IPTT

IGLV- VIVA EVALUATION REPORT

EVALUATION OF THE CULTIVATION TRIALS OF INDIGENOUS/TRADITIONNAL GREEN LEAFY VEGETABLES UNDER THE IGLV-VIVA 2005-2006 PROGRAM

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Under the UPDP funds

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1. Introduction

This report follows the progress report of September 2005 and is together with the PHASE 2 of the Processing and Marketing Trials closing this phase of the IGLV-VIVA programme. The report covers the time frame from November 2005 to September 2006. No cultivation trials were done during the winter months of May and July-2006.
The processing and marketing was finalised and reported in August 06. The current report will concentrate on the cultivation trials and evaluate the latter in the light of its economical viability.

Based on the findings of the Marketing and Processing trials, discussions during the IPTT meetings and the previous programme progress reports, the second phase of cultivation concentrated mainly on Cleome Gynandra and Amaranthus thunbergi. Two trials were done on Hibiscus sabdariffa as theses were already planned in 2005 on UNAM's own initiative after having received seeds from the Programme coordinator. It would also have been too early to completely leave out one of the traditional leafy vegetable based on a very inconclusive and small Market research only.

Cultivation trials were organized at the following locations:

Ben-hur in the Omaheke region at the Komeho RDC

2 Trials on Cleome Gynandra and Amaranthus thunbergi with different combinations of fertilizer and farmyard manure (Nov-05-Jan-06)

Mannheim in the Oshikoto Region

Trials on spacing for Amaranthus thunbergi failed due to flooding of the area during heavy rain fall in February and March-06 (see attached photos Appendix 5.). The trial was discontinued. Given the extensive literature cover on spacing and limited variations between recommended spacing for Amaranthus thunbergii, no replication of that trial was organized.

Instead, a new trial started from August to September to see the potential of winter cultivation under a floppy sprinkler system and under different irrigation frequencies.

Bagani, eastern Kavango region

Trial on Cleome Gynandra Dec 05-Jan-06
Trial on Amaranthus thunbergi Jan-March-06
Both trials were on different treatment of compound fertiliser and manure.

Rundu urban trial, Kavango Region

A first trial on Amaranthus thunbergii was done from Dec-05-Jan-06 to compare different types of fertilizer (Drip irrigation was in place but not used as rain was sufficient).

From Feb-06-March-06 a second trial was done on Amaranthus thunbergii to compare efficiency of cultivation under drip irrigation on bow benches (plastic sheeting to avoid water loss) and without plastic sheeting.

UNAM trials at the Ogongo Campus, Omusati Region

Under the supervision of the lecturers at the department of crop science the following trials were done.

Trial on the effect of Plant Density on the growth and yield of Hibiscus sabdariffa as well as the effect of transplanting on two different varieties. The trial was done from May-05 to July-05. The report was done in August-05, but only a hardcopy of the latter was send to the coordinator in August-06. As the main supervisor at UNAM is out of the country no raw data could be evaluated and thus only the final findings are commented and reported in this report.

Trial on the effect of transplanting and direct planting on different accessions of Cleome gynandra from April to July-05. A report was compiled in 2005 but as for the previous trial, it only reached the project coordinator in 2006 as a hardcopy. Only final results can be reported.

Trial to determine the water effect on vegetative growth and yield of H. sabdariffa under different treatment (as secondary factors) which lasted from Dec-05 to July-2006.

A germination trial on Amaranthus thunbergi in different medium was also organized but has not yet been received and evaluated at the writing of this report.

A Trial at Desert green was discontinued as the commercial farmer who was selected by the programme coordinator as a potential partner, used the plot for planting spices and trials on olive trees. A part form germination measurements in seed trays no further records were done by this partner (the data is recorded in Appendix 3).

At the beginning of the rainy season in 2006 the project coordinator organized some communities and plant stations to produce Amaranthus thunbergi and Cleome gynandra to be harvested for the processing and marketing trials only.

2. Cultivation for harvesting

Before the cultivation trials, seeds collected during the 2005 season were distributed for cultivation to the communities and research stations. In total 8 different locations were earmarked in January and February-06 for harvesting. The plot at the Ogongo campus was not ready and only had Hibiscus ready at the time of harvest, while one urban trial was approaching its 3rd harvest in February and was thus not considered to provide more IGLV in March 2006. The IGLV were harvested from Mannheim, Mashare, Bagani as well as three community gardens in the Kavango region. IGLV were harvested from 6 different locations of which 5 were east of Rundu in the Kavango region.

Harvest and Delivery of IGLV for processing trials

Harvest Dates	Stored	Sending date and packaging	Delivered in Whk (time unknown)	Quantity of Amaranhtus	Quantity Cleome	Period of harvest	Treatment	Origin
09.03.06		09.03.06 16.45 paper bags inside plastic bags	10.03.06 14.30!	9.22		6 weeks after planting	None	Mannheim
14.03.06		15.03.06 14h50	16.03.06	4.4	3.11	7 weeks after planting	None	Mannheim
11/12-14.03.06	Cold room for 3 days	16.03 17h00. 17 white woven plastic 20 & 50kg bags	17.03.06	36	4.5	6 weeks after planting	None	Mashare constituency (Community garden & Mashare)
	Chest Fridge for 1 day	17.03.06 16.30	Delivered before 9.00 AM	1.43		At 20cm Mix of wild and planted	None	Salem Rundu rural east
31,03.06	Chest fridge at 4C for 2 days	3.04 white woven plastic 20 & 50 kg bags	04.04 delivered around 9.00 AM	9.96		7 weeks after planting	NPK and Manure from field trial	Bagani
TOTAL:				**61 kg**	**7.11 kg**			

In addition to the field guidelines, written harvesting guidelines were also provided to all partners before the harvest (Appendix 1.). Transport was organized by overnight courier to Windhoek by the programme coordinator. Payment was done directly to the collectors while collecting the bags. As initial bags were packed too tightly the quality of the first delivery was deteriorating, however through feedback from the processor receiving the first batch, the following deliveries were improved. In total 5 deliveries were organized to Windhoek

Problems encountered:

Due to the heavy rain during the planting and harvesting, most locations had a low harvest as a result of seeds having been washed out (see photos in Appendix 5).

As the processing trials kicked of late, the insect infestation of the final harvest was also bigger than anticipated. Especially cleome gynandra was attacked by Bagrada Bugs and hardly usable and started flowering while still small. The above explains why the quantity of *Cleome* leaves (Ombidi) delivered was very low compared to Amaranthus which were less exposed to these constraints (See pest infestation in Appendix 5). As leafs were to be used for processing trials we did no try to use pesticides.

Due to the heavy rain, a lot of mud splashed on the leaves, and as the average size of the harvest was only 20cm above the ground, this left a heavier burden of washing and cleaning to the processor.

Most of the IGLV had to be stored in a cold room in Mashare and Rundu prior to dispatchment, as dispatching on Fridays was posing a problem to the IGLV processing partner in WHK. Vegetables harvested thus needed to be stored until Monday. Due to the rains, harvest at the beginning of the week was not always possible.

Delivery time of the overnight courtier for the first two batches was too long.

In general the quality of the delivery improved a lot from the first two to the last two batches, as transport and harvest conditions improved. While the delivery time of the first batches was unreliable (time wasted in warehouse, contributing to a further deterioration of the leaves), the last three deliveries improved as the courier got used to the cargo and our requirements.

While the program coordinators guidelines were not always followed on site during the first batch, later deliveries were received in WHK in excellent conditions.

3. Cultivation trials

Planning

After the seeds from the previous seasons were distributed to all locations, the planting and field management was done according to the 2005 Research protocol.

Evaluation of results

Significance if any of the differences between treatments is determined by analysis of variance. The descriptive study of all the results was done using Microsoft excel as well as SPSS12 (or Sigma stat for UNAM) from which graphs were drawn to present the data. Then One-Way and Two-Way ANOVA at 95% confidences interval was used to test for significant difference between the treatments.

3.1 Treatment of different concentration of farmyard manure and fertilizer on Amaranthus thunbergii and Cleome gynandra

Planning

The research was conducted at Ben-hur (Komeho rural development agency) in the Omaheke region situated 50km southeast of Gobabis. Both *Amaranthus* and *Cleome* were grown during spring to summer. A randomized block experiment replicated three times was conducted. Ten treatments of different concentration of farmyard manure, NPK (2:3:4) (30%) + 30.0 lime and combination of different amounts of NPK and manure were tested. Farmyard manure was classified as LM (1kg/m^2) and HM (2kg/m^2) while NPK were classified as LNPK (50g/m²), MeNPK (100g/m²) and HNPK (200g/m²) both in plots sizes of 2.25m² (1.5m x 1.5m). Both seeds were obtained from the program coordinator (*Cleome gynandra* from Ogongo and *Amaranthus thunbergii* from the Kavango region). Both vegetables (*Cleome and Amaranthus*) were spaced at 10cm between plants, 15cm between plants and 1m paths between plots, which amounted to an area of 336m².

Soil analyses done and results for the trial plot (based on five soil samples at 20cm depth):

N%	Pppm	Kppm	Cappm	Mgppm	Nappm	pHw	Ecw	Om%	CaCO3 Est %	Texture	Sand %	Clay %	Silt %
0.019	4.4	81	356	46	70	6.91	88	0.47	none	sand	90.7	2,9	6,4

Seeds were directly sown. *Amaranthus* (30 plots) were sown on the 4th of November 2005 and started germinating after 6- 10 days with germination first observed in plot no. 30, 31 , 39 and 55 while Cleome (30 plots) were seeded on 5th of November and started germinating after 7-9 days with germination first observed in plot no.34, 45 and 56. White permanent tags were used to mark plot numbers and their treatment.

Management

Most plants were thinned after 10-11 days at a spacing of 10cm distance between plants in row and 15cm distance between rows at the height of about 10- 15cm except plot no.7 of cleome and 2, 22, 46 and 50 of *Amaranthus* where the growth rate was very slow.

Photo 1: Shows a well-thinned *Amaranthus* plot.

10 liters of water were applied everyday in the afternoon, before germination until the first harvest. After the first harvest, 10 liters of water were applied every second day until the last harvest. No watering was done if rain has been received. For the whole testing season 500 and 380 liters of water were used (*Amaranthus and Cleome*) and 204mm of rain was received. As the growing period of Cleome was shorter with a maximum of 3 harvests, less water was used.

A chemical called Bexadust was used to control Bagrada bugs, which attacked Cleome gynandra. Weeding was done weekly.

Two plants in the net plot (0.99m²) of each plot were selected according to the height of most plants in the plot and two more other plants to measure the growth rate and determine the yield per plant. Two plants in the net plot were also selected to determine the growth rate.

Harvesting and post harvesting

Amaranthus should be ready for harvest 20-45 days after sowing depending on variety and plat type (Palada and Chang, 2003). In our trial the first leaves could be harvested 3 weeks after the seed emergence. Mature leaves were cut about 10cm from the ground to allow shoot growth. Only plants in the net plot were harvested, plants outside the net plot were not cut, for more seeds collection after the trial. The first harvest was done 23-31 days after germination depending on the maturity of leaves. Cleome was harvested three times from the 02.12 to the 25.12 with a maximum of 10 days between the harvests, while *Amaranthus* was harvested four times from the 12.12.05 to the 14.01.06, with two weeks between each harvest. After harvesting the yield of fresh and dried leaves were measured. The seeds for cleome were harvested at end of the record period, while the seeds of Amaranthus were not ready for harvesting until one month after the last harvest in February-06. Harvest of Amaranthus seeds is more labor intensive as the harvest of the Cleome seeds, as the seeds do not come out of the pods easily, but must be grinded and separated from the shell with a sieve.

Results for Amaranthus thunbergi

Harvest in g of fresh leaves per net plot.

Tab.1

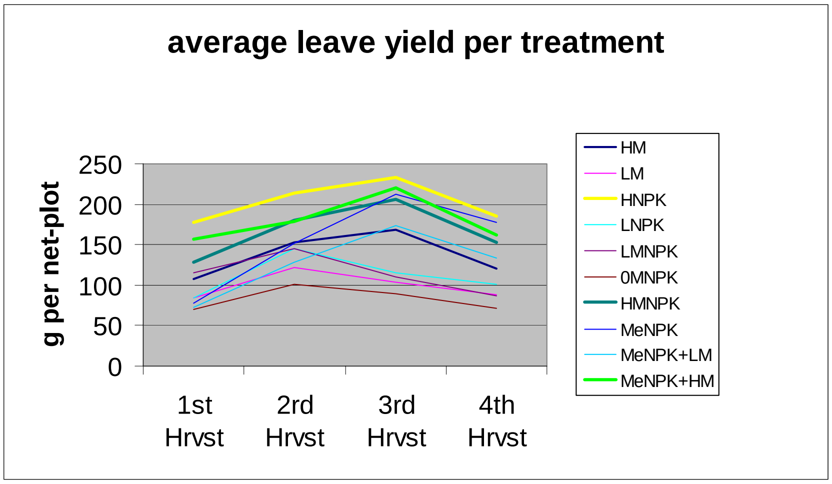
		1st Hrvst	2rd Hrvst	3rd Hrvst	4th Hrvst	TOTAL HARVEST
1	**HM**	108	153	169	121	551
2	**LM**	84	122	103	88	397
3	**HNPK**	178	214	233	185	810
4	**LNPK**	84	145	115	102	445
5	**LMNPK**	115	146	111	87	458
6	**0MNPK**	70	102	90	72	333
7	**HMNPK**	128	180	206	153	667
8	**MeNPK**	77	152	213	178	620
9	**MeNPK+LM**	72	128	174	134	508
10	**MeNPK+HM**	157	179	220	162	718
		1073	1520	1632	1281	5506

Treatments:

Entry 1: HM — High level of manure 2kg/m2
Entry 2. LM — Low level of manure 1kg/m2
Entry 3. HNPK — High level of NPK 200g/m2
Entry 4. LNPK — Low level of NPK 50g/m2
Entry 5. LMNPK — Low level of Manure + Low level of NPK

Entry 6. 0MNPK Control Plot
Entry 7: HMNPK High level of manure & NPK
Entry 8: MeNPK Medium, NPK 100g/m2 no Manure
Entry 9: MeNPKLM Medium NPK Low Manure
Entry10: MeNPKHM Medium NPK High Manure

Fig.1



a.) Amaranthus under HMNPK

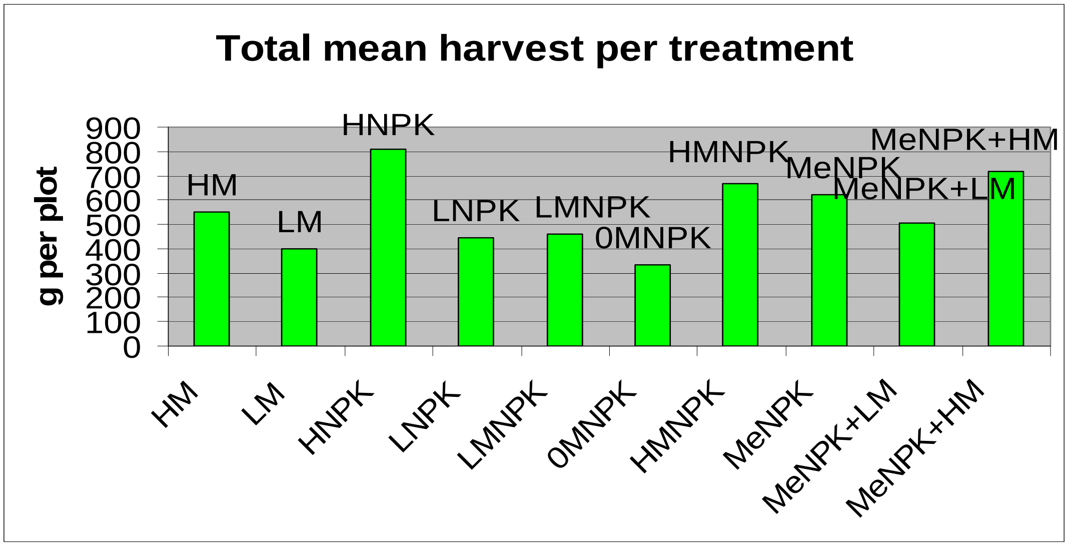
b.) Control Plot (no treatment)

Photo 2.

Photo 3.

Good **germination, fastest growth and good harvest** were observed in plots which were treated with HNPK, HMNPK, MENPK+HM, MeNPK+LM while the opposite was observed in plots that were treated with LM, LNPK, LMNPK and 0MNPK.
Plots treated with HM, HNPK AND HMNPK showed an increased second and third harvest. The LNPK and Control exhibit a decreased second harvest while all had a declined third harvest due to nutrients used up by plants. LNPK with no manure seems to use up nutrients most fast.

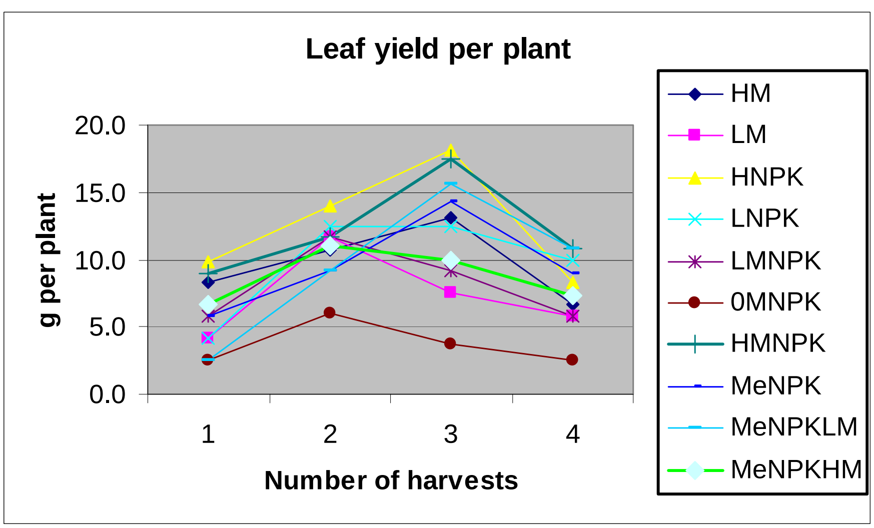
Fig.2



Tab.2

		Average Leaf yield (g\plant)			
		1st	2nd	3rd	4th
E1	HM	8.3	10.7	13.2	6.7
E2	LM	4.2	11.7	7.5	5.8
E3	HNPK	9.8	14.0	18.2	8.3
E4	LNPK	4.2	12.5	12.5	10
E5	LMNPK	5.8	11.7	9.2	5.8
E6	0MNPK	2.5	6	3.7	2.5
E7	HMNPK	9	11.7	17.5	10.8
E8	MeNPK	5.8	9.2	14.3	9.0
E9	MeNPKLM	3	9	16	11
E10	MeNPKHM	6.7	11.0	10.0	7.3

Fig 3.



Remarkably the results of the effect of treatment on leaf yield per plant are the same than total harvest with highest results on HNPK and HMNPK

A one way between group analysis of variance with post-hoc tests was conducted to explore the impact of the different treatments on the total harvest of Amaranthus thunbergii. Homogeneity of variance should be assumed (Sig. value larger than 0.5), however given the equal number of trials in each group and the alternative test for the Levene Statistic the ANOVA remains a robust test.

