YIELD OF THREE COMMERCIAL WATERMELON CULTIVARS IN KENYA AS COMPARED TO A LOCAL LANDRACE

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ABSTRACT

High yield is a major goal for watermelon (*Citrullus lanatus*) breeders. The objective of this study was to measure the yield potential of some watermelon accessions available in Kenya and identify high yielding ones for growers and for use in breeding programmes. A field trial was conducted at Maseno University Research Fields for two seasons between September 2007 and May 2008. Accessions studied included three most common commercial cultivars in Kenya, namely: 'Sugarbaby', 'Crimson Sweet' and 'Charleston Gray', one cultivar ('Yellow Crimson') newly introduced from the United States, and one local landrace (GBK-043014) from Kakamega district in Western Kenya. The experiment was laid out in a Randomized Complete Block Design with three replications. Data was collected on total number of female flowers per plant, main vine length, number of branches on the main vine, number and weight of fruits. Data collected were subjected to analysis of variance using SAS version 9.1 and significantly different means were separated using the Least Significant Difference test at P = 0.05. Linear regression was done to establish relationships between variables. Results revealed significant variation among accessions in all the yield components that were measured. The landrace had the highest yield compared to commercial cultivars owing to its long vine and extensive branching. It was therefore concluded that selection of desirable traits in this accession be given priority for future breeding programmes. 'Yellow Crimson' performed much better than other commercial cultivars and is therefore recommended to Kenyan growers as the cultivar with highest yield potential.

Key Words: *Citrullus lanatus*, Kenya, Watermelon commercial cultivars, Watermelon landraces, Yield potential

INTRODUCTION

Watermelon (*Citrullus lanatus*) is one of the most widely cultivated crops in the world (Huh *et al*., 2008). Its global consumption is greater than that of any other cucurbit. It accounts for 6.8% of the world area devoted to vegetable production (Guner and Wehner, 2004; Goreta *et al*., 2005). China is the leading producer of watermelons, followed by Turkey, United States, Iran and Republic of Korea (Huh *et al*., 2008; Wehner and Maynard, 2003). There are over 1,200 varieties of watermelon worldwide (Miles, 2004) and a wide range of watermelons have been cultivated in Africa (Zohary and Hopf, 2000). Several of these varieties have been recommended for Kenyan range of climates. These include 'Sugarbaby', 'Crimson Sweet', 'Charleston Gray', 'Chilean Black', 'Congo', 'Fairfax' and 'Tom Watson' (Tindall, 1983). However, among these seven cultivars, only the first three are available in Kenyan markets with 'Sugarbaby' being the most popular (HCDA, 2006). Demand of watermelon in Kenya is higher than production, making the fruit to be very expensive and only affordable by rich consumers. With local demand unsatisfied, its potential for export cannot be realized. To meet the local demand and may be create some surplus for export, production of watermelon in Kenya needs to be increased (HCDA, 2006).

There is growing need for watermelon improvement to increase disease and insect pest resistance and also fruit qualities to better meet market demands (Levi *et al*., 2001a). Improvement must be done while considering consumer preferences, yield potential, desired earliness, fruit size and shape, disease and insect pest resistance, among others. Like other cucurbits, watermelon cultivars display a wide range of fruit morphology (Langer and Hill, 1991). They vary in fruit size, fruit number, fruit shape, flesh colour, rind colour and seed colour (Zohary and Hopf, 2000). Although modern-bred watermelons produce very large fruits up to 10 kg in weight, there are a number of hard-fleshed smaller and more primitive genotypes that are cultivated for their fruit, which is used to make jam and pickles (Langer and Hill, 1991). There are also seedless varieties and supersweet round ones that fit nicely into the refrigerator (Wolford and Banks, 2005). Owing to their different genetic composition, different varieties of watermelon respond differently to various stresses. To come up with the best variety for a given agro-ecological zone, it is essential to perform trials with common varieties and some additional varieties (Marr and Tisserat, 1998).

Although many watermelon cultivars have been developed throughout the world during the last century, there is little information regarding their ancestry (Levi *et al*., 2001b). In Kenya, for example, some watermelon landraces have been identified, but there is scant data available comparing them with modern cultivars. The factors which result in farmers preferring local landraces over modern varieties are not very well understood. The available information suggests that modern varieties often lack additional characters which farmers consider important (Hardon and Boef, 1993). There is therefore a need to evaluate the agronomic performance of various watermelon accessions in Kenya to generate comparative data for local crop development. This data will be essential to validate suggested comparative advantages of landraces over modern cultivars or vice versa, and may provide new options for plant breeding. The objective of this study was to compare agronomic performance and yield of three most popular commercial watermelon cultivars in Kenya with one newly introduced cultivar and one local landrace.

