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LEAF YIELD AND YIELD RELATED ATTRIBUTES IN JUTE MALLOW (*Corchorus olitorius* [L.]) GROWN IN COCONUT COIR SUBSTRATE

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Abstract
Jute mallow cultivation in coconut coir substrate under polyethylene house is not popular among growers in sub Saharan Africa. The consequences of climate change and rising demand for safe vegetable necessitate an evaluation of leaf yield and yield related traits. A pot experiment was arranged in completely randomised design with four replications. Data were collected on leaf growth, leaf yield and yield related traits. The significant mean squares ($P \leq 0.01$) for accession, and accession by season interaction for leaf weight, leaf width, and number of nodes/plant suggest cross over performance across season. This led to variation in mean values for traits in different seasons. FUOJM 1 and 14 hold promise for leaf fresh weight, FUOJM 4, FUOJM 9 and FUOJM 15 for leaf area, and FUOJM 11, FUOJM 1, FUOJM 10 and FUOJM 7 for number of leaves/plant. FUOJM 1 performed best for leaf fresh weight, total plant weight, and number of leaves/plant. High performance for leaf weight, number of leaves/plant, and leaf size is consistent with photosynthetic rate and accumulation of photosynthates. Determinants of leaf fresh weight are total plant weight, plant length and number of leaves/plant. FUOJM 1 with potential for multiple traits (leaf fresh weight, total plant weight, and number of leaves/plant) would make a good variety for cultivation in coconut coir substrate in polyethylene house.

Keywords: *Jute mallow, protected cultivation, polyethylene house, leaf yield and yield related traits*

Introduction

Jute mallow, (*Corchorus olitorius* [L.]) is an underutilized, household leaf vegetable in sub-Saharan Africa, diploid, annual leaf vegetable that reaches 2 – 4 m in length at maturity (Maundu *et al*., 1999; Grubben and Denton, 2004). Fresh leaves are serrated and lanceolate in shape, green and glossy about 5 –15 cm long (Grubben and Denton, 2004). It thrives best in locations with day temperature between 25 to 32°C and rainfall from 600 to 2000 mm annually. High fresh leaf and dry leaf yield have been reported in day length of 12.5 h (Maundu *et al*., 1999). Fresh leaves are used in cuisines around Asia, Middle East, and Africa. The green leaves are rich in protein, thiamine, riboflavin, niacin, folate, and dietary fibre, beta carotene, iron, and calcium, and vitamin C (Grubben and Denton, 2004), and antioxidants important in preventing chronic disease (Dubick and Omaye, 2001; Giovannucci, 2002; Dorais *et al*., 2008; Ehret, *et al*., 2013). The mucilage in the leaves enhance mastication of starchy foods made from cassava flour, pounded boiled cassava and cassava granules, yam flour, maize, sorghum flour and rice. At the peak of the rainy season, farmers in the northern Nigeria harvest fresh jute mallow leaves, dry and preserve them for use during the prolonged dry season. Leaf quality attributes (leaf freshness, leaf mucilage and taste) of milled leaves are low compared to fresh leaves. Hence, the need to avail technologies that will ensure sustainable supply of fresh leaves all year round.

Open field cultivation for fresh leaves is popular among growers in home garden, small and medium scale farms for household consumption and market. Growers use poor quality seeds and traditional system of production. A silty-loam soil with a pH of 4.5 to 8.0 is adequate for cultivation in the open field. Growers broadcast seeds on vegetable beds previously treated with decomposed organic wastes. Germinating plants are overcrowded and less vigorous (Maundu *et al*., 1999; Grubben and Denton, 2004). Foliar application of Urea (45 % N) is done at three weeks after sowing to provide nitrogen for leaf growth. Vigorous plants are culled by uprooting at five or six weeks after sowing, less vigorous plants are harvested four to five weeks thereafter, this practice is not sustainable. Open field cultivation of Jute mallow is challenged by low leaf yielding varieties, poor soil physical attributes (Saginga *et al*., 2001) and low chemical properties of the soil. In addition, heat stress, within season drought, flooding, poor cultivation methods, attacks from grasshoppers (*Zonocerus variegatus*), leaf worm (*Spodoptera littoralis*), flea beetle (*Podagrica* *uniforma*), red spider mites (*Tetranychus cinnabarinus*), and virus diseases transmitted by leaf hoppers (Maboko and Du Plooy, 2007). Growers spray pesticides to reduce the menace of insect and disease attack. This practice constitute health hazard to growers and consumers.

