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CHARACTERISATION OF COMMUNITY IDENTIFIED *Uapaca kirkiana* PHENOTYPES FOR DOMESTICATION.

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Summary
Variability in fruit attributes across sites and relationships between desired selection traits and fruit and tree characteristics were investigated in the central watershed of Zimbabwe. Sample trees were selected based on taste preferences by local communities in six sites across the country. Tree heights and crown depths, fruit lengths and diameters were determined for possible correlation with desired selection attributes for domestication. Twenty ripe fruits were collected from different crown positions of each tree for determination of pulp weight and TSS. The data was analysed with ANOVA and LSD using SPSS (Version 10). The results exhibited significant ($P<0,05$) variability in fruit attributes across the sites. The models to establish the relationship between tree and fruit characteristics to desired selection traits, pulp weight and TSS indicated significant ($P<0,05$) R^2-values of 0.681 and 0.113 respectively. The measured tree and fruit characteristics may be used to determine pulp weight, but not completely so for TSS.

Introduction

Rural communities in Africa depend heavily on forests and forest products at various times of the year (Dewees, 1994). The fruit-producing tree species are important for food security, especially in the dry season. Studies on the nutritional value of indigenous fruits show many to be rich in sugars, essential vitamins, minerals, vegetable oils and proteins, most of which are critical for the health of children and pregnant women (Campbell and Brigham, 1993; Wehmeyer, 1996). *U. kirkiana Muel. Arg. (Euphorbiaceae)* has been found to contain

4.1% glucose, 2.7% fructose, 1.5% sucrose, 0.2% xylose and traces of ribose, raffinose and galactose (Sufi and Kaputo, 1977). Other than direct nutritional benefits the fruit can be processed into products such as jam, wine, fresh drink, resins and furthermore, the fruit is also important as an income earner.

As *U. kirkiana* fruits are generally collected from the wild, their continued availability is therefore highly dependent on good management and conservation of woodlands that are threatened by ever-increasing expansion of land for cropping. This situation is causing substantial loss in germplasm and also the degradation of particular gene pools (Gale and Lawrence, 1984). In an effort to arrest this threat, the domestication of *U. kirkiana* has been suggested (Maghembe *et al*, 1993; Sambo, 1992; Mwamba, 1988; Dewees, 1994).

Domestication, the bringing of a wild species under the management of man (Campbell, 1996), is a method of plant breeding in the sense that when successful, it provides fruit varieties that are superior to ones previously available (Alston, 1992). It involves increasing the quality and quantity of forest products through selection and genetic improvement and the incorporation of improved cultivars in agro-ecosystems, which fully realize the genetic gain obtained (Sambo, 1992, Leakey and Newton, 1994). Plant breeders exploit the variability existing in trees by selecting desirable characteristics for use in genetic improvement and the subsequent domestication (Maghembe *et al.*, 1994).

Large variations exist among *U. kirkiana* trees in terms of fruit quality. It is believed that phenotypic characteristics are related to the variation in fruit quality and quantity (Alston, 1976; Quinlan and Tobutt, 1990; Ladipo et al., 1991). Fruit quality is defined by minimum fruit aspects that involve three groups of characteristics, external (fruit colour, shape, fruit size and scars), internal (juice content, Total Soluble Solids (TSS), acidity, and seed quantity) and legal considerations (maximum pesticide residue content and labelling) (Ladipo, 1995, Wehyemer, 1966). The main objective of this research was to assess tree and fruit characteristics that could be used as selection determinants for the domestication of *U. kirkiana*.

Materials and Methods

Site Description

The study sites and distribution of *U. kirkiana* in the central watershed of Zimbabwe are shown in Figure 1 and explained in Table 1.

