EFFECT OF SPACING ON QUALITY AND YIELD OF JUTE MALLOW (Corchorus olitorius) PHENOTYPES IN KENYA

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Abstract

Local vegetables are important crops grown in many parts of African countries including Kenya. They are at times given various names depending on their where about grown, for example, *Corchorus olitorius* is also known as Jute mallow, African Sorel or Jew's mallow. In Kenya Jute mallow is highly nutritious and is of commercial value. Their production has been low due to poor farming practices such as spacing, processing and post-harvest handling. This study seeks to investigate the effect of various spacing on quality and yield of Jute mallow. Field experiments were established at Kenya Agriculture Livestock Research Organization, Kitale farm and University of Eldoret, Chepkoilel farm using Randomized Complete Block Design (RCBD) with three replicates and three levels of spacing. Seeds were drilled and later plants thinned to spacing of 20 x 30, 30 x 30 and 40 x 30 cm. Data was collected on five tagged plants per plot and their plant heights, branching at main stem, pod count and fresh leaf yield determined. Data collected was analyzed using computer package GENSTAT and means separation done using DMRT at p≤0.05. The results showed that Jute mallow accessions responded best to wider spacing of 40 cm x 30 cm with tallest plant height of 35 cm and 35.6 cm and shortest plants at 31.6 cm and 31.4 cm on short varieties GEMS and BEMS, respectively. Varieties GLMT and BLMT had highest mean branching at 6.7 and 6.0 and highest mean number of pods of 21.8 and 21.6 from Eldoret (site 1) and Kitale (site 2), respectively. Fresh leaf yield per plant showed late maturing varieties (GLMT, BLMT) had highest fresh leaf weight of 77.02 g and 74.93 g per plant for Eldoret and Kitale site, respectively. It is concluded that wider spacing of 40 cm x 30 cm increases Jute mallow yield perhaps due to low plant competition. This study recommends that farmers use wider spacing for higher crop yield.

Key words: spacing, quality, yield, jute mallow, vegetables

Introduction

Indigenous vegetables are plants that have evolved as vegetables naturally in a given location (Abbass, 2000). They are also plants that have been introduced and have adapted well such that they have come to be considered local to those places and referred to as local or traditional vegetables (Abukutsa-Onyango, 2003). This is true to African Leafy Vegetables including Jute mallow whose leaves and young shoots are consumed (Gotor, 2010). These local vegetables have become an integral part of the local food web though they have received less study attention. Across world over, agricultural studies has focused mainly on major food and cash crops (AIPP, 2014) leaving out the underutilized crops like indigenous vegetable, fruits and other crops that are important for other uses like medicinal value. Crops like this could be having specific importance in the farming systems like nutrition and even for farmers' cultural value (Aluma, 2004).

Indigenous knowledge of these crops is important in developing strategies for their conservation and improvement (Dweba and Mearns, 2011). The much studies done around few plant species (20 species) by man for use as food out of many (3,000 plants of different species) being commercialized, has resulted in a vast number of potential food-plant species being neglected (Smith and Eyzaguirre, 2007). This has resulted in genetic erosion and loss of indigenous knowledge (Kimiywe, *et al*. 2007) reported that in recent past, local vegetables like Jute mallow has gained study focal point for their nutritive, medicinal as well as food security status in many countries. However, vegetable growers have not been able to satisfy demand for consumption and marketing aspect at the production point of view. Small-scale farmers and other growers have continued to rely on the little information available for use in crop production (Figueroa, *et al*. 2009). This has resulted in decline in production though consumption is increasing due to relatively expensive of other food sources like eggs or meat that are eaten with starchy foods (Mroso, 2003). Apart from nutritional qualities, local vegetables have medicinal, pesticidal and edible oil (Nekesa and Mesa, 2003).

Jute mallow species broadly exists by two categories i.e. narrow leaved and broad leaved. Direct seeding at a spacing of 45 cm between the rows and 15 cm within the plants has been adopted for both cultivars though can be varied (Abukutsa-Onyango, 2003; 2007). Wider spacing's are used for tall varieties with broad leaves, multiple branches, and harvested several times (Adebooye, *et al.* 2005). Narrower spacing's are used for short and bushy varieties and once-over harvesting. Rows are spaced 10 cm apart with 5–10 cm between plants within row (Sivakumar and Ponnusami, 2011). At transplanting it should be done in the late afternoon or on a cloudy day to minimize transplant shock. *C. olitorius* is easily susceptible to moisture stress in easily drying up top soils owing to its shallow rooting depth though can be solved by applying irrigation (Fasinmirin, 2001). Dig holes 10 cm deep, place the transplant in the hole, cover the roots with soil and lightly firm. Irrigate immediately after transplanting to establish good root-to-soil contact. The seedlings are then thinned two weeks later to a spacing of 30 cm x 30 cm and experimental plots kept weed free throughout experimental period (Bhattacharjee, *et al.* 2000).

