Effect of sowing dates, heat, photoperiod and drought on the performance of bambara groundnut (*Vigna subterranea*) landraces.

Research Team

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INTRODUCTION

Bambara groundnut is an indigenous African legume. It is an indeterminate crop and carries a trifoliate leaf on a prominent petiole. The crop is similar to peanut and forms pods and seeds on or just the ground. The flower stalk penetrates the soil and develops into a pod containing the seeds.

- The crop has been reported as a drought tolerant crop which is capable of producing some yields where other crops such as groundnut fail to survive (Linnemann and Azam-Ali, 1993).

- The crop is useful in the cropping system and found intercropped with cereals and root and tuber crops. In Botswana and Burkina Faso bambara groundnut is intercropped with maize, millet and sorghum (Chaba, 1984; Drabo *et al.,* 1997).

- The crop has a high potential for the attainment of food security and poverty alleviation in most countries of the African continent especially for women who form the bulk (63%) of producers (Berchie *et al.,* 2010, Sesay *et al.*, 2008).

- With the rapidly changing climatic conditions such as erratic rainfall, global warming and its attendance effect on agriculture, every research effort to improve on the yield and acceptability of bambara groundnut will be a major boost towards solving the problem of hunger and malnutrition in most parts of Africa and beyond.

Introduction

- Factors limiting increasing utilization of the crop include lack of awareness, lack of improved varieties, poor agronomic practices, limited potential as a cash crop, hardness to cook unavailability of seeds and variation in yields from season to season.

Bambara groundnut seeds

Fig. 1: Bambara groundnut seeds

Introduction

- Harris and Azam-Ali (1993) attributed the low and unpredictable yields obtained by subsistence farmers to the year to year variation in planting dates.

USES

Bambara groundnut is essentially grown for human consumption

- Immature seeds are boiled and eaten as snack
- Mature dry seeds are boiled and eaten as pulse
- Mature seeds can also be ground into flour after roasting to prepare porridge (Brink and Belay, 2006)
- Doku and Karikari (1971) reported that bambara groundnut could be canned and in Ghana, 40,000 cans of various sizes were produced annually which tasted as baked beans.

Bambara has a balanced protein and high carbohydrate content compared to Soybeans and Peanuts

Legume	Protein	Carbohydrate	Lipids
	%	%	%
Soybean	34	32	19
Peanut	23	25	46
Cowpea	22	63	1
Bambara	12-25	43-69	5-7

Source: Biochemistry Division, CSIR-Crops Res. Institute. June, 2008.

The oil content of Bambara is low……

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Source: Biochemistry Division, CSIR-Crops Res. Institute. June, 2008.

THE LOW OIL CONTENT OF BAMBARA MAY EXPLAIN WHY IT IS AN UNDER-UTILISED AND UNDER-RESEARCHED CROP

- Smart and Simmonds (1995) observed that peanuts which were introduced into West Africa from Brazil may have replaced bambara groundnut because peanuts contain significant amount of oil and can be grown as an oil seed crop.
- A cash crop with export potential for the colonial powers replaced a food crop for the subsistence of the local population

The Paradox

"The story of *Vigna subterranea*, until fairly recently, has been one of neglect, decline and relegation. It is a paradox that an indigenous African crop which produces an almost complete food, is one of the most drought tolerant, easy to cultivate crops which makes very little demand, if at all, on the soil, should be so relegated in its own countries without being accorded any research attention and, worse still earn the "accolade" of a poor man's crop." (Doku E. V. 1996).

STUDY OBJECTIVES

- Identify genotypic responses of selected bambara groundnut landraces to different sowing dates.
- Identify the responses of the selected genotypes to heat and drought stress on the field
- Identify genotypic responses to photoperiod
- Identify genotypic responses to drought stress under controlled environment.

Material and methods

Plant materials

Seven bambara groundnut landraces were used for the study in Wenchi and Kumasi. These are; Black eye, Ada, Burkina: Tom, NAV 4, NAV Red and Mottled Red.

Experimental design and plot size

- Experimental design was an RCBD factorial with three replicates
- Plot size was 6m x 6m (13 rows and 31 hills).
- Seeds were sown at 2 seeds/hill at inter row spacing of 50 cm and intra spacing of 20 cm.
- Seedlings were thinned to one plant/hill 20 DAS (Plant population of 10 plants/m^2)

- Plants were sown on six sowing dates in 2008 in Wenchi (Transition agro-ecology) and CSIR-Crops Research Institute, Fumesua-Kumasi (Forest agro-ecology)

- Five landraces were used in the heat and drought trial at Tono in the Upper East Region of Ghana. The trial was sown on the 10th of February, 2007. The field was irrigated to field capacity once weekly till maturity using a furrow irrigation.

- Drought trial, Tono: Sown on the 11th of February, 2007.
- The trial was irrigated once weekly till 30 DAS after which irrigation ceased

Photoperiod and drought study at the University of Guelph, Canada

- Plant materials

13 bambara groundnut landraces were used for the study. Five of these were used in the 2-yr field study in Ghana. The remaining seven are;

Red eye
Zebra-coloured
Black seed
Mottled cream
Brown with white eye
Tan 1 from Tanzania
Tan 2 from Tanzania

Plant material

Photoperiod Treatment

- Seeds were sown on the 11th of October (Day 0) 2008 at two seeds per pot and thinned to one seedling per pot on emergence. Plants were arranged in a Completely Randomised Design (CRD) with 6 replicates per landrace per growth chamber
- Photoperiod treatments were 12 hrs:12 hrs (Growth Chamber 6) and 14 hrs:10 hrs (Growth Chamber 7) light:darkness.
- Growth chamber temperatures were maintained at 30^{o}C in the day and 25^{o}C in the night at a relative humidity of 60%
- Light : Light was maintained at PAR of 200-250 umol m^{-2} $s^{-1.}$ Pot positions were randomised every 4 days to prevent possible biasness due to light and growth chamber effect. Plants were irrigated every three days till the termination of the experiment.

Drought Treatment

- Seeds were sown on the 30th of October, 2008. Treatments imposed were :
- Drought: Irrigation ceased at 30 DAS and resumed at 60 DAS. The control was irrigated every three days.
- Data was analysed for Analysis of variance (ANOVA) using the Statistical Analysis System (SAS), USA Version 9.1.
- Days to flowering, emergence, pod dry weights and root dry weights (photoperiod trial) were log transformed before analysis.

Data taken included

- Days to emergence
- Days to flowering
- Days to maturity
- Shoot dry weight
- Root dry weight
- Mature pod dry weight
- Total pod dry weight

Table 1: Total dry weight, pod dry weight, pod harvest index and seed harvest index as affected by bambara groundnut landraces. Wenchi, 2008.

