.

8. <u>Indirect costs</u>:
UCD: 41.2 %
MSU: 45 %

11. <u>University contribution</u>:

UC Davis contributes to this project directly through a part of the salary and benefits of the PI and Co-PIs:

P. Gepts	25 %	$ 14,774
R. Gilbertson	15 %	8,078
S. Temple	15 %	9,315
		32,167

For Budgets 1 and 2, percentages of 20, 15, and 10, respectively were used.

Additional more difficult to quantify contributions relate to use fo facilities and equipment.

E. ANTICIPATED TRAVEL

1. HC:

Extensive travel within Malawi for HC biological and social sciences researchers is required to complete the yearly research agenda.

HC PI A. Mkandawire will travel to US once every other year (in alternacy with US PI P. Gepts' trip to HC) to assess progress of US component and write reports and workplans with US PI and Bean Team at UC Davis.

HC social scientist R. Mkandawire will present a paper on project research at a professional conference once a year (usually in Africa). He will travel to the US institution once every other year in alternacy with HC PI A. Mkandawire.

HC students will travel to US to initiate their studies (Plant Breeding and Entomology students: 1992; Social Sciences student: 1994); at completion of their studies they will return to HC. Plant Breeding and Entomology students may carry out part of their thesis in Malawi (from FY 94 on)

2. US:

US PI P. Gepts will travel to Malawi once every other year (in alternacy with HC PI A. Mkandawire) to assess overall progress of HC component and to write reports and workplans with HC PI and Bean Team.

US Co-PI R. Gilbertson will travel each year to Malawi to: 1) participate in co-evolution studies; 2) assist in the disease resistance screening in breeding nurseries (principally, angular leafspot and anthracnose); and 3) monitor BCMV incidence and resistance breeding.

US Co-PI S. Temple will travel to Malawi each year to assist the HC bean breeding program.

US social scientist A. Ferguson will travel to Malawi once a year and spend at least one month there working with her collaborators. She will also present a paper on project research at a professional conference once a year (usually in the US).

US student in Plant Pathology may be traveling to HC to complete part of his/her their thesis (from 94 on).

Project researchers from Bunda College and from the US institutions will periodically attend regional CRSP, CIAT/SADCC, and other meetings.

B. EQUIPMENT REQUESTS 1. US: No equipment requested

2. HC:		Year 1	Year 2	Year 4	Year 5
Biological Sciences					
2.1. Equipment for a plant pathology laboratory:					
Miniautoclave	US $ 4,500				
Transfer hood (bench top)	2,200				
Compound light microscope (+ accessories)	3,000				
Dissecting microscope	1,000				
Weighing balance	1,350				
pH meter	700				
Refrigerator	600				
Incubator	1,750				
Drying oven	1,200				
Hot plate stirrers (2 @ 300)	600				
Waring blender	500				
Pipetman (2 @ 300)	600				
Total for plant pathology lab equipment		18,000			
2.2. Glassware: for plant pathology lab		7,000			
2.3. Backpack sprayer		1,000			
2.4. Greenhouses: 2 units @ 5,600 + blinds + freight			13,000		
2.5. Camera: + accessories			500		
2.6. Motorcycles: 2 @ 3,500			7,000		
2.7. Laptop computer			2,000		
2.8. Printer			1,000		
2.9. Four-wheel-drive car (shared with Social Sciences; 50 %)				20,000	
2.10. Computer: 286, 60 Mb HD					2,000
2.11. Printer					1,000

Social Sciences

2.12. Four-wheel-drive car (shared with Biological Sciences; 50%)			20,000		
2.13. Laptop computer	2,000				
2.14. Printer	1,000				
2.15. Motorcycle		3,500			
Total for Social Sciences					26,500
Total per year	29,000	27,000	40,000	3,000	
Grand total					99,000

BEAN RESEARCH METHODS TRAINING COURSE
BUNDA COLLEGE OF AGRICULTURE
MALAWI

20 - 31 AUGUST 1990

A

REPORT

by

Jeff Mutimba
CIAT Regional Training Officer

Background

The request for this course originally came from Malawi and Zambia and was approved by the Regional Steering Committee in March 1990. In response to a training survey which was going on at the same time, Zimbabwe had indicated they also required training at the same level. Hence they were invited to send their staff to this course.