The implication of climate shocks makes it realistic to deploy jute mallow varieties with stable and improved performance for leaf yield and yield related traits. The rising demand for safe vegetable has stimulated use of organic substrates and nutrient in vegetable production. Protected cultivation in organic substrate is popular among vegetable growers in Asia, Europe and USA. The coconut coir is a waste product of the coconut fruit, and has been promoted as substitute for peat moss in growth media (Evans *et al*., 1996). It can be reused in cultivation for about 4 cycles. Jute mallow is economically important crop for production under protected cultivation, there is limited information on leaf yield potential of jute mallow under organic production systems in polyethylene house. This is one of the reason why organic jute mallow leaf production is not considered to be viable alternative to conventional vegetable production.

The phenotypic expression of a trait depends on interaction between the genotype and environment (GEI). The accession x season interaction analysis is important for identifying genotypes with adequate adaptation to target season. The GEI makes selection of stable and promising genotypes difficult (Yan and Kang, 2003). The stepwise regression analysis have been used by many workers to determine the contribution of characters (independent variables) to dependent variable (yield) (Rao *et al*., 1990). The evaluation of growth, leaf metric and leaf yield attributes in jute mallow grown in coconut substrate over seasons (rainy and dry seasons) with organic fertilizer in polyethylene house will identify promising accessions for specific and multiple traits. The objectives of this study were to 1) evaluate variation for leaf yield and yield related traits among jute mallow accessions grown in coconut coir substrate, 2) determine the contribution of traits to leaf yield and 3) identify promising accessions for single and multiple traits.

Materials and Methods

Experimental Design and Nursery Management

A pot experiment was carried out between 9 November to 23 December 2018 (dry season) and repeated in 9 May to 30 June 2019 (rain season) in polyethylene house 36 x 12 m (~432 m^2) and 15 m high, situated on the Experimental Farm of Federal University Oye Ekiti, Department of Crop Science and Horticulture, Ikole campus Nigeria (Latitude 70^o 48.36'N, Longitude 005^o 29.82'E), at 555 m above sea level. The temperature and relative humidity in the polyethylene house were measured during 2018 and 2019. (Figure 1).

