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Effect of Harvesting Height and Harvesting Frequency on the Growth and Yield of Jute Mallow (*Corchorus olitorious L.*)

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Abstract: Jute mallow *Corchorus olitorious* is a vegetable from the Tiliaceae family, which is widely consumed in Africa, particularly in West Africa, where it is used as a staple vegetable. Harvesting height and frequency is key to determining the quantity and quality of this crop. Field and laboratory studies were carried out to examine the growth, herbage yield and proximate composition of Jute mallow *Corchorus olitorious* as influenced by harvesting height and frequency. The studies were composed of three harvesting heights (H1- harvesting at 10 cm above the ground, H2 - harvesting at 15 cm above the ground, H3 - harvesting at 20 cm above the ground) and three different harvesting frequencies (F1 – every week harvesting, F2 - every two weeks harvesting, F3 - every three weeks harvesting). Growth and yield characteristics and proximate composition were assessed. The results revealed that harvesting height and frequency increased the number of leaves and branches of *C. olitorious* except for the stem diameter. The yield and proximate composition of *C. olitorious* were significantly enhanced and it was observed that plants harvested every week at 10 cm above the ground (H1F1) produced lower herbage yields (1.50 and 1.87) t ha^{-1} compared with the ones harvested at 20 cm which produced higher yield (7.85 and 4.39) t ha^{-1} at three weeks harvesting frequency (H3F3) however, better quality vegetables in terms of proximate composition were harvested every week at 20 cm above ground level (H3F1).

Keywords: Harvesting height, Frequency, Jute, Proximate

INTRODUCTION

Jute mallow (*Corchorus olitorious* L.) is a dual purpose African leafy vegetables which is cultivated for its leaves and for its fibre content. It is widely distributed, cultivated and traded in some tropical and sub-tropical regions of the world and a leading leafy vegetable in many parts of Asia, middle-East and the Caribbean. In south western Nigeria, it is widely consumed because for its tender, delicious and viscose leaves. The leaves of Jute mallow is rich in calcium, galactose, magnesium and iron and contains a high percentage of vegetable protein (Grubben and Denton 2004). In Nigeria, despite the increase in demand of this vegetable the production and nutritional values are limited due to poor agronomic practices. Proper harvesting height maximizes yield while maintaining high quality seeds, herbs and stand longevity (Daniel *et al*. 2007). According to Falodun and Edafe (2020), in their work on fertilizer and harvesting height, they reported that plants harvested at some distance above soil level produced higher cumulative herbage yield, nutrient uptake, crude fat, fibre and protein content of *A. cruentus* compared to those harvested lower. Harvesting at low harvesting height removes majority of photosynthetic tissue and non-structural carbohydrates thereby reducing the energy sources for growth (Jones *et al*. 2017).

Alderman *et al*. (2011) emphasized that the energy for regrowth is supplied by carbohydrates generated in the remaining photosynthetic tissue and non-structural carbohydrates stored in lower stems of plants. Onyeonagu and Asiegbu (2012) reported a significant effect of harvesting frequency on the yield and quality of herbage produced and increase in harvest frequency was found to increase the dry matter yields of leaf blade, stem and inflorescence fractions of a degraded pasture (Onyeonagu 2008) while Teixeira *et al.* (2007) observed that the dry mass was reduced with frequent harvesting. Ibanez *et al*. (2012) reported that harvesting only temporarily reduced the rate of appearance of new shoots for a certain time and thereafter the vegetative growth continued at the same relative rate as in undisturbed plants especially in plants that were harvested at a specific height and intervals. Research has shown that repeated harvesting when done at adequate height and frequency produced higher shoot yield and more economic returns of vegetables compared with harvesting once. Therefore, this study is aimed to evaluate the response of *Corchorus olitorious* to harvesting height and frequency.

MATERIALS AND METHODS

Location of the study area

The study was carried out at the Teaching and Research Farm of the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City, Edo State, Southern Rain Forest zone of Nigeria, characterized with about 10 month rain of about 1200 mm annually. The maximum temperature is about 30^0 C and the area has a potential for two cropping seasons which is marked as the rain and dry seasons.

Soil and poultry manure collection and analysis

Prior to planting, soil samples were randomly collected from a depth of 0 – 30 cm using a metal soil auger. Composite soil samples and poultry manure were analyzed for pH, organic carbon and total nitrogen. The available phosphorous was determined by (Bray and Kurtz, 1945) and Murphy and Riley (1962), blue colour method was used to estimate phosphorus. Flame photometer was used to estimate the exchangeable sodium and potassium while Atomic Absorption Spectrophotometer (AAS) was used to determine the calcium and magnesium content of the soil. The soil is sandy loam with particle size distribution of sand (88.50 %), silt (60.00 %) and clay (55.00 %).