Landrace	Total dry weight (Kg/ha)	Pod dry weight (Kg/ha)	Seed dry Weight (Kg/ha)	Pod harvest index	Seed harvest index
Ada	7925.0	4436.0	3011.5	0.56	0.38
Black eye	8505.0	4631.0	3402.0	0.54	0.40
Burkina	8095.3	4511.0	2995.2	0.56	0.37
Mottled Rd	8265.1	4537.1	3388.7	0.54	0.41
NAV 4	8219.4	4508.4	3370.0	0.55	0.41
NAV Red	8316.2	4381.2	3076.8	0.54	0.37
Tom	5861.2	378.3	293.1	0.06	0.05
CV (%)	11.6	39.9	39.2	38.4	38.1
LSD (0.05)	1032.6	1775.7	1769.2	0.18	0.06

Table 2: Total dry weight, pod dry weight, pod harvest index and seed harvest index of bambara groundnut landraces as affected by sowing dates. Wenchi, 2008.

Sowing Date	Total dry weight (Kg/ha)	Pod dry weight (Kg/ha)	Seed dry Weight (Kg/ha)	Pod harvest index	Seed harvest index
28/02/08	8120.0	3900.0	2923.3	0.48	0.36
13/03/08	8530.3	4230.4	3326.8	0.50	0.39
20/03/08	8833.1	4373.1	2914.9	0.50	0.33
13/04/08	8437.2	4017.2	2784.3	0.46	0.33
17/06/08	7967.4	3937.0	2629.2	0.49	0.33
23/06/08	7283.0	3013.3	2112.1	0.41	0.29
CV (%)	6.6	12.1	12.8	7.2	10.0
LSD (0.05)	615.6	540.0	520.0	0.04	0.04

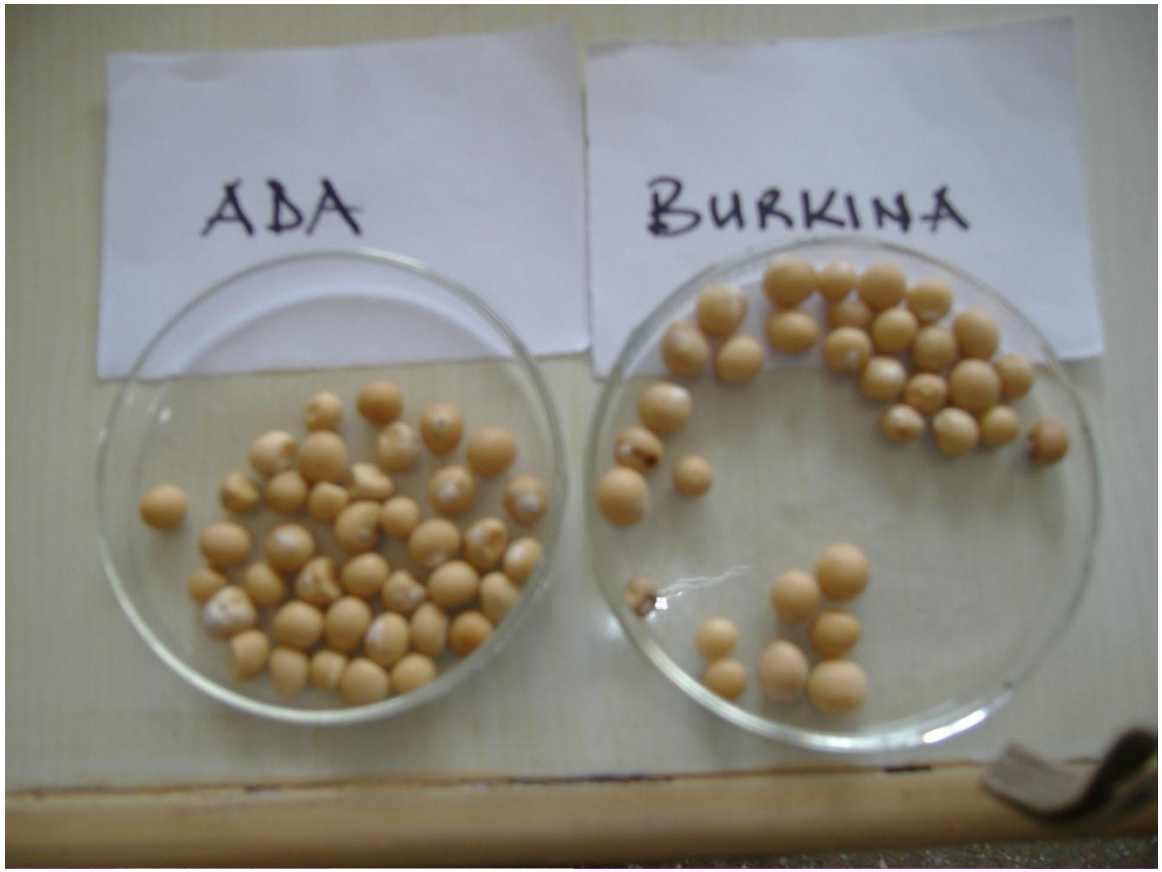


Fig.2: Seeds of Ada and Burkina

Table 3: Days to 50% emergence, 50% flowering, maturity and pod yield as affected by bambara groundnut landraces, Fumesua-Kumasi, 2008.

	Days to 50% emergence	Days to 50% flowering	Days to maturity	Pod yield (kg/ha)
Landrace				
Black eye	8.6	44.2	105.2	1102.0
Burkina	8.9	44.0	105.8	1167.3
Mottled Red	8.3	44.4	105.7	1493.1
NAV 4	8.7	43.6	106.2	1172.4
NAV Red	8.4	42.8	102.2	1772.5
Tom	8.6	48.7	114.5	917.0
CV (%)	6.6	2.3	3.3	14.2
LSD (0.05)	NS	0.7	2.4	180.3

Table 4: Days to 50% emergence, 50% flowering, maturity and pod yield of bambara groundnut landraces as affected by sowing dates, Fumesua-Kumasi, 2008.

	Days to 50% emergence	Days to 50% flowering	Days to maturity	Pod yield (kg/ha)
Sowing date				
12/03/08	9.4	44.8	105.7	2081.3
19/03/08	8.2	41.5	110.8	2332.0
14/04/08	8.3	45.7	111.1	1416.4
28/04/08	8.2	41.6	106.6	1190.3
10/06/08	8.2	46.1	111.3	335.2
18/06/08	9.2	42.9	98.2	279.3
CV (%)	6.6	2.3	3.3	14.2
LSD (0.05	0.4	0.7	2.4	432.0

Table 5 : 100 pod dry weight, 100 pod seed weight and 100 seed dry weight of bambara groundnut landraces sown in August at Wenchi, 2007.