Once the decision was made to support the course, there was considerable discussion between the National Coordinators concerned, DJA, OTE and myself on the contents of the course. This was followed by a visit to Malawi by myself for a planning meeting with Dr Mkandawire (Malawi Bean Programme Coordinator).

Although the course was meant for those research assistants with out formal agricultural training, a decision was made to include a few certificate holders who were doing similar work and had not received in-service training.

Participants

Nineteen research assistants participated in the course. Two came from Zimbabwe, four from Zambia (including one female) and the rest were from Malawi (Appendix I)

Their average age was 30 years with a range of 23 to 44. They were involved in bean research whilst the majority of them were also involved in other legume crop like cowpea, groundnuts and soybeans. They also did work on maize and sorghum which are usually grown in association or relay with beans. Their average length of experience was 10 years with a range of 1 to 15. Only five participants had received formal training in agriculture (certificate in Agriculture) and the rest were secondary school leavers.

Only two participants were involved in on-farm experimentation. There were indications however that a few more would be involved in on-farm work in Malawi as there were plans to increase such activities.

Resource persons

In all 10 resource persons were involved in the course - eight of these were from the Bean Programme in Malawi (mainly from Bunda College) and one came from Zambia (Appendix II).

There was impressive cooperation from all concerned and three of the resource persons actually set through most of the course.

There were no complaints about allowances as such but the question had be raised with the National Coordinator during planning meetings. They had expected to be compensated for interrupting their holidays to take part in the course (they were supposed to be on vacation during this College shut-down period).

All the same, the policy still needs further 'polishing up'. As it is, there was a feeling that the policy favoured participants and 'demean' resource persons contribution.

Course administration

Course administration was done jointly by the author and Dr Mkandawire who also made available his staff to assist whenever it was necessary.

Objectives of the course

The objectives of the course were:

1. to provide the necessary skills for improving the quality of work by research assistants;

2. to equip the research assistants with the necessary skills to enable them to perform their duties with confidence;

3. to provide uniform methodology in bean research,

Participants expectations

At the beginning of the course, the participants were asked to write down on manilla cards what they expected to learn from the course. The purpose of this exercise was to see how far the course would go in meeting their needs and to identify areas that might have been overlooked and areas that needed emphasis. The cards were posted on the wall and kept as a 'check' throughout the course. Except for one request for a session on "how to work with people", all their expectations were well covered in the programme. The majority wanted to learn pest and disease identification and assessment.

Offial Opening

The course was officially opened by Dr G.Y. Kanyama-Phiri (See full speech Appendix III).

Course Content

The course covered the essential elements of bean research and the topics covered included

- Site selection
- Land preparation
- Trial design and layout
- Trial input calculations
- Planting
- Management (including data collection)
- Pest and Disease identification
- Seed handling
- On-farm research (See Appendix IV)

The method of instruction included discussion lectures (to provide the essential theoretical background), classroom exercises, field practicals and a field visit. Of particular interest to many participants were practicals on planting on ridges. This is widely practised in Malawi but labour saving methods have not yet been developed.

The irrigated bean trials at both Bunda College and at Lifuwu Research Station were practically free of pest and disease except for beanfly and BCMV. There was therefore limited opportunity for participants to practice pest and disease identification and assessment. There is need to consider this aspect in planning future courses.

Field Trip: Saturday 25/8/90

We visited Lifuwu Research Station 160 km North-East of Bunda College in the Salima District and near Lake Malawi.

Lifuwu is a Ministry of Agriculture rice research station on which the College is also running several bean trials. At the time of the visit, there were trials which included a South Africa Bean Variety Trial (12 entries plus 3 checks), a Preliminary Variety Trial (100 entries plus 1 check), a Residual Moisture Trial (12 entries) an Adaptation Variety Trial (12 entries plus 3 checks) and a National Bean Variety Trial (12 entries and 1 check).