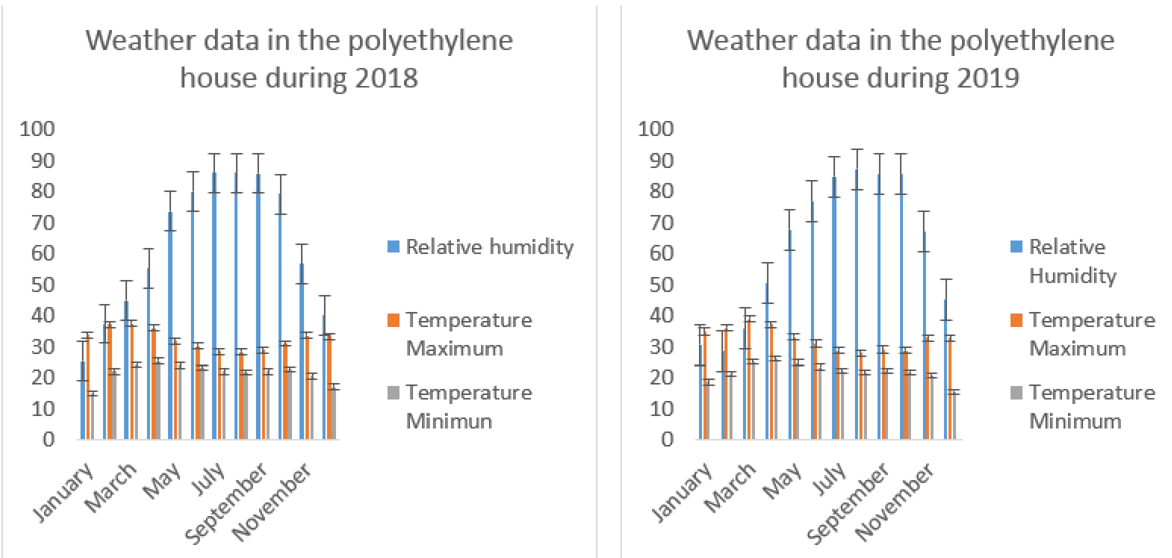

Figure 1. Weather data (temperature and humidity) in the polyethylene house during 2018 and 2019

Fourteen accessions of *Corchorus olitorius* were obtained from the Genetic Resources Unit, National Center for Genetic Resources and Biotechnology, Ibadan, Nigeria and one from Ilotin, Ikole Ekiti (Table 1). Coconut coir was supplied by Psnutrac, Lagos, Nigeria. Each polythene pots (30 x 15 cm) was filled with 3.5 kg of coconut coir, water was added to each substrate to field capacity. The hot and cold water treatment was used to break dormancy in the seeds, thereafter seeds were air-dried. Three polyethylene pots were allotted to each accession and replicated four times in a completely randomized design (CRD).

At planting, seeds (2 g) were sown per pot, each pot received 1 litre of water in the morning and evening for the first seven days. Thereafter, 2 litres of water was applied until 4 weeks after sowing (WAS). At 2 WAS, organic fertilizer Super Gro fertilizer (Ethoxylated, Alkylphenol, and Polysiloxane), was applied at the rate of 10 ml in 10 litres of water using hand held sprayer. At four weeks after sowing, five plants were randomly picked for determination of plant length (using meter rule), number of nodes/plant and number of leaves/plant were counted. Leaf length and width were measured with a meter rule (cm) on the longest and widest points on each leaf. Plants were uprooted and weighed on sensitive weighing balance for determination of total plant weight. Leaf weight was determined on a sensitive electronic weighing balance and bulky weights were measured with a weighing balance. The leaf area was calculated by multiplying leaf length by leaf width, and a coefficient of 0.75 (Leaf length x Leaf width x 0.75 Carvalho and Christoffoleti, 2007).

Table 1. Accessions of Jute mallow

Sn	**Breeder's code**	Accession name	Source
1	NGB/00292	FUOJM 1	NaGRAB[a], Ibadan
2	NGB/00202	FUOJM 2	NaGRAB, Ibadan
3	NGB/00235	FUOJM 3	NaGRAB, Ibadan
4	NGB/00221	FUOJM 4	NaGRAB, Ibadan
5	NGB/00197	FUOJM 5	NaGRAB, Ibadan
6	NGB/00230	FUOJM 6	NaGRAB, Ibadan
7	NGB/00198	FUOJM 7	NaGRAB, Ibadan
8	Ikole	FUOJM 14	FUOYE[b], Ekiti
9	NGB/00190	FUOJM 8	NaGRAB, Ibadan
10	NGB/00229	FUOJM 9	NaGRAB, Ibadan
11	NGB/00226	FUOJM 10	NaGRAB, Ibadan
12	NGB/01660	FUOJM 11	NaGRAB, Ibadan
13	NGB/00238	FUOJM 12	NaGRAB, Ibadan
14	NGB/00222	FUOJM 13	NaGRAB, Ibadan

[a] *NaGRAB = National Genetic Resources and Biotechnology Center*
[b] *FUOYE = Federal University Oye Ekiti, Nigeria*

Laboratory Analysis of Coconut Coir Substrate for Physical and Chemical Properties

