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Research Article

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Ecological Adaptation Drives Growth: An Ecotype Study of African Spider Flower Locally Designated as "Qetso" in Southern Ethiopia

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Abstract

The world is experiencing a shrinking land against the increasing fertility of mankind. This is creating a demand supply imbalance subsequently resulting in severe food insecurity, malnutrition and ultimately poverty. This complication is coupled with highly fragmented land for farming practices as urbanization is prominently surpassing in the 21st century. Increasing arable land is unlikely while regulating the population particularly in Africa is a delicate. Therefore, an alternative to mitigate this imbalance between the crop and population productivity is of a pertinent approach. The best approach designed in this study is growing a neglected crop named; African Spider Flower (Cleome gynandra L.) locally named"Qetso" in the marginal lands where no crops are growing. Growing this crop in the marginal lands has several benefits over the existing conventional experience. As the crop is rich nutritionally, while it can also be considered for its medicinal value accounted to its richness in vitamins and minerals. Therefore, the objective of this study was to evaluate and compare the growth performance indicator traits among three African spider flower ecotypes. The experiment was laid out in randomized completed block design (RCBD) with three replication at the research and demonstration site of Kulfo Campus, College of Agricultural Sciences of Arba Minch University. Data on the growth performance viz; plant height, leaf number per plant and number of primary branches per plant, shoot fresh weight and shoot dry weight were collected and the organized data was subjected to ANOVA. All growth traits among ecotypes of African spider flower are statistically affected by the differences in the ecology from where they collected at ($p<0.05$). Arba Minch ecotypes are superior in all growth traits over the Holte and Humbo ecotypes.

Keywords: African Spider Flower, Qetso, Wild Edible, Holte, Humbo, Cleome Gynandra L

1. Introduction

African spider flower (*Cleome gynandra L.*), is locally known by different names in Africa; African spider flower, African cabbage, Qetso, Cat`s-whiskers, bastard-mustard, Shona cabbage and spider plant [1]. It is annual leafy plant traditionally designated for its tender leaves, delicate stems, pods and flowers boiled in water or milk along with spices and consumed as vegetable [2]. The center of origin for African spider flower is not exactly defined though it likely has its origin either in South Asia or East Africa [3]. The crop has long been used as source of food during the periods of drought, famine while its consumption is common in areas that experience recurrent wars where playing prominent roles in the food security and socioeconomic values [4].

In Africa, the cultivation of spider plant is highly localized to marginalized societies and commonly consumed by resource poor people where availability of water for growing other crops is a challenge [5]. There are professional assertions on the introduction of exotic vegetable crops in to the continent as this development has left Africa without exhaustive cultivation and consumption of its indigenous species like African spider flower [4]. This and other factors have prompted African researchers to captivate in the development of coordinated trans-boundary researches studying the agro morphological characters along with the nutritional and therapeutic values of its indigenous but, neglected underutilized crops across Sub Saharan Africa [6]

Given the proper consideration from the scientific community to enhance the cultivation and utilization of neglected crops such as African spider flower, the prevalence of malnutrition, famine and food insecurity could be sustainably contended in Africa and elsewhere in the world. Therefore, the objective of this research was to determine the growth performance response of three African spider flower (*Cleome gynandra L.*) ecotypes against Arba Minch agro ecological condition.

2. Materials and Methods

2.1. Description of Experimental Sites

A field experiment was conducted ex-situ for all ecotypes in the promotion garden of neglected edible plants located in Kulfo Campus, Arba Minch University. Arba Minch is found in Gamo zone, the Southern Ethiopia Regional State (SERS). Moreover, it is geographically located in southern part of east African rift valley at the absolute location between 6° 08”N latitude and 37°33”E to 37°37‘E longitude. One of the collection site was Humbo and it is located in SERS, Wolayta Zone Administration, at about 395 km south of Addis Ababa whereas; Holte is found in Gardula Zone Administration of SERS; which is 645km far from Addis Ababa. The experimental sites are located at an altitude range of 1,285-2500meters above sea level.