As would have been expected during this 'dead' period, (it was Winter in Malawi) the beans, which was between V_3 and V_4, was free from disease. There was however evidence of beanfly setting in and BCMV was observed on one plot.

Of particular interest was the Residual Moisture Trial. Researchers were looking at bean production using residual moisture after harvesting paddy rice which is widely grown in the area. There were problems of seed bed preparation. The land was either too wet or too dry. On this trial they had to apply water to break the clods using a rotorvator. This obviously poses a problem for small growers who have neither tractors nor rotorvators.

Apart from the RMT, the other four were irrigated.

They were also growing a local variety, Nasaka, for seed bulking.

This relatively short trip was not altogether smooth with no less than five flat tyre problems - three of them from the same side of a mini-bus we hired from a commercial tour company. We started the journey at 0900 hrs on Saturday and only got back at 0300 hrs on Sunday.

Progress evaluation

Participants progress in gaining knowledge and skills was monitored through classroom discussions and exercises and through observations during practicals. In addition their progress was measured through three written test and a trip report each participant wrote on the field trip. Through these four 'tests' participants were ranked for the purposes of awarding book prices to the top three (Appendix V). (An interesting remark from one of the College staff was that book prizes should be given to the least performing participants - they need them more).

Participants evaluation of the course

At the end of the course, participants evaluated the course by completing a pre-prepared questionnaire (Appendix VI).

The following was their assessment:

A. Arrangements

	% Responses			
	Very Good	Good	Fair	Poor
1. Transportation				
- From home to Bunda	53	26	21	
- During the course	27	42	26	5
- On field visits	16	31	37	16
2. Accommodation	42	58		
3. Meals	42	42	16	
4. Recreation	26	11	32	26
5. Classroom	48	47	5	
6. Coffee breaks	47	53		

Participants expressed satisfaction with the arrangements. However recreation and transport for field visits were rated as fair to poor by more than 50% of the participants. Transport was rated so because of the several flat tyre problems on the long trip.

B. Course Content

1. Duration:

a) Too long
b) Too short 74%
c) Adequate 21%
d) V[illegible]factory 5%

Participants felt the duration of the course was too short. This feeling has been expressed in all the previous courses for technicians. It might be worth considering a three-week course in future.

2. Subject matter

a) Easy to understand 84%
b) Difficult
c) Not sufficiently detailed 11%
d) With too much detail 5%

Participants did not have problems with the subject matter as such apart from the fact that they felt some of the sessions were rushed because of time constraints.

3. Balance between lectures and practicals

a) Very good 32%
b) Good 37%
c) Fair 31%
d) Poor

Opinion on this aspect was divided between 'fair', 'good' and 'very good' with close to 70% rating the balance as 'good' to 'very good'

A. Lecture notes

a) Very good 63%
b) Good 26%
c) Fair 11%
d) Poor

The notes (which included CIAT study guides) were rated as good to very good by close to 90% of the participants. All the handouts were spiral-bound on the last day of the course.

5. All the participants recommended the course to their colleagues.

6. Materials covered:

a) All of it useful 53%
b) Some of it not useful
c) Necessary 5%
d) Most of it useful 42%
e) Very little of it useful

Fifty three percent considered all the course material as useful whilst 42% felt that most of it was useful Unfortunately, there were no additional comments indicating which sessions might have been less useful to some participants.

7. Suggestions for future courses.

Apart from the duration of the course which a number of participants suggested again that it should be longer, there were a number of other suggestions made but by one or two people each.

These included:

- the course should be held during the growing period;
- resource people should also include those from participating countries;
- resource persons should not just read their notes when teaching
- resource persons should be supplied with resource materials to assist them in preparing their training notes;
- days should end at 16.30;
- improve transportation
- improve recreation

After completing the evaluation forms, there was an open discussion to allow participants to raise issues that they wished to have immediate feedback on.