Test of Homogeneity of Variances

g per net-plot

Levene Statistic	df1	df2	Sig.
2.662	9	19	.035

ANOVA

g per net-plot

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	600138.741	9	66682.082	2.844	.026
Within Groups	445560.500	19	23450.553		
Total	1045699.241	28			

As Sig. (P) is less than 0.05 there is a significant difference somewhere among the treatments.

The statistical difference between each pair of group is provided in the table in Appendix 6. labeled “multiple comparisons”.

Based on theses findings only differences between LM and HNPK, HNPK and Control could under the current circumstances been classified as significant.

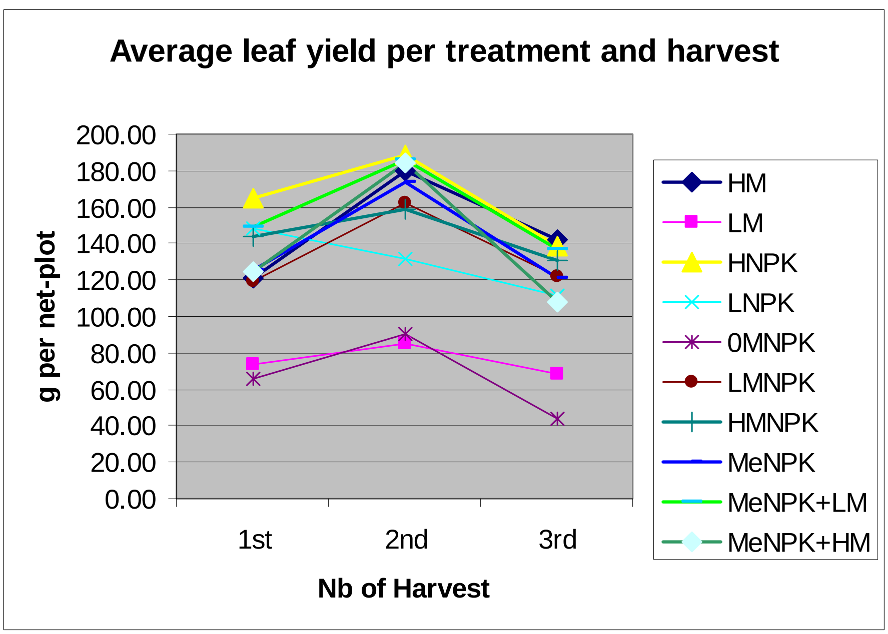
Results for Cleome gynandra

Slow growth and poor germination were observed in plots treated with HMNPK and LMNPK. Moderate germination and fast growth were observed in plot treated with HNPK and LNPK while poor germination and slow growth were observed in plots treated with LM and OMNPK.

Tab.3

Treatments	1st	2nd	3rd	Total harvest
HM	121.33	179.67	142.00	443.00
LM	73.33	85.00	68.00	226.33
HNPK	165.00	189.00	138.33	492.33
LNPK	148.00	131.33	111.17	390.50
0MNPK	66.00	90.00	44.17	200.17
LMNPK	119.00	162.00	122.17	403.17
HMNPK	144.00	159.00	131.00	434.00
MeNPK	125.33	174.00	120.67	420.00
MeNPK+LM	149.00	186.00	136.67	471.67
MeNPK+HM	125.00	184.00	107.62	416.62

Fig.4



All Cleome plots showed increased second harvest and decreased third harvest. The highest harvest was recorded in plots treated with HMNPK, MeNPK, HNPK, MeNPK+LM. While the lowest harvest was recorded in plots treated with LM and 0MNPK (Control). Medium growth has been observed for LNPK and HM. Harvest increased from the 1st to the 2nd harvest and decreased for third harvest for all treatments, except for LNPK which decreased already for the second harvest.

Statistical evaluation:

Robust Tests of Equality of Means

g per net-plot

	Statistic(a)	df1	df2	Sig.
Welch	35.039	9	7.916	.000

a Asymptotically F distributed.

ANOVA

g per net-plot

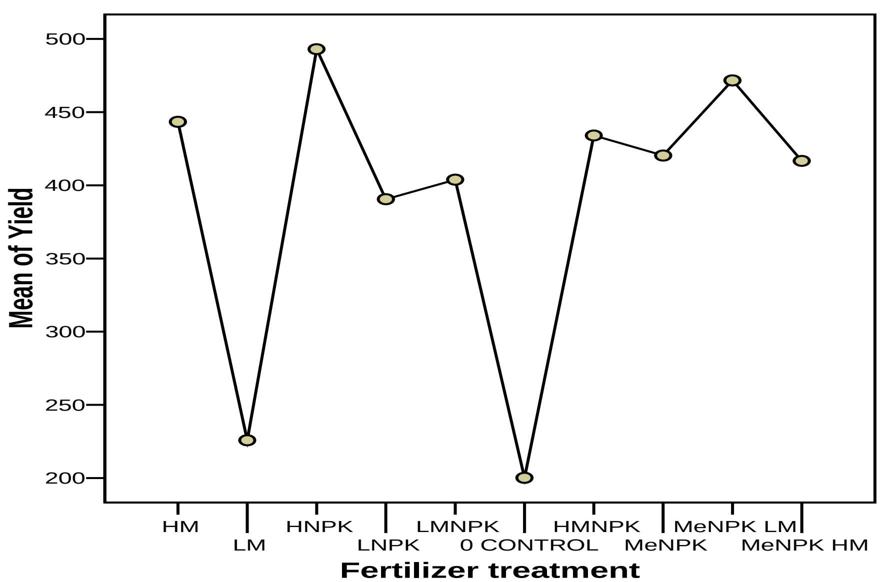
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	260609.874	9	28956.653	4.878	.002
Within Groups	118729.252	20	5936.463		
Total	379339.126	29			

For the effect of fertilizer treatment the P value = 0.002 (< 0.05) hence there is a significant differences among the chosen treatments. (F=4.878 df=9, P=0.002)

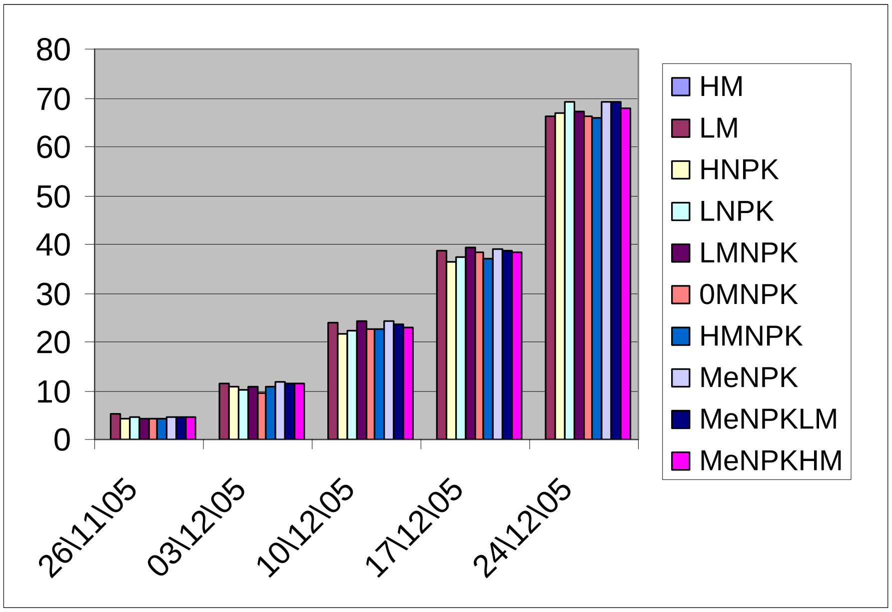
Significant differences based on multiple comparisons done on SPSS were only found between.(APPENDIX 6)

HM and LM, Control, HNPK
HNPK and LM, Control
LMNPK and Control,
HMNPK and LM, Control, MeNPK
MeNPK LM and Control,

Fig.5



Plant heights
Fig.6



No differences in final plant heights referring to treatment were noticed.

3.2 Treatment of different concentration of farmyard manure and fertilizer on Amaranthus thunbergii and Cleome gynandra.
(BAGANI TRIAL).

Planning

Idem to the previous, with random plot design, with three repetitions, but only one harvest. (See plot design in Appendix 2).
Soil analyses for trial plot (mixture of five samples)

Tab.4

N%	P ppm	K ppm	Ca ppm	Mg ppm	Na ppm	pHw	Ecw	Om%	CaCO3 Est %	Texture	Sand %	Clay %	Silt %
0.02	6.41	30	500	40	0	8.37	30	0.45	none	Loamy sand	89.2	10	0.8

Sowing of Cleome started on the 29/11/05 with a first emergence on the 08/12/05 after 10 days, was done 18 days after the first germination (20.02.06)

Germination was poor, as half of the trial plots had poor germination with 16 out of 25 having an emergence of less than 50 %.

Only the plots with entry HM, LM+HNPK and HM+LNPK had better emergences and plant counts above 50%.

Leaves were harvested 5 weeks after thinning and 8 weeks after sowing.

Pest attack was strong but less on plants which were well established

Labor

For 9.6 X28 = 268 m2

Planting = 5 hrs
Thinning = 4 hrs
Weeding = 5 hrs
Harvesting = 18 hrs
TOTAL HRS = 32 hrs

Different effects of treatment on harvest and other parameters

Tab.5

	Foliage fresh mass per harvest	Average leaf size	Average plant height	Pest infestation
HNPK	**0.66**	4.3	40.3	**3.3**
LM+HNPK	**0.62**	6.3	38.4	**2.5**
LM	**0.43**	5.5	29.0	**2.5**
CONTROL	**0.44**	5.3	25.6	**3.3**
LNPK	**0.76**	4.5	32.0	**3.0**
HM	**0.71**	5.8	37.6	**2.5**
HM +LNPK	**0.878**	**6.8**	**38.7**	**2.5**

Pest infestation: 1 none 2 medium 3 heavy 4 severe

Correlation coefficient between

Good Harvest and height CORR G HEI	0.694234416
Correlation between good harvest and pest invasion.	
CORR HA PEST	-0.245607908

Despite bug infestation, the total harvest result is only weakly correlated while good harvest and height are strongly correlated.

Statistical evaluation

Descriptives

g per net-plot

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
LM	3	.42833	.076376	.044096	.23860	.61806	.345	.495
LNPK	3	.76000	.135277	.078102	.42395	1.09605	.630	.900
HM	2	.71250	.045962	.032500	.29955	1.12545	.680	.745
HNPK	3	.65667	.122916	.070966	.35133	.96201	.540	.785
CONTROL	3	.43667	.070946	.040961	.26043	.61291	.360	.500
LM + HNPK	2	.61500	.014142	.010000	.48794	.74206	.605	.625
HM + LNPK	2	.87750	.045962	.032500	.46455	1.29045	.845	.910
Total	18	.62528	.174242	.041069	.53863	.71193	.345	.910

Test of Homogeneity of Variances

g per net-plot

Levene Statistic	df1	df2	Sig.
1.045	6	11	.448

Assumption of homogeneity is not violated.

ANOVA

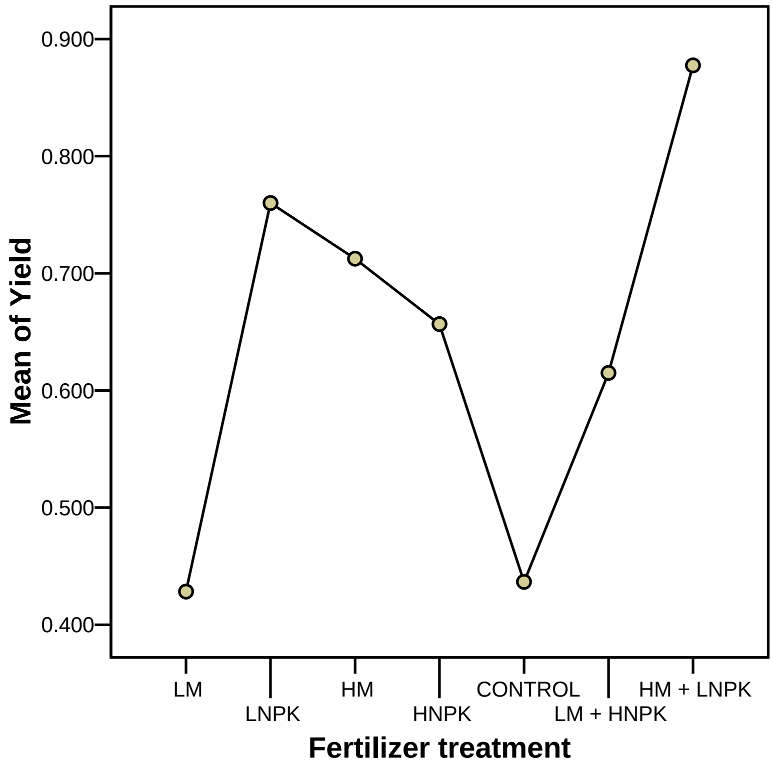
g per net-plot

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.423	6	.071	8.344	.001
Within Groups	.093	11	.008		
Total	.516	17			

As $P < 0.05$ there is a significant difference among the mean score of the dependant variable (harvest). The statistical difference of the difference between each pair of treatments is provided in the multiple comparison tables in Appendix 6 which gives the result of the post-hoc test.

Mean differences are significant at the .10 level for:
LM – LNPK, HNPK, CONTROL, AND HM + LNPK
LNPK –CONTROL,
HM- LM, CONTROL
CONTROL- LNPK, HM, HM+LNPK

Fig.7 Mean plots



Highest values are at HM LNPK. HNPK seems to have less positive affect than for the Komeho trial.

Amaranthus thunbergii

Sowing of Amaranthus started on the 27/01/06 with a first emergence after one week only, thinning was done 18 days after the first germination (20.02.06)
Leaves were harvested 5 weeks later between the 28 and 30 of March, with a last harvest on the 3rd of April. No major pests were observed apart from some larvae at the end of the season. Most plots were well established with a 75 % seed emergence. However the control plot failed as nearly no seeds emerged

Other plots with low emergence such as plot 307, 403 were not considered in the data records as it would have biased the other trial results.

Effects of treatment on harvest:
Fig.8

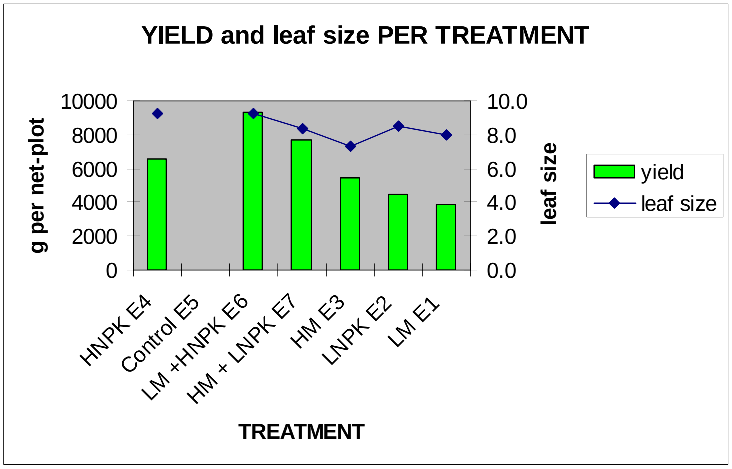
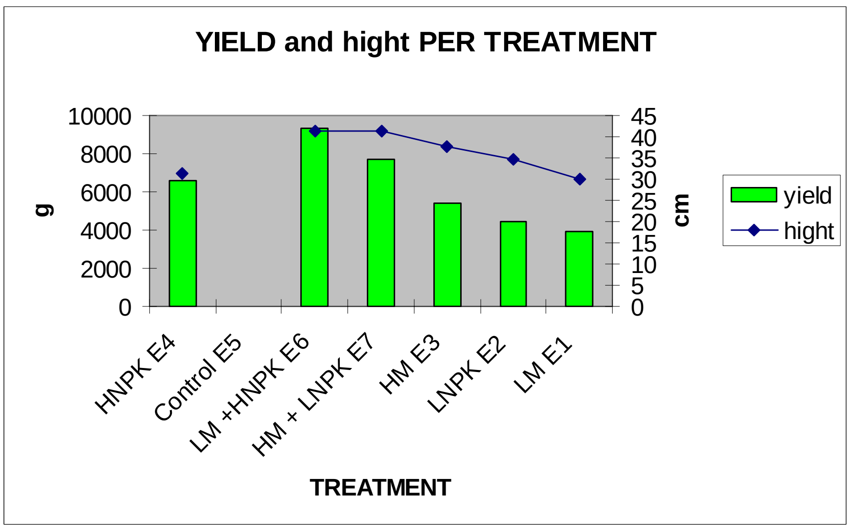


Fig.9



<u>Statistical evaluation</u>

Treat. and leaf size. Correlation	0.584123
Treat. and Height Correlation	0.754497

Test of Homogeneity of Variances

g per net-plot

Levene Statistic	df1	df2	Sig.
4.336	5	11	.020

Assumption of Homogeneity of variance is violated as significant value is less than 0.05 , however ANOVA is still robust to this violation as the size of the groups are the same.

ANOVA

g per net-plot

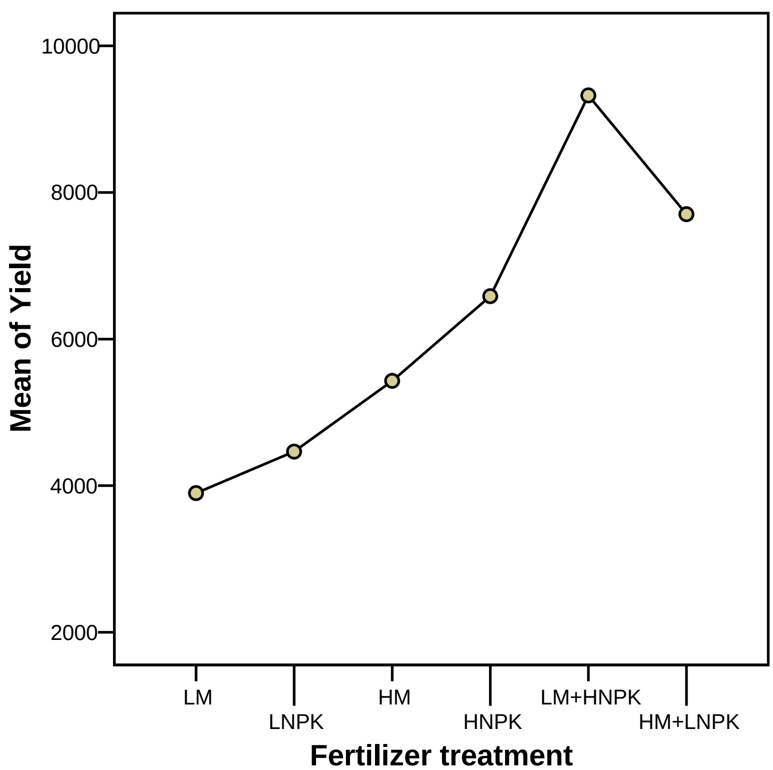
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	63041388.235	5	12608277.647	3.971	.026
Within Groups	34927850.000	11	3175259.091		
Total	97969238.235	16			

For the treatment results the P value = 0.026, hence there is a significant differences among the treatments. (F=3.971, df=5, P=0.026)

Significance differences were observed between the following treatments only:

LM-LM HNPK
LNPK-LM HNPK

Means Plots (computed by SPSS 12)
Fig.9



Highest yields were obtained form LM HNPK, and there is a steady increase from
LM ---LNPK----HM----HNPK---LM HNPK. While HM LNPK is situated between HNPK AND LM HNPK.