Experimental design

To determine the growth and yield response of *C. olitorious*, harvest heights of (H1- harvesting at 10 cm above the ground, H2 - harvesting at 15 cm above the ground, H3 - harvesting at 20 cm above the ground) and three harvesting frequencies (F1 – every week harvesting, F2 - every two weeks harvesting and F3 - every three weeks harvesting) were the treatments; replicated 3 times and arranged in a randomized complete block design. Seeds were planted in the nursery with soil rich in organic matter and seedlings were transplanted three weeks after sowing (WAS) at one seedling per stand into the experimental field. The established stands were rain fed and weeds were controlled by holing.

Data collection and Analysis

Data collection commenced at four weeks after transplanting (WAT) until inflorescence appeared. Parameters measured were plant height (cm), number of leaves, number of branches, leaf area (cm^2) and stem diameter (cm). At Harvest, fresh weights were immediately measured using electronic scale balance. The cumulative herbage fresh yield was determined at the end of the last harvest for all the treatments and used to estimate its herbage fresh yield in ($t\ ha^{-1}$).

Determination of proximate composition of *Corchorus olitorious* leaves

Leaves were harvested and air dried based on the treatment. The dry leaf samples were weighed and ground into uniform powder using Thomas Wiley Laboratory Mill Model 4 and stored in an air tight container for two weeks. The ground leaves were subjected to chemical analysis for proximate composition following the procedures described by (AOAC,1990). The moisture content was determined by oven drying at 130°C for one hour and weight differences recorded. Data collected were subjected to analysis of variance of the randomized complete block design and means were separated using LSD at 5% level of probability

RESULTS AND DISCUSSION

Physical and chemical properties of soil

The soil textural class in the study area is sandy loam and has a pH of (5.02) which is acidic, with adequate organic matter content of ($28.30\ g\ kg^{-1}$). The essential plant nutrients status of the soil, total N, ($0.05\ g\ kg^{-1}$), available P, ($14.70\ mg\ kg^{-1}$) and K, (0.20 c mol) before planting were lower than the critical values needed to support plant growth and development. (Table1).

Table 1. Chemical and physical properties of experimental soil

Soil Depth	**Soil properties**										**Soil particle size distribution (%)**			**Textural class**
		(%)	**(%)**	**(g/kg)**		**(cmol/kg)**								
0-15	pH (H_2O)	Organic matter	Total N	P	K	Ca	Mg	Na	H^{+1}	Al^{+3}	Sand	silt	clay	Sandy loam
	5.02	28.30	0.05	14.70	0.20	0.77	0.18	0.10	0.21	0.12	88.50	5.50	6.00	

Chemical properties of broilers manure

It was observed from Table 2, that the chemical analysis of the nutrients in the manure were adequate for crop production.

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Table 2. Chemical properties of broilers manure

Properties	(%)	(%)	(g/kg)	(cmol/kg)			
$pH(H_2O)$	Organic matter	Total N	P	K	Ca	Mg	Na
6.21	25.08	2.14	1.92	1.28	0.70	0.12	0.34

The effect of harvesting height and harvesting frequency on number of leaves was significant at all the sampling period. Number of leaves increased with decrease in harvesting frequency. Plants harvested every week (F1) irrespective of the harvesting height significantly produced lower number of leaves compared with those harvested every two and three weeks interval. In 2021and 2022 cropping seasons, harvesting height of 10 cm above ground level with harvesting frequency of every week interval (H1F1) significantly produced lower number of leaves per plant (122.07 and 104.71) respectively compared with (168.52 and 141.28) harvesting height of 20 cm above ground level with harvesting frequency of two weeks (H3F2) and then (175.31 and 160.33) harvesting height of 20 cm above ground level with harvesting frequency of three weeks interval (H3F3) which produced significantly ($P < 0.05$) higher number of leaves per plant (Table 3).