There was considerable discussion on the timing of the course with everybody agreeing that it should be during the growing season. Participants expressed concern however that some of them might not be allowed to leave their trials during that critical and busy period.

There was also a suggestion that such courses be held more frequently.

Course expenses

The following is a statement of expenditure actually incurred during the course excluding air-fares for the two Zimbabwean participants and the Training Officer.

ITEM	Cost in USD
Stationery	605.67
Transport (participants & field trip)	311.50
Accommodation and food	6230.84
Participants out-of-pocket all.	3677.34
Resource persons out-of-pocket all.	857.60
Participants airport tax	22.10
	11705.05

The author administered the payments from the $13200 he had brought from CIAT, Arusha.

Closing ceremony

On the last day of the course, there was a reception during which the Dean of Bunda College of Agriculture, Prof. Makambera performed the closing ceremony. In his speech (Appendix VII), he made a request to CIAT to increase sponsorship for higher degrees.

Through their representative, the participants also moved a vote of thanks (Appendix VIII).
All participants were presented with certificates of attendance and the top three participants also got book prizes.

Appendix I

BEAN RESEARCH METHODS TRAINING COURSE FOR RESEARCH ASSISTANTS: BUNDA COLLEGE OF AGRICULTURE, MALAWI: 20 - 31 August 1990

LIST OF PARTICIPANTS

NAME	ADDRESS
1. BABTISTA KATAYA CHIRWA (MRS) 2. MWENYA MWANSA 3. PAUL E. PHIRI	Msekera Research Station P.O. Box 510089 Chipata Zambia
4. GUNDE N. MAUDENI 5. FRANCIS F. KALUMBA 6. BRAISON B. CHIOKO 7. LORDWIN H.C. KANKHANDE 8. CHARLES B. ZEMBENI 9. M^{C}LONNEX L. KUMFELA 10. FRED F.M. MCHENGA 11. WISDOM D. MUNTHALI 12. DEVLYNE A.B. KANYIMBO	Bunda College of Agriculture P.O. Box 219 Lilongwe Malawi
13. WILLY D. KARIKHO	Kasinthula Research Station P.O. Box 28, Chikwawa Malawi
14. BORNWELL CHIBOWO	P.O. Box 510407 Chipata, Zambia
15. KIZITO C. MUSEKIWA 16. STEPHEN ZENDA	Dept. of R & SS P.O. Box 8100, Causeway Harare, Zimbabwe
17. TYMO B. MDJMA	Matapwata Agricultural Station P.O. Box 40, Mikolongwe Malawi
18. EDDINGS W. JAMBE	Lunyangwa Reseasch Station P.O. Box 59, Mzuzu, Malawi
19. IBACK T.F. NYIRENDA	Ngonga Research Station P/A Ngonga, Rumphi Malawi

Appendix II

BEAN RESEARCH METHODS TRAINING COURSE FOR RESEARCH ASSISTANTS: BUNDA COLLEGE OF AGRICULTURE, MALAWI 20 - 30 August 1990

LIST OF RESOURCE PERSONS

1. Dr A.B.C. MKANDAWIRE 2. MR J. BOKOSI 3. MR O. MULEKANO 4. MR D.S. JERE 5. MRS Y. TEMBO 6. DR W. MSUKU	Bunda College of Agriculture P.O. Box 219, Lilongwe Malawi
7. MR L. MUMBA	Kasinthula Research Station P.O. Box 28, Chikwawa Malawi
8. MR C. KAPUNDA	Lunyangwa Research Station P.O. Box 59, Mzuzu, Malawi
9. MR K. MUIMUI	Msekera Research Station P.O. Box 510089, Chipata Zambia OR Bunda College of Agriculture
10. MR J. MUTIMBA	CIAT, P.O. Box 67, Debre Zeit Ethiopia

Appendix III

University of Malawi
BUNDA COLLEGE OF AGRICULTURE

BEAN RESEARCH METHODS COURSE FOR TECHNICAL ASSISTANTS
BUNDA COLLEGE OF AGRICULTURE, MALAWI 20-31 AUGUST, 1990

OFFICIAL OPENING
by
Head, Crop Production Department

The CIAT Regional Training Officer
Resource Personnel
Participants
Colleagues

I wish to welcome you all, from the neighbouring countries, of Malawi, the Warm Heart of Africa. I hope you all had a wonderful trip to Lilongwe, which I would regard as the Warm Heart of Malawi. For those of you that travelled from other parts of Malawi I also extend to you a sincere welcome.