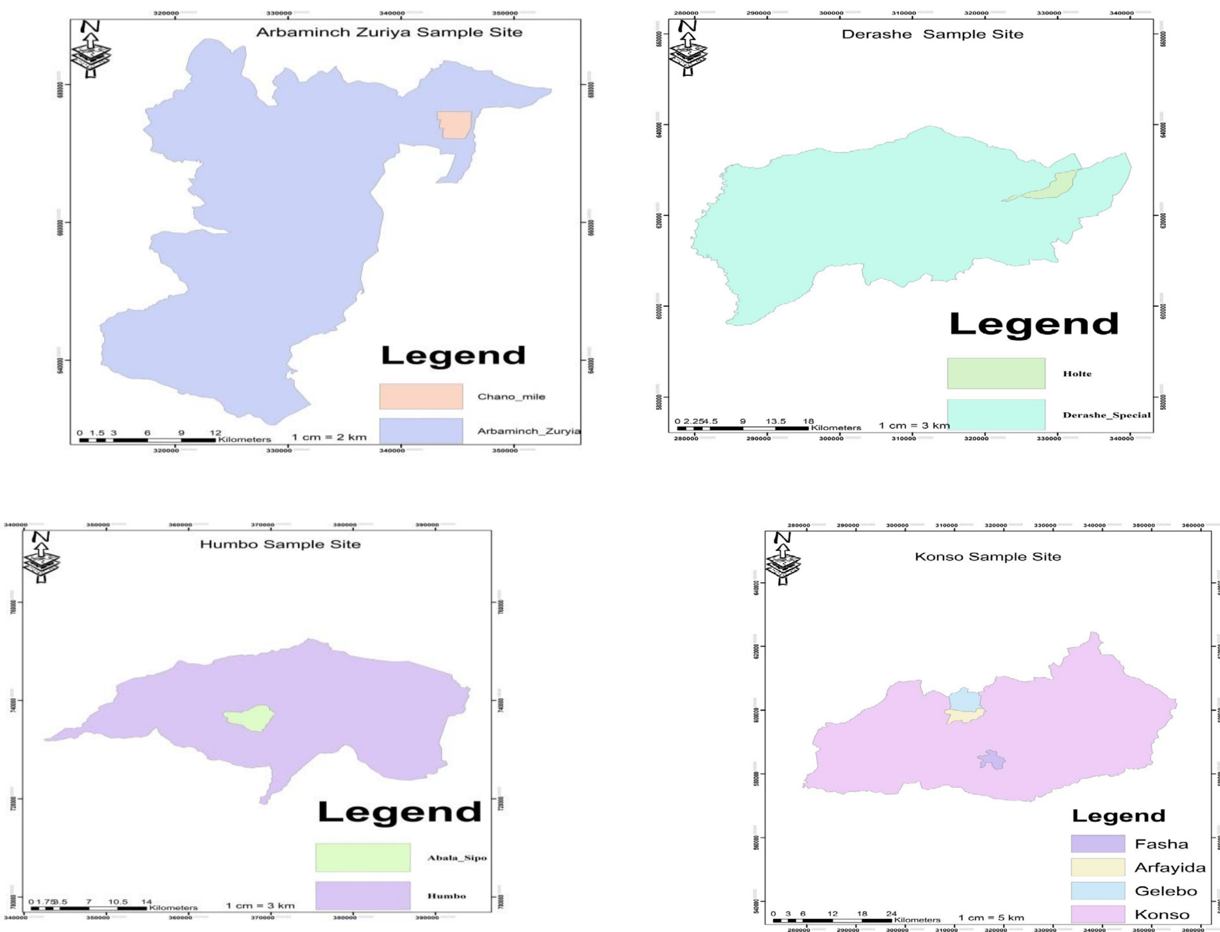

Figure 1: Map of Sample Site

2.2. Experimental Materials

Seed for “Qetso” plant was collected from wild field around Gamo Zone Arba Minch Zuriya Woreda Chanomile Kebele; Wolaita Zone, Humbo Woreda Abalasippa Kebele; Gardula zone, Derashe Woreda, Holte Kebele.

