PLANT GROWTH AND GRAIN YIELD OF QUINOA (*CHENOPODIUM QUINOA* WILLD) UNDER IRRIGATED CONDITIONS IN DIFFERENT ENVIRONMENTS OF CENTRAL MALAWI

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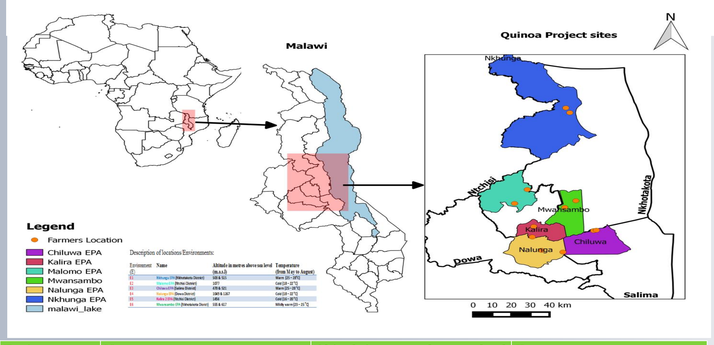
INTRODUCTION

Quinoa is an emerging important food crop in the world today. It is a pseudo cereal, originating from the Andean region of Chile, Peru, Bolivia, Ecuador and Colombia, where it was domesticated 5,000 to 7,000 years ago (Garcia 2003). Quinoa is more nutritious than cereals that are staple food crops for many populations of the world. This crop has been relatively obscure in the rest of the world until UN and FAO declared 2013 as an international year of quinoa to promote its introduction in regions of the world that are challenged by food & nutritional insecurity. Since then there have been introductions of quinoa for adaptability studies in several countries outside the Andean region including Africa. The Lilongwe University of Agriculture and Natural Resources (LUANAR) in collaboration with Washington State University introduced 13 varieties and genotypes in 2012 for adaptability studies in Malawi.



Environment (E)	Name	Altitude in metres above sea level (m.a.s.l)	Temperature (from May to August)
E1	Nkhunga EPA (Nkhotakota District)	503 & 515	Warm (25 – 28ºC)
E2	Malomo EPA (Ntchisi District)	1077	Cold (18 – 22 ºC)
E3	Chiluwa EPA (Salima District)	470 & 521	Warm (25 – 28 ºC)
E4	Nalunga EPA (Dowa District)	1049 & 1267	Cold (18 – 22 ºC)
E5	Kalira 2 EPA (Ntchisi District)	1456	Cold (16 – 20 ºC)
E6	Mwansambo EPA (Nkhotakota Disrict)	555 & 617	Mildly warm (23 – 25 ºC)

Figure 1: A map showing quinoa's adaptability experimental sites in Malawi during the 2014 experimental period.

JUSTIFICATION FOR THE STUDY

Quinoa has potential to contribute to Malawi's food and nutritional security. The crop has wide climatic adaptation hence potential crop for mitigating climate change impacts (in drought prone areas) of the country. Demand for quinoa grain is also growing especially in developed countries hence can contribute to income of farmers from exports and domestic markets.

OBJECTIVES

1.To evaluate plant growth and grain yield performance of quinoa in different environments (low to high altitude areas) of central Malawi

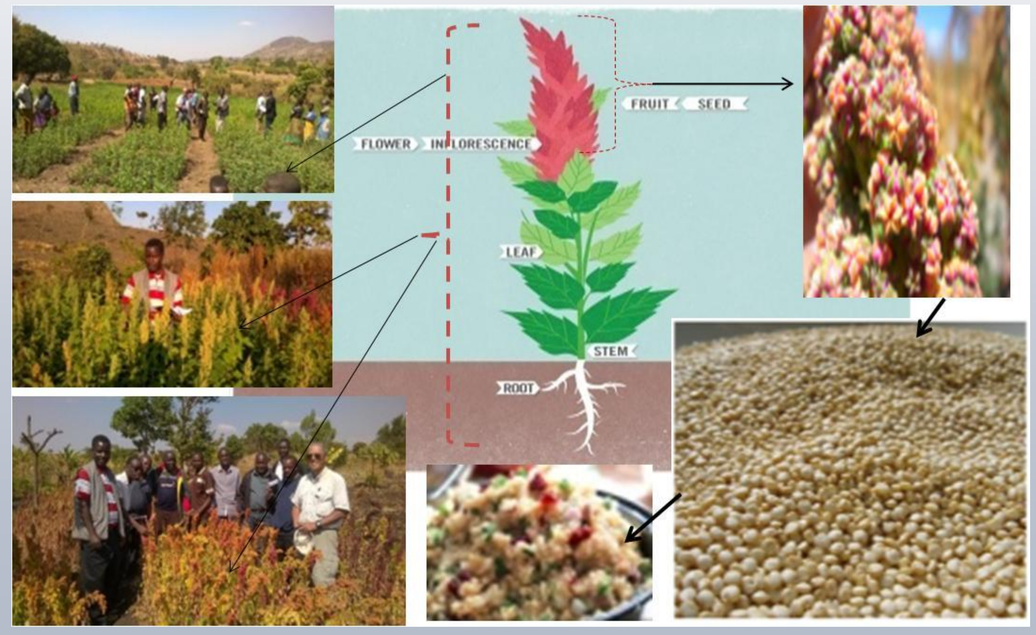
2.To determine variation in plant growth and grain yield performance among different varieties of quinoa under irrigated and rainfed conditions

MATERIALS AND METHODS

Evaluation experiments were conducted in six sites with varied altitudes, of Central region of Malawi. In each site two different experimental plots, close to a water source for irrigation, were identified. Nine varieties (Table 1) were evaluated in each experimental plot, laid out in a Randomized Complete Block Design (RCBD) replicated 3 times. The experiments were conducted from May to August, and repeated from September to November, 2014.