Labour

Planting = 5 hrs
Thinning = 3 hrs
Weeding = 3 hrs
Harvesting = 18 hrs
TOTAL HRS = 29 hrs

For 2 persons

Total man-hours: 58 hrs for on a 200 m2 of Amaranthus. Or 29 hrs per 100m2 for one harvest only.

3.3 Rundu urban trial on amaranthus thunbergii
(Trial one effects of 3 different type of fertilizer and effect of bow benching)

3.3.1 Effect on different type of fertilizer

Sowing was done on the dates 20-24/11 The thinning and 1st harvest of Amaranthus thunbergi on the 22/12/05 one month after sowing followed by a 2nd harvest on the 5th of January 2006 and a 3rd harvest on the 23rd of January 06.

Plants were planted both sides of the drippers (30cm between each hole), and drip lines were 30cm apart on a 18 X 7,20 m plot. Due to pre-installed drippers along 6 net plots, randomized plot allocation was not possible. Net-plots consisted of 5 plots of 16.56m2 and one plot of 10m2.

Inputs
100g fertilizer /m2
2kg FYM per m2

E1 = NPK 411
E2 Ammonium
E3= NPK 232

Entry 1 : NPK 4.1.1 (31%)
20,6% 5,2% 5,2%
Literature recommendation: **50g/m2-100g/m2**
206g N/kg NPK

Entry 2 : Ammonium sulphate 100g/m2
210g/kg N

Entry 3: NPK 2.3.2 (22%)
6,3% 9,4% 6,3%
Recommended **60g/m-100/m2**
63gN/kg NPK

Practical indication to workers was:
<u>1 lata = 750g   for (7,5m2) 2 lata per 15m2</u>

Emergence /germination rate got interferences from Farm manure born seedlings thus % was more than actually planted.

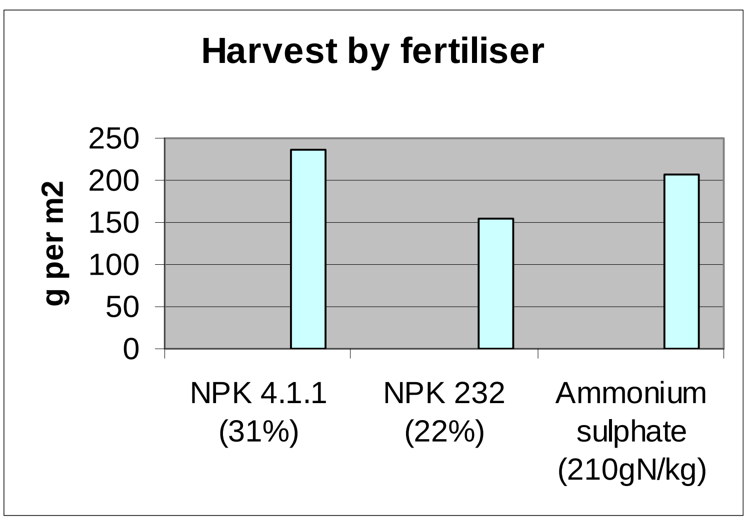
<u>Results</u>

Tab.6
Total of three harvests per m2

g/m2

Fertilizer	plot	Entry	
NPK4.1.1 (31%)	1	E1R1	211
NPK4.1.1 (31%)	4	E1R2	262
NPK 4.1.1 (31%)			**237**
NPK232 (22%)	3	E3R1	167
NPK232 (22%)	6	E3R2	143
NPK 232 (22%)			**155**
Ammonium sulphate (210gN/kg)	2	E2R1	236
Ammonium sulphate (210gN/kg)	5	E2R2	177
Ammonium sulphate (210gN/kg)			**207**

Fig.10



Taking the average total mean value of all harvests, NPK 411 would induce the highest harvest in green leafy vegetables.

Statistical evaluation

As shown by the value of Sig.in the ANOVA table the findings of the above are not significant P > 0.05 (P = 0.189) enough to make any definite recommendations on any specific fertilizer to use.

ANOVA

harvest total

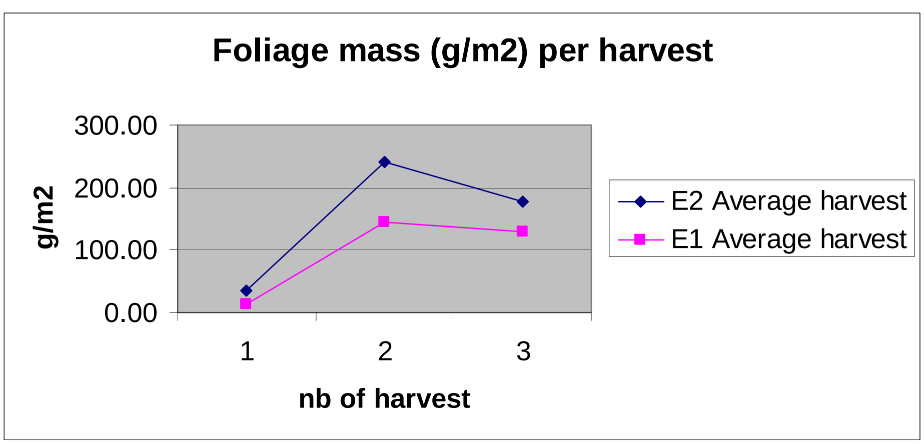
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6825.863	2	3412.932	3.058	.189
Within Groups	3347.730	3	1115.910		
Total	10173.593	5			

3.3.2 Trial on water saving bow benching versus normal plot

Tab.7

Treatment	**Foliage fresh mass (g) per harvest**			
	1st harvest	**2nd harvest**	**3rd harvest**	**TOTAL**
E2 R1	33.82	236.11	193.24	463.16
R2	28.99	227.66	178.74	435.39
R3	41.06	262.08	158.82	461.96
E2 Average harvest	34.62	**241.95**	**176.93**	**453.50**
E1 R1	16.00	111.00	92.00	219.00
R2	9.66	177.23	148.55	335.45
R3	10.87	142.51	146.74	300.12
E1 Average harvest	**12**	**144**	**129**	**284.86**
MAX	**41**	**262**	**193**	
E2 BOWBENCH				
E1 NORMAL PLOT				

Fig.11



Evaluation of the results:

Test of Homogeneity of Variances

Harvest total

Levene Statistic	df1	df2	Sig.
4.334	1	4	.106

ANOVA

Harvest total

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42662.547	1	42662.547	22.387	.009
Within Groups	7622.615	4	1905.654		
Total	50285.162	5			

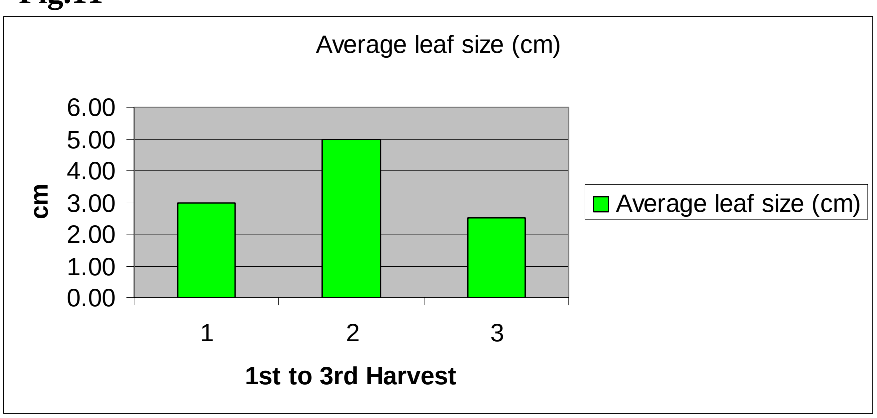
The statistical evaluation of the data gives us the above ANOVA summary table with an F ratio of 22,387 at df1 and p=0.009. The sig value gives the likely hood of this value to happen by chance. As the observed significance is less than 0.05 we can say that there was a significant difference effect of the treatment (Bow bench or not). Which in the current trial means that Bow benches give better results, not just in saving water, but also in yield. This can be interpreted in nutrients saved from leaching which become more available to the plants.

As secondary measurement was done on the leaves to show decreasing benefit of a third or fourth harvest as harvest would be too labour intensive and uneconomical to continue.

Tab.8

1st harvest	2nd harvest	3rd harvest
Average leaf size (cm)		
3.00	5.00	2.5

Fig.11



3.4 Trial on Amaranthus thunbergii on floppy sprinkler irrigation

This trial was the only done during the dry winter season, and not planned in the initial research protocol. A new protocol for this trial was done prior to this trial and can be found in Appendix 2.

Objective of the trial: Measure effect of amount and type of irrigation under floppy sprinkler on performance of Amaranthus thunbergii.

Set up and Management

Sowing was done as per protocol in rows 30cm apart and 30cm in-between.
Sowing dates 17/07/06 (Line 1) to 18/07/06 (Line 2).
Weeding dates in all plots 16/07, 21/08 & 01/09.
One single harvest was done on the 12/09/06

Tab.9. Soil analyses

N%	Pppm	Kppm	Cappm	Mgppm	Nappm	pHw	Ecw	Om%	CaCO3 Est %	Texture	Sand %	Clay %	Silt %
0.019	33.7	90	2852	748	89	8.73	128	0.84	high	Sandy loam	73.8	13.9	12.3

Note:
The above soil analyses is very different from all other trial locations with much higher clay content, higher pH and P, Ca, Mg and Na.

<u>Sprinkler and trial layout</u>
(See Appendix 2. for outline)

The sprinkler are spaced at 12 X14 meters odd triangular. The total plot size is 36 by 70m (excl. the distance from lateral lines to boundary). The sprinklers are at 3m high and the clearance from the crop canopy to the sprinkler is more than 2m.

As per the layout, the boundary lines are approximately 3m from the field boundary.

The laterals are 12 meters apart with sprinklers spaced 14m apart on the laterals. Spacing on alternate laterals is staggered 7meters i.e. form the center of the previous lateral spacing to form triangles.

<u>Design Criteria</u>

The design does not allow random block attribution, and as such each line will be seen as a trial plot with four repetitions per entry. The trial plot (planting area) is limited to the inner line of each lateral and will measure 15m in length and 6m in width. <u>The net plot (from which records are taken) is limited to 15 by 4m</u>. The net-plot will only reach 2m to the right and left of each lateral cable line, to avoid interferences from the other lateral lines and influences from different soil water gradients. Entry 4 (highest irrigation) and Entry 1 (lowest irrigation) were planned to be at both ends of the field as per layout.

Plot length : 15m
Plot width : 6m
Net plot width: 20 inner rows (10 rows to the left and right of overheadcables)
Net plot length: 50 rows.

16 Plots :
Entry1 : Plots L4R1 L4R2 L4R3 L4R4
Entry2 : Plots L2R1 L2R2 L2R3 L2R4
Entry3 : Plots L3R1 L3R2 L3R3 L3R4
Entry4 : Plots L1R1 L1R2 L1R3 L1R4

System	Floppy Overhead Cable System Black Floppy Sprinkler
Sprinkler Spacing	12X14m Triangular Laterals spacing 12m & Sprinkler spacing 14m
Sprinkler Height	3meters
Gross Application Rate	4.3mm/hour
Flow rate per sprinkler	720l/h
Net application Rate 3.8mm	
Average application efficiency	89%
Filtration	500 micron for systems with sprinklers below 4 Bar.

IRRIGATION TIMING

From 1-4 days
For 1 hour per day. ½ hr early morning 9.00 and ½ hr late afternoon 16.00
Initial planning as per protocol was:

Line 1 = Plot 1 = Entry 4	Line 2 = Plot 2 = Entry 2	Line 3 = Plot 3 = Entry 3	Line 4 = Plot 4 = Entry 1
4 days	2 days	3 days	1 day
1h	1h	1h	1h

Reducing amount of water per week from L1 to L4.

However by mistake the students executed the following scheme:

Line 1 = Plot 1 = Entry 4	Line 2 = Plot 2 = Entry 2	Line 3 = Plot 3 = Entry 3	Line 4 = Plot 4 = Entry 1
4 days	3 days	2 days	1 day
1h	1h	1h	1h

(Which will form the new recorded code key for the rest of the study).

Fertilizer prior to planting

2 bags of 50 kg of fertilizer available at the research station were used for the whole plot, thus in each line 25kg were applied. The amount of fertilizer used: 100kg
This type of fertilizer used contained: Lime Ammonium Nitrate (L. A. N) with 28% of nitrogen, SUPERPHOSPHATE with 10.5% of phosphorus.

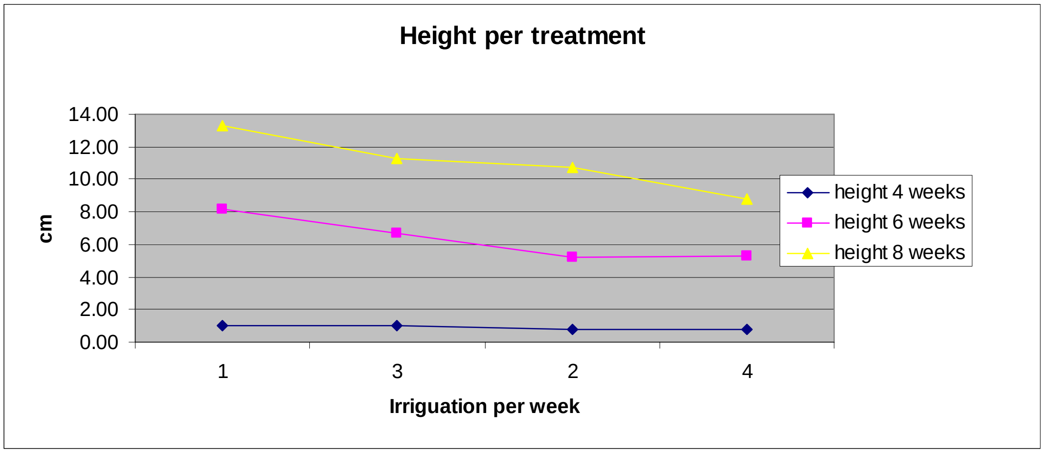
Records

As with the other trials, average heights and yield per net plot were recorded, together with man hours labored.

Total Labor hours can be found in Appendix. 3 (CD version)

Results

Fig.12



Total yield of leaves, average heights and leaf sizes

Tab.9

yield	Irr .	height 4 weeks	height 6 weeks	height 8 weeks	leaf size
1500	**1**	1.03	8.20	13.27	7.37
1343	**3**	1.00	6.67	11.27	6.33
1195	**2**	0.80	5.25	10.75	5.70
1007	**4**	0.80	5.27	8.77	6.03

Evaluation of the results:

Test of Homogeneity of Variances

g per net-plot

Levene Statistic	df1	df2	Sig.
.448	3	7	.727

As homogeneity of variances is not violated we proceed with the Analyses of Variances:

ANOVA

g per net-plot

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	394034.848	3	131344.949	1.425	.314
Within Groups	645183.333	7	92169.048		
Total	1039218.182	10			

The statistical evaluation of the data gives us the above ANOVA summary table with an F (df 3) and a ratio of 1,425. As the observed significance is 0,314 and > than 0,05 we can say that there was no significant effect due to watering frequency.

Which in the current trial means that watering with floppy sprinklers 4 times a week or twice a week give no better or worse results. However this picture might be quiet different for different sprinkler systems and on different soils (less splashing of water and less water logging)

The poor results on more frequent irrigation were not expected and thus this sprinkler system is not recommended for Amaranthus thunbergii on a loamy soil.

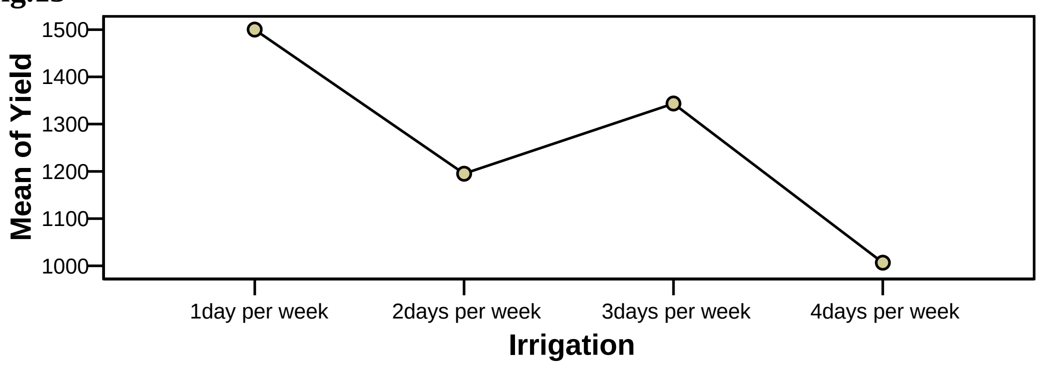
Other constraints might have influenced this results such us:

Good germination but slow grow in the first two plots in Line 1 and 2 were detected due to the cold weather that affected them two weeks after germination. The weather killed many plants in the first plot of Line 1.

The last plots in Line 3 and 4 were the poorest in germination, which could be caused by hardness of the soil, high in clay content.

Mean harvests per treatment:

Fig.13



3.5. Unam trials

Introduction

4 trials in total were organized together with the UNAM Department of Crop Science at the Ogongo northern campus on all three IGLV's (Amaranthus thunbergii, Cleome gynandra and Hibiscus sabdariffa) under the supervision of Mr U. Kuvare. 2 trials in 2005 and 2 trials in 2006. The 2005 trials have been supervised by the lectures themselves, regular feedback were requested by the PC, but as the trial had to fit into the students time plan and were part of the fulfillment of their Bachelor of science degrees in Agriculture, only final reports where handed to the PC.

The 2006 (trial 3) was better supervised and is reported in more detail. Results on the fourth trial on germination of Amaranthus thunbergii under different conditions have not been forwarded to the Program Coordinator at the time of reporting.

Another trial on Cleome Gynandra seeds which was initially not part of the IGLV-VIVA program was done by the Department of Biology on seed viability and germination success. The student sent the Program coordinator a draft report with all the raw data of the measurements. The statistical evaluation, done by the Program Coordinator and reported here is based on Ms Remmie's Moses data but not on her report which was not yet approved by her supervisor at the time of reporting.

3.5.1 Trials at the Ogongo Crop Science Center

In total four trials were executed, with three trial results handed over to the Project coordinator for evaluation. The Ogongo station was visited twice between 2005-2006, to introduce the IGLV-VIVA program and discuss trial set ups and preferences with the supervisor. Unfortunately the students assigned could not been met on both occasions (exams and holiday). The direct contact person for the trial between 2005-2006 was Mr Uparura Kuvare a lecturer at the campus. A second lecturer of crop science contacted in 2005 dropped out of the program in 2006.