2.3. Plant Passport

- Botanical Name = *Cleome gynandra L.*
- Family = *Cleomaceae*
- Genus = *Cleome*
- Species = *C.gynandra*
- Edible part = Leaves
- Leaf structure = leaves are compound
- Root system = long tap root
- Place = Arbaminch, Humbo and Holte
- Collection date =18-30/01/2012 E.C
- Weather = Meher

Figure 2: Pictorial and Botanical description of African Spider flower

2.4. Experimental Design and Treatments

The experimental field was laid out in a randomized complete block design (RCBD) consisting 12 treatments in a single factor arrangement each replicated three times. A distance of 0.5m and 1m was maintained between plots and blocks respectively. The treatments consisted of three different ecotypes. The experiment was conducted on a plot size of 3mx2m (6m^2). Three to five seeds per hole were sowed at the spacing of 60cm between rows and 50cm between plants. Each plot had three planting rows and therefore, contained a total of 18 plants. All the plots were weeded manually.

2.5. Experimental Procedures

The land was cleared and ploughed to avoid cobbles. After the planting field was properly leveled, 36 experimental plots, each 3m length and 2m width (= 6m^2) were prepared. Furrows were prepared to allow proper furrow irrigation, air circulation and for ease of agronomic practices. Hence, seeds were planted in each plot at a spacing of 60 cm between rows and 50 cm between plants on each plots and each plot contained 18 plants. Water was applied every three days interval to bring the soil moisture content to field capacity uniformly for all treatments during the whole growing season. The data was collected from 6 plants per plot that are grown at the center of the plot.

2.6. Data Collection

To analyze the growth performance indicator traits, the data collected was described in the following section.

2.6.1. Soil Sampling and Analysis

Twelve composite soil samples from 0 – 20 cm depth were taken before setting up the experiment using the zigzag method [7]. The soil sample was then cleaned from root and other debris, air dried thoroughly, mixed and ground to pass through 2 mm sieve prior to submission for laboratory analysis. Then soil texture, organic carbon, electrical conductivity (EC), pH, and available phosphorus (P), total nitrogen (N), magnesium (Mg), calcium (Ca), Iron (Fe), Zinc (Zn), Copper (Cu) and cation exchange capacity (CEC) were determined in Soil Laboratory, College of Natural and Computational Sciences, Abaya Campus of Arba Minch University.

No	Location	Altitude	Temperature	Rain Fall	Source
1	Arba Minch	1000-1100m	17- 31°C,	920-1100mm	Minda, 2014
2	Humbo	1690-1842m	12-150c	843-1403mm	Tony R., 2007
4	Holte	500-2545 m	14-260C	700-1025mm	unpublished, 2010

Table 1: Agro Ecologies Where the Experimental Materials (ecotypes) were Collected From

3. Results

Soil properties	Value	Rating	Source
Textural class	Sand (56%), Silt (29%) and Clay (15%)	Sandy Loam	Christopher (2012)
Soil PH	5.8	Moderately acidic	Tekalign (1991)

Total N (%)	0.14	Moderate	Tekalign (1991)
Available P(ppm)	5.04	Low	Olsen et al (1954)
Organic C (%)	1.35	Very Low	Landon (2014)
CEC meq/100g soil	51.85	Very Low	Landon (1991)
EC (μs)	0.78	Low	Tendon (2004)
Iron (mg/l)	1.74	Low	Tendon (2004)
Zinc (mg/l)	1.11	Medium	Tendon (2004)
Copper (mg/l)	0.37	Medium	Tendon (2004)
Magnesium (mg/l)	1.84	Low	Tendon (2004)
Calcium (mg/l)	2.01	Low	Tendon (2004)