Before sowing and at harvest, coconut coir were sampled, air dried, crushed and sieved for determination of particle size distribution according to Bouyoucos (1951) and the hydrometer method described by Bouyoucos (1962). Organic Carbon (OC) was determined by sulphuric acid-dichromate digestion followed by titration with ferrous ammonium sulphate (Walkley and Black, 1934; Nelson and Sommers, 1996). Total nitrogen was determined using Macro Kjeldahl method (Brenner and Mulvaney, 1983). Basic cations (Ca, K, Mg and Na), cation exchange capacity, exchangeable acidity and phosphorus were analysed using the method of Udo *et al*., (2009). Available P was determined using Bray I method as described by Bray and Kurtz (1945). Organic matter was calculated by multiplying OC by 1.724. Available P was determined by the Olsen method (Okalebo *et al*., 2002). 0.5 g of a substrate was digested with 0.5 mL H_2SO_4, 0.6 mL concentrated HNO_3 and 1.8 mL concentrated HCl for 2 h at 95°C, cooled and diluted to 10 mL with deionized water, and analysed for As, Cu and Zn using a spectrophotometer. Heavy metals (Pb, Ni, Co and Cd) in each substrate was determined by the method described by Carter and Gregorich (2007).

At 4 WAS, leaves were harvested, air dried, grinded and sieved. 50 g of plant tissues was used for determination of heavy metals in the leaf tissues using the procedures as indicated above. The data collected were summarized and subjected to analysis of variance using PROC GLM of SAS (ver. 9.4, SAS Institute, Cary, NC). The accessions and season were fixed, means were separated by Tukey's HSD test. Using total plant weight and number of leaves/plant as a dependent variables, stepwise multiple regression analysis was done using PROC STEP of SAS (ver. 9.4, SAS Institute, Cary, NC).

Results

Physical and chemical properties of coconut coir

The coconut coir is slightly acidic at sowing and harvest with different values (Table 2). The concentration of nitrogen and organic carbon were high (at sowing) and low (at harvest). The constituents of phosphorus (K), sodium (Na), magnesium (Mg), Zinc (Zn) and Iron (Fe) were high at sowing. On the other hand, exchangeable CEC, Cu, Ca and available P had low concentration at sowing. The concentration of lead (Pb), Nickel (Ni), Chromium (Cr) and Cadmium (Cd) were low in coconut coir at harvest.

Table 2. The Physical and Chemical Properties of Coconut Coir

Soil physical/chemical properties	At sowing	At harvest
pH (H20)	5.8	6.2
OC (%)	51	4.27
% N	6.0	0.17
Available P (c mol/g)	0.1	14.72
K (C mol/kg)	5.8	1.49
Na (C mol/kg)	1.9	0.17
Ca (C mol/kg)	3.0	3.05
Mg (C mol/kg)	2.7	1.50
Exchangeable $Al3^{+}$	-	0.14
Exchangeable H+	-	1.62
CEC	1.0	6.21
ECEC	-	7.97
% Base saturation	-	77.92
% Al saturation	-	1.76
Mn (mg/Kg^{-1})	8	29.9
Fe (mg/kg)	943	49
Cu (mg/kg)	8	56.9
Zn (mg/kg)	16	12.1
Pb (mg/kg)		0.06
Ni (mg/kg)		0.5
Cr (mg/kg)		0.28
Cd (mg/kg)		0.01

As shown in Table 3, there were significant variations among Jute mallow accessions grown in coconut coir substrates ($P\leq 0.01$) for plant length, leaf length and width, number of leaves/plant and number of nodes/plant and total plant weight, fresh leaf mass, leaf dry mass/pot, leaf area index, leaf dry matter yield and total plant weight. Season significantly influenced ($P< 0.001$) plant length, leaf fresh weight, leaf width, number of leaves/plant and leaf weight among the accessions. The accession by season interaction (ASI) mean squares were statistically significant ($P\leq0.01$) for plant length, leaf fresh weight and leaf width.

Table 3. Combined analysis of variance for leaf metric, leaf yield and yield related traits in Jute mallow cultivated in coconut coir during the dry and rainy season of 2018/19.

