Influence of Intra-Row Spacing, Training and Pruning on Performance of Vine Spinach (*Basella Alba L)* in Western Kenya

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Abstract

Basella alba L is a highly nutritious indigenous leafy vegetable besides medicinal benefits as compared to other leafy vegetables. Locally known as 'Enderema' in Luhya (Western Kenya) has the potential to alleviate malnutrition among communities in Western Kenya and beyond. However, production is limited by a number of factors, including competition for land area with other crops, lack of skills in preparation for consumption and storage, unavailability of seed and lack of appropriate husbandry practices. In order to promote production, an experiment was conducted to evaluate training, spacing and pruning effect on biomass production. Three types of training and spacing and two types of pruning were evaluated. A one season experiment was laid in a Randomized Completely Block Design (RCBD) with three replicates in two sites in Busia and Bungoma counties. All plots were applied with Farm yard manure and Mavuno planting fertilizer (N P K Cao Mg S) after soil analysis. Data was collected and subjected to analysis of variance at (P <0.05) using SAS Mixed linear model version 2012. The parameters measured included Plant height, Number of leaves, Number of branches at 88 Days after Transplanting (DAT). Analysis of variance indicate that trellising gave the highest plant height (54 cm), Number of leaves (34), Number of branches (25) and dry matter (28 tons/ha). While no staking, no pruning and intra-row spacing of 15 cm gave the lowest plant height, Number of leaves and Number of branches and dry matter. Bumala and Kabuchai showed similar trends. The best combination is the interaction of trellising, double stem pruning and intra-row spacing of 20 cm which gave mean plant height of 54 cm and dry matter (33 tons/ha). From the present study I recommend a combination of intra-row spacing of 20 cm, double stem pruning and trellising for optimum yield. A study on the most economical and appropriate training method to establish viable and farmer friendly method.

Key words: *Basella alba,* Intra-Row Spacing and Western Kenya.

INTRODUCTION

Basella alba belongs to the family Basellacaceace, genus basella and species alba, It is native to tropical Asia, (Grubben and Denton, 2004) and Africa. It is a fast growing indigenous leaf vegetable, which is cultivated both as perennial and annual crop for home gardens and as a cash crop. It is propagated by seed, root or long tip cuttings. The leaves are thick, semi, succulent heart –shaped, with a mild flavour and mucilaginous texture. It is a vigorous growing with climbing habit and does better with support when sprawling on the ground to keep the foliage clean (Palada and chang, 2003). *Basella alba* does well in tropical and subtropical climate. However it being perennial performs poorly due to insect pest and high temperature [Grubben.1997]. is highly nutritious compared to most indigenous leafy vegetable, available in western Kenya *Basella alba* and East Africa. It is nutritionally rich in vitamin A, B, C, iron and calcium, (Grubben and Denton, 2004).The juice of leaves has been prescribed against constipation especially for children and pregnant women [Duke and Ayensus 1985]. Since it is a crop it plays a role in food and nutrition security particularly during the dry period (Mandu *etal.*, 1999). Research conducted in the glass house at Lareastein International Agricultural College (LIAC), Deventer.

Indigenous vegetable production in Kenya has been on a declining trend (Ministry of Agricultural 2014, annual report). In Bungoma County in 2014 of the targeted 42 MT only 35 MT of indigenous vegetables were produced. There is scanty information of *Basella alba* production levels in western Kenya, and the current production is less the 1 MT per annum despite its nutritional and economic importance (MOA report 2015). The reasons for low production include poor training methods, poor agronomic management especially pruning, spacing as well propagation materials. The area under indigenous vegetables is also low compared to other vegetables, for instance only 500 hectares were allocated to indigenous vegetables of the total 14893 hectares under vegetables (Annual report, MoA Bungoma county 2015). Besides People often consider vegetables to be of limited importance, mainly because they are not aware of the nutritive value. This is a clear misconception because the human body needs major minerals like iron, calcium, phosphorus, magnesium as well as trace elements and vitamins that are essential for the health of the people, especially vitamins such as ß-carotene and ascorbic acid.