Trial 1: The effect of direct planting and influence of different varieties on growth of Cleome gynandra.

Trial 2.: The effect of spacing and variety (green variety/red variety) on plant yield of Hibiscus sabdariffa.

Trial 3.: Determine the water effect on vegetative growth and yield of H. sabdariffa.

Trial 4. : Germination trial on Amaranthus thunbergi in different medium (not received at the writing of this report.)

LOCATION

All field experiments were conducted at Unam- Ogongo campus research garden under a 50% shade-net and water supplied systems. The study area is located at 17° South latitude and 15°East longitude. The area receives an annual precipitation of approximately 250mm to 600mm, with about 380mm per annum on average (Burger, 2002).

According to Rigourd at al 1998, the north central soils in this region around Ogongo are characterized by their light texture which ranges from sand to sandy loamy. On average they found that the sand content is 87%, clay is 9,5 % and silt 3.5 %. The soil analyses on the college campus had even poorer clay and mineral contents than the suggested average ppm.

Trial 1: the effect of direct planting and influence of different varieties on growth of cleome gynandra.

Purpose of the study

Assess the effect of planting and transplanting on the growth of Cleome gynandra, and to evaluate the maximum root depth of the plant at the end of the growing period.

Trial design (in Appendix UNAM trial 1)

Randomized block design with six replications was used. Two sowing methods were used: Direct and transplanting. Seeds of two accessions *Onhuno* and *Ogongo* were obtained from the IGLV-VIVA Program coordinator. The trial layout can be found in the UNAM Appendix to this report. Total size 15m x 15m. Plot sizes 3 by 2,5m. In total there were 24 plots.

Soil sample

N%	Pppm	Kppm	Cappm	Mgppm	Nappm	pHw	Ecw	Om%	CaCO3 Est %	Texture	Sand %	Clay %	Silt %
0.009	17	95	410	102	58	7	141	0.69	none	sand	92.8	3,9	3,3

Measured parameters

- Plant height.

Measured weekly for 12 weeks. Growth rate was carried out on 6 representative plants per plot. In total 36 plants per variety were assessed per seeding method. Height included the flower.

- 50% flowering
- Maximum root depth per plant

Results

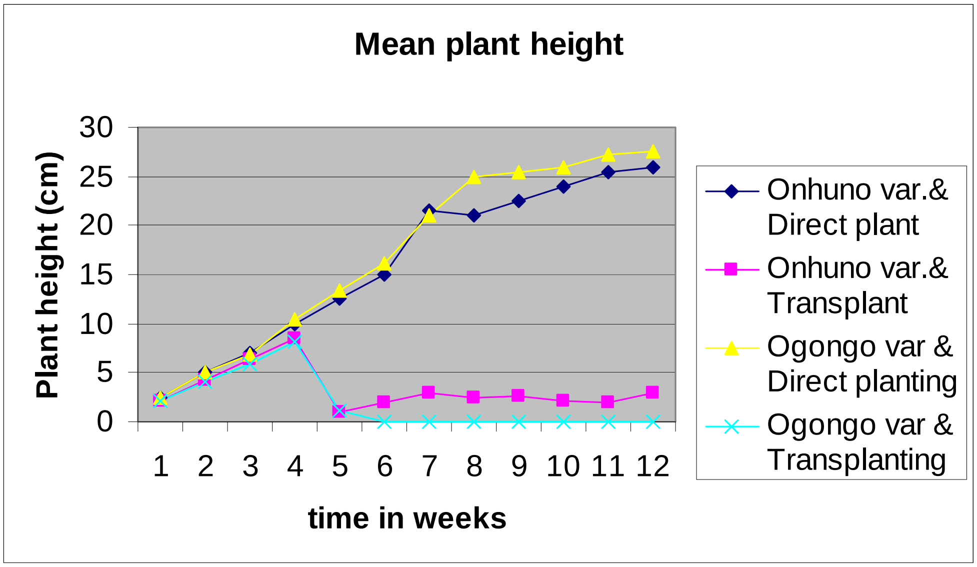
Results were analyzed in Microsoft excel and Sigmastat by UNAM staff. All data was subjected to a two way ANOVA and means compared using the least significant test at P=0.05

Tab.1.1

Mean effect on varieties on plan height (least square means)

group	week1	w2	w3	w4	w5	w6	w7	w8	w9	w10	w11
Onhuno var.& Direct plant	2.4	5	7	10	12.5	15	21.5	21	22.5	24	25.4
Onhuno var.& Transplant	2.2	4.2	6.4	8.5	1	2	3	2.5	2.6	2.2	2
Ogongo var & Direct planting	2.5	5	6.8	10.5	13.4	16.2	21	25	25.5	26	27.3
Ogongo var & Transplanting	2.1	4	5.9	8.2	1.1	0	0	0	0	0	0

Fig.1.1 Effect of the independent variables (treatments) on plant height (dependant variable)

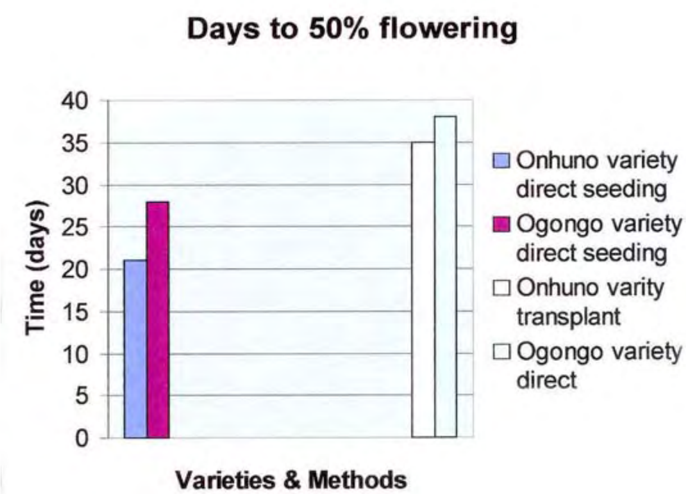


The differences in the mean values among the different levels of Varieties are not great enough to exclude the possibility that the difference was due to random sampling variability. The statistical analyses did not find a significant difference at P = 0.05. As P was 0.366 referring to the mean values of *Onhunoa direct plants* when compared to *Ogongo direct plants.* Similarly there where no significant difference between *Onhuno transplant* and *Ogongo transplants.* (ANOVA tables and F values where not provided with the students report and digital raw data could not been traced anymore by UNAM staff (sic))

However, significant results (P= 0.009) were found between *Onhuno directly planted plants* when compared with *Onhuno transplanted variety* and *Ogongo directly planted* plants and Ogongo transplanted plants.

Theses significant differences could be explained by the fact that some of the plants actually died due to transplant shock and low water regime in family drip irrigation systems (Program coordinators personal comment).

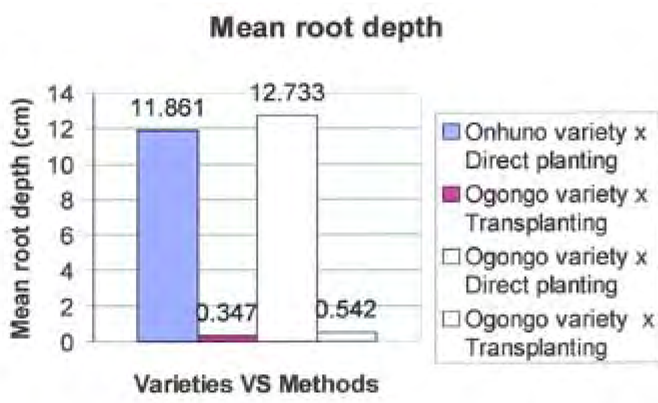
Days to 50% flowering Fig.1.2 Mean days of start to flower



The figure 1.2 above and statistical evaluations (TABLES not handed over with report) showed that there is a statistical significant difference with two accessions when it comes to effect of transplantation to flowering.

Onhuno accession took 21 days to flower when it is directly planted while during transplanting the survivors took 35 days to flower. *Ogongo variety took* 28 days to flower when it was directly planted while when it was transplanted it took 38 days.

Fig.1.3 Maximum root depth per plant



The difference in the mean values among the different levels of varieties was not enough to be statistically significant (P= 0.154 >0.05)

The difference in the mean values among the different methods of planting was greater than would be expected by chance. A statistical significance exists at P< 0.001 between the two seeding methods.

CONCLUSION FOR TRIAL 1.

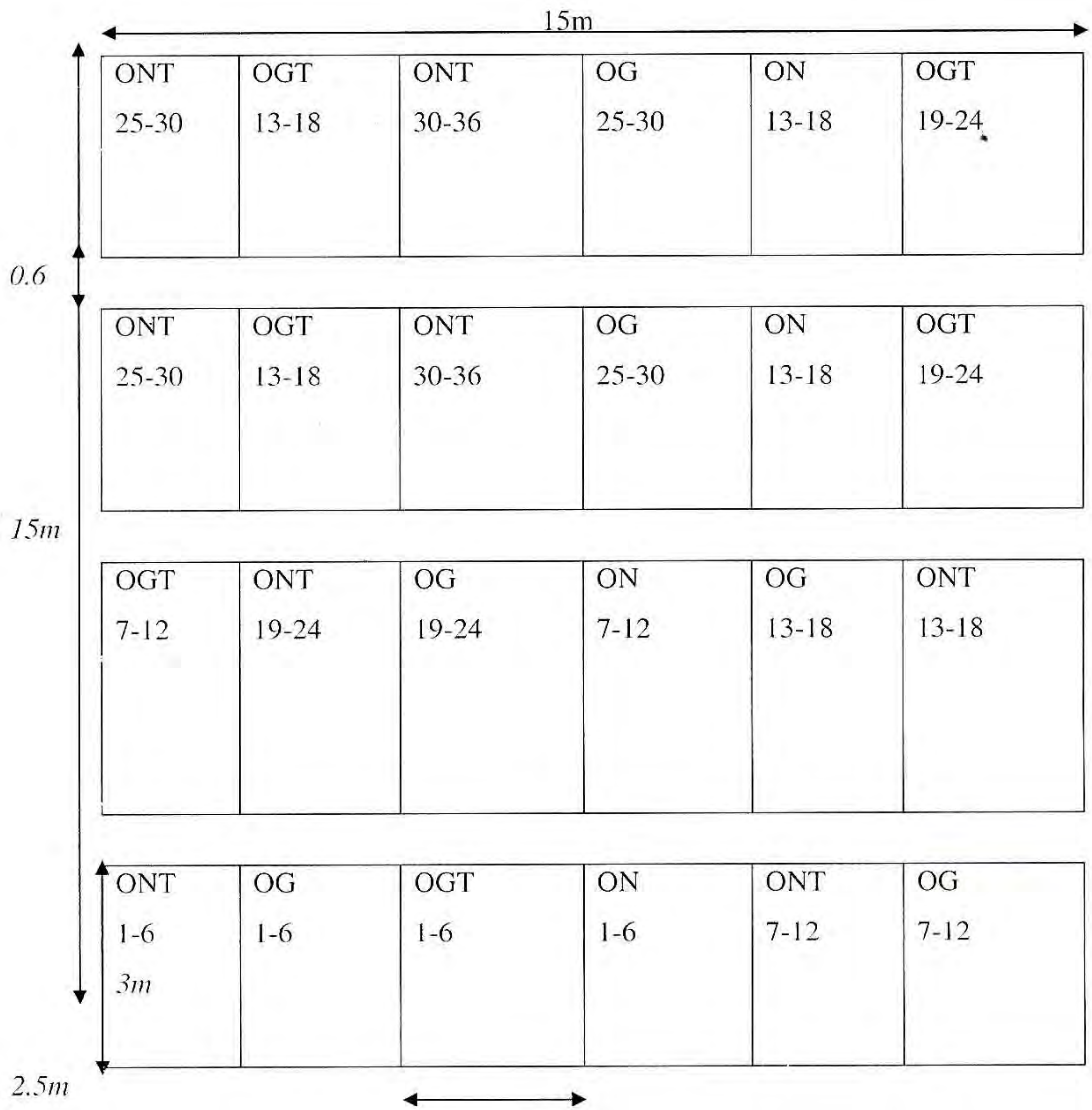
Transplanting under family drip irrigation will not be advisable. Effects under other high water irrigation might give better results but it can be expected that given the significant differences for this trial, that growth, if not as drastic as in this trial, will produce reduced yield in any other set-up as well. The long and fast growing root of Cleome gynandra makes them vulnerable to transplantation if not carefully handled. This also seems to be in line with other literature research (A.Chweya;Mnzava, Cleome Gynadra, Monograph,1997)

Problems noted by the students
(problems of a more human nature !)

- During vegetative stage, local people harvested vegetables and students had to re-plant.
- Even with a 30cm space left between each plot to allow easy access, farm workers formed a path within the plots damaging some of the material.
- Flooding was also one problem caused by overflow of the buffer dam, as a result of the farm workers forgetting to switch off the system.

APPENDIX UNAM TRIAL1.

TRIAL LAYOUT



Key:

OGT-Ogongo transplant

ONT-Onhuno transplant

ON-Onhuno direct planting

OG- Ogongo direct planting

Trial 2. : The effect of plant density on the growth and yield of two varieties of Hibiscus sabdariffa (Mutete)

Purpose of the study

The objective of the trial was to determine the critical spacing between plants and its effect on the yield of two varieties of Mutete (red and green/ white one). As a second factor the effect of the seeding method (transplanting versus direct planting) was determined.

Trial design (in Appendix UNAM trial 2)

The plot design was a split plot design with one main factor as "*spacing*" and two sub-factors such as "*seeding method"* (direct versus transplanting) and two varieties (green and red varieties). A design of 12 plots per replication was done. There were only two replications as the trial had to fit an area of 22 x24m. There were three treatments (independent variables) : spacing, planting method and variety. The Transplanted plants were first planted into seed trays prior to be planted into the trial plot.

Soil analysis

Pppm	Pppm	Kppm	Cappm	Mgppm	Nappm	pHw	Ecw	Om%	CaCO3 Est %	Texture	Sand %	Clay %	Silt %
0.032	11.57	101	1030	138	48	8.36	100	0.48	none	sand	88.5	6.5	5

Measured parameter

Plant height

Plant height was measured three times. It was done every 30 days. Plant height measurement was done on the 9th of April 2005, 8 May 2005 and 11th of June 2005. All plants were measured.

Yield

Yield was measured after harvesting on the 17th of June 2005. Plants were harvested whole,; the leaves and calyces were then stripped off weighed and dried for three days under 70C in the oven.

Crop management

Sowing started on the 18th of March 2005 at the college garden on well prepared land. About 1700 seeds from the IGLV-VIVA program were used. ½ of the seeds were directly sown in the field while the other ½ were sown in seed trays waiting to be transplanted. Two seeds were sown per hole.

Spacing:

Generally spacing between plant stand and plant rows depend on the type of the crops, growing habit, shooting, root system and purpose/use of plant. It determines the ability of each crop to receive its share of nutrients, water, sunlight and optimal growth space. In general, spacing for *Mutete* is more important than for other smaller IGLV like Amaranthus thunbergii and Cleome gynandra. *Mutete* has a higher stand, larger leaves and dual purpose (leafs and calyces)

Different authors give different recommendations for spacing and the recommendations range from 40cm to 100cm. Since this trial was concerned about *spacing*, different lengths between rows was used.

S1 Less than recommended spacing 30cm x 50cm
S2 Spacing by 50 cm x 50cm
S3 Spacing by 80cm x 50cm

Irrigation

The trial was done during the rainy season; sprinkler irrigation was used during dry weeks. Due to different crop spacing other irrigation systems were not suitable.

Weeding

Weeding was done four times in total.

Thinning was done on the 16th of April 2005 during transplantation.

Transplanting

Transplanting was done 30 days after sowing. It was done in the afternoon to avoid shock and was watered immediately.

Results

Data analyses

As we have one ordinal and two categorical/nominal independent variables (factors), (spacing, variety and transplantation) and two dependant variables measured separately, (Height and harvest yield), a multivariate analysis MANOVA would have been appropriated. However the UNAM staff helping the students opted for several ANOVAs (Analyses of variance of mean). This can still be performed if we don't expect error 1 types, rejecting null Hypotheses, (that there is no difference between treatment) when it's true. MANOVA is not essential if we have a good knowledge of the relation ship between the two dependant variables.

Plant height

The report results gave spacing no significant effect on the heights of Mutete at sig. level of 0.05. There was also no significant difference in the heights of the two varieties. However heights were influenced significantly by seeding methods of planting. Direct planted Mutete had mean heights of 24.05 cm at harvest whereas transplanted plots produced plants with mean heights of 6.752 at the same time of growth. This findings were reported significant at $P<0.05$; F (1; 61.06) p = 0.001. Also no significant difference between varieties in heights was observed, the green variety was observed to have grown taller than the red variety.

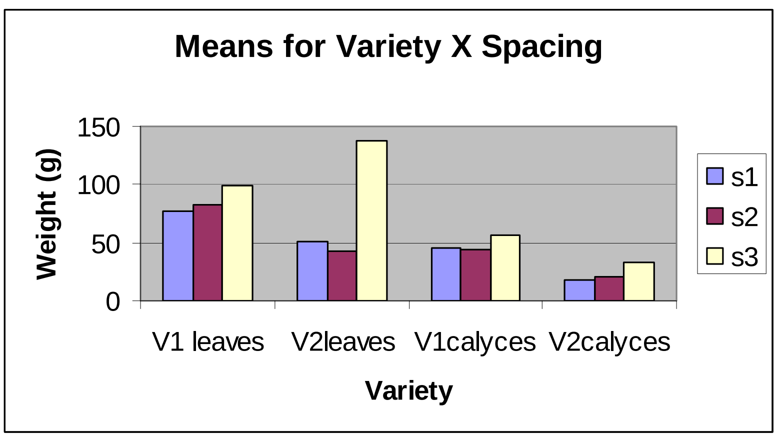
Plant yield

The yield of Mutete was obtained from the weights of dried leaves and calyces.
It was observed that V1 (the green variety) had better performances under narrow spacing.
for both vegetative growth, leaf yield and calyces. V1 also had the best overall performance (all spacing and seeding methods combined). However the findings were not found big enough to be statistical significant at $P <0.05$ (F (2 ;4.596) P 0.053). Thus there is no statistical difference between varieties.