Table 3. Effect of Harvesting height and Harvesting frequency on number of leaves, number of branches and stem diameter of *C olitorious* 2021 and 2022 cropping season

Treatment	2021 Cropping season			2022 Cropping season		
	Number of leaves $plant^{-1}$	Number of branches $plant^{-1}$	Stem diameter $plant^{-1}$ (cm)	Number of leaves $plant^{-1}$	Number of branches $plant^{-1}$	Stem diameter $plant^{-1}$ (cm)
H1F1	122.07^{b}	7.14^{b}	0.87^{a}	104.71^{c}	5.67^{b}	0.45^{a}
H1F2	139.93^{ab}	8.42^{a}	0.88^{a}	123.98^{b}	5.34^{b}	0.50^{a}
H1F3	141.70^{ab}	8.55^{a}	0.61^{a}	126.67^{b}	6.58^{a}	0.48^{a}
H2F1	124.25^{b}	7.60^{b}	0.72^{a}	110.82^{bc}	4.68^{b}	0.30^{a}
H2F2	124.17^{b}	8.58^{a}	0.69^{a}	131.40^{ab}	6.59^{a}	0.40^{a}
H2F3	144.12^{ab}	8.81^{a}	0.69^{a}	154.58^{a}	6.76^{a}	0.47^{a}
H3F1	130.20^{b}	7.75^{a}	0.75^{a}	128.85^{b}	5.76^{ab}	0.42^{a}
H3F2	168.52^{a}	8.36^{a}	0.79^{a}	149.28^{a}	6.61^{a}	0.48^{a}
H3F3	175.31^{a}	8.67^{a}	0.70^{a}	160.33^{a}	6.72^{a}	0.40^{a}
LSD	20.89	1.41	0.30	14.79	1.15	0.46
Significance	*	*	Ns	*	*	Ns

(H1- harvestings at 10cm above the ground, H2 - harvestings at 15cm above the ground, H3 - harvestings at 20cm above the ground) and three different harvesting frequency (F1 – every week harvesting, F2 - every two weeks harvesting, F3 - every three weeks harvesting

The higher number of leaves produced with two and three weeks harvest interval suggests that these frequencies of harvest encouraged new flushes to emerge. On the other hand, the lower number of leaves obtained from harvesting every week at 10 cm above ground level (H1F1) could be attributed to the frequent harvesting wounds inflicted on the plants at the time of harvest. These wounds expose the crop to rapid transpiration that can result in excessive loss of water and consequent reduction in the general metabolism of the plant. In both, cropping seasons there were significant differences in the number of branches, plants harvested every week at 10 cm above ground (H1F1) significantly produced lower number of branches compared with those harvested every two and three weeks interval. Stem diameter and leaf

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area were not significantly influenced by harvesting height and harvesting frequency (Table 3 and 4).

Table 4. Effect of harvesting height and harvesting frequency on leaf area (cm ^{2}) fresh and dry herbage weight of *C olitorious* in two cropping seasons

Treatment	2021 Cropping season			2022 Cropping season		
	Leaf area plant $^{-1}$ (cm^2)	**Fresh herbage weight plant $^{-1}$ (g)**	**Dry herbage weight plant $^{-1}$ (g)**	**Leaf area plant $^{-1}$ (cm^2)**	**Fresh herbage weight plant $^{-1}$ (g)**	**Dry herbage weight plant $^{-1}$ (g)**
H1F1	117.96^{a}	62.87^{d}	13.37^{d}	103.68^{a}	46.12^{c}	14.28^{c}
H1F2	118.94^{a}	47.89^{d}	10.84^{d}	104.75^{a}	56.13^{bc}	15.45^{ab}
H1F3	123.85^{a}	58.60^{d}	12.92^{d}	105.85^{a}	76.92^{abc}	20.70^{bc}
H2F1	121.96^{a}	161.28^{cd}	30.61^{cd}	103.53^{a}	54.56^{bc}	13.95^{c}
H2F2	126.89^{a}	141.65^{cd}	30.52^{cd}	116.82^{a}	87.30^{ab}	17.31^{c}
H2F3	125.36^{a}	203.77^{c}	47.09^{c}	115.34^{a}	108.88^{a}	28.53^{ab}
H3F1	115.25^{a}	402.13^{b}	85.83^{b}	116.23^{a}	84.14^{ab}	16.03^{c}
H3F2	119.03^{a}	476.52^{ab}	112.18^{ab}	119.12^{a}	107.13^{ab}	24.41^{ab}
H3F3	126.69^{a}	592.46^{a}	129.57^{a}	124.47^{a}	109.90^{a}	31.42^{a}
LSD	19.62	125.45	28.15	19.61	36.02	9.99
Significance	NS	*	*	NS	*	*

(H1- harvestings at 10cm above the ground, H2 - harvestings at 15cm above the ground, H3 - harvestings at 20cm above the ground) and three different harvesting frequency (F1 – every week harvesting, F2 - every two weeks harvesting, F3 - every three weeks harvesting)