Limited information available on the mode of preparation suggests that the presence of undesirable chemical compounds in these potential crops cannot be overruled. Most of the indigenous vegetables have been reported to contain anti-nutrient factors. Oxalates found in Amaranthaceae and Solanaceae vegetables may bind calcium and render it unavailable, Alkaloids found in the bitter types of *Crotalaria* and *Solanum* species may cause stomach-ache if eaten in excess, Spider plants contain phenolic compounds which bind proteins thereby reducing the nutritional value of the vegetable. The smell of spider plant caused by an acrid volatile oil has a high phenolic content and glucosinolates which interfere with iodine metabolism as occurs in *Brassica carinata*.

Despite its nutritional and medicinal benefit, *Basella alba* is consumed at minimum rate due to low level of production as it is almost getting extinct in western Kenya Abukutsa-onyango, (2007). Hence there is need to improve on the production so as to promote consumption, thereby preventing nutrient deficiency diseases, such as night blindness scurvy ,and rickets which are common in slums and rural areas.

Therefore understanding the appropriate agronomic practices especially spacing, training and pruning would enhance productivity of *Basella alba* in Western Kenya. *Basella alba* is well adapted to harsh climatic conditions and disease infestation and are easier to grow in comparison to their exotic counterparts such as tomatoes and cabbages among others. Indigenous leafy vegetables can produce seed under tropical conditions unlike the exotic vegetables. They have a short growth period with most of them being vegetables ready for harvesting within 3-4 weeks, and respond very well to organic fertilizers. Most of them have an in built ability to withstand and tolerate some biotic and abiotic stresses. They can also

flourish under sustainable and environmental friendly cropping conditions like intercropping and use of organics.
Furthermore, because most of them have not been intensively selected, they have wide genetic bases, which will be important in sourcing for new genotypes and/or genes for adaptation to climate change.

Trainings is an important agronomic management practice in the production of *Basella alba*. It reduces disease and pest infestation; ensure quality leaves, easy field activities i.e. pruning, spraying, weeding and fertilizer application among others. However, there is little information on methods of training and relative advantage of each on *Basella alba*. Farmers in Western Kenya just allow the crop to grow widely. Therefore there is need to establish the best and most economical method of training the crop in Western Kenya. Research conducted elsewhere indicated trellis give optimum yield when constructed at 30 cm above the ground. The stake must also be stout and at least 2 meters tall (Lucas, 1988).

On the other hand *Basella alba* requires pruning for optimum growth just like other vegetables such as tomatoes. In order to maximize the efficiency of photosynthesis and minimize the risk of disease, each tomato leaf must have plenty of room and be supported up off the ground. When a tomato plant lies on the ground, or when its growth is extremely dense, many of its leaves are forced into permanent shade, which greatly reduces the amount of sugar they produce. If a leaf uses more sugar than it makes, eventually it will bes yellow and drop off. A pruned and staked plant will produce larger fruit two to three weeks earlier than a prostrate one.

MATERIALS AND METHODS

Experimental sites

The study was conducted at two sites, namely Kabuchai and Bumala sub-counties in Bungoma and Busia Counties. The sites for trial were moderately fertile soil, homogeneous in terms of soil fertility status neither on slopes nor on shallow soil,had similar cropping and past management history. The sites represented the broad agro-ecological zones of Bungoma and Busia Counties. .Kabuchai site was at altitude of 11592 m above sea level .It was humid receiving an annual rainfall Between 1200 -1800mm with a mean temperature of 22c ,soils were sandy –clay on gentle sloping land ,well drained .Bumala site was at altitude of 1321 m above sea level. It receives between 1100 -12450 mm rainfall amounts with a mean temperature of 28, soils were sandy loan on gentle land well drained.

