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Production Status and Diversity of Jute Mallow (*Corchorus Olitorius*) Collections from North Rift Region, Kenya

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Abstract*: Production of Jute mallow (Corchorus olitorius) globally has been low due to many reasons, one of them being poor quality seeds. The yield of crop has remained low, 2-4 tons/ha/annum as compared to expected yield of 5-8tons/ha/annum. Observations from vegetable growing areas showed that as much as 7 kg/ha instead of 5 kg/ha of seed was being used, which is required for a density of 250,000 plants/ha. This is 40% extra seed. The objective of the study was to evaluate quality of seed and morphological diversity of Jute mallow. A survey was conducted where farmers were asked about the husbandry of crop and seeds collected from them for quality tests on analytical purity, germination and vigor according to ISTA, (2004). Sub-samples of collected seeds were planted at green house and phenotypic characteristics recorded; data analyzed using descriptive statistics and GENSTAT package. The survey results showed that 80% of farmers growing Jute mallow crop were middle (41-59 years) and old age (60 years and over), where 92% of them were female. Only 14% of the farmers were trained on vegetable seed production and agronomy. Education level showed 54% of farmers have not attended school. The analytical purity results showed Jute mallow seed was of superior quality as its percentages were above 98%. On seed germination and emergence, the regions average was 57% being below the quality standard of 60%. Phenotypic characterization showed morphological diversity in collected seed with four varieties coming out namely; Green Early Maturing Short, Brown Early Maturing Short, Green Late Maturing Tall and Brown Late Maturing Tall. It was concluded that seed grown by farmers in North Rift region was of poor physiological quality and are diverse and that farmers be trained on seed production for enhanced knowledge on seed production of Jute mallow.*

Key words: Indigenous, Vegetable, Jute mallow, Quality, Seed.

"1. Introduction"

Jute mallow (*Corchorus olitorius*) belongs to the genus *Corchorus* and *Tiliaceae* family. Its origin is probably south China, but is now found growing wild and in parts of Tropical Asia (India) and Tropical Africa [25, 26]. It has been naturalized in many Tropical countries including Kenya [24]. The local forms have been selected in many regions [11], many of these are dwarf, branching forms, growing to 150 cm in height, for instance in Nigeria, two main types have been described by Epenhuijsen [8]; *Amugbadu*- with large finely serrated leaves, growing to 180 cm in height and *Oniyaya*- with broad leaves, coarsely serrated, growing to 150 cm in height and is widely branched.

Jute mallow is an important local leafy vegetable consumed in Kenya due to it being source of vitamins, proteins, minerals and fiber [9], especially in areas where animal protein is deficient [1]. The government has also been advocating for production and consumption of local vegetables in its strategy for food self sufficiency in the country [18]. In Kenya, there is ample production potential, not only to meet the growing demand for the domestic use requirement, but also produce surplus for export [17]. They are mainly grown in kitchen gardens for home consumption and little for the urban market [2]. However they have been neglected in terms of research on agronomic aspects, seed production and improvement [19]. In most cases, they have been allowed to regenerate at onset of rains without serious efforts to plant new seed or even apply other cultural practices on them [22].

The local demand for the vegetables is still largely unmet and farmers have continued to use their own seed or purchase the scarce seed of unknown quality from the local market [15]. Currently, there are few good quality seeds of Jute mallow from the breeders/stockists to the farmers [20]. Farmers have for instance been using re-cycled planting seed of *Corchorus olitorius* every season from the local markets and farms whose potential is not assured [22]. The yield of the crop has remained low, 2-4 tons/ha/annum as compared to the expected yield of 5-8 tons/ha/annum [14] and the major constraint has been poor quality seeds since farmers use as much as 7 kg/ha instead of 5 kg/ha of seed which is required for a density of 250,000 plants/ha, which amounts to 40% extra seed [18]. Though Kenya Agricultural Research Institute (KARI) is focusing her efforts on generation of appropriate strains of the vegetable, little is being done to examine seed being re-cycled by farmers for its quality.

The use of good quality seed has raised yields and consequently has stimulated interest in farming [3]. Quality seeds combined with other inputs like fertilizers to significantly increase yield levels e.g. it was found to have increased 112% in cereals, 124% in potatoes and 142% in sugar beet in central Europe [4, 6, and 7]. In India quality seed increased wheat production from 12 million to 31.3 million tons over a short period of ten years [10]. No amount of good husbandry or expensive chemical inputs will overcome an initial handicap of poor quality seed [21]. Otherwise as has been aptly said, “what are known as seeds of hope may turn into seeds of frustration” [27].