As you may know, Bunda College of Agriculture of the University of Malawi, is given the mandate to coordinate and conduct bean research for the country as an arm of the Department of Agricultural Research in the Ministry of Agriculture. This is done by the Bean Program which is in the custody of the Department of Crop Production at Bunda College. The University of Malawi is an institution that strives for excellence. And Bunda College being part of the University strives for the same. And so it was very gratifying to hear from the Coordinator of the Bean Program and Host Country Principal Investigator of the Bean/Cowpea Project that the SADDC/CIAT Steering Committee at its eighth meeting in Maseru, Lesotho agreed to support a course of this nature. It was further gratifying that Malawi would be hosting the said course. This is one avenue in which Bunda College once again is at the forefront on the hourney to research excellence. It is said that training is the biggest investment in any plan of activity. This is because personnel trained within these two weeks will have the Bean Programs benefit for years to some.

Malawi is a bean producing country. Just to provide a background, the beans that are grown (just like in our neighbouring countries) originated in the two centres of origin, i.e., the Andean region (Peru, Bolivia, Colombia etc) and Meso-America (Mexico). These beans reached this region through the Portuguese traders that brought them to Mozambique and then up with the Zambezi and shire rivers a little over 300 years ago. In Malawi beans are largely produced by the smallholder farmers. In terms of land area this amounts to about 100,000 hectares. However, in terms of quantities or volume of production we produce about 30,000 metric tonnes annually. A simple calculation from these figures indicates that we only attain a bean yield level of 300 kg/ha. Knowing that beans are capable of yielding in excess of 2,000 kg/ha it would not be inconspicuous to notice that a lot needs to be done. This course is one way in which the gap between reality and potential could be lessened. We hope that after this course you will be going back to the field with renewed strength to work as hard as possible in your job. This will help in identification of genotypes of great potential so that our farmers in all three countries (Zambia, zimbabawe and Malawi) are given the choice to higher yielding bean varieties.

For those of you coming from the neighbouring countries, your coming symbolises oneness and brotherhood. I wish to encourage you to interact with your brothers and sisters from Malawi, not just during this course but for the rest of your time doing bean research. For those from Malawi I ask you to take this course seriousely because the Coordinator told me that he will be coming to the field to check on whether you are practising what you learnt during this course.

We are very grateful to CIAT for supporting this course. Our view is that participation by coordinators of national programs on the Steering Committee will help address the issues that really need attention in our region.

Having said these few remarks, Mr CIAT Regional Training Officer, Resource Personnel, Participants and Colleagues, I declare this course officially open.

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BEAN RESEARCH METHODS TRAINING COURSE FOR RESEARCH ASSISTATNTS: BUNDA COLLEGE OF AGRICULTURE, MALAWI: 20 - 31 August 1990

PROGRAMME

unday, 19 August

pm	Arrival and registration	

onday, 20 August

0800 - 0830	Introductions in pairs	J. Mutimba
0830 - 0900	Participants expectations	"
0900 - 0930	Profile of the Regional Bean Programme	"
0930 - 1000	Official Opening	G.Y.Kanyama-Phir
1000 - 1030	TEA	
1030 - 1130	Structure of National Bean Programme and its activities	A.B.C. Mkandawire
1130 - 1230	Bean Production Systems	J. Mutimba
1230 - 1400	LUNCH	
1400 - 1530	Stages of bean development	A.B.C. Mkandawire
1530 - 1600	TEA	
1630 - 1730	Bean Irrigation	L. Mumba