When seed is used to raise the crop, then seeds are sown by direct drilled on lines prepared beds, preferably at the beginning or the end of the wet season, and the seedlings thinned to leave plants at various spacing's including a square spacing of 20-30 cm x 20-30 cm, depending on the vigor of the selection and use as vegetables or for seed. Alternatively, seeds may be sown in a seedbed and transplanted in rows 15 cm – 55 cm, between plants (AVRDC, 2004). Jute mallow crop destined for seed production may either be left without cutting or cutback once at 20 cm above ground to stimulate lateral branching. Plants need to be spaced at 50 cm x 50 cm and well fertilized to get a good seed yield. Soaking of seeds in warm water before sowing may overcome erratic germination due to a dormancy factor. Approximately 5kg/ha of seed is required for a density of 250 000 plants/ha, giving leaf yield varying from 5-8t/ha per annum (MOA, 2009). Irrigation may be required during dry period to maintain an adequate level of soil moisture (KARI, 2010).

These species are source of nutritional contents (IPGRI, 2000) and is being out competed by the introduction of exotic vegetables which has confined the cultivation of most local vegetables into home gardens in mixed stands, with no documentation of their production acreage (Mavengahama, *et al*. 2013). These crops have been offering opportunity to the poorest in community to earn a living as producers and traders without resorting to large capital investment (Okeno, *et al*. 2003). To sustain exploitation of indigenous vegetables for purposes of nutritional and food security as well as help in reducing poverty, knowledge on best agricultural practices must be developed through research and made available to farmers and producers (Makokha and Ombwana, 2002). Also to introduce commercialization of these crops more knowledge or information is required for references (Mnzava and Chigumira, 2004). Such is possible because local vegetable has advantage of growing fast and harvested within a short period of time thereby contributing to addressing food scarcity (Raymond, 2000).

In Kenya for instance there has been consistent chronic food insecurity which has been transitory due to drought and floods leading to over reliance on some crop like maize (Ngugi, *et al*. 2006). To this effect increasing production through improved agricultural practices during growing of crops like Jute mallow will in a long way improve the livelihood, food situation, nutrition and health of the people (Abukutsa-Onyango, 2007). Though so, Jute mallow production in Kenya in most cases is done without strict adherence to recommended agronomic practices by farmers (MOA, 2009) and there are little documentations about cultivation technique as well as knowledge and potential improvement of it, reason being that the vegetables have been regarded as minor crops (The National Academies of Science, 2009). Such has led to their yields during production be low due to poor farming practices such as spacing, seed processing and post-harvest handling necessitating this study to investigate the effect of various spacing on quality and yield of Jute mallow specifically looking at plant heights, branching at main stem, pods and fresh leaf yield.

Materials and Methods

Experimental sites

The overall study was carried out in two sites of Kenya Agriculture Livestock Research Organization (KALRO) Kitale and The University of Eldoret (UoE). Kenya Agriculture Livestock Research Organization (KALRO) Kitale is situated at latitude of 1^{o} 02’North and 35 ^{o} East longitude and altitude of 1901 meters above sea level in Trans Nzoia county, Kenya. The University of Eldoret (UoE) is situated at longitude 0’30’’N and latitude 35’15’’E and altitude of about 2140 m above sea level, which is 9 km North of Eldoret town in Uasin Gishu county, Kenya.

Field experimental management and data collection

The Jute mallow plant material (varieties: GEMS, GLMT, BEMS, BLMT) used in the experiment were sourced from five counties of Keiyo, Uasin Gishu, Nandi, Trans Nzoia and West Pokot in Kenya and planted at two sites of UoE farm and KALRO - Kitale farm over one season between May – November 2015. The information from the farmers was collected using questionnaire by stratified random sampling method with a population sample of 250 Jute mallow production farmers and simultaneously collected seed accessions from them. Thereafter Seeds were drilled after fertilizer applied (Diaz, *et al*. 2011) in field in well prepared demarcated seed beds at the experimental plots. Weeding was carried out in all plots in the sites simultaneously. The seedlings were then thinned two weeks after sowing to spacing treatments of 20 cm x 30 cm, 30 cm x 30 cm and 40 cm x 30 cm (Abukutsa-Onyango 2007). Data collection was done on five plants in each plot systematically random sampled (Gomez and Gomez, 1984) and tagged. Data was collected on plant heights, branching at main stem, pod count and leaf yield determined (Maritim, *et al*. 2009). The data was analyzed using computer package GENSTAT and significant means separated using DMRT at $\alpha = 0.05$.