1.1. Importance of *Corchorus olitorius*

Nutritionally Jute mallow, contribute significant amounts of beta-carotene and ascorbic acid (Vitamin C), protein, minerals (particularly calcium) and carbohydrate [9]. The vegetable is nutritious and popular with expectant mothers since it stimulates production of more milk during breast feeding period [5]. In Kenya the vegetable is popularly used to blend with other local vegetables like *Solanum nigrum, Crotalaria brevidens, Cleome gynandra, and Amaranthus spp.* They are also often added to soups and stews to thicken it. The leaves and young shoots of Jute mallow contain a high proportion of mucilage and are used as cooked vegetable, in a similar manner to spinach greens [1]. The protein content of young leaves is approximately 1.5% while that of older leaves vary from 5-6%. Harvested leaves may be dried and stored for significant periods [7].

The objective of research was to examine seed production status and the quality of seed grown by farmers in respect to analytical purity, germination, vigor and determine the varietal diversity of seeds and as well describe phenotypic characteristics of the main observed varieties of *Corchorus olitorius* grown by farmers in North Rift region Kenya.

“2. Materials and Methods”

2.1. Seed survey and collection

The study was conducted during the long rains period, June to December. *C. olitorius* seed samples were collected differently from various markets and farms of Iten, Eldoret, Kapsabet, Kitale, Kapenguria and Kenya Seed Company, Kitale (North Rift region, Kenya). A sample size of 500 farmers was visited by use of stratified random sampling method. The information collected using a structured questionnaire included age, sex, education background and seed and agronomy training of each farmer. Also the status of jute mallow crop and seed production was captured. The seed samples collected were then well-labeled and taken to the University of Eldoret seed laboratory for quality analysis as per ISTA [13]. Some seed sub-sample was thereafter grown in the green house in for diversity evaluation.

2.2. Seed testing as per ISTA [13]

2.2.1. Analytical purity test.

“Jute Mallow collected vegetable seeds were mixed well by passing through a seed divider several times and subsequently reconstituting them. The sub-samples for each source were obtained by successively halving the sub-sample until sample of required weight was got. Working samples of 15 grams were taken. Weight was taken for each sample and recorded. The working samples were placed on a purity work board and meticulously examined and separated to determine; seed purity. Weights of each group were separated and their percentages worked out from their initial weight of each sample (15 g) and results reported as per ISTA [13]”.

2.2.2. Germination test.

“Four replicates of 100 random seeds were obtained from the pure seed sample using a vacuum seed counter (with 100 holes) and placed on moistened filter paper inside a Petri dish, ensuring the seeds were sufficiently spaced. Seeds were placed in growth chamber set at 30°C temperature. Evaluation of germination was done with 1st count on 3rd day and last count on 5th day and recorded as follows: Normal seedlings, abnormal seedlings and dead seeds."

2.2.3. Electrical conductivity (Seed vigor) test.

"Distilled water of 250 ml was measured and put in 24 well labeled flasks and covered with aluminum foil to control any contamination. Other 2 flasks of distilled water of 250 ml was each set aside as control and covered with aluminum foil. The flasks were put on bench for 24 hrs at room temperature (20-23°C). Jute mallow seeds (50) were added to each flask and left to soak for 24 hours. The soaked seeds was then swirled gently for 10-15 seconds and conductivity (μ S $cm^{-1}g^{-1}$) of soak water was measured upon meter showing constant reading. Between measurements, dip cell was rinsed twice in distilled water and dried using clean dry paper towels. The conductivity per gram of seed weight for each replicate was calculated after accounting for the background conductivity of the original water and the average of the four replicates provided the seed lot result".