MATERIALS AND METHODS

The study was carried out at Maseno University. The site lies along Kisumu-Busia highway in Maseno Division, Nyanza Province, Kenya within the upper Midland 1 agro-ecological zone (Jaetzold and Schimidt, 1982). It lies at latitude $0^{o}1$'N – $0^{o}12$'S, longitude $34^{o}25$'E – 47'E and 1500 m above sea level. It receives bimodal rainfall averaging 1750 mm annually (Mwai, 2001). The first rainy season falls between March and July and the second between September and early December. No month, however, is completely dry (Jaetzold and Schmidt, 1982). The mean annual temperature is 28.7^{o}C (Mwai, 2001) with the hottest season occurring between January and April (Jaetzold and Schmidt, 1982). The soils are classified as dystric nitisols, which are well-drained, deep reddish brown, slightly friable clays with pH ranging from 4.5 to 5.4. Soil organic carbon and phosphorous content are 1.8% and 4.5 mg/kg, respectively (Mwai, 2001).

The experiment was conducted in two seasons from September to December 2007 and from January to May 2008. The experiment was laid in a Randomized Complete Block Design with three replications. Five watermelon cultivars grown in Kenya were used in this study. These included 'Sugarbaby', 'Charleston Grey', and 'Crimson Sweet', which are the most popular commercial cultivars in Kenya; 'Yellow Crimson' which is a newly introduced commercial cultivar from United States; and one landrace (GBK-043014) from Kakamega district (altitude 1250-1500 m ASL) in Western Kenya. Seeds of the landrace were obtained from the National Genebank of Kenya at Muguga in March 2007 and were grown at Maseno University horticultural research field for seed bulking. Seeds of commercial cultivars were obtained from local shops, except 'Yellow Crimson', which was obtained from Rispern Seeds, Beecher, Illinois. 'Sugarbaby', 'Charleston Grey' and 'Crimson Sweet' were from East Africa Seeds Company, Kenya. 'Yellow Crimson' was included in the study because it can be found in some local supermarkets, although its seed are not readily available in Kenya.

The seeds were directly sown in the field at a spacing of 1.5 m x 1.5 m. Since watermelon is reported to have poor germination, five to ten seeds were planted per hole and thinned to leave only one seedling three weeks after planting. Organic manure and 17N:17P:17K fertilizer were applied in the planting holes before sowing at the recommended rate of 30 t/ha and 200 kg/ha, respectively. Two rows of 'Sugarbaby' were used as guard rows around the experimental field. Other agronomic practices including irrigation, weeding and topdressing were conducted as required uniformly in all plots. No insect pest and disease control was done.

Data collected on reproductive growth and yield, included total number of female flowers per plant, main vine length, number of branches on the main vine, fruit number and weight. For each parameter, data was taken as the mean value of three measurements made on three plants per replicate. The data were subjected to analysis of variance using SAS version 9.1 (SAS Institute, 2005). Significantly different means were separated using the Least Significant Difference test at P = 0.05. Linear regression was done to establish relationships between variables. Descriptive statistics (mean, standard deviation, and coefficient of variation), were generated using the SAS procedure, UNIVARIATE.

RESULTS

All watermelon accessions were climbers. The length of the main vine varied significantly ($P<0.001$). GBK-043014 had significantly ($P<0.05$) the longest main vine averaging 448 cm, while 'Crimson Sweet' had significantly ($P<0.05$) the shortest main vine, averaging 201 cm. 'Sugarbaby', 'Charleston Gray', and 'Yellow Crimson' recorded a combined season main vine length of 228 cm, 233 cm, and 244 cm, respectively. Seasonal differences in vine length were significant ($P<0.01$), but accession x season interactions were not significant ($P>0.05$). There was a strong ($R^2=0.84$) and significant ($P<0.001$) positive relationship between main vine length and fruit number (Figure 1).