Data collected included number of days to flowering, to maturity, plant height and panicle length at harvest and grain yield. The data was subjected to analysis of variance.
Additive main effects and multiplicative interaction (AMMI) and Genotype main effect and genotype x environment interaction (GGE) were employed in the evaluation of genotypes.

Variety			Origin	Notes
1	G1	Black-seeded	Colorado, US	Developed from cross between Chenopodium quinoa and Chenopodium berlandieri. Very tall variety (>2 m tall)
2	G2	Brightest Brilliant Rainbow	Oregon, US	Bred by Frank Morton of Wild Garden Seeds
3	G3	Bio-bio	Chile	
4	G4	Cherry Vanilla	Oregon, US	Bred by Frank Morton of Wild Garden Seeds
5	G5	Multi-Hued	British Columbia, Canada	
6	G6	Red Head	Oregon, US	Bred by Frank Morton of Wild Garden Seeds
7	G7	QQ74	Chile	Heat tolerant Chilean landrace
8	G8	Puno	Denmark	Bred by Sven-Erik Jacobsen
9	G9	Titicaca	Denmark	Bred by Sven-Erik Jacobsen



RESULTS

•Maturity period of quinoa varied ($p<0.001$) among sites (figure 2). In the low altitude sites quinoa matured within 90 days, in the Mid altitude quinoa matured in 100 -110 days while in the high altitude took up to 120 days.
• Grain yields varied ($p<0.001$) among sites and with significant site X variety interactions (figure 4). Highest yielding varieties were BBR (2669 kg/ha) and Multihued (2018 kg/ha) in Chiluwa EPA, Cherry vanilla (4141 kg/ha, Multihued (3203 kg/ha) & Biobio (2630 kg/ha) in Nkhunga for the low altitude and warm ecological area. For the mid altitude area in Mwansambo, Biobio (4290 kg/ha), Puno (3982 kg/ha), QQ74 (3721 kg/ha) and Cherry vanilla (3701 kg/ha) were highest yielding. In Nalunga it was Cherry vanilla (4141 kg/ha), Red head (3685 kg/ha) & Multihued (3529 kg/ha); in Kalira 2 it was BBR (1302 kg/ha), Biobio (911 kg/ha) and Titicaca (911 kg/ha); while in Malomo it was BBR (4583 kg/ha), Biobio (4375 kg/ha), Multihued (4323 kg/ha) and Cherry vanilla (3984 kg/ha) as highest yielding varieties.

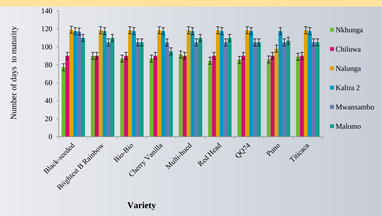


Figure 2: Maturity period of quinoa varieties evaluated in six different sites of central Malawi

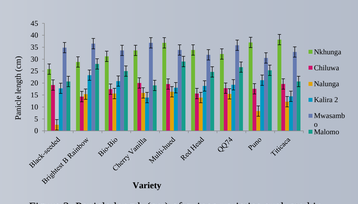


Figure 3: Panicle length (cm) of quinoa varieties evaluated in six different sites of central Malawi

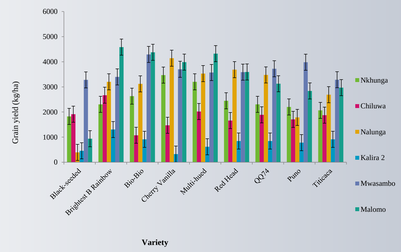


Figure 4: Grain yield (Kg/ha) of quinoa varieties evaluated in six different sites of Central Malawi during the 2014 irrigated season)

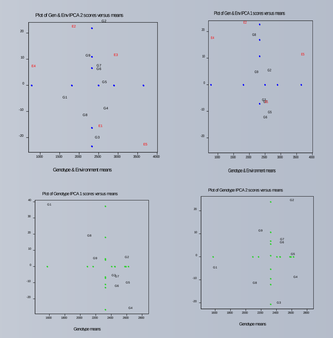


Figure 5: GGE-biplots showing varieties and their ideal environments for yield performance. **black** and red numbers stand for varieties and environments (sites), respectively.

CONCLUSIONS

The results showed that quinoa can be grown in all environments of central Malawi ranging from warm ecological areas to the cool areas of the mid altitude and high altitude areas. Grain yields up to 4 tonnes/ha are achievable under irrigated conditions.

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This research was funded by NORAD through Total land care's the MACC II project.