Treatments

The experiment consisted of eighteen (18) treatments. The treatments were:
Intra-row spacing of : (I_1) 15 cm, (I_2)- 20cm and (I_3)-25cm
Pruning: (P_1)- No Pruning (P_2)- Double stem pruning
Training : (T_1)- No staking (T_2)- One stake per plant (T_3)-Trellising

Table 1: Treatment combination

		I_1	I_2	I_3
	P_1	$I_1 P_1 T_1$	$I_2 P_1 T_1$	$I_3 P_1 T_1$
T_1	P_2	$I_1 P_2 T_1$	$I_2P_2 T_1$	$I_3 P_2 T_1$
	P_1	$I_1 P_1 T_2$	$I_2 P_1 T_2$	$I_3 P_1 T_2$
T_2	P_2	$I_1 P_2 T_2$	$I_2 P_2 T_2$	I_3 P2 T_2
	P_1	$I_1 P_1 T_3$	$I_2 P_1 T_3$	$I_3 P_1 T_3$
T_3	P_2	$I_1 P_2 T_3$	$I_2 P_2 T_3$	$I_3 P_2 T_3$

Experimental Design

The experiment was factorial laid out in a Randomized Complete Block Design (RCBD) with three replicates. The plot sizes were 3m x 4 m. A blanket application of .All plots were applied with farmyard manure at the rate of 240g per plot i.e. 2 tons/ha and Mavuno planting (NPK Cao Mg S) at the rate of 180 g per plot i.e 20% elemental Phosphorus.The fertilizer was incoprerated in the plot before planting.

Parameters measured

Data collected included plant height, which was determined using a tape measure, Number of leaves and branches by visual counting, above ground biomass, which was measured using a weighing balance (5000 g with 0.001 precision). Fresh biomass was oven dried and weight using a weighing balance. These data was collectd at 88 Days after Transplanting (DAT).

Data Analysis

Data collected was subjected to analysis of variance to determine the effects of trellising, pruning Intra-row spacing and their interaction on *Basella*. *alba* agronomic and yield performance using mixed linear model (Mixed procedure SAS Institute 2012).The means were compared using Least Significance Difference (LSD).

RESULTS

Effect of training on mean plant height, number of leaves, Number branches and dry matter of *Basella alba* in Kabuchai and Bumula

Analysis of variance show that training signficanttly influences plant height in Kabuchai and Bumala. At Kabuchai trellising gave the hghest plant height (54 cm) which was not statistically different from one stake per plant (52 cm) but both significantly differed from no staking (38 cm) (Table 2). A similar trend was shown in Bumala (Table 3).

In terms number of leaves, training als0 signfcantly influenced with Trellising giving highest (32) while one stake per plant gave 31 although statistically similar and no staking recorded the lowest number of leaves (25) at Kabuchai (Table 2). In Bumula trellising and onestake per plant also statistically differed with no staking (Table 3). Number of branches and dry matter also showed similar trend as trellising resulted in higest branches and dry matter respectively in both Kabuchai and Bumala (Table 2 and 3).

Table 2: Effect of Training on mean plant height, number of leaves, branches and dry matter of Basella alba -Kabuchai

Training	Mean Plant height (cm)	Mean number of leaves	Mean number of branches	Average DM ton/ha
No training (T_1)	38b	25b	14b	9c
Staking (T_2)	52a	31a	17a	26b
Trellising (T_3)	54a	32a	16a	28a
CV%	26.1	23.1	31	30
Lsd	10.1	3.2	1.6	0.42

Means with same letters in the column are not significantly different.

Table 3: Effect of Training on mean Plant height, Number of leaves and branches of Basella alba-Bumala

Training	Mean Plant height (cm)	Mean number of leaves	Mean number of branches	Average DM ton/ha
No training (T_1)	35b	23b	11b	5c
Staking (T_2)	48a	30a	13a	21b
Trellising (T_3)	46a	27a	14a	24a
CV%	20.1	24.1	22.5	23.6
Lsd	5.2	3.5	1.8	1.2

Means with same letters in the column are not significantly different.