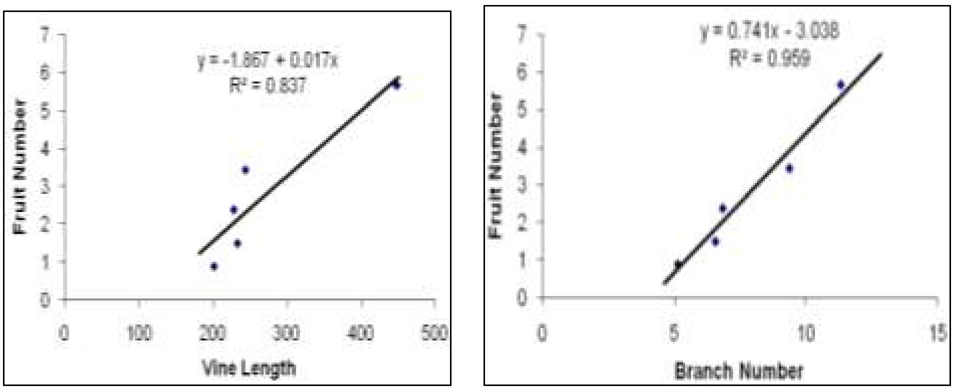

Figure 1. Linear regression between fruit number and branch number (left); fruit number and vine length (right)

Significant ($P<0.001$) variation in branch number was observed (Table 1). GBK-043014 had significantly the highest number of branches (11), followed by 'Yellow Crimson' with an average of 9 branches. On the other hand, 'Crimson Sweet' had the lowest number of branches (5 branches). The GBK-043014 had 8 branches, while 'Sugarbaby' and 'Charleston Gray' had 7 branches. Seasonal differences in branch number were highly significant ($P<0.001$), but accession x season interactions were not significant ($P>0.05$). There was a strong (R^2=0.96) and significant ($P<0.001$) positive relationship between the number of branches on the main vine and fruit number (Figure 1).

Table 1. Variation in yield and yield components

Accession	Main vine length (cm)	Branch number	No. of female flowers	Fruit number	Fruit weight (kg)
Sugarbaby	227.86^{c}	6.83^{c}	8.78^{c}	2.39^{c}	2.05^{b}
Yellow Crimson	243.56^{b}	9.39^{b}	10.67^{b}	3.45^{b}	3.01^{a}
Crimson Sweet	200.56^{d}	5.11^{d}	6.11^{d}	0.89^{e}	1.44^{d}
Charleston Gray	232.83^{bc}	6.56^{cd}	8.33^{c}	1.50^{d}	1.77^{c}
GBK-043014	447.67^{a}	11.33^{a}	12.56^{a}	5.67^{a}	1.99^{bc}
$LSD_{0.05}$	15.616	1.646	1.7078	0.578	0.235
CV (%)	4.76	15.98	25.77	27.89	29.41
SD	92.495	2.913	2.394	1.797	0.603

Means followed by the same letter within a column are not significantly different at P = 0.05.

The number of female flowers was highly influenced ($P<0.001$) by accession. GBK-043014 produced significantly ($P<0.05$) the highest number of female flowers averaging 12.56 flowers per plant (Table 1). The landrace was significantly ($P<0.05$) different from 'Yellow Crimson' which followed closely with an average of 10.67 flowers per plant. 'Sugarbaby' produced an average of 8.78 flowers per plant and was not significantly ($P>0.05$) different from 'Charleston Gray' which produced 8.33 flowers per plant. 'Crimson Sweet' consistently recorded the lowest number of female flowers averaging 6.11 flowers per plant.

Highly significant ($P<0.001$) variation in fruit number was observed among accessions. The GBK-043014 emerged significantly the best yielder with 5.67 fruits per plant (25200 fruits/ha) followed by 'Yellow Crimson' with 3.45 fruits per plant (15333 fruits/ha). 'Sugarbaby' and 'Charleston Gray' had an average yield of 2.39 fruits per plant (10622 fruits/ha) and 1.5 fruits per plant (6667 fruits/ha), respectively, while 'Crimson Sweet' had the lowest yield of 0.89 fruits per plant (3956 fruits/ha). Seasonal differences in fruit number were also highly significant (P<0.01) but accession x season interactions were not significant (P>0.05).

Highly significant (P<0.001) variation in fruit weight was observed among the accessions. 'Yellow Crimson' again had significantly (P<0.05) the biggest and heaviest fruits averaging 3.01 kg. The fruits of GBK-043014, 'Sugarbaby' and 'Charleston Grey' did not differ significantly (P>0.05) in weight. They averaged 1.99 kg, 2.05 kg, and 1.77 kg, respectively. 'Crimson Sweet' produced significantly (P<0.05) the smallest and lightest fruits among the cultivated accessions averaging 1.44 kg (Table 1). Seasonal differences in fruit weight were significant (P<0.001) but accession x season interactions were not significant (P>0.05).

DISCUSSION

Evaluated accessions portrayed a wide range of variation in yield and yield components. Highly significant (P<0.001) variation in length of the main vine was observed between accessions in both seasons. This concurs with the results of Dittmar (2006) who also reported differences in vine vigour and growth among watermelon cultivars. The GBK-043014 landrace had the longest main vine as compared to cultivated accessions. This considerably long vine of GBK-043014 along with its extensive branching could be one of the factors responsible for its relatively high yields.