Results

Plant height

Plant heights were significantly different ($p<0.05$) for different spacing, with spacing of 40 cm x 30 cm (S3) having the tallest plants across locations and varieties (Table 1). Short varieties (GEMS and BEMS) had 35 cm and 35.6 cm as the tallest plants and shortest plants at 31.6 cm and 31.4 cm respectively. There was also significant variance ($p<0.05$) in effect by spacing's treatments on the tall Jute mallow varieties (GLMT and BLMT) where both had 81.8 cm and 81.9 cm as short plants and 86.9 cm and 86.6 cm as tall plants respectively.

There was no significant difference ($p<0.05$) within the early maturing varieties (BEMS and GEMS) with mean plant height of 33.44 cm and 32.81cm at Eldoret site and 33.15 cm and 34.07 cm at Kitale site, respectively. Also within late maturing (GLMT and BLMT) there was no significant difference ($p<0.05$) with mean plant height of 83.74 cm and 83.85 cm in Eldoret site and 84. 59 cm and 84.73 cm in Kitale site respectively. Between the varieties mean separation of the early maturing varieties (BEMS and GEMS) and late maturing (GLMT and BLMT) showed no significant difference ($p<0.05$) with the shortest plant height of 33.44 cm and 33.15 cm and tallest of 83.85 cm and 84.74 cm at site 1 and site 2.

Number of branching per plant

Results on number of braches per plant of Jute mallow varieties (Table 2), shows that use of wider spacing of 40 cm x 30 cm led to an increase in number of braches per plant from both sites 1 and 2 within varieties and across varieties. Both the GEMS and BEMS varieties had highest mean branching at 5.8 and lowest at 3.2 branching respectively from both site 1 and2. Both GLMT and BLMT had highest mean branching at 6.7 and lowest 6.0 branching respectively from both site 1 and 2. Generally there were higher branching of plants in site 2 (6.6 branching/plant) than those in site 1 (5.8 branching/plant). In comparison, the control (S1) had lowest mean branching numbers of 3.2 and 3.8 from both sites respectively, while wider spacing (S3) had lowest mean branching at 5.0 and 5.8 respectively.

The number of branches ($p<0.05$) showed no significant difference within the early maturing varieties (BEMS and GEMS) with lowest mean number of branches of 4.07 and highest being 4.77 for site 1 and 2 respectively. There was significant difference ($p<0.05$) within late maturing (GLMT and BLMT) with lowest mean branching of 4.37 and highest of 5.59 for site 1 and 2 respectively. On comparison, There was significant difference ($p<0.05$) between early maturing varieties (BEMS and GEMS) and late maturing (GLMT and BLMT) with lowest mean branching of 4.07 and 4.37 and highest mean of 4.77 and 5.59 from both site 1 (Eldoret) and 2 (Kitale) respectively.

Number of pods per plant

The number of pod per plant results shows that use of wider spacing of 40 x 30 cm (S3) from sites 1 and 2 increases number of plant within and across varieties (Table 3). The GEMS and BEMS had lowest mean pod count at 6.8 and 7.3 in site 1 and 2 respectively and highest mean pod count at 8.9 and 9.9 from site 1 and 2 respectively. The GLMT and BLMT had lowest mean pod count at 18.4 and 16.8 and highest mean pod count of 21.8 and 21.6 from site 1 and site 2 respectively. The control plots (S1) had the lowest mean pods per plant at 6.8 and wider spacing (S3) had highest pods per plant of 7.4 pods per plant. This indicates that spacing variation has effect on the overall pods per plant, thereby also affecting overall seed yield of Jute mallow.