Source of variation	DF	Plant Length (cm)	Leaf Fresh Weight (g)	Total Plant Weight (g)	Leaf Length (cm)	Leaf Width (cm)	Number of leaves per Plant	Number of nodes /Plant	Leaf Area (cm^3)
Accession	13	109.23**	272.98**	1827.91**	2.56**	4.12**	44.34**	6.99**	21.20**
Season	1	5011.02**	16.86*	37.90	0.23	4.24*	32.14**	29.00**	31.97**
Accession x Season	13	87.86**	272.96*	12.73	0.03	4.86**	0.41	1.37	0.33
Error	84	3.66	2.09	11.24	0.27	1.77	6.33	0.66	0.95
CV (%)		8.64	9.84	6.98	14.88	6.68	23.67	8.82	6.35
Mean		22.04	142.72	18.13	3.48	1.99	10.82	9.19	15.30

Significant differences at $p \leq 1\%$, and 0.1% are depicted with asterisks (**, and *** respectively)

The mean performance of leaf yield and yield related traits in jute mallow accessions cultivated in coconut coir substrate across seasons showed high variability among the accessions (Table 4a). FUOJM 15, is significantly tall, followed by FUOJM 14 and FUOJM 2. The leaf fresh weight was maximum in FUOJM 7, next is FUOJM 5. Top three genotypes for total plant weight are FUOJM 7, FUOJM 1 and FUOJM 9. Also, FUOJM 5, FUOJM 7 and FUOJM 2 were promising for leaf length, FUOJM 4, FUOJM15 and FUOJM 9 performed best for leaf width. Considering leaf area, FUOJM 4, FUOJM 9 and FUOJM 15 outperformed others. FUOJM 11, FUOJM 10 and FUOJM 1 had significantly high number of leaves/plant. The number of nodes/plant was high in FUOJM 14, FUOJM 15 and FUOJM 16. The total plant weight (g/pot) peaked in

FUOJM 7, FUOJM 1 and FUOJM 9. The leaf fresh weight was maximum in FUOJM 1 followed by FUOJM 14. For multiple traits, FUOJM 7 is promising for total plant weight, leaf length and fresh leaf weight. Also, FUOJM 1 is promising for total plant weight and leaves/plant. As shown in Table 4b, the mean performance for plant length, total leaf weight and leaf width were not stable across seasons.

Table 4a. Mean of leaf yield and leaf yield related traits in jute mallow cultivated in coconut coir during dry and rainy seasons of 2018 and 2019.

Accessions	Total plant weight	Leaf length	Number of leaves/ plant	Leaf area	Node per plant
FUOJM 7	82.07a	3.80b	12.50abc	5.88def	9.00cde
FUOJM 1	71.16b	3.13bc	13.75ab	6.64bcde	8.75cde
FUOJM 10	57.49c	3.06bc	13.88ab	5.97cdef	8.75cde
FUOJM 9	59.95bc	3.53bc	8.25cd	7.61b	9.02cde
FUOJM 5	53.29c	4.90a	11.13abc	6.40bcde	9.25ced
FUOJM 3	46.48d	3.85b	9.75bcd	6.79bcd	7.88e
FUOJM 14	46.17d	2.03bc	10.88abcd	6.10cdef	11.25a
FUOJM 15	43.92	3.65b	9.38cd	7.21bc	10.87ab
FUOJM 12	43.41d	3.31bc	8.00d	4.93fg	8.25de
FUOJM 11	42.98	2.69d	15.00a	5.08fg	9.63bcd
FUOJM 8	41.00	3.13bc	12.00abcd	5.47efg	8.75cde
FUOJM 4	35.71	3.20bc	10.75bcd	12.00a	8.50ced
FUOJM 16	33.56	3.57bc	8.00d	4.56g	9.75bc
FUOJM 2	22.66	3.88b	9.25de	4.43g	9.00cde

followed by the same letter do not differ significantly at $p = 0.05$ by Tukey HSD

Table 4b. Accession and season interaction[a] effects on leaf yield and yield related attributes.