Tab2.1 Means for yield of Mutete in grams

	V1 leaves	V2leaves	V1calyces	V2calyces
s1	76.47	50.52	45.72	17.5
s2	82.1	42	43.5	20.575
s3	98.825	138.1	56.45	32.55
Overall	**257.395**	**230.62**	**145.67**	**70.625**
D	149	152.38	95.53	46.85
T	42.6	10.36	5.58	5.26

Figure.2.1



S1 Less than recommended spacing 30cm x 50cm
S2 Spacing by 50 cm x 50cm
S3 Spacing by 80cm x 50cm
V1 (green variety)
V2 (red variety)

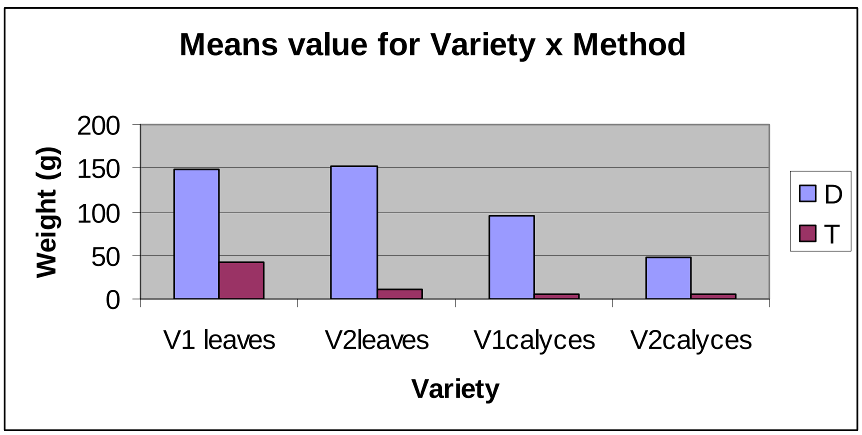
Average weight of leaves
Tab.2.2

	Leaves	Calyces
s1	63.495g	31.61
s2	62.05g	32.04
s3	118.46g	44.50

The average weight of leaves and calyces seems to be highest when density is low (wider spacing). Under the ANOVA statistical evaluation however theses observations in difference of performances between the spacing were not significant at P<0.05 F (2; 2.137), p= 0.161)

However seeding methods resulted in significant differences in the overall yield of both leaves and calyces at (P < 0.05) F (1;29.81) p=0.001 and F(1;37.348) p=0.001). As with the previous IGLV trial on Cleome gynandra, the direct planted Mutete show higher performance than those that were transplanted. The average yield for dry leaves was 150.69g for direct planting and 52.96 g for transplanted Mutete measured at the same time. The average yield of calyces is 71.19g for direct and 10.84g for transplanted Mutete.

Fig. 2.2



Statistical evaluation tables

Summary of the effects for yield on Mutete plants (statistically significant effect sig.=0.05 is highlighted)

Tab.2.3 Dry weight of calyces

Effect	F	P
Variety	4.596	0.053
Spacing	0.524	0.605
Seeding methods	37.348	0.001
Variety X Spacing	0.0191	0.981
Variety X Seeding Methods	4.480	0.056
Spacing X Seeding Methods	0.578	0.576
Variety X spacing X S. Methods	0.0125	0.988

Tab.2.4 Dry weight of leaves

Effect	F	P
Variety	0.123	0.731
Spacing	2.137	0.161
Seeding methods	29.810	0.001
Variety X Spacing	0.926	0.423
Variety X Seeding Methods	0.235	0.637
Spacing X Seeding Methods	2.525	0.122
Variety X spacing X S. Methods	0.805	0.470

Summary of the effects of the height on Mutete plants (statistically significant effect sig.=0.05 is highlighted)

Tab.2.5 Height of Mutete plants

Effect	F	P
Variety	4.635	0.052
Spacing	0.338	0.720
Seeding methods	61.060	0.001
Variety X Spacing	0.213	0.811
Variety X Seeding Methods	1.154	0.304
Spacing X Seeding Methods	0.988	0.401
Variety X spacing X S. Methods	0.213	0.811

Conclusion:

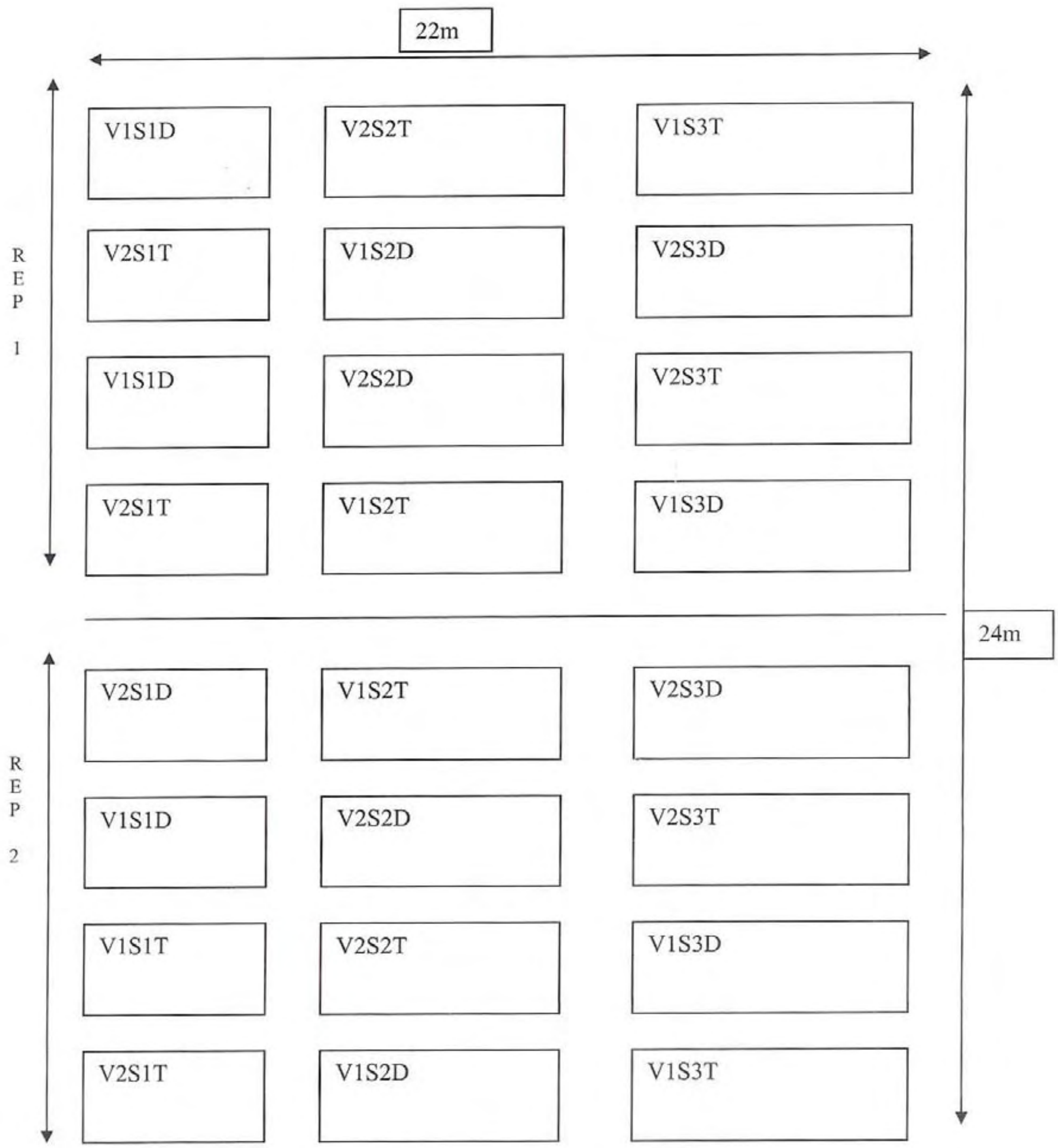
Of all the treatment analyzed, spacing, variety and seeding methods, it is the seeding method which has the most significant effect, followed by spacing and only last by the variety.

The retarded growth of Mutete after transplantation can have different underlying reasons which were not explained, and there was no clear recommended seed tray or transplanting pot size in the literature. Constraints like water regime, temperature, pot sizes might influence the transplanting success. However given the additional work transplanting demands and clear indications that direct sowing is gives the best performances, the recommendation that the study can give is to recommend direct in row sowing. .

There is no statistical difference in yields of varieties. The data does not elucidate why most farmers in the Kavango region prefer the green variety. Hence the reason behind this choice is taste, as the green variety proves to be less bitter than the red one. The choice of the red variety during the IGLV Market research (combined with the wrong cooking procedures) also explains the low ranking of Mutete among the panel test.

Appendix UNAM Trial 2

Layout of trial and keys for plot identification



Keys Used for Plot Identification:

Replication 1

- V1S1D = Variety 1(green), Spacing 1 (30cm) and Direct sown.
- V1S2D = Variety 1(green), Spacing 2 (50cm) and Direct sown.
- V1S3D = Variety 1(green), Spacing 3 (80cm) and Direct sown.

- V2S1D = Variety 2 (Red), Spacing 1 (30cm) and Direct sown.
- V2S2D = Variety 2 (Red), Spacing 2 (50cm) and Direct sown.
- V2S3D = Variety 2 (Red), Spacing 3 (80cm) and Direct sown.

- V1S1T = Variety 1(green), Spacing 1 (30cm) and Transplanted.
- V1S2T = Variety 1(green), Spacing 2 (50cm) and Transplanted.
- V1S3T = Variety 1(green), Spacing 3 (80cm) and Transplanted.

- V2S1T = Variety 2 (Red), Spacing 1 (30cm) and Transplanted.
- V2S2T = Variety 2 (Red), Spacing 1 (50cm) and Transplanted.
- V2S3T = Variety 2 (Red), Spacing 1 (80cm) and Transplanted.

Replication 2

- V1S1D = Variety 1(green), Spacing 1 (30cm) and Direct sown.
- V1S2D = Variety 1(green), Spacing 2 (50cm) and Direct sown.
- V1S3D = Variety 1(green), Spacing 3 (80cm) and Direct sown.

- V2S1D = Variety 2 (Red), Spacing 1 (30cm) and Direct sown.
- V2S2D = Variety 2 (Red), Spacing 2 (50cm) and Direct sown.
- V2S3D = Variety 2 (Red), Spacing 3 (80cm) and Direct sown.

- V1S1T = Variety 1(green), Spacing 1 (30cm) and Transplanted.
- V1S2T = Variety 1(green), Spacing 2 (50cm) and Transplanted.
- V1S3T = Variety 1(green), Spacing 3 (80cm) and Transplanted.

- V2S1T = Variety 2 (Red), Spacing 1 (30cm) and Transplanted.
- V2S2T = Variety 2 (Red), Spacing 1 (50cm) and Transplanted.
- V2S3T = Variety 2 (Red), Spacing 1 (80cm) and Transplanted.

Trial 3.: Determine the water effect on vegetative growth and yield of *H. sabdariffa.*

Purpose of the trial

The overall objective of the study was to determine the water effect on vegetative growth and yield of *H. sabdariffa.*

The specific objectives of the study were to:

- To assess the rate of growth per mean plant height.
- To assess the watering effect on harvestable yield

Data collected for all dependent variables (weekly mean plant height, mean plant number, mean leaf, calyces yield and mean biomass production) were entered on Microsoft Excel program. Statistical analysis for all dependent variables was conducted using the SigmaStat version 3.1 program. All data were subjected to a two way Analysis of variance (ANOVA).

PLANNING AND CROP MANAGEMENT

Experimental design and treatments

The experimental study had a total of 94.3m^2. A split plot design with watering application levels assigned as a main factor, which splits among blocks; and varieties assigned as a secondary factor. A trial was demarcated into three blocks; each consisting of six sub plots of 3.6m^2. An experiment had 18 subplots in total. An experiment consisted of two treatments; water application levels and varieties. The three water application levels were; high (watering plants every day), moderate (watering plants two days a week) and low (watering plants once a week). The three *H. sabdariffa* varieties were provided by the program coordinator from three different areas in the Kavango region: *Sarukwe*, *Bagani* and *Rundu* accessions were used as a *treatment* and were randomly planted on the subplots. The trial was done under a 50% shade-net and water was supplied by a family drip irrigation system.
(UNAM appendix 1).

Sampling and measurement

Four plants were used for data capturing per plot or.72 plant stations representative out of 540 plants, were randomly selected. All the samples were obtained from the middle row. Parameters on which data were collected include; weekly mean plant height (cm) and mean plant number, mean leaf yield sample (g)/plant; mean calyces yield (g)/plant and mean biomass production (g)/plant. Data on mean plant height and mean plant number were collected throughout the growing period, starting from week 5 of the growing period.

Crop management

The Seedbeds, on which seeds were planted, were prepared manually by loosening the soil using hand hoes and rakes to level the soil. This was done on the 30th of November 2005. The trial for *H. sabdariffa* was planted on the 1st December 2005, at a spacing of. 40 x 20.

A maximum of three seeds were planted per station at a depth of 1cm. 98% emergence observed in all varieties within 7 days after planting. 0.004g of inorganic fertilizer was applied per plant during vegetative phase of the crop.

Watering

The trial was watered uniformly until week 5 of the growing stage. Subsequently, application of water varies in each block. Plants grown in block A, B and C, where irrigated every day, two days a week and one a week respectively. Amount of water emitted by dripper was determined by measuring the water dripping in a jag over time. A stop watch was used to measure the time. Approximately 0.4*l* of water emitted per dripper in 20 minutes. Duration of irrigation/day applied to the plants.

Weeds and pests control

The most common dominated weed species observed and identified in the trial was *Senecio consanguineous* (Grabandt, 1985). Weed control was carried out using hand hoes as well as puling out with hand. This was done once weeds were observed in the trial. Apart from weeds, the trial was attacked by *Armoured ground cricket* before and during flowering, which caused slightly damage to plants. An application of *Betacyfluthrin* (Bullock) pesticide at a rate of 10ml in 12 liter of water was effective in pest's control.

Thinning

Weak plants were pulled out by hand. This activity was carried out at week 5 of the growing stage.

Harvesting and weighting

Leaves and calyces were harvested from plants from the sample, which were previously selected for height and mean plant number measurement. Data on yield were obtained from four plants per plot. Mean leaves, calyces and mean biomass production was manually harvested using Secateurs. Plastic Bags were used for keeping the harvests until transported to the laboratory. The first leaf harvesting was done on the 1st April 2006 at an 8-week growth stage and a second leaf harvest was done a month later on the 1st May 2006 during the 12 weeks stage, whereby developed side shoots could be collected.

Fresh fruits (calyces) for *H. sabdariffa* were picked about 4 weeks after flowering. At the end of the growing period, the plant samples were cut above the ground for mean biomass. Leaves, calyces yield and biomass were weighed while fresh, using an electronic scale and then dried in the lab oven. Fresh leaves, calyces and mean biomass production from individual plant samples per treatment were weighed separately to determine its fresh mass respectively. The total harvests (leaves and calyces) for each plot were weighed to obtain the total yield per plot.

3.5.2 Results and Discussion

The two-way ANOVA allows simultaneously testing for the effect of each of the two independent variables (variety and water) on the dependent variable (height, leaf number, yield, and biomass). MANOVA was not considered as all dependent variable are linked. (PC personal note).

The test performed did analyse main effects of differences in varieties and differences in water levels on plant performance (height, leaf number, yield, and biomass), meaning it analyses varieties and water levels separately, as well as the interaction between variety and water level. Results noted are averages of individual dependent variables.

3.1 Mean plant height

Figure 1. Effect of high water application levels on mean plant height

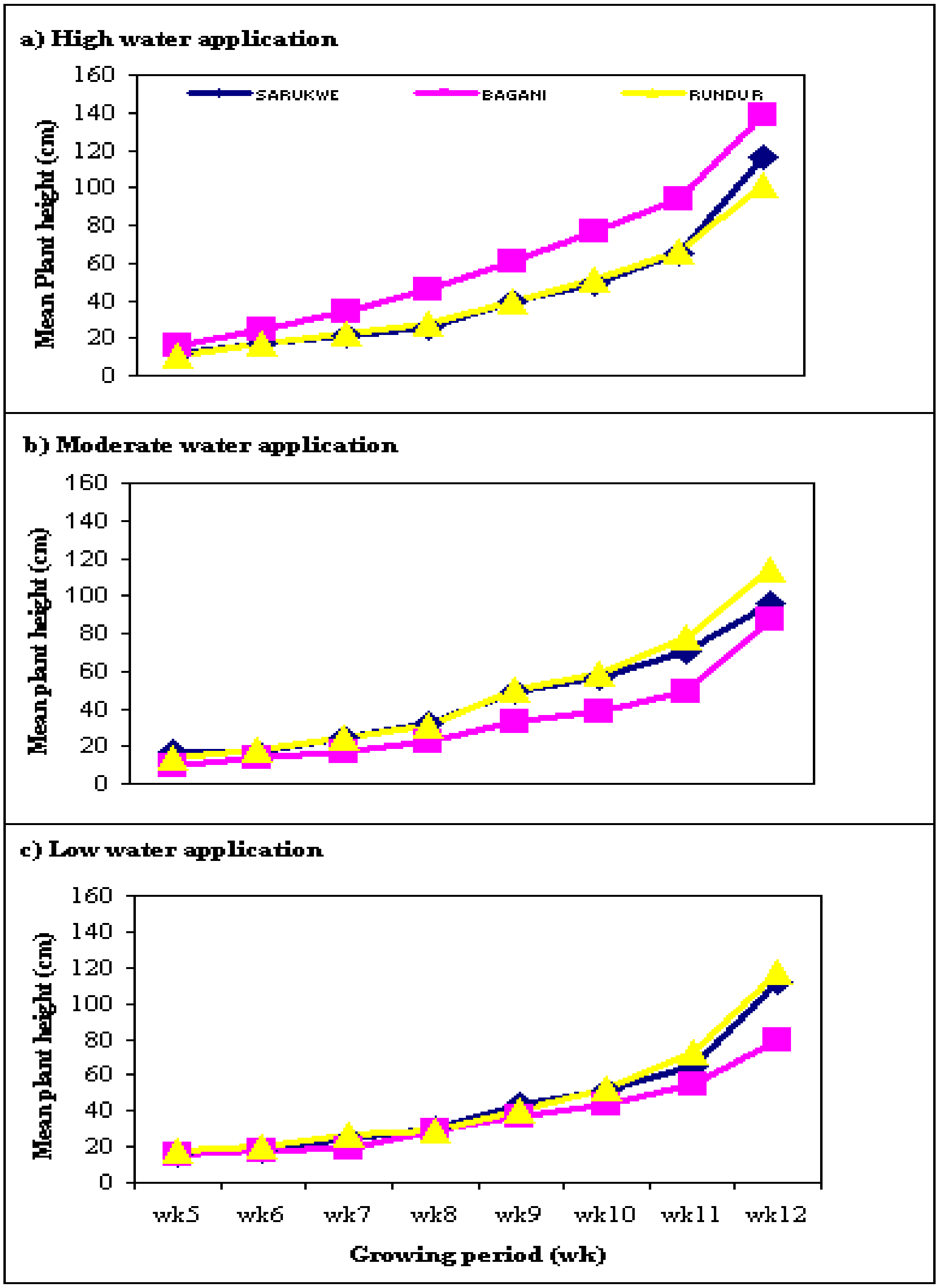


Fig .1(a) indicates that the *Bagani* variety has an increase in mean plant height to 138 cm as compare to the *Sarukwe* and *Rundu* rural varities, with a mean plant height of 115cm and 101cm respectively, at high water application. There is similarity on plant mean height for *Sarukwe* and *Rundu* rural varieties as from week 5 to week 11, but there is a slightly difference at week 12 among variety, where the *Sarukwe* variety followed an increased mean plant height.

Fig .1 (b) illustrates that the *Rundu* rural and *Sarukwe* varieties have an increased mean plant height with no variation as from week 5 to week 10, but there was a slightly difference on mean plant height at week 11 and 12 with the *Rundu* rural variety showing an increased mean plant height at week 12. The *Bagani* variety had a relative decrease in mean plant height throughout the growing period at moderate water application. There was no greater variation on mean plant height between the *Bagani* and the *Sarukwe* variety at week 12.