Tuesday, 21 August

0800- 1000	Seed handling - Multiplication and variety maintenance - Treatment	C. Kapunja
1000 - 1030	TEA	
1030 - 1230	Seed storage and quality control	J. Bokosi
1230 - 1400	LUNCH	
1400 - 1500	Germination tests	O. Mulekano
1500 - 1530	TEA	
1530 - 1700	Practical on germination tests	"

Wednesday, 22 August

0800 - 0900	Trial site selection	J. Mutimba
0900 - 1000	Land preparation/Tillage system	L. Mumba
1000 - 1030	TEA	
1030 - 1130	Experimental designs (basics) - Randomized Complete Block - Completely Randomized - Split plot - Factorial	L. Mumba

1130 - 1230	Trial input calculations - Fertilizer - Chemical - Seed	J. Mutimba
1230 - 1400	LUNCH	
1400 - 1800	Marking out trials	J.Mutimba/D.S.Jer

Thursday, 23 August

0800 - 0900	Field book interpretation	J. Bokosi
0900 - 1000	Theory on breeder's records and data collection	"
1000 - 1030	TEA	
1030 - 1200	Theory on breeder's records	"
1200 - 1400	LUNCH	
1400 - 1530	Practicals on breeder's records and data compilation	" "
1530 - 1600	TEA	
1600 - 1700	Trial input calculation	J. Mutimba

Friday, 24 August

0800 - 1000	Variety identification by seed; Seed preparation and putting out seed for trials	K. Muimui
1000 - 1030	TEA	
1030 - 1230	Practical on putting out seed	C.Kapunda/D.S.Jer
1230 - 1400	LUNCH	
1400 - 1600	Practical on putting our seed	"
1600 - 1800	Practical on planting	K.Muimui/D.S.Jere

Saturday, 25 August

Visit Lifuwu Research Station and Salima Agricultural Developmen Division.

Sunday, 26 August

FREE

Monday, 27 August

0800 - 1000	Agronomic data collection	K. Muimui
1000 - 1030	TEA	
1030 - 1230	Weed identification and assessment	O. Mulekano
1230 - 1400	LUNCH	
1400 - 1530	Practical on agronomic data collection	K. Muimui
1530 - 1600	TEA	
1600 - 1700	Reading of germiniation test result	O. Mulekano

Tuesday, 28 August

0800 - 1000	Disease identification and assessment	W. Msuku

1000 - 1030	TEA	
1030 - 1230	Disease identification (Cont'd.)	W. Msuku
1230 - 1400	LUNCH	
1400 - 1700	Practical on diseases	W. Msuku

Wednesday, 29 August

0800 - 1000	Pests identification and assessment	Y. Tembo
1000 - 1030	TEA	
1030 - 1200	Pests identification and (Cont'd.)	Y. Tembo
1200 - 1400	LUNCH	
1400 - 1800	Shopping in Lilongwe	

Thursday, 30 August

0800 - 0900	Handling germplasm materials	C. Kapunda
0900 - 1000	Harvesting	D.S.Jere
1000 - 1030	TEA	
1030 - 1230	On-farm research - concept/stages - farmer selection - choice of designs - planning OFT	J. Mutimba
1230 - 1400	LUNCH	
1400 - 1500	Visit library for materials	Ng'ambi?
1500 - 1600	Test	

Friday, 31 August

0800 - 1000	On-Farm Research - Roles - Researcher/farmer/ extension - farmer evaluations	J. Mutimba
1000 - 1030	TEA	
1030 - 1230	Open-ended evaluations	J. Mutimba
1230 - 1400	LUNCH	
1400 - 1500	Selecting and recording data in open-ended evaluations	"
1500 - 1530	TEA	
1530 - 1630	General discussion and course assessment	J. Mutimba
1800 - 2000	Official closing and reception	Dean

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BEAN RESEARCH METHODS COURSE:
BUNDA COLLEGE OF AGRICULTURE:
20 - 31 August 1990