Analysis of plants harvested showed that frequent harvesting of one week interval at 10 cm harvesting height above ground level (H1F1), significantly produced lower fresh (62.87g and 46.12g) and dry herbage weight (13.37g and 14.28g) of *C. olitorius* in both cropping seasons (Table 4). This could probably be as a result of increase in harvesting pressure and constant removal of leaves which slowed down growth and production of new leaves in affected plants. The leaves serve as both source and sink for photosynthates and frequent harvesting of the leaves obstructs the crop for effective photosynthesis leading to reduced dry matter accumulation. This result corroborates the report of Umunnakwe *et al.*, (2022); Chukwudi and Agbo (2014), that marketable leaf yield of fluted pumpkin declines in as a result of increase in leaf harvest frequency. It was observed that the herbage fresh and dry weight of *C. olitorius*, followed similar pattern in both years and increased with delay in harvest frequency and with increase in harvesting height. In both years, harvesting of three weeks interval at 20 cm harvesting height above ground level (H3F3) produced significantly ($P < 0.05$) higher fresh herbage weight (592.46g and 109.90g) and dry herbage weight (129.57g and 31.42g) respectively. The higher fresh herbage and dry weight produced with delay in harvesting frequency, may be due to the fact that the plants had more time to recuperate for higher vegetative growth which is in agreement with (Ahmed and Muhinda, 2017). Highest cumulative fresh yield (7.85 t ha $^{-1}$ and 4.39 t ha $^{-1}$) and dry yield (2.59 t ha $^{-1}$ and 1.26 t ha $^{-1}$) were produced at harvesting of three weeks interval at 20 cm height above ground level (H3F3). This was not significantly different from (6.53 t ha $^{-1}$ and 4.24 t ha $^{-1}$) and (2.47 t ha $^{-1}$ and 1.13 t ha $^{-1}$) produced for harvesting of two weeks interval at 15 cm (H2F3) while lowest herbage yield (1.87 t ha $^{-1}$) was produced at harvesting height of 10 cm above ground level with harvesting frequency of every week interval (H1F1) Table 5.

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Table 5. Effect of harvesting height and harvesting frequency on fresh and dry herbage yield of *C olitorious* in two cropping seasons

Treatment	**2021 Cropping season**		**2022 Cropping season**	
	Fresh herbage yield (t ha $^{-1}$)	**dry herbage yield (t ha $^{-1}$)**	**Fresh herbage yield (t ha $^{-1}$)**	**Dry herbage yield (t ha $^{-1}$)**
H1F1	1.50^{c}	0.32^{b}	1.87^{c}	0.49^{d}
H1F2	3.47^{bc}	0.75^{b}	3.44^{ab}	0.80^{bcd}
H1F3	6.72^{a}	2.29^{a}	3.04^{abc}	0.71^{cd}
H2F1	1.28^{c}	0.29^{b}	2.18^{bc}	0.55^{d}
H2F2	3.42^{bc}	0.76^{b}	3.49^{ab}	1.09^{abc}
H2F3	6.53^{a}	2.47^{a}	4.24^{ab}	1.13^{ab}
H3F1	1.37^{c}	0.30^{b}	2.28^{bc}	0.64^{d}
H3F2	4.95^{b}	0.82^{b}	2.03^{bc}	0.58^{d}
H3F3	7.85^{a}	2.59^{a}	4.39^{a}	1.26^{a}
LSD	2.68	0.68	1.44	0.39
Significance	*	*	*	*

* Significant at 5% level of probability. (H1- harvestings at 10cm above the ground, H2 - harvestings at 15cm above the ground, H3 - harvestings at 20cm above the ground) and three different harvesting frequency (F1 – every week harvesting, F2 - every two weeks harvesting, F3 - every three weeks harvesting)