Landraces	100 pod dry weight (g)	100 pod seed wt (g)	100 seed dry wt. (g)	Total pod yield (Kg/ha)
Ada	82.7b	62.7b	56.0b	4000.0b
Black eye	82.7b	62.7b	56.3b	4570.0a
Burkina	83.3b	63.3b	56.3b	4100.0b
NAV 4	82.7b	65.0b	58.0b	3897.0b
NAV Rd	86.3b	65.3b	58.0b	4537.0a
Tom	116.7a	98.7a	94.7a	2260.0c
CV (%)	3.6	2.0	3.1	5.2

Figures in a column bearing the same letters are not significantly different (p=0.05) by Duncan's Multiple Range Test

WHAT GIVES THE CROP THE POTENTIAL OF A HIGH YIELDER

- Almost vertical canopy architecture of the crop which enhances maximum interception of irradiance.
- Low sink demand of the thin and much branched stem which offers little competition for assimilates relative to the developing pods.
- Ability to survive and produce some yield under high temperatures which enables the crop to relatively overcome photorespiration and thus enhance net photosynthesis.
- The low lipid content of the crop gives it a high product value of carbohydrate per gram glucose synthesised relative to soybean and groundnut which are high in lipids.

Tom (L) showing few pods and more vegetative characteristics. Black eye (R), more pods and less vegetative

Fig.3a Tom

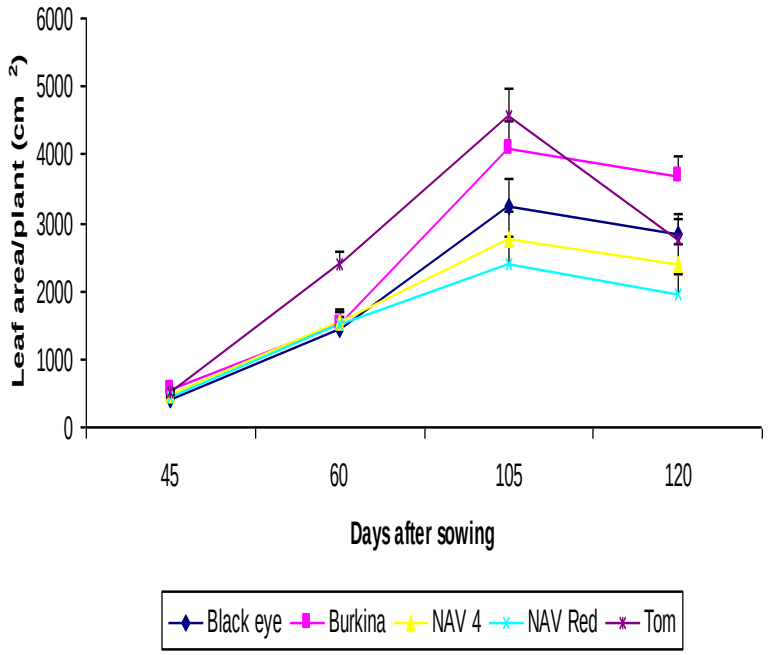
Fig 3b Black eye

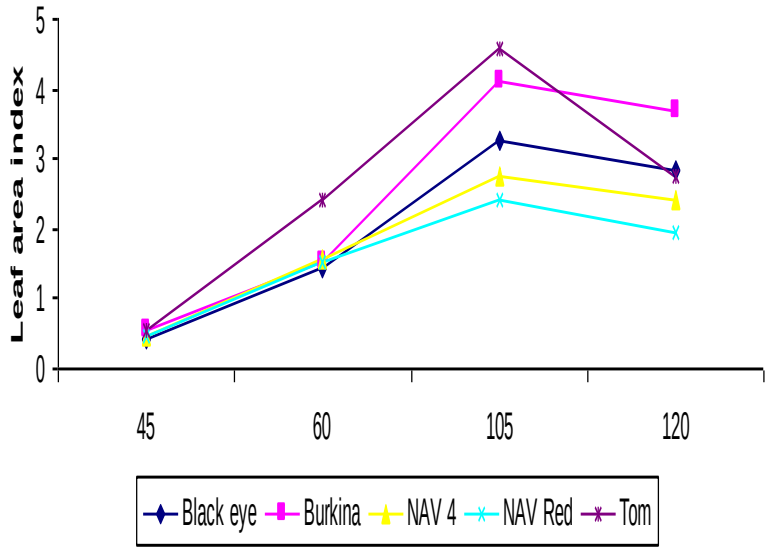
Table 6: Plant height, plant width and pod dry weight for bambara groundnut landraces Tono (Heat trial) (2007)

	Plant height (cm)	Plant width (cm)	Pod dry wt. (g/m^2)
Landrace			
Black eye	20.5	38.2	48.7
Burkina	20.5	30.9	118.5
NAV 4	21.3	39.9	54.0
NAV Red	22.5	36.5	52.5
Tom	25.3	40.2	0.0
Mean	22.0	37.1	54.7
CV (%)	7.2	10.7	20.5
LSD (0.05)	2.5	6.1	17.3
P value	0.005	0.037	<0.001

Table 7: Root dry weight and leaf dry weight (Tono) drought trial.

	Root dry weight (g/m^2) 120 DAS	Leaf dry weight (g/m^2) 105 DAS	Leaf dry weight (g/m^2) 120 DAS
Landrace			
Black eye	2.10	142.0	103.8
Burkina	3.66	159.3	196.3
NAV 4	2.30	146.7	106.4
NAV Red	1.84	154.7	132.7
Tom	2.17	162.0	93.9
Mean	2.41	152.9	126.6
CV %	21.3	22.1	22.4
LSD (0.05)	0.96	NS	53.5
P value	0.017		0.013





Figs. 4 a & b: Leaf area and leaf area index against days after sowing Tono, drought experiment