2.3. Phenotypic characterization of *Corchorus olitorius* at the green house

The experiment was done in the green house. Boxes measuring 50 cm x 30 cm x 30 cm were filled with well mixed naturally fertile well – drained, friable, sandy clay soil of Ferro - orthic acrisol with an average pH of 5.0 and seed samples from markets centers, farms and Kenya Seed Company planted. At the green house, boxes were laid out using randomized complete block design each seed source with three replications in three blocks. Phenotypic characteristics from each sample were done and recorded as follows:

(a) Plant height: Five random plants from the net plot (box) were measured for stem height from the base to the tip at harvesting time.
(b) Number of pods per plant: Five plants were sampled, from the net plot at harvest and the average number of pods determined.
(c) Leaf petiole length: Five plant leaf petioles were sampled, from the net plot at harvest and the lengths determined.
(d) Leaf Lamina: Five plants were sampled, from the net plot at harvest and leaf lamina shape recorded, its length and width determined.
(e) Leaf Serration: Five plants were sampled, from the net plot at harvest and the direction of serration recorded.
(f) Leaf tip shape: Five plants were sampled, from the net plot at harvest and the leaf tip shape recorded.
(g) Leaf color: Five plants were sampled, from net plot at harvest and the leaf color recorded.
(h) Flower characteristics: Five plants were sampled, from the net plot at harvest and the flower shape, color, number of sepals and its length and width recorded or determined.
(i) Fruit characteristics: Five plants were sampled, from the net plot at harvest and the fruits' shape recorded and its length and width determined.
(j) Seeds per pod: Five plants were sampled, from the net plot at harvest and number of seeds per pod determined.

"3. Results"

3.1. Seed survey and collection

3.1.1. Education level of farmers

"Education level analysis from various areas of North Rift region of Kenya showed that 46% of the farmers have attended school. This means that over half of the farmers doing seed production are illiterate that is they cannot read and write and so cannot prepare or use farm records tool to produce quality seed, but rely on their memories for information. Low level of education (figure 1) could be one of the hindrances to use of farm records in areas of North Rift region that was surveyed".

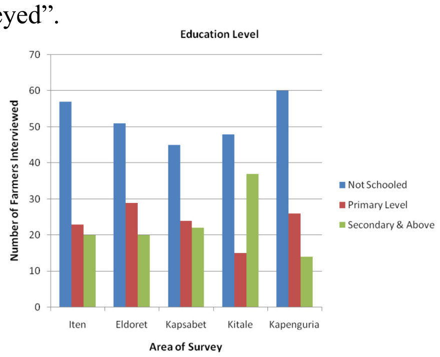

Figure 1: Education levels of farmers interviewed in each area in North Rift region

3.1.2. Seed supply outlets of Jute mallow

"The farmers interviewed showed 98% depended on the informal seed supply sector for their Jute mallow seed, while only 2% depended on the formal seed supply sector. It was also observed that 69% of farmers use own saved seed for planting, while 24% got Jute mallow seed from neighbors, 5% from Informal seed sector (local market) and only 2% from Formal seed sector market".

3.1.3. Age and gender of farmers at farm level

"Most of the farmers growing Jute mallow vegetable at farm level were aged people over 40 years accounting for over 80% of total farmers interviewed. It was also noted that all were female (table 1) of which when asked why, the answer given was that men from the region shy away from its farming considering vegetable production women's work".

Table 1: Age (years)/number of farmers at farm level dealing with Jute mallow in North Rift region

Location	19-40 years (Young)		41-59 years (Middle)		60 years and Over (Old)	
	F	M	F	M	F	M
Iten farms	9	0	36	0	50	0
Eldoret farms	12	0	44	0	39	0
Kapsabet farms	10	0	36	0	49	0
Kitale farms	19	0	42	0	34	0
Kapenguria farms	7	0	32	0	56	0
North Rift region total	57	0	190	0	228	0

3.1.4. Age and gender of farmers at market level

"Seed survey showed that men were missing in Jute mallow seed business in areas like Iten, Kapsabet and Kapenguria markets but were present in Eldoret and Kitale at the middle age (41-59 years) amounting to only 8% in the region (table 2)".

Table 2: Age (years) and number of farmers at market level dealing with Jute mallow seed in North Rift region

Location	19-40 years (Young)		41-59 years (Middle)		60 years and Over (Old)	
	F	M	F	M	F	M
Iten market	1	0	2	0	2	0
Eldoret market	2	0	1	1	1	0
Kapsabet market	1	0	1	0	3	0
Kitale market	2	0	1	1	1	0
Kapenguria market	1	0	1	0	3	0
North Rift region total	7	0	6	2	10	0

3.2. Jute mallow crop husbandry

3.2.1. Fertilizer use for quality crop

"Fertilizer use showed 66% of the farmers interviewed do not use any fertilizer during the production of Jute mallow. Those farmers who apply fertilizer at planting do not top dress as required for improving quality of seed and crop that meet market grade /requirements".