Table 2: Physico-Chemical Properties of the Soil in the Experimental Site

3.1. Growth Traits of "Qetso" Ecotypes from Different Ecologies

3.1.1. Plant Height (cm)

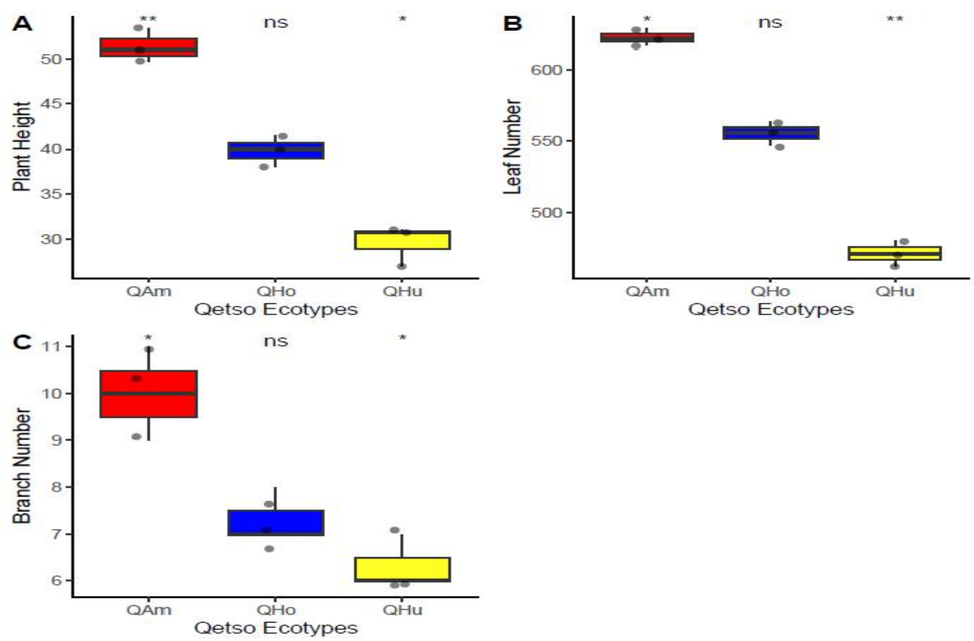

Figure 3: Box plots illustrating the effects of Qetso ecotypes on the plant height (A), Leaf number (B) and Branch number (C). NB QAm= from Arba Minch, QHo= from Holte, QHu= from Humbo

Analysis of Variance (ANOVA) unveiled statistically significant differences at ($p<0.05$) in plant height among the "Qetso" ecotypes (Figure 3A).

Likewise, the maximum plant height (51.4cm) was recorded by the Arba Minch ecotype followed by the Holte ecotype (39.8cm). Whereas; the Humbo ecotype demonstrated the shortest plant height (29.6cm). The result apparently demonstrated a difference of 21.8cm in plant height between the Arba Minch and Humbo ecotypes and 11.6 cm between the Arba Minch and Holte ecotypes. Moreover, it is evident that the difference in the ecology from where the plants are collected has a pronounced effect on the height of the plant. Altitudinal gradients strongly influence plant ecotype morphology; lower altitudes are warmer with characteristically longer growing seasons generally produce plants that are taller and more biomass-intensive compared to higher elevations [8,9]. Our result also elucidates that the lower altitude in Arba Minch has likely offered climatic conditions enhancing growth of the African spider flower "Qetso" plants (51.4cm) than the relatively higher altitude with cooler sites of Holte(39.8cm) and Humbo(29.6cm) respectively.

Moreover, the two ecotypes; Holte and Humbo, are grown in ecology entirely different from their original ecological characters (ex-situ) in temperature, rainfall and soil nutrient status, while the Arba Minch ecotype is grown nearly in its original ecological zone. This could be the reason for the surpassed performance of Arba Minch ecotype in plant height over the other two ecotypes. Moreover, variations in the genetic traits among the collections have created a difference in plant height as well. According to Wasonga, African spider flower grows in a wide range of environmental conditions and exhibits high level of diversity with various phenotypic expressions affecting its vegetative growth. On the other hand, according to Chweya and Mnzava (1997), it can grow up to a height of about 1.5m based on the environmental conditions but its height is mostly confined to 0.5-1.0m. Looking at the plant height recorded by the Arba Minch ecotype (51.4cm), it is in the range of 50-100cm (0.5-1m) and this explicates that Arba Minch ecotype is better fitting to the global standard in producing average plant height than the others.