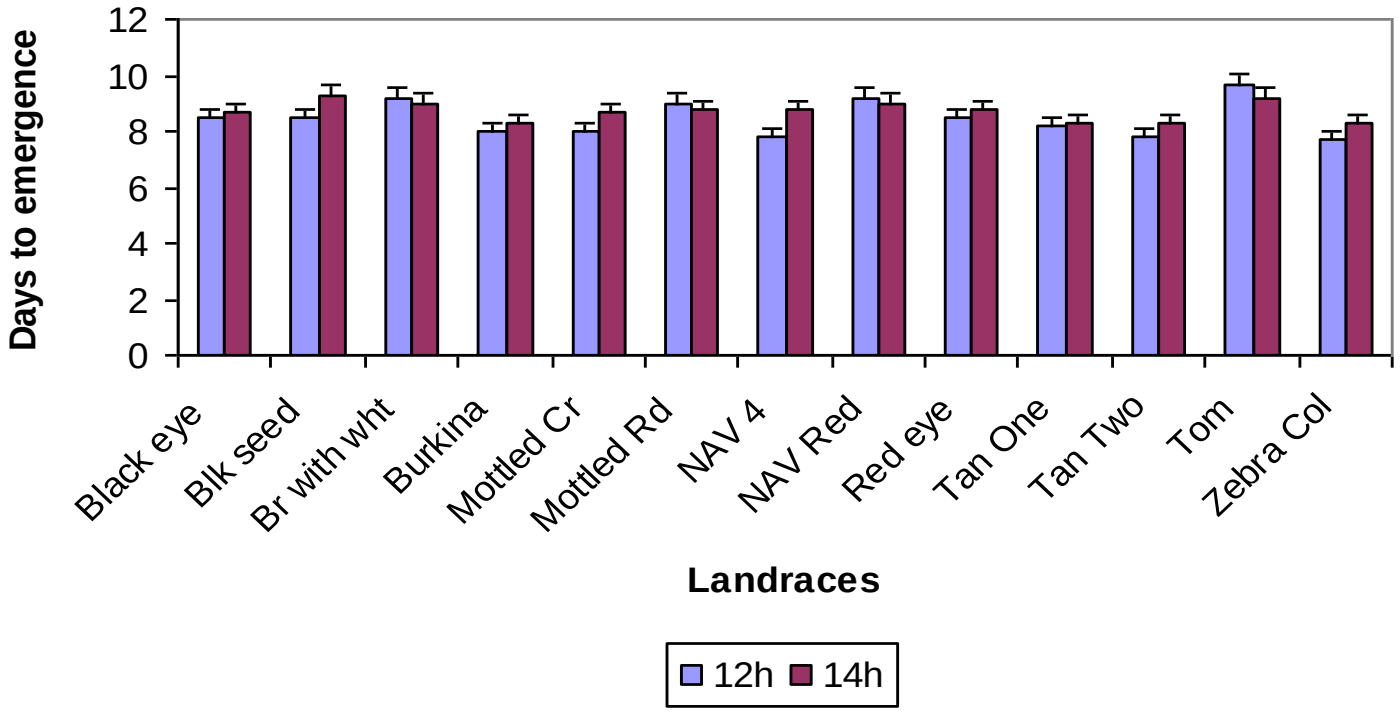


Figure 6: Days to seedling emergence as affected by landraces and 12 and 14 h photoperiod.

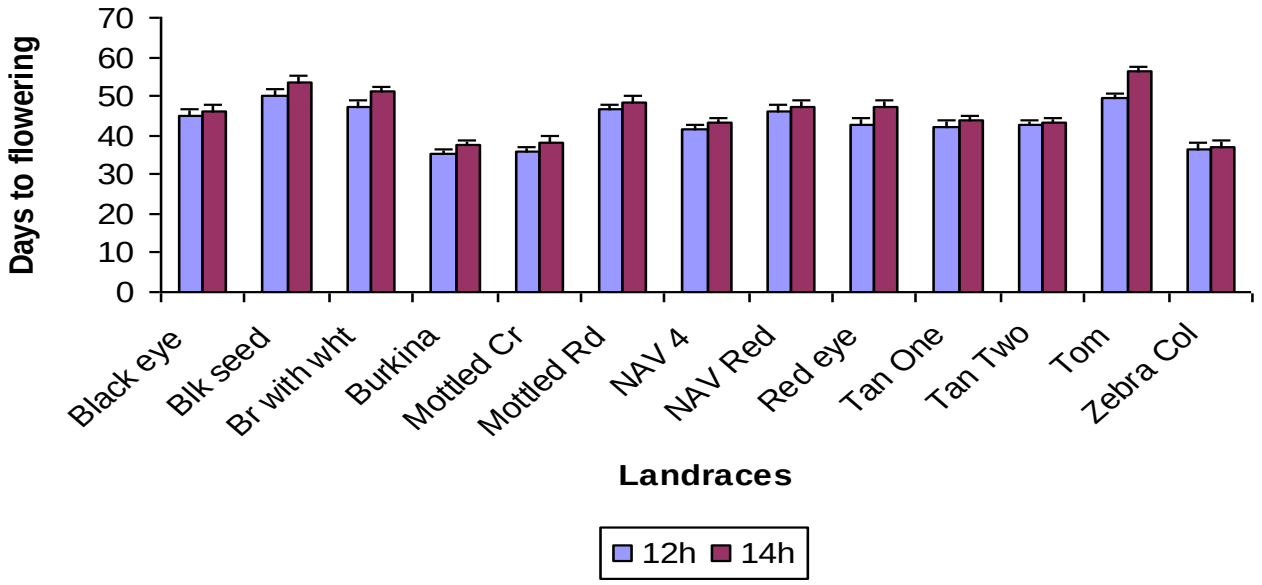


Figure 7: Days to flowering as affected by landraces and 12h and 14 h photoperiod