3.2.2. Method of planting Jute mallow

"During the planting of Jute mallow, 73% farmers broadcasting seed, thereby using higher seed rates as compared to 27% drilling in lines. It was observed that only 19% farmers use the optimum seed rate of 5 kg/ha, 10% under use seed (3% use 3 kg/ha and 7% use 7 kg/ha) as opposed to 71% of farmers that over use the seed rate (29% use 6 kg/ha and 42% use 7 kg/ha)".

3.2.3. Indicators of Jute mallow pod maturity and harvesting method

"Majority of the farmers (84%) indicated that pod has matured when it turns from green color to tan indicating seed has reached harvest maturity, or the stage of seed development when it has dried to a moisture level at which it can be harvested without appreciable risk of mechanical damage. The method of harvesting Jute mallow seed by farmers involves cutting the whole plant as done by 75% of the farmers as opposed to 25% farmers who chose to hand pluck pods that have matured".

3.2.4. Handling of Jute mallow seed from harvest to storage

"On the method of Jute mallow seed extraction, 98% farmers extracted their seed from pods by beating with sticks. In Jute mallow seed drying, it was observed that all the farmers (100%) dry their Jute mallow seed in direct sunlight as opposed to drying in shade for 4 days and only 1 day in sunlight. In seed storage, most of farmers (83%) store their Jute mallow seeds in pots/tins and plastic/synthetic. On storage duration, half of the farmers (53%) had saved their seeds for over 5years. Those that had stored for 4years was 23%, 3years was 20%, 2years was 15%) and those stored for 1year was 12%".

3.3. Training of farmers

Results on training of farmers showed that on average 14% of all the total farmers interviewed in North Rift region had been trained on agronomy, crop protection and seed production aspects of Jute mallow. The remaining 86% farmers were doing Jute mallow seed production without any form of training at all. The trained farmers per area are: Kitale-24% (highest in the region), Eldoret-16%, Kapsabet-12%, Iten-11% and Kapenguria-8% (lowest in region).

3.4. Seed quality testing of Jute mallow

3.4.1. Analytical purity results of Jute seed

"The processed seed from Kenya Seed Company had the highest purity percentage (100%) compared with seed from both the markets (99%) and farms (98%), though seeds from market were of higher purity than seeds from farms. The quality of seed is considered superior if analytical purity percentage is above 98% [13]. Purity analysis results showed that all the Jute mallow vegetable seed were of superior quality since their analytical purity percentages were above 98%".

3.4.2. Germination results of Jute mallow seed

"Germination test results showed highest germination of Jute mallow seed was from processed source, Kenya Seed Company (86%) and the lowest germination was from farms source with 53%, though germination from markets were equally low (54%) and the North Rift region average showed 57% (table 3). This means that compared to ISTA [13] minimum Jute mallow seed germination requirement of 60%, Jute mallow seeds from North rift region does not meet this minimum standard.

Table 3: Germination and Emergence percentage of Jute mallow from various sources

Location	Standard germination test in percentages (%)			
	Dead seeds	Abnormal seedlings	Normal seedlings	Emergence of radicle
Iten market	40	6	54	60
Eldoret market	29	5	66	71
Kapsabet market	42	4	54	58
Kitale market	46	5	49	54
Kapenguria market	47	5	48	53
Average of markets	41	5	54	59
Kenya Seed Company (Processed source)	12	2	86	88
Kitale farms	27	6	67	73
Eldoret farms	28	6	66	72
Iten farms	35	6	59	65
Kapsabet farms	63	5	32	37
Kapenguria farms	55	2	43	45
Average of farms	42	5	53	58

Radicle seedlings (normal and abnormal seedlings), result showed Kenya Seed Company had highest seedling emergence (88%) and Kapsabet farms (37%) had lowest compared with markets (59%) and farms (58%), (table 3). Also though seedling emergence of Kitale farms (73%) and Eldoret farms (72%) were high, germination percentage were reduced to Kitale (67%) and Eldoret (67%) by high number of abnormal seedlings by 6% (Kitale farms) and 6% (Eldoret farms). This trend was also observed in seed from other areas of North Rift region. On average, over half of seeds from North Rift region germinated on the 1st day".