The means of number of pods per plant showed no significant difference (p<0.05) within the early maturing varieties (BEMS and GEMS) with lowest mean number of pods being 7.78 and 8.70 and highest being 7.81 and 8.63 pods from both site 1 and site 2 respectively. There was no significant difference (p<0.05) within the late maturing varieties (GLMT and BLMT) with lowest mean number of pods being 19.44 and 20.42 and highest being 19.89 and 20.67 pods per plant in both site 1 and 2 respectively

Table 1: Means of plant height in centimeters from site 1 (Eldoret) and 2 (Kitale)

Spacing (S)	Site 1 (Eldoret-UoE)				Site 2 (Kitale-KALRO)			
	Varieties				Varieties			
	GEMS	BEMS	GLMT	BLMT	GEMS	BEMS	GLMT	BLMT
S1	32a	31.4a	81.8a	81.9a	31.6a	32.6a	82.7a	82.6a
S2	33.3a	33a	83.4a	83.3a	33.3a	34b	84.2b	85.1b
S3	35b	34b	86b	85.7b	34.6b	35.6b	86.9b	86.6b

Where, S denotes Spacing; S1=20x30 cm, S2=30x30 cm, S3=40x30 cm
[a]Means followed by same letters are not significantly different at 5% probability level.

Table 2: Means of number of branches per plant from site 1 (Eldoret) and 2 (Kitale)

Spacing (S)	Site 1 (Eldoret-UoE)				Site 2 (Kitale-KALRO)			
	Varieties				Varieties			
	GEMS	BEMS	GLMT	BLMT	GEMS	BEMS	GLMT	BLMT
S1	3.2a	3.2a	3.7a	3.4a	3.8a	3.9a	4.4a	4.1a
S2	4.0ab	4.0ab	4.8ab	4.3ab	4.8ab	4.6ab	5.7ab	5.2ab
S3	5.0b	5.0b	5.8b	5.3b	5.8b	5.8b	6.7b	6.0b

Where S denotes Spacing; S1=20x30 cm, S2=30x30cm, S3=40x30cm
[a]Means followed by same letters are not significantly different at 5% probability level.

Table 3: Means of no. of Pods per plant from site 1 (Eldoret) and 2 (Kitale)

Spacing (S)	Site 1 (Eldoret-UoE)				Site 2 (Kitale-KALRO)			
	Varieties				Varieties			
	GEMS	BEMS	GLMT	BLMT	GEMS	BEMS	GLMT	BLMT
S1	6.8a	6.8a	18.4a	16.8a	7.4a	7.3a	19.5a	19.3a
S2	7.8ab	7.8ab	19.4ab	18.0ab	8.8ab	8.9ab	20.6ab	20.3ab
S3	8.9b	8.7b	20.4b	18.9b	9.9b	9.7b	21.8b	21.6b

Where S denotes Spacing; S1=20x30 cm, S2=30x30 cm, S3=40x30cm
[a]Means followed by same letters are not significantly different at 5% probability level.

Fresh leaf yield

The fresh leaf yield per plant revealed that use of wider spacing of 40 x 30 cm (S3) had highest yield weight (77.02 g) for late maturing GLMT variety and 51.16 g for early maturing BEMS variety (Table 4). This trend of increase in yield weight of fresh leaf yield per plant from both sites within and between varieties was observed in other varieties as well. Though so, BEMS plants from site 2 (Kitale) had higher weight (51.16 g) than those from site 1 (Eldoret) of 50.88 g. GEMS varietal plants on control plots (S1) had lowest plant weight (41.30 g) and highest of 41.62 g.

Results across late maturing varieties (GLMT, BLMT) show lowest plant leaf weight was 68.69 g 63.69 g, while highest weight was

77.02 g and 74.93 g respectively for site 1 (Eldoret) and 2 (Kitale). The fresh leaf yield means separation showed no significant difference ($p<0.05$) within early maturing varieties (GEMS and BEMS) with mean yields per plant of 46.25 g and 46.33 g and 46.54 g and 46.51 g respectively at site 1 and 2. But there was significant difference ($p<0.05$) within late maturing (GLMT and BLMT) with mean yields per plant of 72.52 g and 69.15 g respectively at site 1 and 72.46 g and 69.02 g respectively at site 1 and 2. In comparison, fresh leaf yield, showed no significant difference ($p<0.05$) between early maturing varieties (BEMS and GEMS) and between late maturing (GLMT and BLMT) from both site 1 and 2.

Table 4: Means of fresh yield results (g) per plant from site 1 (Eldoret) and 2 (Kitale)

Spacing (S)	Site 1 (Eldoret-UoE)				Site 2 (Kitale-KALRO)			
	Varieties				Varieties			
	GEMS	BEMS	GLMT	BLMT	GEMS	BEMS	GLMT	BLMT
S1	41.35a	41.30a	68.69a	63.69a	41.53a	41.62a	68.96a	63.78a
S2	46.84b	46.80b	71.85b	68.82b	46.97b	46.77b	72.03b	68.67b
S3	50.55c	50.88c	77.02c	74.93c	49.13c	51.16c	76.40c	74.61c

Where S denotes Spacing; S1=20x30 cm, S2=30x30 cm, S3=40x30 cm

[a]Means followed by same letters are not significantly different at 5% probability level.