Fig .1(c) indicates that there was a slight variation on mean plant height among varieties until week 10. Variation on mean plant height among varieties as it has been observed during the maturity phase of the growing period at week 11. The *Rundu* rural and the *Sarukwe* varieties grow relatively well with slight variations, to the maximum mean plant height of 117cm and 112cm respectively as compared to 80cm for *Bagani*. Results indicate a sharp growth for the *Rundu* rural variety during the 11th week of the growing period. However, low water application level affects mean plant height as compare to high and moderate water application levels; since a minimum mean plant height of 101cm (Fig 1a) was observed on the *Rundu* rural variety and 88cm (Fig 1b) for the *Bagani* variety at high and moderate water application levels respectively, is greater than the minimum mean plant height of 80cm for *Bagani* (Fig 4.1c) at low water application levels.

Likewise the maximum mean plant height of 138cm observed on the *Bagani* variety at high water application level (Fig 1a) is greater than a maximum mean plant height of 117cm observed on the *Rundu* rural variety at all water application levels. The *Bagani* variety suits well to high watering application levels. It indicates that the *Rundu* rural and Sarukwe varieties are well suited to water deficit.

3.2 Mean plant leaf number

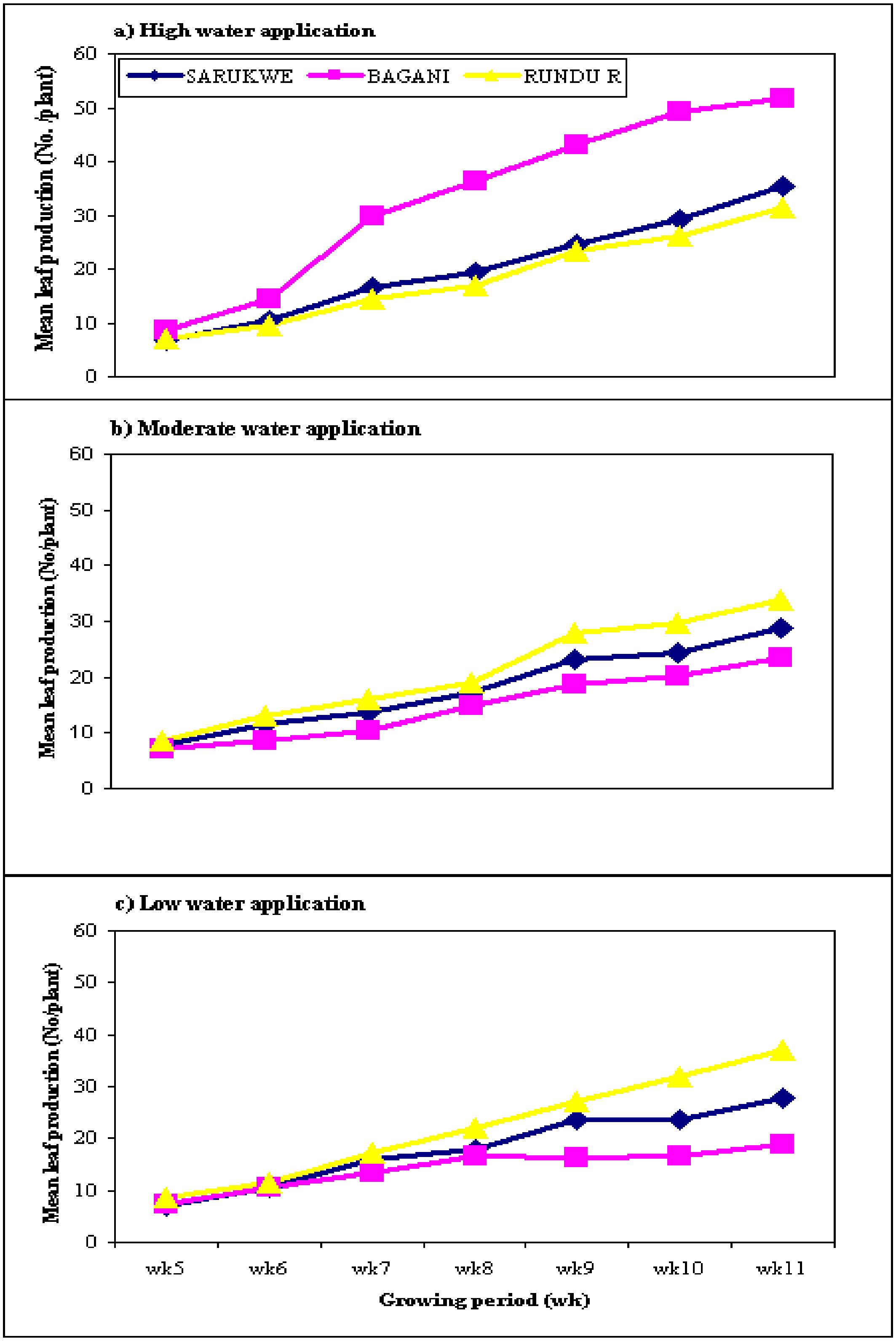


Figure 2. Effect of water application on mean plant number among three varieties

Fig 2 (a) indicates that the *Bagani* variety observed a high mean plant leaf number with a maximum of 52 at high water application levels when compared to the *Sarukwe* and *Rundu* rural varieties with 35 and 31 mean values respectively. The results received from this experiment show that the mean leave production increased with an increase in mean plant height as observed in Fig.1 (a) and Fig 2 (b) for the *Bagani* varieties at high water application levels. Among three varieties, high water application levels had the highest effect on mean leaf plant numbers, for the *Bagani* variety.

Fig .2 (b) shows that the *Rundu rural* variety has high mean leaf numbers with 34 mean leaf numbers followed by the *Sarukwe* variety with a 29 mean plant number, whereas *Bagani* has a 24 mean leaf number. Decreased water application intervals decreases mean leaf numbers as compared to high water applications as it shown in Fig.2 (a) whereby a high mean leaf number has observed.

Results on Fig.2 (c) illustrate that there was no variation among varieties on mean leaf number from the fifth week to the seventh week. However the variation occurs as from the eight week to week eleven, whereby the *Rundu* rural variety was observed with a high mean leaf number followed by the *Sarukwe* variety, and the *Bagani* variety observed with less mean leaf numbers.

3.3 Mean leaf yield

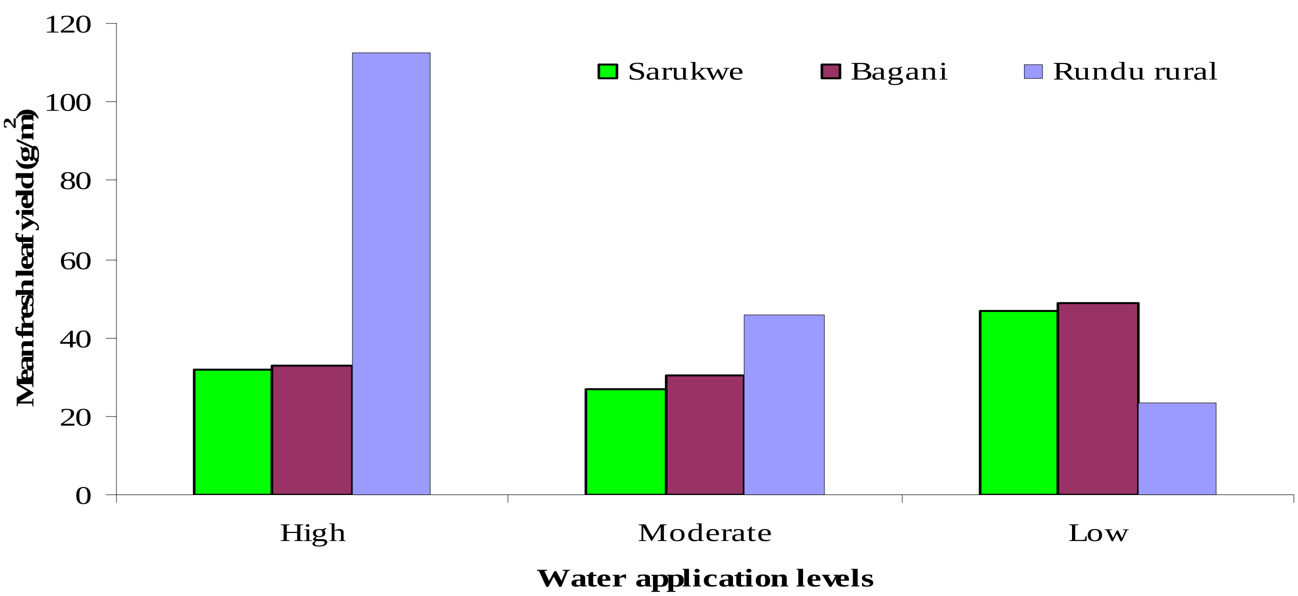


Figure .3 Water application levels effect on mean leaf yield on three varieties.

Fig 3. shows high mean leaf yield of 113g which has observed on the *Rundu* rural variety at high water applications. The *Bagani* and *Sarukwe* varieties give low yield of 33g and 31g respectively at high water application level. Mean leaf yield for all varieties decreases at moderate water application levels (Fig 3). Mean leaf yield for the *Bagani* and *Sarukwe* varieties increases at low water application levels, whereas mean leaf yield for the *Rundu* rural variety reduced drastically. The *Rundu* rural variety was observed with high total leaf yields (t/ha) at all water applications, but highest at high water applications of 3.87t/ha which is close to the optimum leaf yield of 5t/ha (Schippers, 2000) as compared to 1.70 t/ha and 1.49 t/ha for the Sarukwe and *Bagani* varieties at high water application level.

3.4 Mean calyces yield

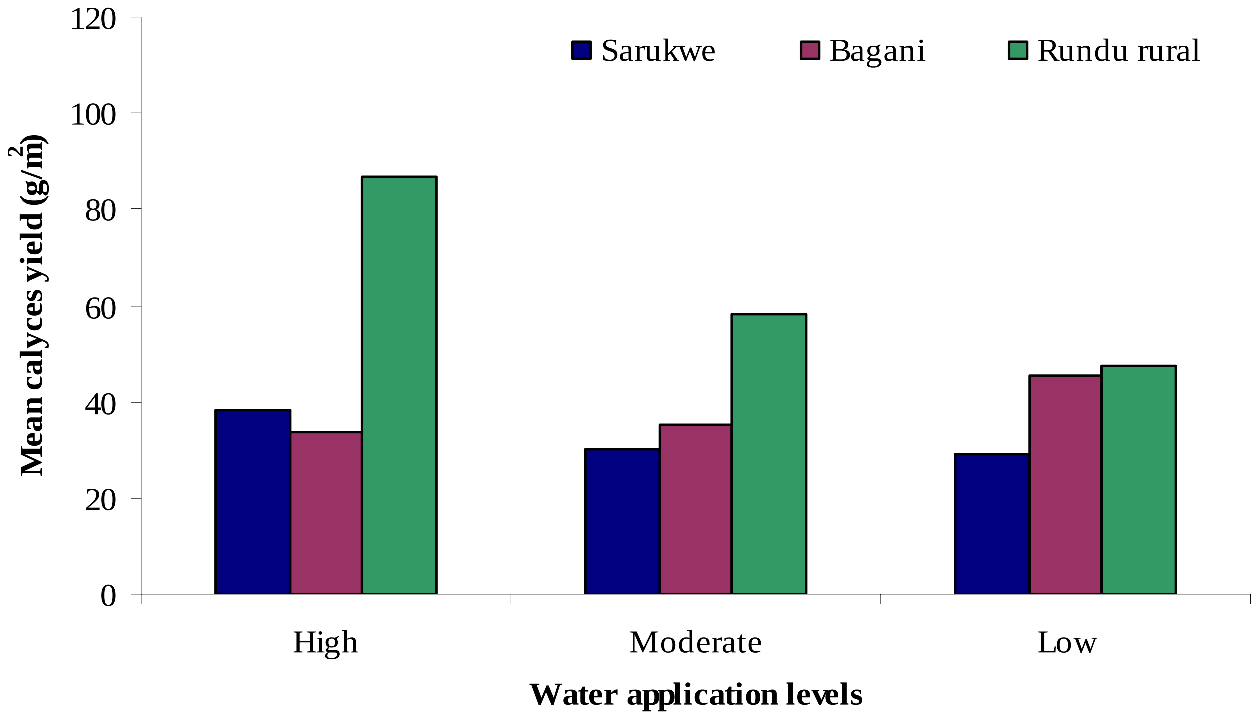


Figure 4. Water application levels effect on mean calyces yield

Fig 4. indicates that there was a greater variation on mean calyces yield among varieties in response to different water application. The *Rundu* rural variety observed with high mean calyces yield of 80.3g for high water application levels. High mean calyces yield were observed at high water application levels in this study correspond to the work of Duke (1978) who commented that sufficient amount of water is required for calyces production of *H. sabdariffa*. There were no greater variation on mean calyces yield between the *Bagan*i and *Sarukwe* varieties at all level of water application.

Mean calyces yield for the *Rundu* rural variety decreases as water application interval decreases. Low mean calyces yield were observed on the *Bagani* and *Rundu* rural varieties at all level of water applications. High total calyces yield in tonne per hectare were observed at high water applications with 1.79 t/ha for the *Rundu* rural variety, compared to moderate and low water applications.

3.5 Mean biomass production

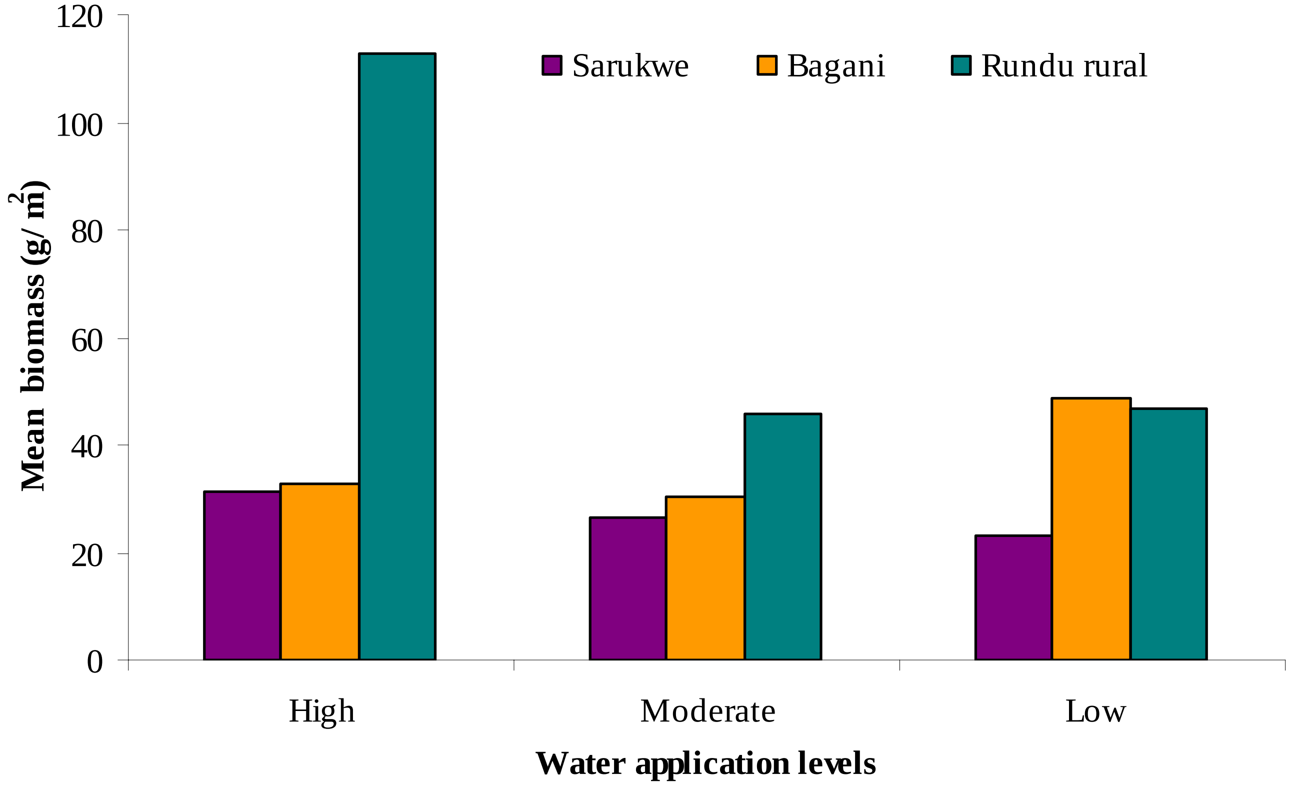


Figure 5. Effect of water application levels on mean biomass production

Results on Fig 5. indicate that greater variation on mean biomass production among varieties was observed at all water application levels. An increase in mean biomass production has been observed for the *Rundu* rural variety at high water application levels as compared to moderate and low levels of water applications. This result is in agreement with Gardener, Pearce and Mitchell (1985) who wrote that water typically comprises 80-95% of the plant mean biomass production. (Fig.5) illustrated that mean biomass production decreases as water applications reduced for the *Rundu* rural variety.

There was similarity on the *Bagani* and *Sarukwe* varieties on mean biomass production at high and moderate water application levels. Slight variations occur at low water application levels, where the *Bagani* and *Rundu* rural varieties show higher mean biomass production than the *Sarukwe* variety which had lower mean biomass production at low water application.

4. Statistical evaluation and significance of findings

Analysis of variance (ANOVA) Tables for all dependent variables.

4.1: Analysis of variance for Mean plant height

Source of Variation	Degrees of freedom	Sum of Square	Mean square	F	P
Varieties	2	3.229	1.614	0.0159	0.984
Treatment	2	72.602	36.301	0.358	0.72
Residual	4	406.111	101.528		
Total	8	481.942	60.243		

4.2: Analysis of variance for mean plant mean plant number

Source of Variation	Degrees of freedom	Sum of Square	Mean square	F	P
Varieties	2	10.007	5.003	0.125	0.886
Treatment	2	110.647	55.323	0.38	0.35
Residual	4	160.307	40.077		
Total	8	280.96	35.12		

4.3: Analysis of variance for mean leaf yield

Source of Variation	Degrees of freedom	Sum of Square	Mean square	F	P
Varieties	2	416.667	208.333	0.579	0.601
Treatment	2	199.82	99.91	0.278	0.771
Residual	4	1438.533	359.633		
Total	8	2055.02	256.877		

4.4: Analysis of variance for calyces

Source of Variation	Degrees of freedom	Sum of Square	Mean Square	F	P
Varieties	2	507.607	253.803	0.581	0.600
Treatment	2	900.707	450.363	1.032	0.435
Residual	4	1746.007	436.502		
Total	8	3154.34	394.292		

4.5: Analysis of variance for mean biomass production

Source of Variation	Degrees of freedom	Sum of Square	Mean Square	F	P
Varieties	2	2642.376	1321.188	2.662	0.184
Treatment	2	1000.722	500.361	1.008	0.442
Residual	4	1985.071	496.268		
Total	8	5628.169	703.521		

Results for the response to water application levels were not statistical significant in all variables. Similarly, analysis shows that, results for different levels of varieties were not significant in all variables with $P > 0.05$ for all F ratios and degrees of freedom. The difference in the mean values among the different levels of varieties and treatments is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of difference in treatment or variety.