'Yellow Crimson', which is a newly bred cultivar, had the longest main vine among the commercial cultivars, while 'Crimson Sweet' had the shortest main vine. Main vine length, however, did not vary much amongst commercial cultivars as compared to the GBK-043014 landrace whose vine length was more than double that of 'Crimson Sweet'. Warren *et al.* (1998) noted that watermelon vines if left undisturbed will normally attain a length of between 360 and 480 cm. The vine lengths of all inbred cultivars were therefore below average and this could have contributed largely to their low yields. Warren *et al.* (1998) reported that watermelon plants with longer vines also produce higher yields than those with shorter vines. This was confirmed by a strong and highly significant positive relationship that was observed between main vine length and fruit number.

The main vines of GBK-043014 and 'Yellow Crimson' were significantly (P<0.05) the most branched with some of the branches even managing to produce sub-branches. However, the GBK-043014 landrace produced more sub-branches than 'Yellow Crimson' and its sub-branches also bore female flowers, which successfully developed into fruits that culminated in higher yields. The strong positive relationship between the total number of female flowers and the fruit number indicate that flower formation and successful pollination is crucial for production of high fruit yields in watermelon. The main branches of 'Yellow Crimson' produced very few sub-branches which produced a few female flowers which hardly developed to mature fruits. The GBK-043014 landrace therefore ultimately managed to produce more fruits than 'Yellow Crimson' even though the two accessions produced approximately equal number of branches from their main vines. 'Charleston Gray', 'Sugarbaby' and 'Crimson sweet' produced relatively fewer branches with considerably very few if any sub-branches which hardly produced any fruits hence their low yields.

Warren *et al.* (1998) indicated that watermelon plants with many branches produce higher yields than those with few branches or those whose branches have been pruned. This was confirmed by a strong and highly significant relationship that was observed between branch number and fruit number. The high yields of the GBK-043014 landrace were also attributed to its apparently good adaptation to climatic and edaphic conditions of Maseno, probably because of the close proximity of Maseno to Kakamega.

Although the GBK-043014 landrace produced more fruits than 'Yellow Crimson', its total yield in kilogrammes was just slightly above that of the latter, which emerged significantly ($P<0.05$) the best yielder among the commercial cultivars. The high fruit yields of these two accessions were attributed to their relatively higher disease and pest resistance (Gichimu *et al.*, 2008), and their vigorous growth, extensive branching and longer vine length. They also produced more sub-branches than the rest of the accessions resulting in more foliage. Warren *et al.* (1998) indicated that more watermelon foliage translates into high photosynthetic and assimilation rates and ultimately more fruits, and any reduction in foliage reduces fruit yields. The researchers added that watermelon plants with longer vines also produce higher yields than those with shorter vines. Since watermelon flowers develop in the nodes of the plants, additional branching on some watermelon accessions creates more locations for the flowers to develop (Dittmar, 2006). High yields of 'Yellow Crimson' may also be attributed to its tolerance to acidic soils and its wider geographic adaptability (Anonymous, 2001).

Development of new varieties with wide range of geographic adaptability to soil, temperature and moisture conditions is one of the primary goals of breeding (Hall, 2004). The production of other commercial cultivars was below average, ranging from 1 to 2 fruits that were relatively small compared to those of 'Yellow Crimson'. McFarlane (2007) reported that watermelon fruits vary in weight from less than 4 to over 18 kg, depending on the variety but none of the accessions in the present study fell in this range. This could have been caused by poor agro-ecological conditions that these accessions were exposed to, including acidic soils of Maseno, as indicated by Mwai (2001). In addition, the low fruit yield of commercial cultivars, as compared to the GBK-043014 landrace was attributed to their higher susceptibility to diseases and pests, especially melon fly (Gichimu *et al*., 2008).

CONCLUSION AND RECOMMENDATIONS

The study was the first report comparing three most popular commercial watermelon cultivars in Kenya with a newly introduced cultivar and one Kenyan landrace. The landrace had the highest yield potential although it contains some undesirable traits such as poor taste and so many seeds. This accession should be improved, especially for sweetness as it is very promising in terms of yield. Although 'Yellow Crimson' is a relatively new variety which is hardly known to many Kenyan watermelon growers, it yielded more than other commercial cultivars. It is therefore recommended for adoption by Kenyan growers and seed companies should make efforts of availing its seeds to growers.

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