Stem harvestings at several intervals above the ground permit the lateral shoots to grow and promotes the presence of more functional nodes from which side shoot re-growth occurred. The increase in fresh and dry herbage yield from every three weeks harvesting at 20 cm above ground level (H3F3) could be as a result of the presence of more functional nodes which occurred. This probably could have promoted increase in the number of branches and leaves and subsequently increase in herbage yield. Ahmed and Oladiran (2012); Falodun and Edafe (2020) observed similar results in their work, these results demonstrates that less destructive harvesting heights are beneficial for leafy vegetables. Similarly, delay in harvesting could have influenced the expansion of the cell wall and increased the structural carbohydrate and lignin contents of the plants as the plant matures. Flores *et al.*, (2012) found that dry matter, leaf and stem fractions of a plant increases as the plant matures. The result of the proximate analysis showed differences amongst the treatments. Significantly ($p < 0.05$) higher percentage moisture content, crude protein and fat (6.76, 39. 80 and 14.28) contents respectively were found at harvesting of every week interval at 20 cm harvesting height above ground level (H3F1) with lower percentage ash (7.30) and crude fibre (4.30) contents compared with other treatments. This result was slightly comparable with those obtained from H1F1 in terms of moisture content, crude protein, crude fibre and fat content (6.43, 22.7, 4.21 and 11.33) respectively. The increase in the moisture and crude protein of H3F1 compared to other harvesting intervals may be as a result of frequent harvest of the young succulent leaves and stem fraction. Okwu and Morah (2004) stated that high moisture content in vegetables determines the quality and freshness of the vegetables. The protein values in this study was between 20.10 % and 29.80 %, which is rich in nutritional value and comparable with the leaves of Cassava (24.88 %) and *Piper guineenses* (29.78 %), Akindahunsi and Salawu (2005). The reduction in the crude protein and increase fiber contents of *C olitorious* with delay in the harvesting interval may probably be due to the increase in the proportion of the stem and of senescent material as the plant ages. This observation corroborates the work of Goméz and Valdivieso (1985); Khuc Thi Hue, *et al.*, (2014) who asserted that as the plant biomass becomes older, crude protein decreases with increase in fibre content of plants. Ash content of *C olitorious* was relatively high in H1F1 (10.70), H2F1 (10.37), H2F2 (10.61), H2F3 (10.72), H3F2 (10.34), H3F1 (10.30) and H3F3 (10.95) when compared with the values obtained in H1F2 (8.95) and H1F3 (8.13). Higher crude fat content with early harvesting supports the work of Sossa-Vihotogbe *et. al*, (2013). The Crude fiber did not follow a particular pattern but increased in this other H1F3> H2F3>H2F1>H2F2>H3F3>H3F2>H1F2>H3F1>H1F1.

The nitrogen free extract (NFE) of the leaves revealed fluctuating values (40.82% - 50.75%). Significantly higher nitrogen free extract (50.75) was produced at H1F2 although not significantly different from H1F3 (48.05), H2F3 (48.89), H3F1 (48.89), H3F2 (48.46) and H3F3 (47.62) while lower nitrogen free extract (40.82) was produced at H1F1, but not significantly ($p < 0.05$) different from H2F1 and H2F2 (46.23 and 45.10) respectively (Table 6).

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Table 6. Effect of harvesting height and harvesting frequency on percentage proximate composition of *C olitorious*

Treatments	Moisture (%) content	Crude protein	Ash	Crude Fat	Crude fibre	Nitrogen free extract
H1F1.	8.43[a]	22.70[a]	10.70[a]	11.33[a]	4.21[b]	40.82[b]
H1F2.	5.26[c]	20.10[b]	8.95[b]	10.34 [b]	4.32 [b]	50.75[a]
H1F3.	6.30[b]	21.00[b]	8.13[c]	11.34 [b]	6.05[a]	48.05[a]
H2F1.	8.28[a]	21.00[b]	10.37[a]	10.93 [b]	4.78 [b]	46.23[ab]
H2F2.	6.25[b]	20.90[b]	10.61[a]	11.59 [b]	5.54 [b]	45.10 [ab]
H2F3.	5.16[c]	21.90[b]	10.72 [a]	10.92 [b]	5.93 [b]	48.89 [a]
H3F1.	8.76[a]	29.80[a]	10.30[a]	14.28[a]	4.30 [b]	48.89[a]
H3F2.	6.47[a]	25.90[a]	10.34[a]	11.35 [b]	5.52[b]	48.46[a]
H3F3.	5.13[c]	20.10[b]	10.95[a]	10.36 [b]	5.53[a]	47.62[a]
Significant	*	*	*	*	*	*
LSD	0.653	10.76	0.674	1.699	0.918	6.577

* Significant at 5% level of probability. (H1- harvestings at 10cm above the ground, H2 - harvestings at 15cmabove the ground, H3 - harvestings at 20cm above the ground) and three different harvesting frequency (F1 – every week harvesting, F2 - every two weeks harvesting, F3 - every three weeks harvestin

CONCLUSION

Harvesting height and harvesting frequency significantly influenced some of the vegetative traits, herbage yield and quality of *C. olitorious*. Plants harvested every week at 20 cm above ground level (H3F1) increasingly produced tender and higher values for proximate composition. However, in terms of higher herbage yield *C. olitorious* should be harvested every three weeks at 20 cm above ground level (H3F3).

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Conflict of Interests

There is no conflict of interest declared by the authors.

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