However, levels of water application show some variation on average mean plant height, mean plant leaf number, mean leaf yield, and mean calyces yield and mean biomass production. High water application levels resulted in increased mean plant height and mean plant numbers for the *Bagani* variety as compared to moderate and low water application levels. The Varieties response to water application level shows differences. The *Rundu* rural variety responds positively to low water application levels on mean height and mean leaf plant number variables, since an increased mean plant height and mean plant leaf number were observed in Fig 1(c) and.2(c). More mean plant leaves were observed for the *Rundu* rural variety at all levels but were highest at low water application level, as it indicated in(Fig.2(c).

Although statistical analysis of results shows no significant difference, variation on mean leaf yield in response to water application levels exists among varieties, whereby an increased mean leaf yield was observed at high and moderate water application level for the *Rundu* rural variety as it shown in (Fig.3). Mean leaf yield for the *Rundu* rural variety decreases as water application interval reduced. Low water application increases mean leaf yield for the *Sarukwe* and *Bagani* varieties. Mean calyces yield and mean biomass production decreased as watering application level reduces in all varieties. This phenomenon observed for the *Rundu* rural variety (Fig 4 and Fig 5). However, mean biomass production for the *Rundu* variety increases more than for other varieties as water application levels increases. This is in line with a stronger increase of mean leaves and mean calyces yield for *Rundu* rural than for other varieties at higher water applications variety, though plants were short in height.

Since analysis of results show no significant difference between treatment and varieties in all variables, further statistical analysis should be carried out since analysis might show some pair of treatments and varieties to be significantly different. From theses observation it was recommended that, further in depth studies in different ecological zones could be done to look at the physiological significance on internal responses to water applications. This would lead to a better understanding of water effects on *H. sabdariffa* and thus facilitate accurate management strategies for the production of leaves, calyces and biomass production for *H. sabdariffa* which are suitable to its own environment.

It is recommended that the *Rundu* rural variety should be irrigated at high and moderate water application level for optimum leaf and calyces production in plenty water region, since it gives high leaves and mean calyces yield at high water application level. The *Bagani*, *Rundu* rural variety should be irrigated at low water application level for optimum mean leaf yield, in water scarcity region.

Since there was no major variation among the *Sarukwe* and *Bagani* varieties on mean calyces yield in response to low water applications, it is therefore recommended that all varieties in this study could be irrigated at low water applications in water scarcity region, since they produce almost equal yields at this level. It could further more be recommended that the *Rundu* rural variety should be irrigated at high and moderate water applications if possible for optimum mean biomass production.

APPENDICES UNAM TRIAL 3.
Appendix: 1 Trial layout

4.6

N

BLOCK A: HIGH	BLOCK B: MODERATE:	BLOCK C: LOW
SARUKWE	BAGANI	RUNDU RURAL
BAGANI	RUNDU RURAL	SARUKWE
RUNDU RURAL	SARUKWE	BAGANI
BAGANI	RUNDU RURAL	SARUKWE
RUNDU RURAL	SARUKWE	BAGANI
SARUKWE	BAGANI	RUNDU RURAL

20.5

3M

Appendix 2: Averages for all dependent variables

Table 2.1: High water application level effect on the mean plant height (cm) for three varieties

Varieties	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week12
Sarukwe	11.7	16.8	21.4	26.0	39.1	49.2	65.0	115.8
Bagani	16.1	24.9	34.6	46.2	60.8	76.4	93.9	138.2
Rundu rural	10.6	17.4	22.8	27.8	39.6	51.6	66.2	100.9

Table 2.2: Moderate water application level effect on the mean plant height (cm) for three varieties

Varieties	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week12
Sarukwe	17.5	17.6	24.8	32.0	49.3	56.8	70.5	95.5
Bagani	9.8	14.3	16.8	22.6	32.6	38.5	49.6	87.8
Rundu rural	14.3	18.5	24.4	30.7	49.8	58.5	77.8	114.6

Table 2.3: Low water application level effect on the mean plant height (cm) for three varieties

Varieties	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week12
Sarukwe	15.8	18.3	24.1	29.8	44.2	51.6	65.1	111.7
Bagani	15.2	17.5	19.4	29.0	36.8	43.6	54.7	79.8
Rundu rural	17.9	20.4	26.5	29.0	40.3	52.7	72.4	117.3

Table 2.4: Effect of high water application effect on plant mean plant number

Varieties	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11
Sarukwe	7	11	17	20	25	29	35
Bagani	9	14	30	36	43	49	52
Rundu rural	7	10	14	17	23	26	31

Table 2.5: Effect of moderate water application on plant mean plant number

Varieties	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11
Sarukwe	8	12	14	17	23	24	29
Bagani	7	9	10	15	19	20	24
Rundu rural	9	13	16	19	28	30	34

Table 2.6: Effect of low water application effect on plant mean plant number

Varieties	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11
Sarukwe	7	11	16	18	24	24	28
Bagani	7	11	13	17	16	17	19
Rundu rural	9	12	17	22	27	32	37

Table 2.7: Mean leaf yield (g) response to water application levels

Varieties	High	Moderate	Low
Sarukwe	31.7	26.7	46.7
Bagani	32.7	30.5	48.8
Rundu rural	112.6	46.0	23.2

Table 2.8: mean calyces yield as affected by different water application levels

Varieties	High	Moderate	Low
Sarukwe	24.31	12.84	26.78
Bagani	26.75	18.49	23.43
Rundu rural	80.33	31.63	23.45

Table 2.9: Effect of water application levels on mean biomass production for three varieties

Varieties	High	Moderate	Low
Sarukwe	31.4	26.7	23.2
Bagani	32.7	30.5	48.8
Rundu Rural	112.6	46	46.7

Appendix 3: Total yield (g/m2)

	Total Leaf (g)/m^2		
	High	Moderate	Low
Sarukwe	614.8	543	466.4
Bagani	537.1	496.2	726.7
Rundu Rural	1391.8	933.6	759.9

	Total calyces(g)/m^2		
	High	Moderate	Low
Sarukwe	194.5	122.9	156.6
Bagani	214	127.7	245
Rundu Rura*l*	642.6	253	187.6

Appendix 4: Total yield (t/ha)

	Leaf t/ha		
Variety	High	Moderate	Low
Sarukwe	1.71	1.51	1.30
Bagani	1.49	1.38	2.02
Rundu R	3.87	2.59	2.11

	Calyces t/ha		
Variety	High	Moderate	Low
Sarukwe	0.54	0.34	0.44
Bagani	0.59	0.35	0.68
Rundu R	1.79	0.70	0.52

Appendix 5. Field Photos:
Photo 1. H.sabdariffa on vegetative growth

Photo 2: Plant height measurement

3.5.4 Trial on seed viability and germination success of Cleome Gynandra

This last study aimed to test the germination success of *Cleome gynandra* in different mediums, i.e. the vermiculite, filter paper and soil mixed with cattle manure. The second objective was to compare the viability of Genebank sample seeds of *Cleome gynandra* with freshly collected mature seeds.

The Key Questions were:

1. What is the germination success of *Cleome gynandra* in the different mediums?
2. What is the difference in seed viability between freshly collected and five year old stored *Cleome gynandra* seeds?

Null hypothesis

***Ho*=** Different growth mediums do not affect total germination success *Cleome gynandra* seeds

***Ho*=** *Cleome gynandra* seed viability is equal for both newly collected seeds and Genebank seeds

Alternative hypothesis

***Ha*=** There are significant differences in total germination of *Cleome gynandra* in different growth mediums

***Ha*=** There is a difference in *Cleome gynandra* seed viability between newly collected seeds and Genebank seeds.

<u>Germination on different medium</u>

After drying the seeds were put in Petri dishes

Germination tests were carried out in Petri dishes using three different growing mediums; (1) vermiculite, (2) filter papers and (3) soil manure mixture, (details of more technical descriptions info can be found in the final approved report of Remmie Moses and will thus not be related here).
After a period of one month the seeds were examined under a dissecting microscope and the total germination of seeds were recorded. Germination for this experiment was defined as the protruding of the radical. Each substrate had 180 seeds replicated into 12 Petri dishes with 15 seeds per replicate.

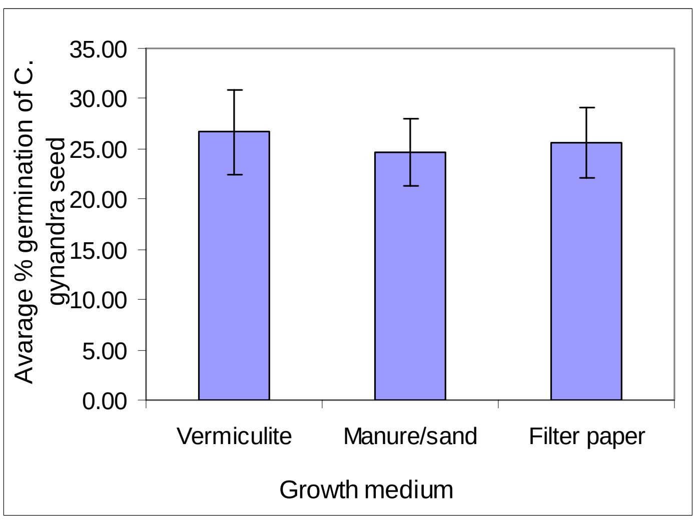
After a first exploration of the data received by RM, the some outliners were removed from the record with SPSS in order to get a better image of the results. Furthermore as recommended in germination trials, each result was ARCSIN transformed to get a more narrow and normal distribution.

Results on average germination per medium were recorded in Excel:

Tab.4.1

	Vermiculite	Manure/sand	Filter paper
1		15.0	35.3
2		21.4	15.0
3	15.0	26.6	21.4
4	15.0		21.4
5	21.4	43.1	39.2
6	26.6	21.4	26.6
7	26.6	21.4	26.6
8	26.6	21.4	35.3
9	31.1	21.4	35.3
10	26.6	31.1	15.0
11	46.9	26.6	21.4
12	31.1	21.4	15.0
MEAN	**26.67**	**24.62**	**25.61**
Stdev	9.54	7.70	8.58
St err	2.755	2.224	2.477

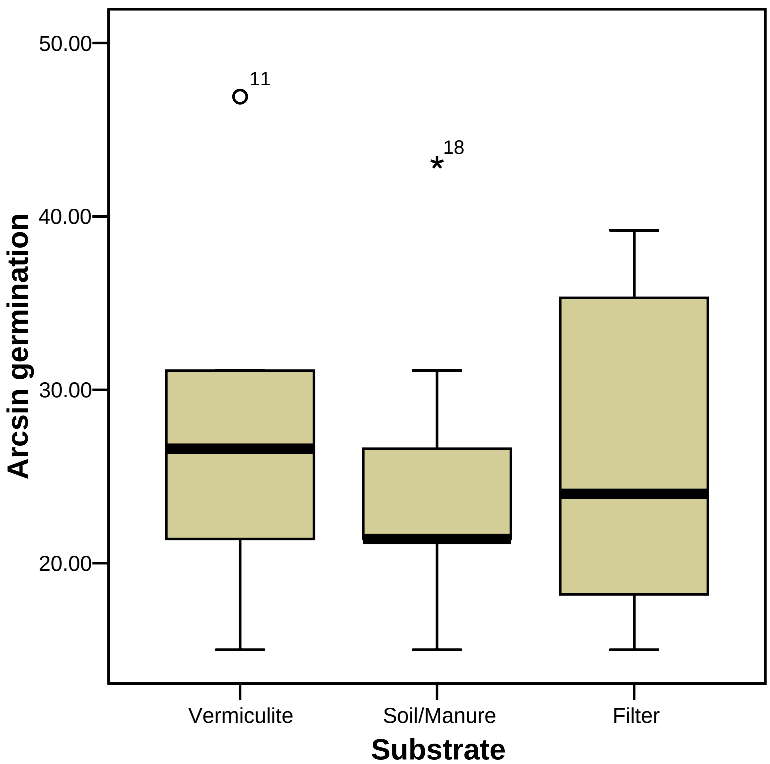
Fig.4.1



According to the figure 4.1 above the mean germination of *Cleome gynandra* seeds of the vermiculite has the highest mean of 26.67 with the lowest error of +-1.37. The next to follow is the Filter paper with a mean of 25.61 and an error of +-1.24. Manure/sand has the lowest mean of 24.62 and the highest error of +-.1.11

Evaluation of the findings

A box-plot gives us the following picture how the germination rates are distributed. They show us the lowest score and the highest. The distance between the lowest lowest horizontal line and the tinted box is the range between which the lowest 25% of scores fall. The box (tinted area) shows the middle 50% of the scores. The slightly thicker horizontal line represents the median.. Number 11 and 18 are outliers.



Given the large range of the data no significant results between the treatments can be expected.

Test of Homogeneity of Variances

Arcsin germination

Levene Statistic	df1	df2	Sig.
.516	2	30	.602

ANOVA

Arcsin germination

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	22.487	2	11.244	.157	.856
Within Groups	2153.988	30	71.800		
Total	2176.475	32			

For the germination result the P value = 0.856, hence there is no significant differences among the three mediums. (F=0.157, df=2, P=0.856)

Seed viability test

A sample of 50 seeds from the Genebank accession as well as 50 seeds from freshly collected seeds was used. The seeds were replicated in 5 Petri dishes.
The seeds were dissected and then placed in Petri dishes containing the 0.1% of 2, 3, 5-triphenyl tetrazolium chloride solution. After 30 minutes the seeds were rinsed with distilled water and examined under a dissecting microscope. The seeds with embryos colored into bright red or carmine red were recorded as viable seeds.

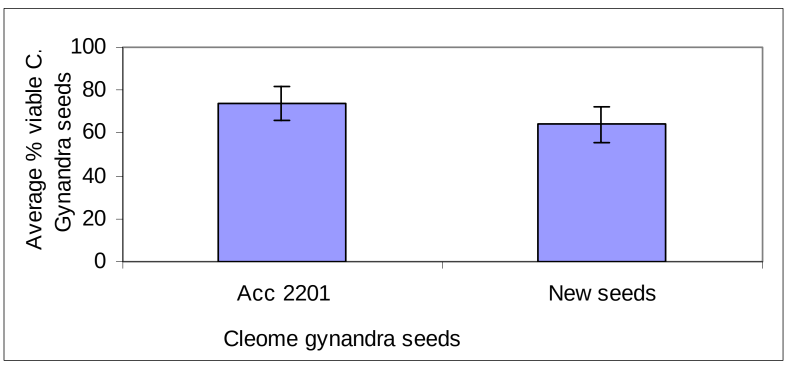
Tab.4.2

Ztest	**Acc 2201**		
Replication	Bright red	Proportion	Arcsine
10	6	0.6	**50.77**
10	9	0.9	**71.57**
10	5	0.5	**45.00**
10	9	0.9	**71.57**
10	8	0.8	**63.43**
50	**37**		
	7.40	mean	60.47
	1.82	Stdev	12.13
	0.524	St err	3.501

Tab.4.3

New seeds			
Replication	Bright red	Proportion	Arcsine
10	7	0.7	**56.79**
10	8	0.8	**63.43**
10	8	0.8	**63.43**
10	5	0.5	**45.00**
10	4	0.4	**39.23**
50	**32**		
	6.40	mean	53.58
	1.82	Stdev	11.00
	0.524	St err	3.176

Fig.4.2



Evaluation of findings

Test of Homogeneity of Variances

Arcsin transf viability

Levene Statistic	df1	df2	Sig.
.111	1	8	.748

ANOVA

Arcsin transf viability

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	118.749	1	118.749	.886	.374
Within Groups	1072.480	8	134.060		
Total	1191.230	9			

The freshly collected seeds showed the lowest mean of seeds that are viable (seeds), with 53.58 and an error of +-1.58, while the mean germination of Genebank seeds (Acc 2201) is 60.47 with an error of +-1.75. To test if there is a statistical significance between the two sample seeds of *C gynandra* we did an ANOVA test at $P < 0.05$. We found that there is no significant difference between the seeds from the Genebank and the newly collected seeds. (F, 0.886, df=1, P=0.374)

Conclusion

This study showed no significant difference between the germination success in different mediums. The conclusion is that there is not sufficient evidence at a 5% level to finally agree that there is a difference in total germination of *Cleome gynandra* because of the different growth mediums. This implies that the seeds germinate in all mediums. Hence different growth mediums (vermiculite, soil mixed with manure and filter papers) do not affect total germination of C*leome gynandra* seeds.

The Test statistics for the viability of the C*leome gynandra* seeds, $P>0.05$ (P=0.38), do not reject the Null hypothesis. The analysis shows that statistically there are no significant differences between Genebank accession and the newly collected seeds of *Cleome gynandra*. This implies that the seeds are equally viable irrespective of when they were collected.

4. Economics of producing IGLV

Based on the Rundu urban trial which was the most reliable and had the best harvesting results the following gross margins where determined.

RAINFED Amaranthus thunbergii

GROSS margins for 100 m2 and for 0.25ha

COSTS

INPUTS	Units	Number	**N$**		Number	**N$**	
Seeds	g	50	2.5		1250	62.5	
Manure	m3	0.2	18		5	450	
Fertilizer	kg	5	22		125	550	
			42.5			**1062.5**	
LABOUR							
prepare field	man-hours	8	20		200	500	
plant seeds	man-hours	14	35		350	875	
thinning & haverst 1	man-hours	8	20		200	500	
harvest 2	man-hours	24	50		600	1500	
harvest 3	man-hours	24	50		600	1500	
		78	**175**		**1950**	**4875**	
Total costs			**217.5**			**5937.5**	
leave yield	harvest 1	3.00					
	harvest 2	18					
	harvest 3	18					
total yield for 3 harvests		**39.00**				**975**	
MARKET PRICE	**per kg**	**7**					
Total revenue			**273**			**6825**	
GROSS MARGIN (N$)			**55.5**			**887.5**	

	Cost (N$)
Notes: Man-days : 8 hrs	**20**

Harvest <u>and</u> local processing and selling on the local Market
(Excl. transport field to town):

RAINFED Amaranthus thunbergii

GROSS margins for 100 m2 and for 0.25ha

COSTS

INPUTS	Units	Number	**N$**		Number	**N$**	
Seeds	g	50	2.5		1250	62.5	
Manure	m3	0.2	18		5	450	
Fertiliser	kg	5	22		125	550	
			42.5			**1062.5**	
LABOUR							
prepare field	man-hours	8	20		200	500	
plant seeds	man-hours	14	35		350	875	
thinning & haverst 1	man-hours	8	20		200	500	
harvest 2	man-hours	24	50		600	1500	
harvest 3	man-hours	24	50		600	1500	
		78	**175**		**1950**	**4875**	
Processing on site							
Washing and sorting	man-hours	**8.00**	40		200	1000	
1.5 l 80u transp vacuum bags&label at 1N$	bags	**36.00**	36		975	975	
Deep freezer running cost / mth (0.72N$/kWh)	mth	2	100.00		2	800	
Depreciation on capital invest (freezer etc)	mth	2	150.00		2	1200	
			176			**2775**	
Total costs			**393.5**			**8712.5**	
leave yield	harvest 1	3.00					
	harvest 2	18					
	harvest 3	18					
total yield for 3 harvests		**39.00**			**975**		
MARKET PRICE	**per kg**	**12**					
Total revenue			**468**			**11700**	
GROSS MARGIN (N$)			**74.5**			**2987.5**	

	Cost (N$)
Notes: Man-days : 8 hrs	**20**

It can be seen from the above two tables, that a suggested price of only N$ 7 per kg leaves, will make the farmer break even but leave only a very small profit for himself (his salary included) <u>N$ 887.5 for the standard 0.25ha size plots.</u> <u>At N$ 8 per kg</u> the gross margin rises to N$ 94.5 and <u>N$1862 for 0.25ha</u> and. Converted to 1 ha and a total harvest of 3.9 t/ha, the gross margin will be N$3550 per ha under rain-fed conditions at N$7/kg and N$ 7448 per ha at N$8/kg.