Means in the same column followed by the same letter do not differ significantly at $p = 0.05$ by Tukey HSD

Accessions	Plant length			Fresh leaf weight			Leaf width		
	Dry season	Rainy season	Across seasons	Dry season	Rainy season	Across seasons	Leaf Width	Dry season	Rainy season
FUOJM 7	24.36b	20.84e	22.94cd	51.43a	56.00a	53.19a	1.60b	1.61h	1.71i
FUOJM 1	18.87gh	20.24e	19.28gh	19.67e	26.35d	22.37c	2.06	1.96e	2.08g
FUOJM 10	17.38h	21.11d	18.79g	20.45d	24.22ef	22.83bc	2.09ab	1.94f	2.11f
FUOJM 9	19.21e	20.11ef	19.57fg	21.19bc	25.89e	23.25bc	2.29ab	2.11c	2.21e
FUOJM 5	28.89a	22.26c	24.48bc	22.98b	29.56b	26.19b	1.55b	1.45g	1.77i
FUOJM 3	13.42i	14.21h	13.30g	19.45e	26.77d	23.21bc	2.18ab	2.09d	2.41c
FUOJM 14	21.03d	30.0ab	25.19b	10.69	12.89j	11.89f	2.05ab	1.96ef	2.22d
FUOJM 15	28.43a	34.41a	31.69a	19.43e	23.89fg	21.58dc	2.29ab	2.14b	2.53b
FUOJM 12	18.07fg	20.92	19.97efg	12.89f	19.03h	15.54e	1.49b	1.26i	1.88h
FUOJM 11	20.81de	22.78bc	21.55def	21.67bc	29.99b	25.69bc	1.61b	1.41g	1.89h
FUOJM 8	21.13d	17.07g	19.08g	20.78d	16.98i	18.85de	2.04ab	1.89g	2.22d
FUOJM 4	17.03g	20.00f	18.59g	20.03de	27.89c	23.04bc	4.18a	3.37a	5.06a
FUOJM 16	20.11def	23.67bc	21.73cd	20.33d	24.78ef	22.38c	1.28b	1.11j	1.45j
FUOJM 2	22.69c	28.45b	25.99b	12.21f	10.35k	11.81f	1.33b	1.23i	1.45j

Jute mallow accessions cultivated in coconut coir substrate had better performance for total plant weight, fresh leaf weight, leaf/plant, leaf width, and node/plant and leaf area index during the rainy season compared to the dry season. (Table 5).

Table 5. Performance for leaf yield and yield related traits during the rainy and dry season in 2018/19

Season	Plant len gth (cm)	Total plant weight (g)	Fresh leaf weight (g)	Leaf/ plant	Leaf length (cm)	Leaf width (cm)	Node/ plant	Leaf area index (cm^3)
Rainy season	28.90a	47.55a	12.07a	11.29a	3.43a	2.19a	9.70a	5.67a
Dry season	15.17b	48.71b	12.57b	11.35b	3.52a	1.50b	8.67b	3.96b

Means in the same column followed by the same letter do not differ significantly at $p = 0.05$ by Tukey HSD

The stepwise contribution of development and leaf yield traits to total plant weight among the accessions showed that fresh plant weight and number of leaves/plant significantly explained 88% of variation in total plant weight (Table 6). They had positive values for partial R^2. The total plant weight, plant length and number of leaves/plant significantly explained variation in fresh

Table 6. Stepwise contribution of growth parameter, leaf metric and weight to total plant weight and leaf weight in Jute mallow

	Variable entered	Partial R^2	Model R^2	Pr > F
Total plant weight (Y)	Fresh plant weight	0.75	0.75	0.0001
	Number of leaves/plant	0.13	0.88	0.005
Leaf fresh weight (Y)	Total plant weight	0.97	0.97	0.0001
	Plant length	0.01	0.98	0.01
	Number of leaves/plant	0.01	0.01	0.01