3.1.2. Leaf Number

Leaf number was significantly affected by differences in ecological zones. At ($p<0.05$) statistically significant difference was recorded among the African spider flower"Qetso" ecotypes in terms of leaf number (Fig 3B). Looking at the result, the highest number of leaves was recorded by the Arba Minch ecotype (622.33) followed by the Holte ecotype (555.33); while the Humbo ecotype has demonstrated the least leaf number (471). As leaf number is mainly controlled by genetic factors, the difference in the number of leaves among the "Qetso" ecotypes could be explained by the differences in the ecological zones where the ecotypes came from. Moreover, soil fertility status of the soil and the environmental factors where the ecotypes came from and where they are growing can still affect the number of leaf so that the Arba Minch ecotype which is nearly grown in-situ demonstrated stable superior performance in leaf number over the Holte and Humbo ecotypes.

In this regard, our finding agrees with the findings of Khoshgoftarmanesh *et al*., (2010) where they reported efficient use of mineral elements from the soil for biomass production is considered as one of the important factors and is highly associated to genotypic specificity of plants and this in turn affects production and productivity of leaves in plants. Likewise, plants from different ecotypes respond differently to soil nutrient status and soil moisture as well. Variations in the physical, chemical, and biological properties of the soil wield discrete effects on the plant growth (i.e. leaf number) and development and depending on the natural adaptation of the plant itself. Research reports by pronounce that plants from different landraces differ in leaf numbers and leaf area which directly decrees carbon partitioning, light interception and photosynthetic efficiency eventually affecting plant biomass and ultimate yield [10].

3.1.3. Branch Number

The statistics has revealed that different ecotypes of "Qetso" plant are significantly ($p<0.05$) affected in branch number (Fig 3C) where the maximum branch number (10) was recorded by the Arba Minch ecotype followed by Holte ecotype (7.33). Whereas; the least branch number (6.33) was recorded by the Humbo ecotype. The differences in the branch number among the ecotypes are accounted to the differences in their genotypes and also the ability of the ecotypes in nutrient uptake and environmental adaptation particularly in terms of nutrient supply and rain fall. Research reports elucidate that African spider plant ecotypes with high primary branch number are associated with increased competition to nutrients and therefore of higher biomass accumulation [11]. Subjected to varying agro ecological regimes such as; water, soil nutrient and sunlight levels, leafy vegetables exhibit pronounced phenotypic plasticity in branch number [12]. This is evolutionarily acquired morphological adjustment of crops in terms of branch architecture towards enhancing photosynthetic efficiency and biomass accretion. The adjustment of African spider flower in terms of branch number commensurate the most majority of other crop species under varying agro climatic events.

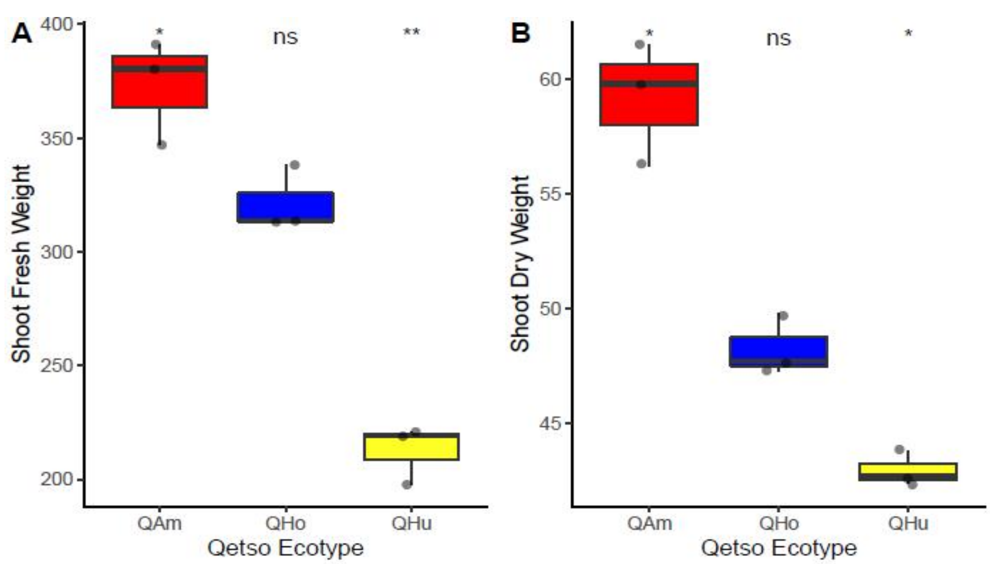

Figure 4: Box Plots Depicting the Effects of Qetso Ecotype on the Shoot Fresh (A) and Dry (B) Weight