Discussion

The spacing variation had an effect on plant height of short varieties (GEMS and BEMS) as indicated by their plant height of 35 cm and 35.6 cm as the tallest plants and shortest plants at 31.6 cm and 31.4 cm respectively. This was 0.6 cm variation attributed caused by spacing of plants. The tall Jute mallow varieties (GLMT and BLMT), also showed same effect by spacing where both had 81.8 cm and 81.9 cm as short plants and 86.9 cm and 86.6 cm as tall plants respectively. This indicates that spacing variation has effect on the overall plant growth i.e. plant height, thereby also affecting plant leaf yield in the Jute mallow production in the end concurring with Abukutsa-Onyango, (2007) who also observed the same.

There was spacing effect on number of braches per plant of Jute mallow varieties as seen in the spacing of 40 cm x 30 cm where there was an increase in number of braches per plant from both sites 1 and 2 within varieties of 1-7 and 1-8 branching/plant respectively and between varieties 1-7 and 1-9 branching/plant respectively. Generally there was higher branching of plants in site 2 with 9 branching/plant than those in site 1 with 7 branching/plant. Such outcome supports what AVRDC, (2004) found out in previous research.

There was spacing effect on pod per plant of Jute mallow varieties where it was observed that use of wider spacing of 40 x 30 cm at both sites 1 and 2 saw an increase in the number of pods per plant within and across varieties. This was outlaid in Green Early Maturing Short and Brown Early Maturing Short which had highest pods per plant of 11 - 13pods respectively compared to the control spacing with 4 - 5 pods per plant respectively. This indicates that spacing variation has effect on the overall pods per plant, thereby also affecting overall seed and crop yield of Jute mallow as also observed by AVRDC, (2004); Bujulu and Matee, (2005).

There was effect by spacing on fresh leaf yield per plant of Jute mallow varieties with wider spacing of 40 x 30 cm showing highest yield of 99.2 g for late maturing GLMT variety and 66.8 g for early maturing BEMS variety. This trend of increase in yield weight of fresh leaf yield per plant from both sites within and between varieties was observed in other varieties as well concurring with what AVRDC, (2004); Buddhadeb, (2012) found out. Though so, BEMS plants from site 2 (Kitale) had higher weight (66.8 g) than those from site 1 (Eldoret) of 66.31 g. an increase in leaf yield by 33 g per plant due to spacing effect. This supports what was also found out by other researchers including Buddhadeb, (2012). The spacing variation also showed that use of wider spacing of 40 cm x 30 cm gave higher leaf weight per plant by up to 67g per plant more than close spaced crop indicating that spacing enhances crop yield of Jute mallow concurring with what was also observed by Sivakumar and Ponnusami, (2011). This effect can be attributed to the fact that wider spacing reduced competition amongst plants thereby enhancing growth of plant parts leading to high yields.

Conclusion

From study it is concluded that there was effect of various spacing on quality and yield of Jute mallow as showed in that accessions responded best to wider spacing of 40 cm x 30 cm with tallest plant height of 35 cm and 35.6 cm and shortest plants at 31.6 cm and 31.4 cm on varieties GEMS and BEMS. The number of braches per plant was varied by the spacing as showed by GLMT and BLMT having highest mean branching at 6.7 and 6.0 branching and highest mean pod count of 21.8 and 21.6 from wider spacing (40cm x 30cm). Such effect was evident on fresh leaf yield per plant seen on late maturing varieties (GLMT, BLMT) having highest fresh leaf weight of 77.02 g and 74.93 g per plant. It is also concluded that to increase production of Jute mallow farmers have to adapt improved agricultural practices like correct spacing of plants during growing of crop. This is supported by the research as spaced plants exhibit varied effect on plant's growth with wider spacing (40x30 cm) exhibiting tall plants and highest branching, pod numbers and yield of Jute mallow. It is recommended that in order to increase crop and seed yield of Jute mallow, wider spacing of 40 cm x 30 cm to be used and strict adherence to recommended agronomic practices by farmers for improved yields. Also further study can be done to evaluate effect of altitude and spacing's on yields of Jute mallow.

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