3.4.3. Electrical Conductivity of Jute mallow seed

"The conductivity results showed that all seeds from the North rift were of high vigor. Kenya Seed Company had the lowest leachate conductivity of 2.69$\mu Scm^{-1}g^{-1}$ and Kapsabet farms had the highest Electrical conductivity of 7.09 $\mu Scm^{-1}g^{-1}$ though so, all the seeds were still of good quality as they were below 10 $\mu Scm^{-1}g^{-1}$ level falling within high vigor as per ISTA [13]."

3.5. Phenotypic characterization of *Corchorus olitorius* at the green house

a). Plant height

C. olitorius plant height showed significant differences (p=0.001) for sources and locations. There was no interaction between variety and locations. The early maturing plants were short (28 cm) or dwarf or less than 50 cm (table 4) as also indicated by [8]. The Green Early Maturing Short (GEMS) and Brown Early Maturing Short (BEMS) (28 cm) were same in height and differentiated by stem color. The Green Late Maturing Tall (GLMT) and Brown Late Maturing Tall (BLMT) (82 cm) were tall and differentiated only by color

Table 4: Mean plant height measurements (cm) at harvesting

Location	Mean plant height		Mean plant height	
	GEMS	BEMS	GLMT	BLMT
Kitale	27±2.5	25±1.7	88±8	89±11.7
Kapsabet	33±2.9	35±2.6	95±13.1	91±0.6
Iten	28±1.5	26±1	83±6.7	80±8.5
Kapenguria	25±1.7	24±1	75±1	72±3.2
Eldoret	29±1.5	30±3.2	81±6.1	84±2.1
Mean of markets	28	28	84	83
Kenya Seed Company (Processed source)	27±1	-	-	-
Kitale	30±2.5	32±3.1	82±3.1	78±7.2
Iten	26±0.6	27±0.6	85±4	81±5.3
Eldoret	30±1	31±3.8	83±7	83±5.5
Kapsabet	29±2.5	30±2.9	90±10.4	77±4
Kapenguria	27±1.5	28±1	83±3.5	82±7.6
Mean of farms	28	29	84	80

Note: (-) denotes variety not present in seed from the source

b). Pod count per plant (numbers)

C. olitorius pod count results showed no significant differences (p=0.001) for source and locations. GEMS and BEMS pod count per plant showed same number of pods (6), likewise to GLMT and BLMT which had17 pods per plant, though BEMS highest was 14 pods from Kenya Seed Company (table 5) and stem color could only differentiate them.

Table 5: Mean pod count in numbers of Jute mallow from various sources at harvesting

Location	Mean pod number		Mean pod number	
	GEMS	BEMS	GLMT	BLMT
Kitale	5±1	6±1	17±0.6	17±1
Kapsabet	6±0.6	6	18±1.5	18±1.7
Iten	5±1.7	5	17±0.6	17±0.6
Kapenguria	4±0.6	4±0.6	16	16
Eldoret	6±1	6±0.6	16±0.6	16±1
Mean of markets	5	5	17	17
Kenya Seed Company	14±2.1	-	-	-
Kitale	5±0.6	6	18±1.5	17±1.5
Iten	5±0.6	5±1	17±0.6	17±0.6
Eldoret	6±0.6	6±0.6	17±0.6	18±1.5
Kapsabet	6±0.6	6±1	17±1.2	17±0.6
Kapenguria	5±0.6	5±0.6	17±0.6	18±0.6
Mean of farms	5	6	17	17
Mean of North Rift region	6	6	17	17

Note: (-) denotes variety not present in seed from the source

c). Leaf measurements

i) Petiole length

C. olitorius petiole length analysis showed no significant difference (p= 0.001) for sources and locations, nor between varieties. The GEMS and BEMS from markets and farms had same length (1.3 cm) and Kenya Seed Company had petiole length of 1.2 cm. GLMT and BLMT both from market and farm had same petiole length (1.7 cm) (table 6).