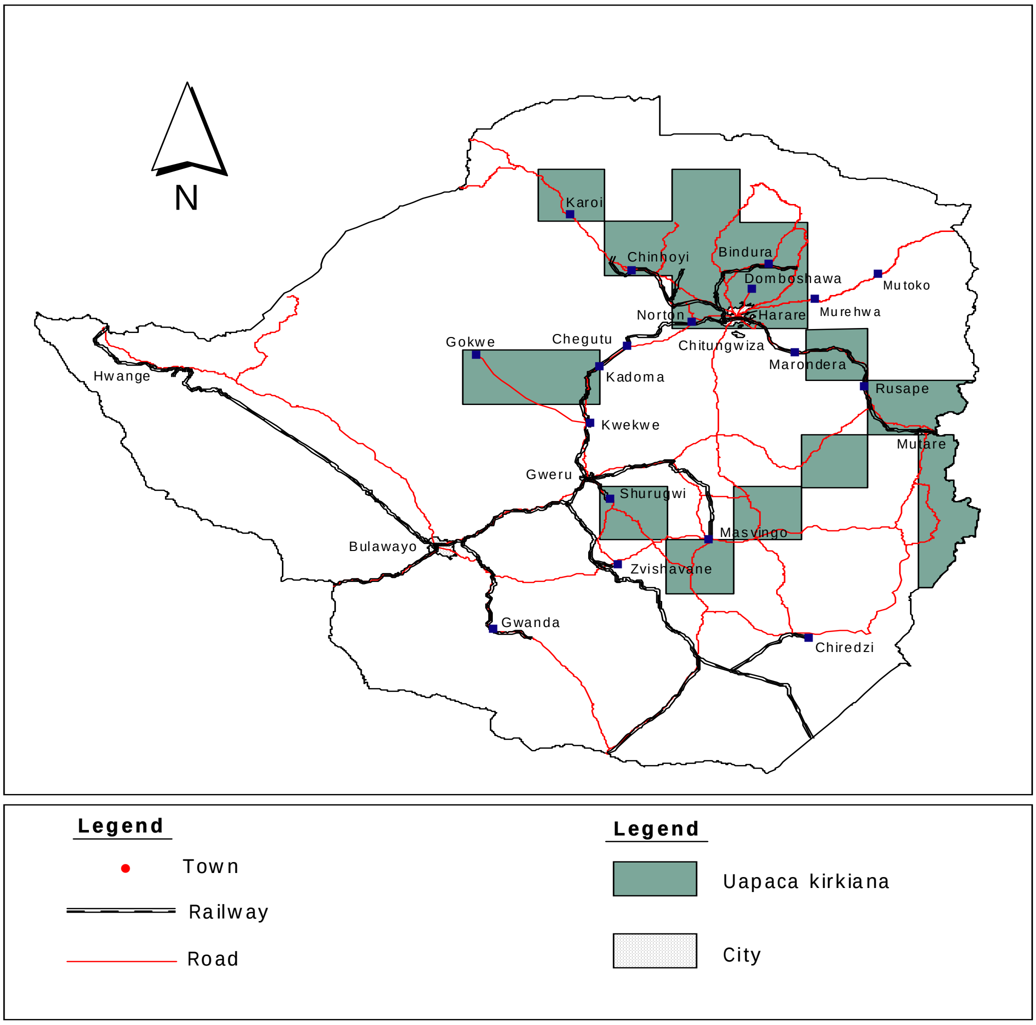

Fig 1: Distribution of *Uapaca kirkiana* in Zimbabwe

Geographical location, altitude, agro-ecological region, mean annual rainfall and soils of the research vary across sites as shown in Table 1.

Table 1. Geographical characteristics of the study sites.

Site	Longitude (^{0}.')	Latitude (^{0}.')	Altitude (M asl)	Agro ecological region	Mean annual rainfall (mm)	Soils
Bindura	31.18E	17.18S	1300	2a	750-1000	Granite paraferralitic sands
Domboshawa	31.14E	17.60S	1200	2a	750-1000	Granite paraferralitic sands
Gokwe	28.93E	18.22S	1282	2b	650-900	Regosols and basaltic vertisols
Masvingo	27.00E	18.05S	1055	4	450-650	Fersialitic lithosols and sodic soils
Murehwa	31.47E	18.00S	1200	2b	650-900	Granite paraferralitic soils
Rusape	32.27E	18.58S	1430	2b	650-900	Granite paraferralitic soils

Data collection

Data was collected from November 2003 to January 2004 when most *U.kirkiana* trees had mature fruit. From each site, trees highly preferred by communities were selected for comparative analysis of tree phenotypic characteristics and fruit attributes. Measured tree parameters were height and crown depth. Samples of 20 ripe fruits were randomly collected from different crown positions of each tree. The measurement of fruit diameter and length was done with a hand calliper. Pulp from each phenotype was extracted, weighed and tested for TSS using a refractometer.

Data Analysis

The data was analysed through one-way analysis of variance (ANOVA) and Least Significant Difference (LSD) tests at 95% confidence level using SPSS package version 10

(1996). A regression analysis was performed to establish the relationships between tree phenotypic characteristics and fruit attributes.

Results

Results of the variation in fruit characteristics by site are shown in table 2.

Table 2. Variation of fruit characteristics by site.

Site	Fresh weight (g) ±SE	Fruit diameter (mm) ±SE	Fruit length (mm) ±SE	Pulp weight (g) ±SE	TSS (%Brix)±SE
Gokwe	26.50±0.77[a]	34.73±0.33[a]	32.44±0.31[a]	13.64±0.58[a]	20.76±0.49[a]
Bindura	22.24±0.71[b]	32.76±0.40[b]	30.56±0.33[b]	10.39±0.50[b]	20.73±0.47[a]
Rusape	14.83±0.31[c]	28.86±0.20[c]	25.01±0.19[c]	6.13±0.20[c]	15.97±0.27[b]
Domboshawa	17.56±0.27[d]	30.70±0.20[d]	29.02±0.19[d]	7.85±0.16[d]	17.05±0.36[c]
Masvingo	24.40±1.17[e]	32.04±0.48[b]	32.06±0.53[a]	12.84±0.81[a]	19.65±0.65[a]
Murehwa	18.33±0.43[d]	29.42±0.31[c]	27.97±0.21[e]	9.83±0.30[b]	23.41±0.40[d]

[a, b, c, d, e] Means in the same column with different superscripts differ significantly ($P<0.05$).