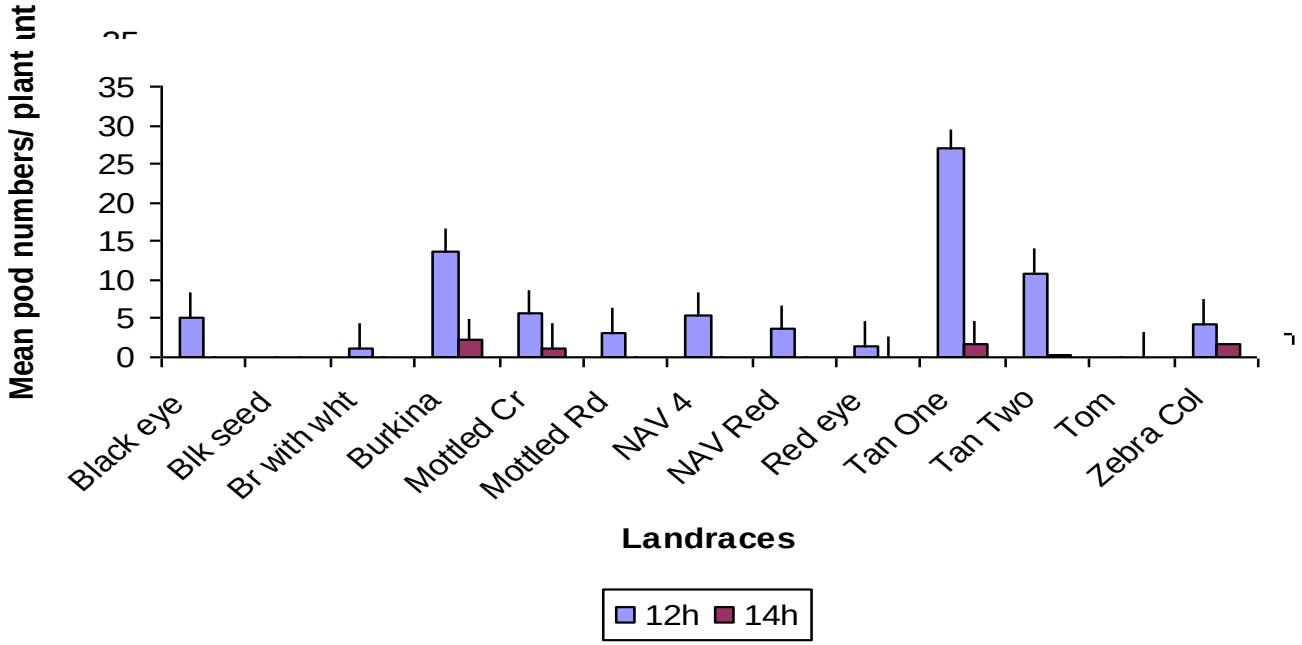


Figure 8: Pod numbers as affected by landraces and 12 and 14 h photoperiod

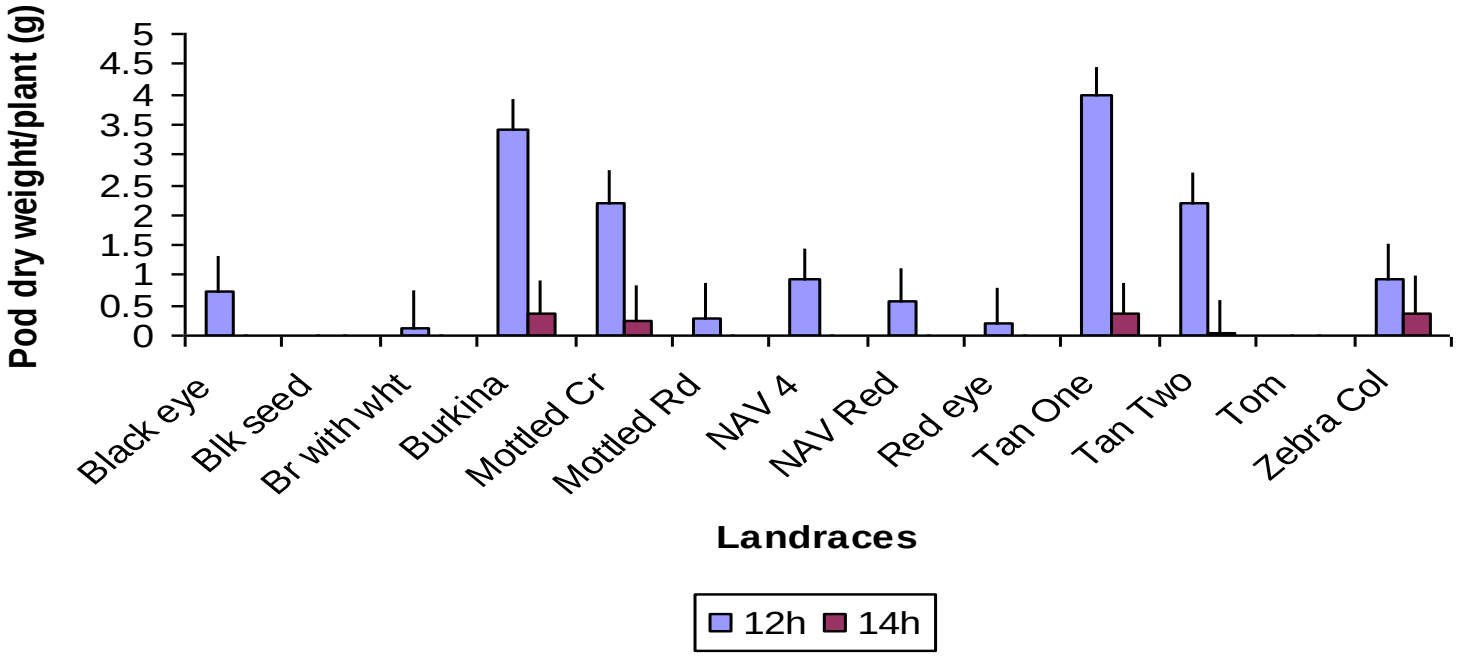


Figure 9: Pod dry weight/plant as affected by landraces and 12 and 14 h photoperiod

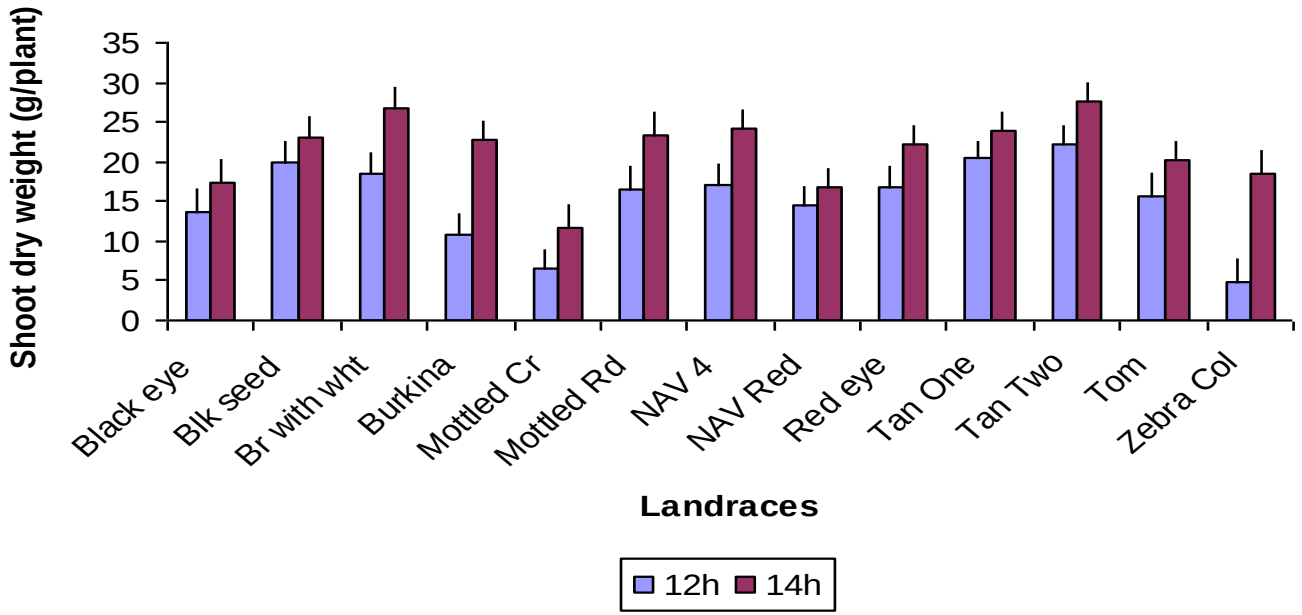


Figure 10: Shoot dry weight/plant as affected by landraces and 12 and 14 h photoperiod