However if the leaves are washed, deep frozen and sold for N$ 12/kg on-farm, a farmer could make a profitable venture out of it. This simplified processing which does not include any previous blanching can preserve the leaves in a very fresh stage for up to 6 month, keeping all its organoleptic characteristics. Selling out of season will also make N$12/kg a very competitive price. On farm selling of 10 N$ will give a profit of N$ 483.5 per 0.25 ha.
Customers in Rundu indeed indicated, that outside the main season they were willing to pay up to N$ 15/kg for frozen and cleaned Mboga/Ekwaka leaves ready to be cooked. It is advisable to sell washed and freshly frozen (but not blanched, to keep the volume) in 500g

bags for N$ 7.5 instead of 1kg bag for 12N$. To make the bags look better and bigger, prior blanching should be avoided if sold in transparent bags. The above calculations assume sales from the grower who would also own a small shop/shebeen/street outlet and does not include any retail management or marketing costs.

Alternative scenarios:

Cultivation of Amaranthus thunbergii under drip irrigation

The following calculation is based on a 2500m² 50 X 50m plot which is the size of a normal community garden. It is also the size recommended for horticulture crops for which gross margins can be compared. Furthermore, drip lines of more than 50m are not advisable as pressure requirements will increase. There are two possible set-ups:
One with a 1.5kw electrical pump and a 2500l mixing tank and one with a solar pump plus 6 panels, mixing tank and a water tank on a stand of 6m to provide the minimum of 0.6 bar necessary to run the system. A diesel pump is not recommendable, as running cost for a small 0.25ha are around 600 N$ per month.

Capital investment to set up the system.

Dripper pipes and fittings (based on spacing of drippers at 30 cm and lines 50 cm apart based on previous recommendations and to make maximum use of available space)

Ideally there should be 2 blocks of 50m long and 25m wide, leaving walking space of 80 cm every five lines. The main line of 40mm is costing N$ 1000. The 50mm line from the water tank to the main-line is estimated at N$500. Each block will have 40 dripper pipes of 16mm which gives a total of 2000m, thus for two blocks we will need 4000m. The price of the dripper pipe is R 1.50/m or N$6000 in total.

A Tank of 10.000 l is N$ 6275 and a mixing tank of 2500l is N$ 1820.
A water stand of 6m height to support the tank will cost N$ 11’000.

A Solar pump plus 6 X 60 Watt panels providing 10m3 liter a day is N$30’000

If there is a possibility to run a system under a main electrical power supply: Costs for 1.5kw pump are N$ 2500. However any installation cost from a high voltage power line at a 50m distance would cost around N$ 50’000 !

Based on this set-up we will be able to plant a minimum of 13’000 plants on a 0.25ha. Water consumption will be 1.2 l per dripper per hour. We recommended irrigating for 20 minutes per day as per cultivation trials. 0.4l X 13’000 plants would need 5200 liter per day. If we irrigate on average 4days a week, we will need around 20’800 liter per week during the dry season. Electricity costs per month can be estimated at N$ 200.

For a drip irrigation system, it is actually advisable to provide the fertilizer directly through the system in a liquid form. Liquid fertilizer mixed applied through the system would require 2.5kg per 5000l applied twice a month, plus calcium nitrate. This will cost N$75 plus N$30 or in total N$ 105 per month. Manure can still be applied prior to the planting.

If the garden uses municipal water the owner has to be aware that he needs 83.2m^3 per month or 166m^3 per harvest/income cycle. Based on an N$7/$m^3$ rate he would have to budget for another N$ 1164.8 and would not break-even anymore.

Electrical pump system (under the assumption of a preexisting connection)

Input costs (first time)

Items needed	**N$**
Mixing tank	1820
1.5kw pump	2500
Main pipes	1000
Supply pipes	500
Dripper pipes	6000
Other fittings and clamps	400
	12220

Input Costs : Running Costs			
INPUTS	Units	Number	**N$**
Electricity			200
Seeds	g	1250	62.5
Manure	m3	5	450
Fertiliser mix	kg	20	210
Pay back capital investement over 5 years			400
LABOUR			
prepare field	man-hours	200	500
plant seeds	man-hours	350	875
thinning & harvest 1	man-hours	200	500
harvest 2	man-hours	600	1500
harvest 3	man-hours	600	1500
Total costs			**6197.5**
leave yield	harvest 1		75
	harvest 2		450
	harvest 3		450
total yield for 3 harvests			975
MARKET PRICE	**per kg**	**7**	
Total revenue			**6825**
GROSS MARGIN			**627.5**

At a price of 8N$/kg the gross margin will be at N$ 1602.5. In case the garden is not connected to the main electrical network, additional capital costs of N$50'000 can be estimated. This would increase costs for each income cycle by a minimum of N$800 (based on a 10 years pay back, excluding interest) at which it would not be possible to break-even anymore at N$7/kg. An alternative option is the solar pump system, presented in the following scenario.

Solar pump system

Input costs (first time)	N$
1 x 10'000 l tank	6,275
Mixing tank	1,820
Solar pump system	30,000
Stand for water tank	11,000
Main pipes	1,000
Supply pipes	500
Dripper pipes	6,000
Other fittings and clamps	400
	56,995

Input Costs : Running Costs			
INPUTS	Units	Number	N$
Seeds	g	1250	62.5
Manure	m3	5	450
Fertilizer mix	kg	20	210
Pay back capital investment over 10 years			950
LABOUR			
prepare field	man-hours	200	500
plant seeds	man-hours	350	875
thinning & harvest 1	man-hours	200	500
harvest 2	man-hours	600	1500
harvest 3	man-hours	600	1500
Total costs			**6547.5**
leave yield	harvest 1	75	
	harvest 2	450	
	harvest 3	450	
total yield for 3 harvests		975	
MARKET PRICE	**per kg**	**7**	
Total revenue			**6825**
GROSS MARGIN			**277.5**

At 8N$/kg the gross margin would increase to N$ **1252.5**

If the system is run in an urban area, water cost would have to be considered. (Based on the assumption that municipal water pressure is at least 0.5bar and no booster pump would be necessary)

Input costs (first time)	**N$**
Mixing tank	1820
Main pipes	1000
Supply pipes	500
Dripper pipes	6000
Other fittings and clamps	400
	9720

Input Costs : Running Costs			
INPUTS	Units	Number	**N$**
Water at 7N$/m3	m3	166	1162
Seeds	g	1250	62.5
Manure	m3	5	450
Fertilizer mix	kg	20	210
Pay back capital investment over 5 years			300
LABOUR			
prepare field	man-hours	200	500
plant seeds	man-hours	350	875
thinning & harvest 1	man-hours	200	500
harvest 2	man-hours	600	1500
harvest 3	man-hours	600	1500
Total costs			**7059.5**
leave yield	harvest 1		75
	harvest 2		450
	harvest 3		450
total yield for 3 harvests			975
MARKET PRICE	**per kg**	**7**	
Total revenue			**6825**
GROSS MARGIN			**-234.5**

As can be seen above, break-even at N$7 would not be possible

Processing under irrigation:

Cultivation with electrical pump

INPUTS	Units	Number	**N$**
Electricity			200
Seeds	g	1250	62.5
Manure	m3	5	450
Fertiliser mix	kg	20	210
Pay back capital investement over 5 years			400
sub-total			1322.5
LABOUR			
prepare field	man-hours	200	500
plant seeds	man-hours	350	875
thinning & harvest 1	man-hours	200	500
harvest 2	man-hours	600	1500
harvest 3	man-hours	600	1500
sub-total			4875
Processing on site			
Washing and sorting		200	1000
1.5 l 80u transp vacuum bags&label at 1N$		975	975
Deep freezer running cost / mth (0.72N$/kWh)		8	800
Depreciation on capital invest (freezer etc)		8	1200
sub-total			2775
Total costs			**8972.5**
leave yield	harvest 1		75
	harvest 2		450
	harvest 3		450
total yield for 3 harvests			975
MARKET PRICE	**per kg**	**12**	
Total revenue			**11700**
GROSS MARGIN			**2727.5**

Solar pump

INPUTS	Units	Number	N$
Seeds	g	1250	62.5
Manure	m3	5	450
Fertilizer mix	kg	20	210
Pay back capital investment over 10 years			950
			1672.5
LABOUR			
prepare field	man-hours	200	500
plant seeds	man-hours	350	875
thinning & harvest 1	man-hours	200	500
harvest 2	man-hours	600	1500
harvest 3	man-hours	600	1500
			4875
Processing on site			
Washing and sorting		200	1000
1.5 l 80u transp vacuum bags&label at 1N$		975	975
Deep freezer running cost / mth (0.72N$/kWh)		8	800
Depreciation on capital invest (freezer etc)		8	1200
			2775
Total costs			**9322.5**
leave yield	harvest 1	75	
	harvest 2	450	
	harvest 3	450	
total yield for 3 harvests		975	
MARKET PRICE	**per kg**	**12**	
Total revenue			**11700**
GROSS MARGIN			**2377.5**

Comparison with the wild harvested crop sold at the Open Markets:

Wild harvested Amaranthus is sold with the stems on (as delivered in May 2005 for the first processing trial). The stems are the lateral ones and the buds. For Amaranthus thunbergii, a lot of people actually eat the small stems, but as the previous panel tests confirmed, they are not the preferred way of consumption (One of the major complain of the first processing report was about rough inhomogeneous quality).

1,360 kg of the "wild crop" is sold for N$6 on the informal street market during the main season (January 2006 price), which gives as approximately N$ 4,50/kg for fresh harvested Amaranthus thunbergii at the height of the season ! (With no inputs or value added).

The sample looks as on photo 1 underneath.
Photo1.

Now if you take of the stems to have a nice batch you will get 0.890 kg out of this 1,360kg
Photo2. leaving 0,470kg as *stem offal*.

This makes 0,890 kg to be 6N$ and 1kg of wild harvested leaves become 6,74 N$/kg.
In addition, a skilled worker will take one whole hour to trim this batch, thus if you buy the untrimmed batch you would still have to add a minimum of N$2 for the labor. (Unless you leave this unpleasant task to your customer)

The above would proof that even the weedy crop can get expensive if some minimal value is added to it. Harvesting the spontaneous IGLV is also not easier or less labor intensive if done according to the requirements of a processing plant.

The wild crop is willingly appreciated on the field but the people are not yet accustomed to the idea of sowing the IGLV between their staple food as it would grow uncontrolled during the next season unless care is taken to remove the mature seeds before they spread which would again involve considerable labor. Farmers who grow Amaranthus thunbergii can harvest the leaves with the possibility of three harvests and improved outputs, or they root out the whole plant and benefit form a "once off income" for a very short time with only half of the potential harvest (max 20kg of usable leave material per 100m2). The later supply will be more un- homogenous, and leave a lot of work to the processor, thus further reducing the margin at the processing side.

Further marketing analyses would be needed to find out the consumers response to displays of plastic frozen bags of 500g. A farmer and a small SME should be able sell the 500g bags for at least 5 N$ on the local market. In order to sell in Windhoek we he would need to share the costs of transport and a functional cold-chain with other stakeholders. Given the previous Market research he would probably not be able to increase the 500g by more than N$2. Real test-marketing would be necessary to answer this question.

Underneath follows a scenario where IGLV would be seen as a catch crop only (based on the same amount than cultivated on a ¼ of a hectare.

Amaranthus thunbergii as a catch crop

INPUTS	Units	Number	**N$**
Raw material at 5N$ /kg	kg	**1500**	**7500**
Processing on site			
Washing, sorting **and** triming	man-hours	600	2000
1.5 l 80u transp vacuum bags&label at 1N$	bags	975	975
Deep freezer running cost / mth (0.72N$/kWh)	mth	1	400
Depreciation on capital invest (freezer etc)	mth	1	600
			3975
Total costs			**11475**
Leaves only (based on a 34% loss)		**975**	
MARKET PRICE	**per kg**		12
Total revenue			**11700**
GROSS MARGIN (N$)			**225**

5. CONCLUSIONS AND WAY FORWARD

1. For contract harvesting, only local processing on location is recommendable as transport by land courier is unreliable. The fact that the biggest harvest is during the rainy season makes dry packaging virtually impossible.

2. The effect of treatment on leaf yield per plant for both Cleome gynandra and Amaranthus thunbergii are the same than total harvest, with highest results on High NPK, high manure and high NPK and low manure and high NPK combined. However medium concentrations of manure and MeNPK give similar results. The only significant differences were observed between HNPK and Medium manure or HNPK versus low NPK and LM and Control plots. As differences between medium applications of fertilizers (100g/m2)/manure (1kg/m2) and high applications (200g/m2 and 2kg/m2) are not significant it is more cost-effective to use medium concentrations.

3. For Amaranthus thunbergii most plots were well established with a 75 % seed emergence.

4. Cleome gynandra only has only 50% germination rates. Only HM, LM+HNPK and HM+LNPK had better germination and plant counts above 50%.

5. Type of fertilizer used does have little effect on vegetative growth, (but might have on nutrient content, which was not part of the trials).

6. Bow benches give better results, not just in saving water, but also in yield. This can be interpreted in nutrients saved from leaching which become more available to the plants.

7. Watering with floppy overhead sprinklers four times a week or twice a week give no better or worse results. This sprinkler system is not recommended for Amaranthus thunbergii on a loamy soil.

UNAM trials

8. Transplanting under family drip irrigation is not advisable. Effects under other high water irrigation trials might give better results but it can be expected that given the significant differences for this trial, that growth, if not as drastic as in this trial, will produce reduced yield in any other set-up as well. The long and fast growing root of Cleome gynandra makes them vulnerable to transplantation if not carefully handled.

9. Of all the treatments analyzed: spacing, variety and seeding methods, it is the seeding method which has the most significant effect, followed by spacing and only last by the variety.

10. There is no statistical difference in yields of varieties of Hibiscus sabdariffa . The data does not elucidate why most farmers in the Kavango region prefer the green variety. Hence the reason behind this choice is taste, as the green variety proves to be less bitter than the red one.

11. Since there was no major variation among the Hibiscus sabdariffa varieties on mean calyces yield in response to water applications, it is recommended that all varieties in this study should be irrigated at low water application in water scarcity region, since they produce almost equal yield.

12. There is no significant difference between the germination success of Cleome gynandra because of different growth mediums. Hence different growth mediums (vermiculite, soil mixed with manure and filter papers) do not affect total germination of C*leome gynandra* seeds.

13. The report showed that statistically there are no significant differences between Genebank accessions and newly collected seeds of *Cleome gynandra*. This implies that the seeds are equally viable irrespective of when they were collected. However once passed the 6months dormancy period after collection there might have been a difference between germination success (program coordinator's personal note). Any further studies in this direction should be supported.

14. A suggested price of only N$ 7 per kg leaves will make the farmer break even but will leave only a very small profit for himself (his salary included). At N$ 8 per kg the gross margin rises to N$ 1862 per 0.25ha (N$ 7448 per ha).

15. However if the leaves are washed, deep frozen and sold for N$ 12/kg on-farm, a farmer could make a profitable venture out of it.

COMPARISON OF DIFFERENT ECONOMIC OPTIONS AND SCENARIOS

Comparison of different **gross margins for cultivation**

	At N$7	At N$8	At N$ 12 (incl. processing)
	Gross margins	**Gross margins**	**Gross margins**
Rain fed	887.5	1862	2987.5
Irrigated (electric)	627.5	1602.5	2727.5
Irrigated (solar)	277.5	1252.5	2377.5
Urban area	-234.5	740.5	< 600*

* Incl. water consumption for washing and sorting.

These margins are for one income cycle of approximately 2months. The rain-fed cultivation would be limited to two cycles while the drip irrigation could expect a minimum of three cycles (cold weather would reduce production beyond this period). Further more a four days drought might cause crop failure if only under rain-fed conditions.

As a comparison find underneath some gross-margins per crop-cycle from other crops on ¼ of a hectare (Adapted from Input Providers and "2001 Horticultural marketing in the Kavango" report) under sprinkler irrigation (except for the lettuce heads, which margins were calculated under drip irrigation) :

CROP	GROSS MARGIN in N$
Lettuce heads	15'000
Cabbage	1000
Cabbage hybrid	5900
Sweet potato	3000
Green Maize	1500
Carrot	1400

In accordance with the prior findings of the final Marketing and processing report, as well as the cultivation trials, Amaranthus thunbergii seems to be the favourite candidate for an SME to make a profitable venture.

However both Hibiscus sabdariffa, (which is the easiest to cultivate) and Cleome gynandra (which is still preferred as an additive to an Amaranthus thunbergi processed mix) shall not be despised in any forth coming programme. The scenario underneath shall be applicable to all three indigenous/traditional leafy vegetables.

The following viable options are possible:

Option 1: See the IGLV as a catch crop only and base the processing on this supply
Option 2: See IGLV as a crop to cultivate under rain fed conditions
Option 3: See IGLV as a crop to cultivate under drip irrigation

Potential strengths and weaknesses of IGLV as a catch crop	
(Potential) strengths	*(Potential) weaknesses*
• Only input would be the payment for delivery at approx. 4kg/day/adult at 20N$	• Limited quality control • Limited control of assured quantity to be expected per cycle (risk of over and undersupply) • Additional work to select, clean and trim during processing • Limited in time (need for deep freezing and or advanced processing "blanching" etc in order to be able to supply all year round and catch a higher price

Potential strengths and weaknesses of IGLV cultivated as a rain-fed crop	
(Potential) strengths	*(Potential) weaknesses*
• Lower inputs and highest gross margin per cycle	• Vulnerable to drought spell who might cause complete crop failure • Limited to 3 months

Potential strengths and weaknesses of IGLV cultivated under drip irrigation (electr.pump)	
(Potential) strengths	*(Potential) weaknesses*
• Good gross margins per cycle • Can produce for 6 months	• Need Higher start up capital • Need existing power supply • Need more trained labor

Potential strengths and weaknesses of IGLV cultivated under drip irrigation (solar .pump)	
(Potential) strengths	*(Potential) weaknesses*
• Good gross margins per cycle • Can produce for 6 months • No need for power supply • Lower running costs than above	• Very high start up capital • Need more trained labor

Potential strengths and weaknesses of IGLV cultivated under drip irrigation (urban area)	
(Potential) strengths	*(Potential) weaknesses*
• Can produce for 6 months • Close to the Market	• Low gross margins • High water costs • Need more trained labor • High town council fees to set up business