3.1.4. Shoot Fresh Weight

The ANOVA has unveiled that shoot fresh weight of "Qetso" plant was significantly ($P<0.05$) affected against different ecotypes (Figure 4A). The highest shoot fresh weight (372.7g) was recorded by the "Qetso" collections from Arba Minch followed by Holte (321.8g). Whereas; the lowest shoot fresh weight was measured by the Humbo ecotype (212.5g). The weather of Arba Minch and Holte are likely similar but, both vary evidently from the Humbo ecotype that tends to be relatively colder. Therefore, associated to this, the adaptation and evolution of the "Qetso" ecotypes vary in their capacity to absorb, translocate and accumulate essential elements in the shoot biomass. The "Qetso" ecotypes collected from Arba Minch and Holte have developed a mechanism to absorb, translocate and accumulate significant amount of nutrients accounted to the hot weather along with elevated evapotranspiration rate they experience compared to the Humbo ecotype. As the "Qetso" collection from the Humbo was adapted to low evapotranspiration along with lower rates of essential nutrients absorption, translocation and accumulation, the rate to develop fresh shoot biomass is lowered too. Beyond the plant`s evolutionary attainment in response to the in-situ weather, we still assume that this difference among the "Qetso" ecotypes could be associated to the differences in the soil physicochemical properties between its original place of collection and the ex-situ experimental site. Moreover, research conducted by states that plant cultivars collected from different ecotypes differ in various growth and yield performance indicator traits which in turn affects the entire biomass yield of the plant [13]. Shoot fresh biomass accumulation varies under changing ecological conditions, with high-yielding potential genotypes often showing reduced biomass accumulation drought stress conditions while optimal biomass accumulation is obtained through tailored management of agro ecological regimes [12].

3.1.5. Shoot Dry Weight

The statistical result revealed that the shoot dry weight at ($P<0.05$) was significantly affected due to different plant of Qetso ecotype (Figure 4B). The maximum shoot fresh weight (59.2g) was recorded by the Arba Minch ecotype followed by Holte ecotype (48.27g), whereas; the least shoot fresh weight was recorded from the Humbo ecotype (42.97g). In fact a plant that has got high shoot fresh weight will have high shoot dry weight unless some other assorted factors affect. Therefore, looking at the shoot dry weight among the "Qetso" ecotypes, it lies on a similar plane of difference with the shoot fresh weight. The differences in shoot dry weight among the ecotypes could be due to the differences in the genetic traits they developed in response to the evolutionary achievement across the selected ecotypes with varying temperature and development of more vegetative growth. Under drought regimes shoot dry weight lowers as much energy is redirected to prioritize development of roots at the expense of shoots. However, in our case and across most of the plants that are primarily meant for their leaves as a vegetable prove significant phenotypic tendency in shoot dry matter while adapting to ecological conditions. Same author designates the superiority of coastal-marine ecotypes in terms of biomass retention under salinity over the montane ecotypes [14].

4. Conclusion and Recommendations

Looking at the details of the results, it is evident that Arba Minch ecotype is superior in growth performance traits compared to the Holte and Humbo ecotypes [15]. It is wise to grow the Arba Minch ecotype in the Arba Minch ecology because of its comprehensive growth performance traits superiority and in African spider flower, the growth performance determines the productivity as it is the leaf that is the economic part of the crop itself [16]. Moreover, it is recommended that a repeated research should be carried out across the three ecologies to look if the "Qetso" ecotypes are ecology specific in their growth performance or remain consistent across the different agro ecologies. Further experiments should be conducted to evaluate the reproduction, breeding, agronomic and nutritional aspects of the crop.

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