Fruit fresh weight was significantly ($P<0.05$) different for all the sites except for Murehwa and Domboshawa. With the exception of Rusape and Murehwa then Bindura and Masvingo, fruit diameter was significantly different ($P<0.05$). In terms of fruit length, all the sites indicated significant ($P<0.05$) variations except for Gokwe and Masvingo. Pulp weight values were significant for all the study sites except for Gokwe and Masvingo as well as Bindura and Murehwa. TSS was not significantly different for Gokwe, Bindura and Masvingo, but was significantly different ($P<0.05$) from Rusape, Domboshawa and Murehwa.

The models to establish the relationship between tree and fruit characteristics to desired selection traits; pulp weight and TSS indicated R^2-values of 0.681 and 0.113 respectively. These relationships were significant ($P<0.05$) in both cases. The models for pulp weight and TSS are shown in equations 1 and 2 below.

Equation 1:

$$Y=-23.869-0.251(Ht)+0.326(Cd)+0.396(Fl)+0.650(Fd)+0.009435(Tss)$$

Where Y = Pulp weight
Ht = Tree height
Cd = crown depth
Fl = Fruit length
Fd = fruit diameter
Tss = Total soluble solids

Equation 2:

$$Y=23.222+0.468(Ht)+0.210(Fl)-0.155(Fd)+0.359(Pw)$$

Where Y = TSS
Ht = Tree height
Fl = Fruit length
Fd = fruit diameter
Pw = pulp weight

Discussion

The high variability in fruit attributes among sites can be attributed to climatic, edaphic, genetic and cultural factors. Climatic factors especially rainfall and temperature have an effect on fruit attributes. Higher levels of TSS and lower acidity result from humid conditions with warm nights whereas the converse occurs in arid areas with cool nights. Fruits need enough light for them to be sweet (Leakey and Newton, 1994) and this affects TSS levels. Differences in TSS (Brix) to acid ratios occur due to environmental factors and cultural practices (Koch, 1984). Chemical changes during ripening usually involve the conversion of starch to sucrose and reducing sugars. The extent of this conversion affects the sweetness of ripe and mature fruits (Alston, 1992). Therefore variability in climatic conditions across sites may have impacted on desired fruit characteristics.

Fresh fruit weight for Murehwa and Domboshawa did not vary significantly as a result of similarities in altitude and soil type. For Rusape and Murehwa, fruit diameter was not different possibly because of the same agro-climatic conditions experienced. Fruit length was not similar for the sites and this could be explained by different genetic attributes. Pulp weight and TSS variations were not easily explained by environmental factors. Pulp weight is basically a result of the accumulation of photosynthetic products and water. In high rainfall regions, fruit pulp weight should be higher compared to drier areas as indicated by the application of irrigation under horticultural production systems. Citrus fruits with sufficient water and nutrients grow stronger, better tolerate pests and stresses, yield more consistently and produce good quality fruit. On the other hand, excessive or deficient irrigation may result in poor fruit quality. Sites such as Rusape with high rainfall have low fruit TSS. In the case of Masvingo with rainfall ranging between 450 and 650 mm/annum and Gokwe with 650 and 900 mm/annum have even higher pulp weight compared to the high rainfall site of Bindura with 750 to 1000 mm. TSS levels for Gokwe and Masvingo are consistent with pulp weight. Such a case could possibly point towards gene pools that have established themselves in the sites.

Genetic factors also have an effect on fruit attributes. According to Okafor (1978), yield and fruit quality is a complex measure influenced by both the genetic make-up of the species and the effect of the environment in which the tree grows. In nature, genetic variation usually takes the form of continuous phenotypic range rather than discrete classes (Ladipo, 1995). The genetic variation underlying quantitative traits results from the segregation of numerous interacting quantitative trait loci (Harris, 1993). Fruit shape for instance may be heritable and hence genetically determined (Ladipo et al, 1991). Therefore, the variability in fruit and tree traits across sites may be attributed to genotype–environment interaction.

Even if all these factors are held constant, differences in management practices will also affect fruit attributes, for example, fruit quality in terms of TSS, acidity, total sugars, reducing sugar and ascorbic acid was found better in flower bud thinning, irrigated and pruning treatments (Thakur and Chandel, 2005). The tree selection for the study ranged from partially managed trees around homesteads to trees growing in the wild.

Although an R^2 value between TSS and fruit and tree characteristics was low, the relationship was significant. This explains that TSS may not be explained simply by the measured parameters, but by other underlying factors. However, this was not the same with pulp weight in relation to tree and fruit attributes where the R^2 value was 0.681 ($P<0.05$). Pulp weight may, from these findings, be determined from the measured tree and fruit parameters whereas TSS may be determined with reservations since these fruit and tree characteristics could not explain the variations. The assumption is that TSS is mainly controlled by genetic-environment interactions.

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