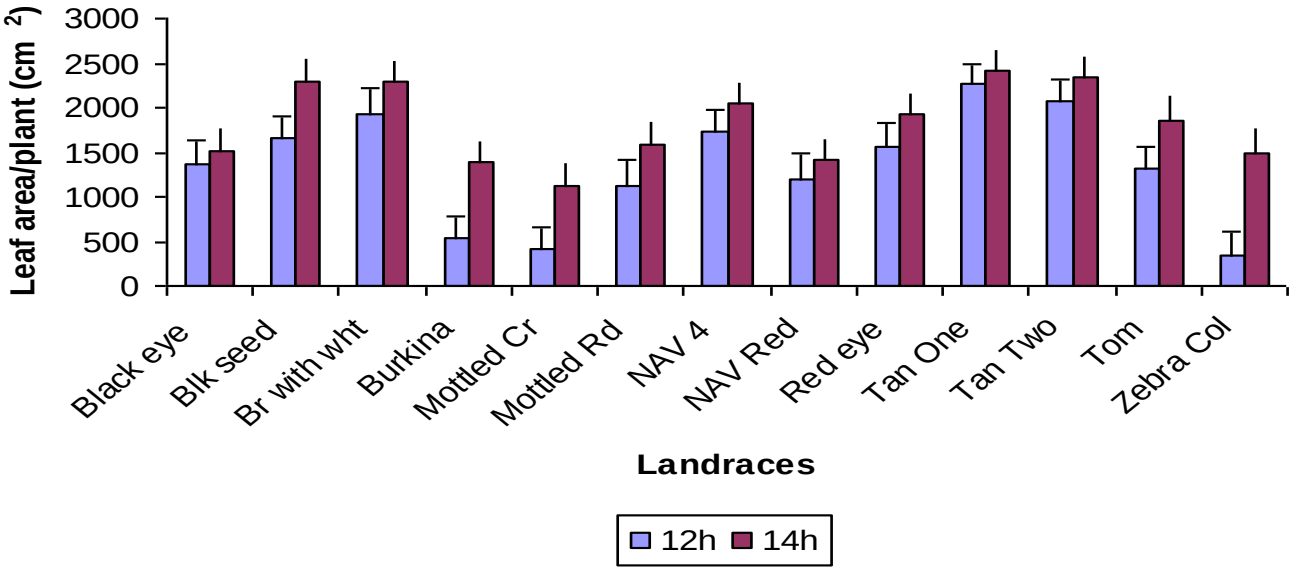


Fig 11: Leaf area /plant as affected by landraces and 12 and 14 h photoperiod

Fig 12 a & b: Podding under 12h and 14 h photoperiod (Burkina L, and Mottled cream, R

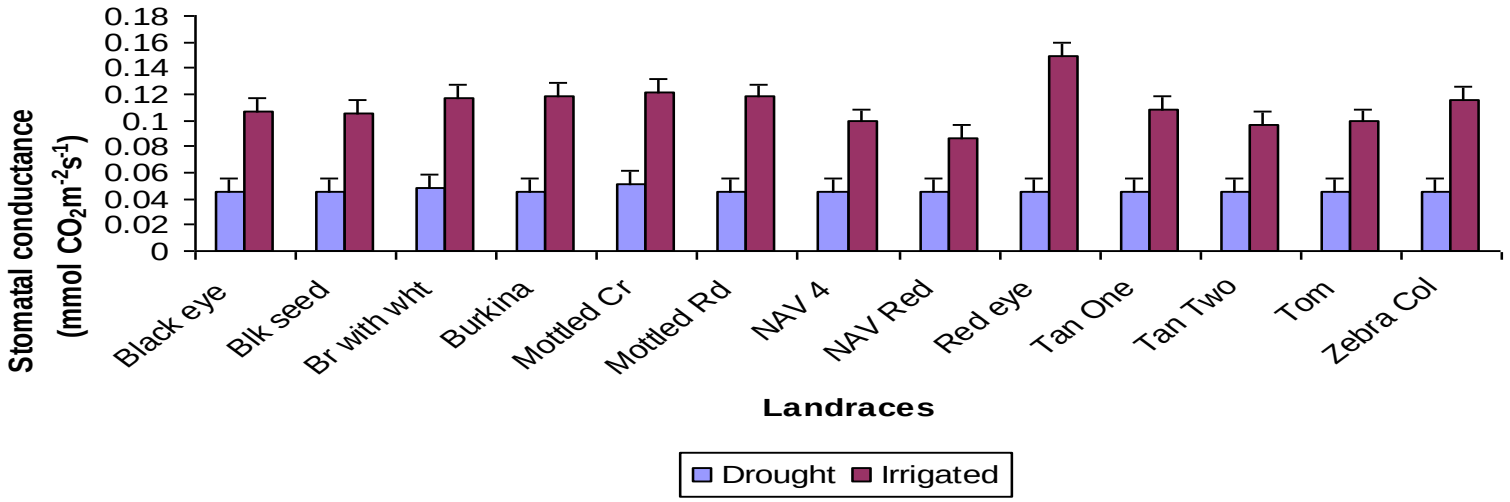


Fig 15: Stomatal conductance as affected by landraces and irr. treatment

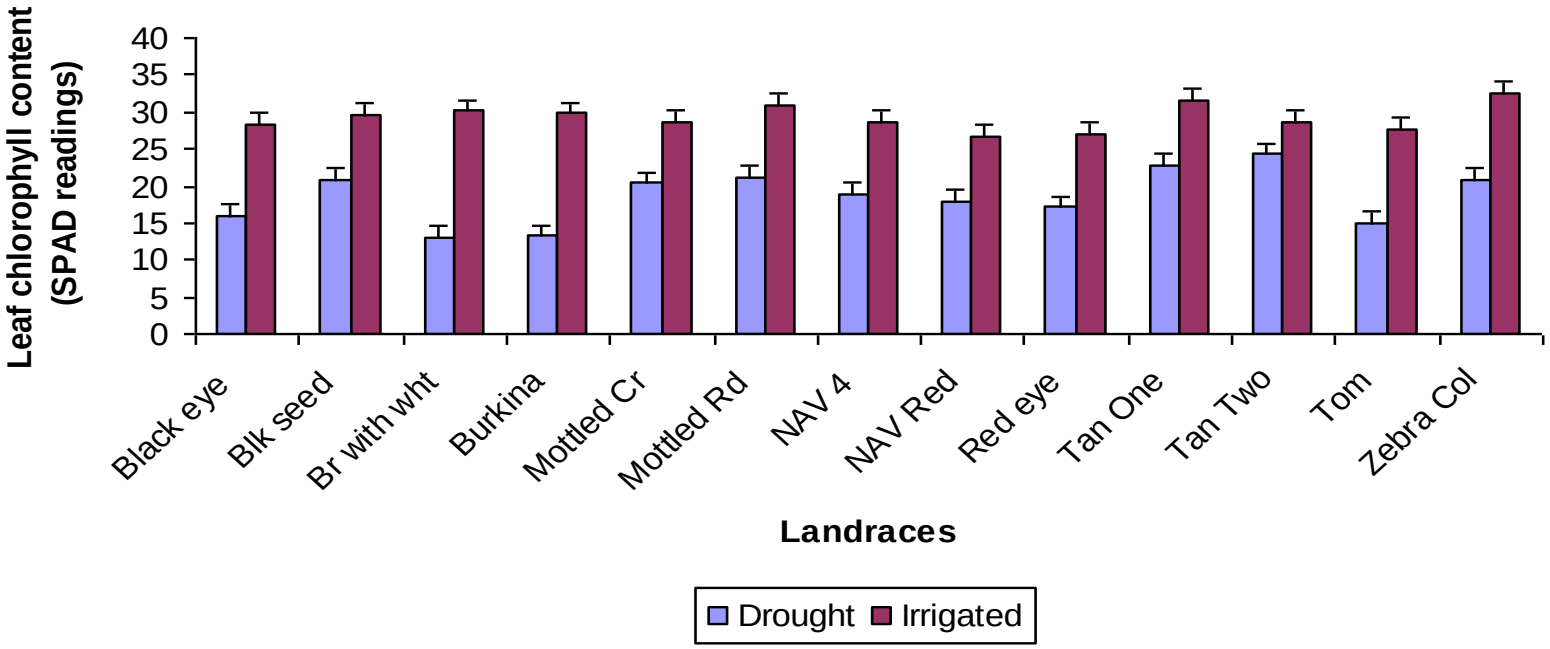


Fig 16 :Leaf chlorophyll content as affected by landrace and irrigation treatment

- Trend of drought effect on the 13 bambara groundnut landraces.