Table 6: Mean petiole length measurements (cm) of Jute mallow varieties at harvesting

	Mean length (cm)		Mean length (cm)	
Location	GEMS	BEMS	GLMT	BLMT
Kitale	1.4±1	1.3±0.1	1.8±0.1	1.7±0.2
Kapsabet	1.3±0.1	1.3±0.1	1.7±0.1	1.7±0.1
Iten	1.3±0.1	1.2±0.1	1.6±0.2	1.6±0.1
Kapenguria	1.1±0.1	1.2±0.1	1.7±0.1	1.8±0.1
Eldoret	1.4±0.1	1.3±0.1	1.8±0.1	1.7±0.1
Mean of markets	1.3	1.3	1.7	1.7
Kenya Seed Company	1.2±0.1	-	-	-
Kitale	1.3±0.1	1.3±0.1	1.7±0.1	1.7±0.1
Iten	1.3±0.1	1.2±0.6	1.7±0.2	1.6±0.1
Eldoret	1.3±0.1	1.2±0.6	1.8±0.1	1.7±0.1
Kapsabet	1.2±0.6	1.2±0.1	1.6±0.1	1.7±0.1
Kapenguria	1.2±0.1	1.2±0.1	1.6±0.1	1.7±0.1
Mean of farms	1.3	1.2	1.7	1.7
Mean of North Rift region	1.3	1.3	1.7	1.7

Note: (-) denotes variety not present in seed from the source

ii) Leaf lamina

C. olitorius leaf lamina shape was lanceolate with no significant difference (p=0.001) in leaf width. The late maturing variety had leaf width of 2.8 cm while early maturing variety had 2.6 cm (table 7). There was significant difference in leaf lengths (p=0.001) across varieties. Leaf length of late maturing (8.6 cm) was longer than early maturing of (6.0 cm).

Table 7: Mean width and length measurements (cm) of Jute mallow leaf at harvesting

Measurement	Mean		Mean of early maturing	Mean		Mean of late maturing
	GEMS	BEMS		GLMT	BLMT	
Width (cm)	2.5± 0.1	2.7± 0.2	2.6	2.8± 0.1	2.8± 0.1	2.8
Length (cm)	5.5± 0.4	6.5± 0.5	6.0	8.4± 1.1	8.8± 1.2	8.6

iii) Leaf serration.

All GEMS, BEMS, GLMT and BLMT had serration present facing leaf apex.

iv) Leaf tip shape.

All GEMS, BEMS, GLMT, and BLMT leaf tips had acute shape.

v) Leaf color.

All GEMS, BEMS, GLMT, and BLMT leaves were green.

d) Flower characteristics.

All the GEMS, BEMS, GLMT, and BLMT flowers shapes were solitary and small and were in opposite side to the leaves, Color being yellow, Sepals were 5 and narrow. *C. olitorius* flower measurements showed no significant difference (p=0.001) for varieties. The GEMS, GLMT, BEMS, and BLMT had same flower width and length (1, 1.2 cm) (table 8).

Table 8: Mean width and length measurements (cm) of Jute mallow flower petals

Measurement	Mean		Mean of early maturing	Mean		Mean of late maturing
	GEMS	BEMS		GLMT	BLMT	
Width (cm)	1.0± 0.1	1.0± 0.1	1.0	1.0± 0.1	1.0± 0.1	1.0
Length (cm)	1.1± 0.2	1.2± 0.1	1.2	1.2± 0.1	1.2± 0.1	1.2

e). Fruit characteristics

i) Size:

C. olitorius fruit width and length measurements showed no significant difference (p=0.001) for varieties. The late maturing (1.3 cm) are significantly same in width as early maturing (1.2 cm). There was variation for late maturing (3.9 cm) and early maturing (3.7 cm) in reference to fruit length (table 9).

Table 9: Mean width and length measurements (cm) of Jute mallow fruit at harvesting

Measurement	Mean		Mean of Early Maturing	Mean		Mean of Late Maturing
	GEMS	BEMS		GLMT	BLMT	
Width (cm)	1.1± 0.4	1.2± 0.5	1.2	1.3± 0.4	1.3± 0.5	1.3
Length (cm)	3.5± 0.5	3.8± 0.6	3.7	3.8± 0.4	3.9± 0.6	3.9

ii) Shape:

All GEMS, BEMS, GLMT, and BLMT had fruits that were cylindrical, 10 ridged, dehiscing by 5 with traverse septa between the seeds.

f). Seed characteristics

All GEMS, BEMS, GLMT and BLMT had pyramidal shape, length of 1 mm and were dark grey in color.