Discussion

Significant variation (P≤0.01) for leaf yield and yield related traits among the jute mallow accessions is sequel to genetic make-up of each accession and differential response to microclimate factors (temperature and humidity) in the polyethylene house. The microclimatic factors (seasons) influenced plant length, number of nodes/plant, and number of leaves/plant and leaf weight. The mean values for these traits were unstable, flexible and responsive to humidity and temperature in the polyethylene house over seasons. Therefore, the need arises for continuous evaluation of jute mallow accessions over seasons and years to select accessions with stable performance for specific season and across seasons. Statistically significant mean squares (P≤0.01) for accession, and accession by season interaction (ASI) for leaf weight, leaf width, number of nodes/plant suggest cross over performance. Therefore the differences in the mean values (Table 4b) recorded during the dry and rainy seasons. The selection and recommendation of the accessions for these traits will be unreliable and complex. On the other hand, traits with not significant (P≥0.05) mean squares for accession by season interaction (ASI) showed similar and inflexible performance over seasons with high predictability. Adeniji *et al*., (2018a and 2018b) working on *Amaranthus cruentus* in the open field reported significant genotype x year interaction (GEI) for number of leaves/plant, fresh and dry leaf weight and insignificant GEI for number of nodes/plant, leaf width and leaf dry weight.

A wide range of mean evident for traits suggest opportunities to identify promising accessions (specific and multiple traits) for further evaluation and recommendation. The mean values for leaf metric and leaf yield traits diverged among the accessions. This is consistent with the genetic factors, humidity and temperature within the polyethylene house. Considering plant length, FUOJM 7, FUOJM 1 and FUOJM 9 are promising for total plant weight. FUOJM 1 and FUOJM 14 hold promise for leaf fresh weight. FUOJM 11, FUOJM 1, FUOJM 10 and FUOJM 7 performed best for number of leaves/plant. High performance for leaf weight, number of leaves/plant, leaf size is attributed to efficient photosynthetic rate and accumulation of photosynthates in the sink organ (leaf). The number of leaves/plant recorded at culling (4 WAS) had higher magnitude compared to those reported by Akoroda, (1988) and Osawaru *et al*., (2013) among field grown jute mallow accessions. FUOJM 4, FUOJM 9 and FUOJM 15 performed best for leaf area. Further, this is an important parameter in plant growth and a preferred trait among consumers of vegetable amaranth in Tanzania (Adeniji and Aloyce, 2013). The number of leaves and size are important aspect in photosynthesis. FUOJM 1 showed high potential for leaf fresh weight, total plant weight, and number of leaves/plant.

Leaf yield is highly variable, and depend on many interrelated and interacting factors. Inter-character association between two traits will ensure a better understanding of the strength of association and implication for selection. Improvement in number of leaves/plant and plant weight will increase total plant weight harvested. In a separate study, Ngomuo et al., (2017) noted positive and significant correlation coefficient between leaf fresh weight and number of leaves/plant in jute mallow grown in the open field in Tanzania. Phenotypic improvement in total plant weight, plant length and number of leaves/plant will complement leaf weight. Accessions promising for plant length will have dense vegetation. Adeniji *et al.*, (2018) working on *Amaranthus cruentus* and Maboko and Du Plooy (2012) on lettuce reported positive association between plant length and number of leaves/plant, leaf size and leaf yield. This implies that as the plant increases in length, more leaves are produced per plant and consequently high leaf yield at harvest.

Conclusion

The performance for leaf yield and leaf related traits differed among the jute mallow accessions. This is consistent with inherent genetic attributes and influence microclimate factors (temperature and humidity) in the polyethylene house over seasons.

The seasons had a strong impact on plant length, number of nodes/plant, and number of leaves/plant and leaf weight. These traits were responsive to temperature and humidity within the polyethylene house with low predictability. Accession and accession by season interaction influenced leaf weight, leaf width and number of nodes/plant. FUOJM 7, FUOJM 1 and FUOJM 9 are promising for total plant weight and plant length. FUOJM 11, FUOJM 1, FUOJM 10 and FUOJM 7 are potential parent for number of leaves/plant. FUOJM 1 is suitable for leaf fresh weight, total plant weight, and number of leaves/plant and FUOJM 4, FUOJM 9 and FUOJM 15 for leaf area.

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