ASSESSMENT OF PARTICIPANTS

	1ST TEST %	2ND TEST %	TRIP REPORT %	FINAL TEST %	GRANT TOTAL %	POSITION
JAMBE	50	100	70	80	300	5
ZEMBENI	25	75	70	46	216	13
IMA	50	100	70	64	284	7
ALUMBA	50	100	50	44	244	10
IBOWO	50	100	65	55	270	8
IRENDA	0	100	50	45	195	15
NDA	25	100	80	82	290	6
NYIMBO	50	50	50	52	202	14
MUSEKIWA	35	100	90	77	302	4
MFELA	0	100	70	67	237	11
IOKO	0	100	40	52	192	16
MCHENGA	0	50	40	66	156	17
UDENI	0	50	40	14	104	18
. KANKHANDE	0	100	70	76	246	9
IRWA	100	100	90	78	368	1
ENYA	100	100	70	80	350	2
IRI	100	100	70	73	343	3
KARIKHO	50	100	70	82	302	4
NTHALI	0	100	60	58	218	12

APPENDIX VI

COURSE EVALUATION BY PARTICIPANTS

A. Arrangements How would you rate the following:

Aspect	Very Good	Good	Fair	Poor
1. Transportation				
- From Home base to Bunda				
- During the course				
- On field visits				
2. Accommodation				
3. Meals				
4. Recreation				
5. Classroom				
6. Coffee breaks				

Additional Comments ______________________________

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B. Course Content

1. What is your assessment of the following aspects?

Duration:
(a) Too long
(b) Too short
(c) Adequate
(d) Very satisfactory

2. Did you find the subject matter?

(a) Easy to understand
(b) Difficult
(c) Not sufficiently detailed
(d) With too much detail

Comments ______________________________

____

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3. How would you rate the balance between lectures and practicals?

(a) Very good
(b) Good
(c) Fair
(d) Poor

4. How would you rate the lecture notes that you were provided?

(a) Very good
(b) Good
(c) Fair
(d) Poor

5. Would you recommend this course to your colleagues?

Yes No

6. What do you think of the materials covered?

(a) All of it useful
(b) Some of it not useful
(c) Necessary
(d) Most of it useful
(e) Very little of it useful

Additional Comments ______________________________

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8. If the course was to be repeated, what changes would you like to see?

Appendix VII

university of Malawi
Bunda College of Agriculture

OFFICIAL CLOSING OF TECHNICIANS TRAINING COURSE

31st August, 1990

by

The Dean
Bunda College of Agriculture
UNIVERSITY OF MALAWI

Head of Crop Production Department
CIAT Regional Training Officer
Heads of Departments
Members of the Bean Programme
Participants
Ladies and Gentlemen

It is my pleasure to officiate at the closing ceremony of the "Research Methods Training Course for Technicians and Research assistants" that was being held here at Bunda College of Agriculture from 20 to 31 August, 1990. And I must assure you I am glad to do so.

The Bean Program started with the moving of Professor L.K. Mughogho from Agricultural Research Council to Bunda College. The first major activity of the Bean Program in 1969, roughly twenty years ago, was the collection of local materials across our country. With the help later of Professor O.T. Edje, Dr U.W. U Ayonadu and Dr W.A.B. Msuku these materials were screened for yielding ability. Much later (1979) six of these materials were released as varieties, viz; Nasaka, Sapelekedwa, Namajengo, Kanzama, Kamtsilo and Bwenziawana. Newer better upcoming varieties are in the pipeline. But one interesting aspect of the program is that it has grown from the humble beginnings in 1969 to probably the largest single crop commodity team that it is now. In about three years' time this program will have eight senior members at Ph.D. level. It might be worth nothing at this time that one of these (Mr Mloza Banda) is already in training under CIAT's sponsorship. We are looking forward to more sponsorship from CIAT for MSc. and Ph.D. for Malawian and indeed SADCC region scientists.