"4. Discussion"

4.1. Seed survey and collection

The seed survey showed that most of the farmers growing Jute mallow vegetable were middle age (41-59 years) and old (60 years and over), accounting for over 80% of the total farmers interviewed meaning that Jute mallow growing was not done by young generation as observed also by [1]. In North Rift region, it was observed that men do not engage in growing Jute mallow crop in the farms which they consider best women work. Different scenario was observed at market where some 8% male practiced Jute mallow seed business in Eldoret and Kitale market and were only at the middle age (41-59 years). Few farmers (14%) in North Rift region had been trained on vegetable seed production and agronomy, leaving 86% farmers doing vegetable seed production without having attended any training. This showed that they were using their own indigenous knowledge in Jute mallow seed production. There were 69% farmers having undergone at least one kind of training on the crop. No farmer had attended four or more trainings in the whole of North Rift region. This could be one of the reasons why Jute mallow yield has remained low at 2-4 tons/ha/annum as compared to the expected yield of up to 5-8 tons/ha/annum concurring with findings put forward by [18]. Education level showed that few farmers (46%) had attended school meaning that over half of the farmers doing seed production were illiterate i.e. could not read and write, so cannot prepare or use farm records to know their level of production, but relied on their memories to store information. Low level of education could be one of the hindrances to use of farm records in North Rift region. This in turn could have contributed to low quality of Jute mallow seed production in the region by farmers. Such decline in seed quality and crop productivity therefore reduces profits, and that low quality seeds leads to non acceptance of the vegetable by consumers because of low quality product.

4.2. Seed quality testing of Jute mallow

4.2.1. Analytical purity of Jute mallow seeds

"Analytical purity showed that Kenya Seed Company had the highest purity percentage (100%) compared with seed from the regions, markets and farms. Iten market and Eldoret farms had the lowest purity (98%). According to ISTA [13], the quality of seed analysis is considered superior if purity percentage is above 98% meaning that all the Jute vegetable seed were of superior quality. Though so, Louwaars, [16] observed that purity *per se* is not gauge of good quality seed but a sum total of several seed attributes, needing more tests to ascertain seed quality".

4.2.2. Germination of Jute mallow seeds

"Germination of Jute mallow seed from Kenya Seed Company (86%) was highest and the lowest germination was from Kapsabet farms (32%). This means that Kenya Seed Company Jute mallow seed would do better in field than all of the seeds from various sources analyzed. The North rift region results analysis showed low germination of 57%, though some of its Jute mallow seed sources like Kenya Seed Company was high (86%). Compared to ISTA [13], which requires Jute mallow seeds germination to have minimum germination percentage of 60%, North Rift region had its Jute mallow germination at 57%, thereby not meeting required minimum standard for it to be used as seed. Jute mallow seeds from Kenya Seed Company had high vigor (88%) in terms of emergence as compared with low Jute mallow seed emergence from other seed sources analyzed in North Rift region. This trend could be expected to perform the same in the field if these seeds were planted on the soils in farm. This low seedling emergence could be contributing to low yields and supports what was observed by [23] and [12].

4.2.3. Electrical conductivity (seed vigor) of Jute mallow seeds

"Kenya Seed Company had the lowest leachate conductivity of $2.69 \mu Scm^{-1} g^{-1}$ meaning that the seeds were of high vigor. Seeds from North Rift region had equally low leachate conductivity of $4.50 \mu Scm^{-1} g^{-1}$. Kapsabet farms had higher Electrical conductivity of $7.09\ \mu Scm^{-1} g^{-1}$ though the seeds were still of good quality. This means that though seeds from North Rift region were of high vigor, further tests on seeds are needed to ascertain why there were low yield in the region. This supports observations made by [3] who recommending several seed tests needed to be done to find out why seeds showed poor performance in field yet laboratory results showed high seed vigor".

4.3. Jute mallow phenotypic characterization at the green house

During phenotypic characterization four varieties came out based on color, maturity and height as follows: Green Early Maturing Short, Brown Early Maturing Short, Green Late Maturing Tall and Brown Late Maturing Tall. Such observation was also found out in Nigeria by [8], though he only found two varieties and named them in Nigerian local language as *Amugbadu*, and *Oniyaya* and acknowledges that in reality there exists diversity in Jute mallow grown by farmers.