Fig. 17: Beginning of treatment 30 DAS, Drought (L) , Irrigated. (R)

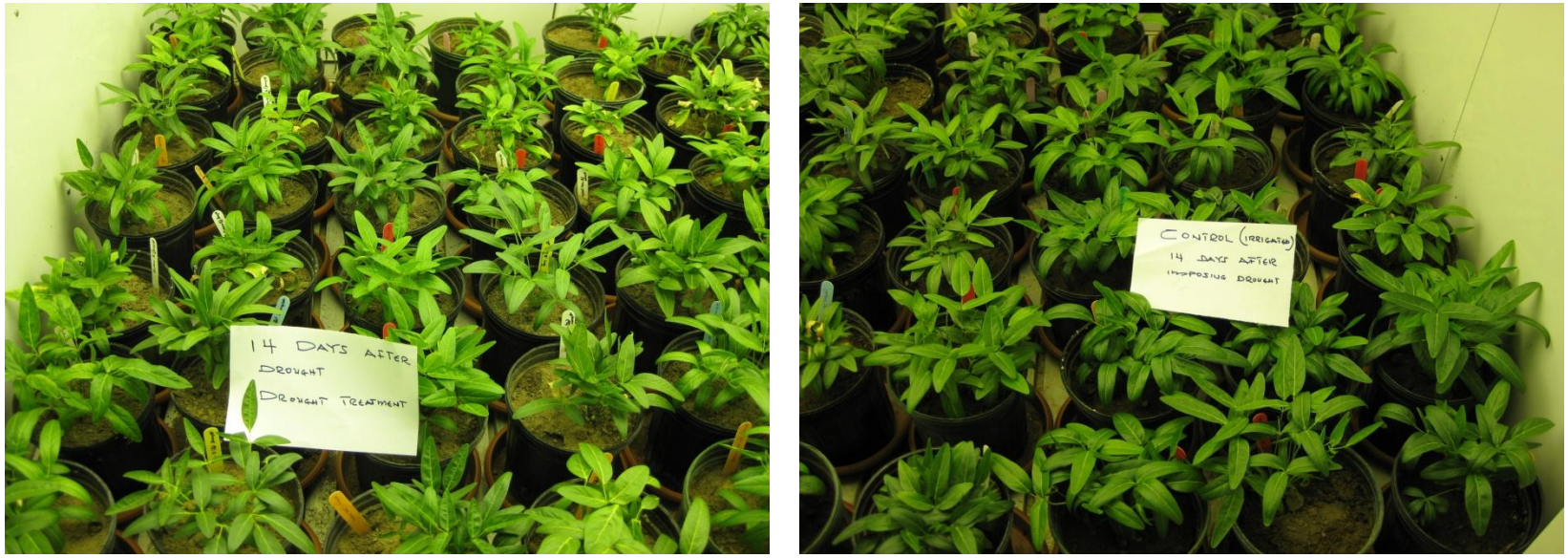


Fig 18: Drought (L) Irrigated (R), 14 days without irrigation, 44 DAS

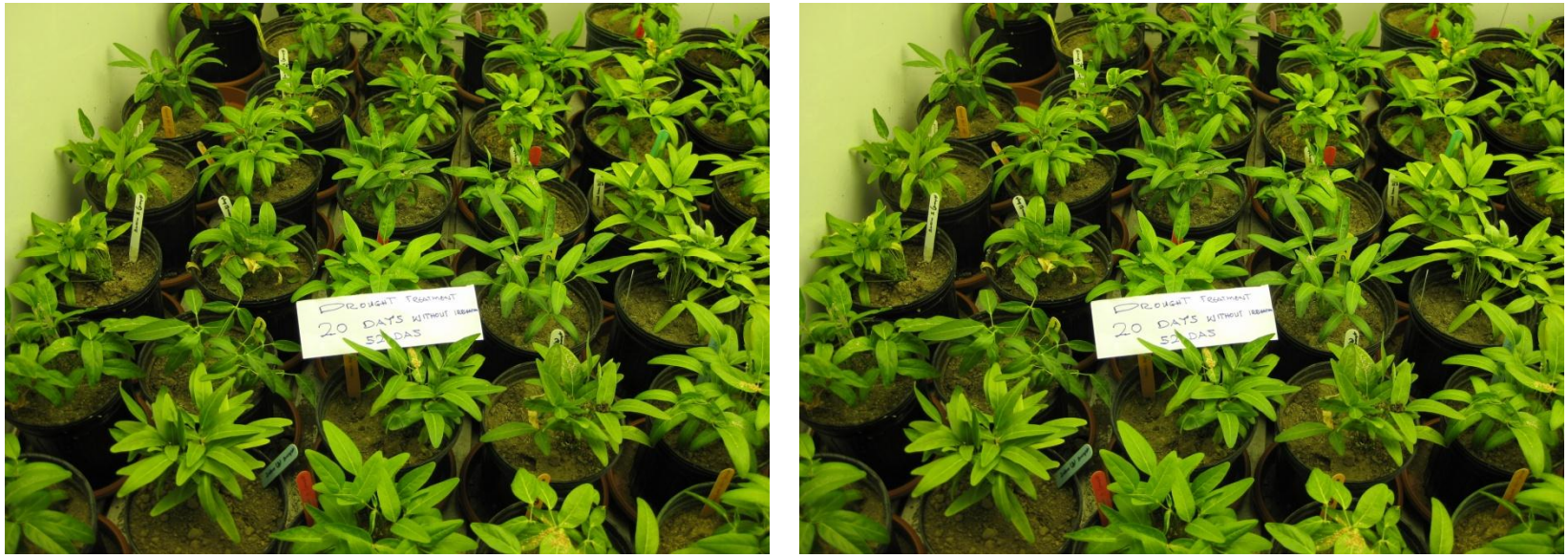


Fig 19: Drought (L), Irrigated (R), 20 days without irrigation 50 DAS

Fig 20: Drought (L), Irrigated (R), 25 days without irrigation, 60 DAS

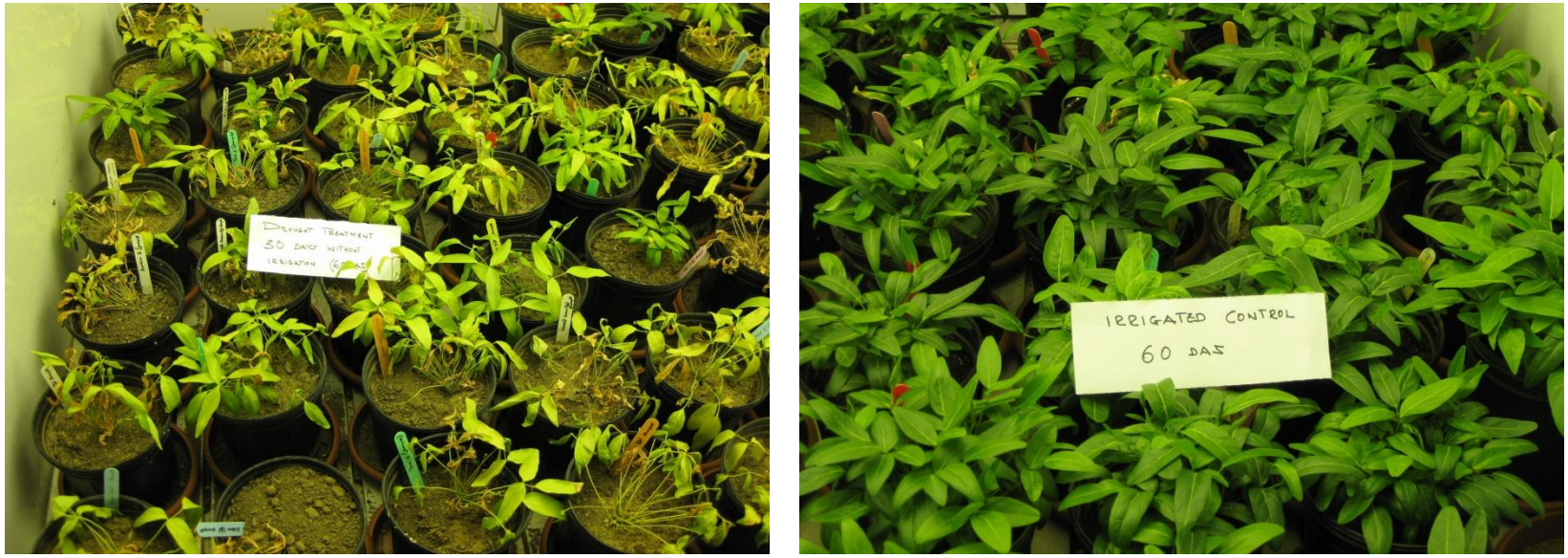


Fig 21: Drought (L), Irrigated (R), 30 days without irrigation, 60 DAS

Fig 22: Tan 1 droughted with spindle-shaped leaves, Mottled cream droughted with reduced canopy size relative to the control

Fig 23: Post drought recovery, Tan One, (L), Black eye (R)
7 days after re-irrigation 67 DAS

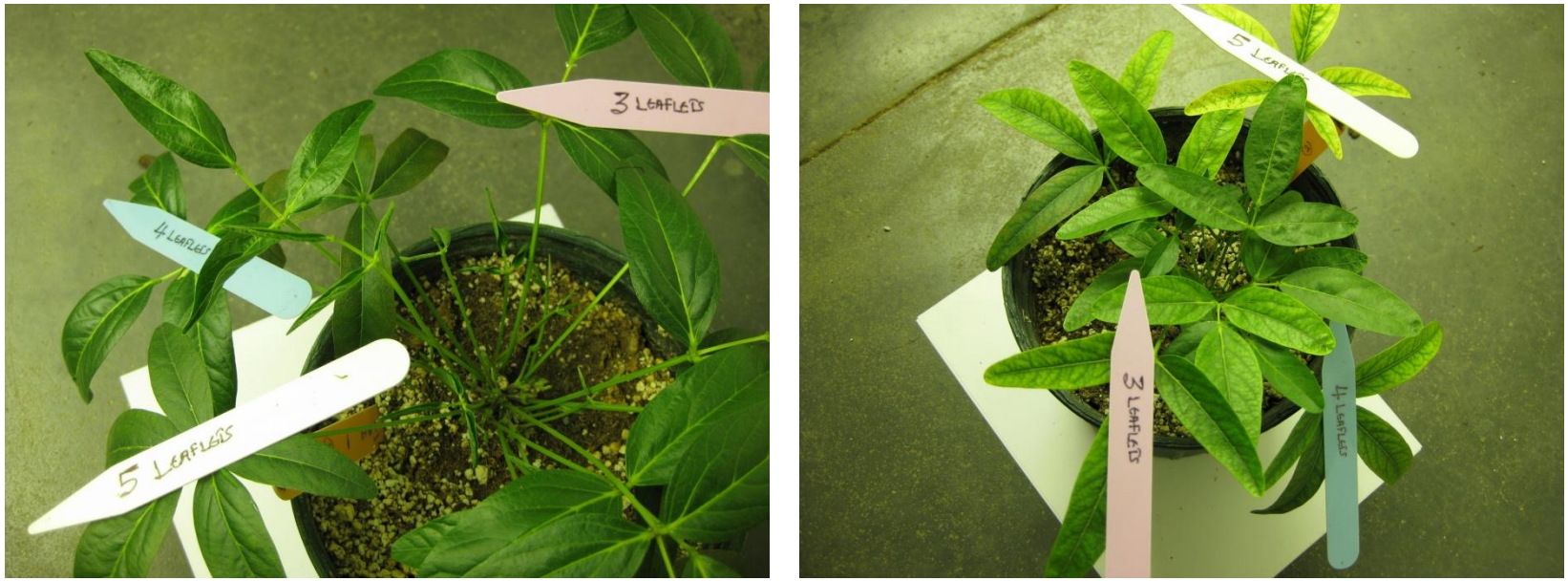


Fig 24: Multiple leaflets on different petioles of same plant

TABLE 8: Effect of seed priming on mean number of days to 50% emergence

Seed priming Treatment	Days to 50% emergence
Soaking seed in water for 24 h	6.9b
Soaking seeds in water for 48 h	6.9b
Control (No soaking in water)	9.3a

- Figures in a column bearing the same letters are not significantly different (p=0.05) by Duncan's Multiple Range Test

TABLE 9: EFFECT OF SEED PRIMING ON MEAN FINAL PERCENTAGE ESTABLISHMENT

Seed priming treatment	Mean final percentage establishment
Soaking seed in water for 24 h	85.6a
Soaking seeds in water for 48 h	79.6a
Control (No soaking in water)	53.4b

- Figures in a column bearing the same letters are not significantly different (p=0.05) by Duncan's Multiple Range Test

CONCLUSION

- The results of the study confirmed that dry season sowing of bambara groundnut in Ghana under irrigation and minor season sowing produced higher pod yield than major season sowing.
- Bambara groundnut yields better in the Transition than the Forest agro-ecology of Ghana
- Long photoperiod favoured vegetative production at the expense of pod production.
- The study observed differences within and between bambara groundnut genotypes with respect to their tolerance to drought and photoperiod.
- 24 h soaking of bambara groundnut seeds in water before sowing enhances seedling emergence and final seedling establishment.

Acknowledgement

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THANK YOU