As you may be aware senior scientists on the Bean Program are engaged in teaching apart from doing bean research as an arm of the Department of Agricultural Research. And indeed the college is very grateful to be able to participate in furthering bean research in the country. And we wish to assure the Chief Agricultural Research Officer and the Principal at Bunda College that the bean program will continue to stay at the cutting edge of the bean research and will provide a lead in some areas, e.g.

angular leaf spot, drought and biological nitrogen fixation, for the SADCC regional program. The other dimension that is also important is the support staff. We did make mention of the growth of the bean program. This has been possible mainly with the support from Bean/Cowpea CRSP since 1982. This project helps in paying support staff in the bean program. These include program secretary, program driver and research assistants. The secretary and driver are normally engaged upon presentation of necessary certificates to interviewing panel. However, the research assistants are engaged after secondary school without any agricultural education certificates. As a result we have seen experiments that were not laid out in the field the way they were on paper. The Bean Program, therefore recognised the need to train these very important staff. A small proposal was drawn up and debated at the Steering Committee Meeting in Lesotho earlier this year SADCC/CIAT agreed to support this effort only if the other participants were included from Zambia and Zimbabwe Bean Programs. Eventually, these funds a little over USD 10,000 were provided.

Trainees have learned principles of some subject areas like pathology, entomology, agronomy etc. What is more pleasing is that they learned the practice of carrying out scientific experiments. This involved calculation of quantities of inputs (seed, fertiliser, chemicals), packing the seed, the lay out of the experimental field and scoring for disease and pest damage as well as collection of other important data. The Bean Programs in our three countries (Malawi, Zambia and Zimbabwe) will greatly benefit from the knowledge that has been instilled. At the beginning of the course the trainees were asked what they hoped to learn from the course. It is most gratifying to note that most of those goals have been achieved. We express our sincere gratitude to CIAT, through the CIAT Regional Training Officer, for supporting this effort. We hope a follow up course in the future to evaluate progress made aquisition of the data and hopefully some statistical analysis to be included.

The course was conducted in a very peaceful environment that the college offered. We wish to sincerely thank the Principal for allowing the course to be held here and for the use of college facilities. The trainees' stay on campus will be greatly remembered by us all for some time to come.

We also wish to express sincere thanks to all those that helped as resource personnel starting with Mr Mutimba, Dr A.B.C. Mkandawire, Dr W.A.B. Msuku, Mr J.M. Bokosi, Mr C.B. Kapunda, Mr K. Muimui, Mrs Y. Tembo, Mr O.L. Mulekano, Mr D. Jere. Mr L. Mumba(in absentia). We shall request for your help in future courses. Lastly we wish to thank you all for coming to the official closing of training course.

PRESENTATION OF CERTIFICATES AND GIFTS.

I now declare the "Training course for bean research assistants" officially closed.

Appendix VIII

Participants vote of thanks

by

Bornwell chibowo

We would like at this juncture to give a vote of thanks to the College Principal for providing the training facilities moral support & indeed protection for our 2 weeks stay.

We also like to thank the National Programme leaders in conjunction with SADCC/CIAT for recognising the need for our training and making available the funds to make this a reality.

Apart from having a tough time, we feel the 2 wks was not sufficient. However, we hope, when we go to our various working places, we shall put into practice the techniques that have been imparted to us on Bean Research Production Methods with the overall goal of increased Bean production for our countries of Origin.

We also wish to thank the Resource Personnel and more importantly, the Training Officer, Mr Jeff Mutimba for the patience he showed to us regardless of the headaches we might have caused during the course. Needless to say, we wish the Training Officer to carry this special message to the Regional Coordinator SADCC/CIAT that we've appreciated the training but this should not be the end - but the beginning.

Last but not the least, we thank the kitchen staff & carterer for providing us with nice food although we had less nsima on menu otherwise everything was ok for us - superb.

We also thank those not mentioned but rendered kind assistance.

We thank you all.

Bunda College of Agriculture
University of Malawi

SADC/CIAT

Regional Programme on Beans in Southern Africa

This is to Certify that

....

attended a Bean Research Methods Course
for Research Assistants held at
Bunda College of Agriculture
from
20th to 31st August, 1990

....
Principal

....
Regional Coordinator