4.3.1. Early maturing short variety characteristics

"The early maturing *C. olitorius* varieties were short or dwarf (less than 50cm).This meant that the GEMS (28 cm) and BEMS (29 cm) had no significant difference in plant height and only differentiated by stem color during selection to different varieties". GEMS pod counts per plant were same for seed sources (6 pods), Kenya Seed Company had highest with 14 pods and the lowest was Kapenguria market (4 pods). This showed that Kenya Seed Company could produce more seed yield per unit area than from farm or market thereby increasing profit margins of farmers. The BEMS pod count per plant showed no significant difference between varieties, the highest was 6 pods and the lowest was 4 pods, leaving the average of the North Rift region BEMS with 6 pods per plant. Farmers could plant BEMS or GEMS as both were easily found within their areas, though if

Kenya Seed Company could make their seed (GEMS) readily available to the farmers they would benefit more in terms of increased seed yield and profit from sales of Jute mallow. From the Petiole length analysis it was observed that there was no significant difference between varieties. On average GEMS and BEMS Petiole length was 1.2 cm and could only be differentiated by their stem colors. The GEMS and BEMS Leaf lamina shape was lanceolate measuring 5.5 cm length by 2.5 cm width and in alternate positions. The Leaf serration of both GEMS and BEMS were present and facing leaf apex. The leaf tip was acute in shape. The leaf color was green. The flowers were solitary, yellow, with 5 narrow sepals".

4.3.2. Late maturing tall variety characteristics

"*Corchorus olitorius* GLMT and BLMT varieties showed no significant difference in plant height with 95 cm being the tallest plant height and with 75cm being shortest and an average of 85cm. There were no tall plants in Kenya Seed Company, which indicated that it had been purified to remove BLMT and GLMT varieties. The farmers could plant any of the varieties and get the required crop for sale during the planting season as both would give same output. There was no significant difference for pods between locations with GLMT and BLMT plants having pod count per plant at 18 pods, with lowest pod count per plant being 16 pods. Kenya Seed Company had no late maturing plants. Both GLMT and BLMT had leaf length at 1.7cm and could only be differentiated by their stem colors. The leaf lamina shapes for both GLMT and BLMT were lanceolate and in alternate position but varied in length sizes where GLMT was longer. Both types had leaf serration which were facing leaf apex with its leaf tips of acute shape. The flowers for both varieties were yellow, solitary, in opposite to leaves, same in size and had 5 narrow sepals. Both varieties had same sized fruit of cylindrical shape having 10 ridges in each fruit dehiscing by 5, with traverse septa between seeds. There were 100 seeds per capsule; seed color was dark grey with pyramidal shape. These seeds were 1 cm in length and had a seed weight of 400 seeds per gram".

"5. Conclusion"

The seed production status of *C. olitorius* seed showed that most of the farmers in the North Rift region get their seed for planting from own saved seed or neighbors where storage was in plastic tins usually stored in the open. Most farmers were illiterate as shown by low level of education, were aged and have not been trained on seed and agronomic aspects of Jute mallow.

The *C. olitorius* seed grown by farmers from North Rift areas though of high analytical purity were of poor physiological quality as seen from the high percentage of dead seeds. The dead seeds could be result of: - immature harvested seed, diseased seeds, poor processing methods/ storage conditions right from farms to markets.

Seeds grown by farmers are diversified. This is true because during phenotypic characterization, four varieties came out based on color, maturity and height as follows: Green Early Maturing Short, Brown Early Maturing Short, Green Late Maturing Tall and Brown Late Maturing Tall.

"6. Recommendation"

Efforts should be made by the government of Kenya and other Stakeholders of the seed sector e.g. Universities, Seed merchants, Kenya Agricultural Research Institute and Kenya Plant Health Inspectorate Service to increase trainings to seed producers either formal or informal to enhance seed production. This could be done through farmer field schools so that the farmers could be reached through group approach to address issues on quality seed production and their related agronomic aspects of seed crop production. The recommended seed for use by farmers is from Kenya Seed Company, Kitale having showed high purity, germination, and vigor. The rest of seed lots from North Rift region should not be used as seed for it will lead to poor yields due to its low quality. It is also recommended that breeders and seed companies come-up with new varieties or improved selections for Jute mallow vegetable industry to increase yields.

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