Effect of Pruning on mean plant height, number of leaves, Number branches and dry matter of *Basella alba* in Kabuchai and Bumula

Pruning signifiacantly influenced plant height in both Kabuchai and Bumala. Double stem pruning gave highest mean plant height (52.7 cm) and (44.7 cm) in Kabuchai (Table 4) and 51.6 cm and 40.2 cm in Bumala (Table 5) respectively.

Analysis of variance also showed that numbers of leaves were significantly influenced by pruning. Double stem pruning (P2) recorded the highest number of leaves (26.5) at Kabuchai and (25.8) at Bumala and lowest number of leaves recorded at no pruning (P1) in both sites respectively.

A similar trend was observed on number of branches and dry matter in both Kabuchai and Bumala. Number of branches was highest at double stem pruning when compared to no pruning i.e.16.9 branches in Kabuchai at and 15.9 at Bumala while lowest number of branches recorded at no pruning i.e. 15.3 and 14.7 in Kabuchai and Bumala respectively.
Pruning positively influenced dry matter with no pruning recording the lowest dry matter (5.7 tons/ha) at Kabuchai and 3.4 tons/ha at Bumala respectively. These were significantly different from double stem pruning as shown in Tables 4 and 5 respectively.

Table 4: Effect of Pruning on mean Plant height, Number of leaves and branches of Basella alba-Kabuchai

Pruning	Mean Plant height (cm)	Mean number of leaves	Mean number of branches	Average DM ton/ha
No pruning (P_1)	44.7b	23.2b	15.3b	5.7b
Pruning (P_2)	52.7a	26.5a	16.9a	11.5a
CV%	26.1	23.1	31	30
Lsd	2.16	1.96	0.88	0.42

Means with same letters in the column are not significantly different.

Table 5: Effect of Pruning on mean Plant height, Number of leaves and branches of Basella alba-Bumala

Pruning	Mean Plant height (cm)	Mean number of leaves	Mean number of branches	Average DM ton/ha
No pruning (P_1)	40.2b	22.7b	14.7b	3.4b
Pruning (P_2)	51.6a	25.8a	15.9a	9.3a
CV%	20.1	24.1	22.5	26
Lsd	6.7	2.1	0.52	2

Means with same letters in the column are not significantly different.

Effect of Intra-row spacing on mean plant height, number of leaves, Number branches and dry matter of *Basella alba* in Kabuchai and Bumula

Intra-row spacing significantly influenced by plant height in both Kabuchai and Bumala as demonstrated in table 5 and 6 respectively. Intra-row spacing of 15 cm (I_1) recorded the highest plant height of 54 cm compared to 50 cm and 48 cm at intra-row spacing of 20 cm (I_2) and 25 cm (I_3) at Kabuchai (Table 6). A similar trend was also observed at Bumala (Table 7) where Intra-row spacing of 15 cm (I_1) recorded the highest plant height of 50 cm compared to 46 cm and 47 cm at intra-row spacing of 20 cm (I_2) and 25 cm (I_3) respectively. Number of leaves were also significantly influenced by intra-row spacing with intra-spacing of 15 cm (I_1) recording more leaves followed by intra-row spacing of 20 cm (I_2) and 25 cm (I_3) at both Kabuchai and Bumula (Table 7).

Intra-row spacing significantly influenced number of branches in both Kabuchai and Bumala. In Kabuchai intra-row spacing of 15 cm (I_1) significantly differed intra-row spacing of 20 cm (I_2) and 25 cm (I_3) i.e. 13, 18 and 16 respectively. However, intra-row spacing of 20 cm (I_2) and 25 cm (I_3) were not statistically different (Table 6). The same trend was observed at Bumala as shown in table 7.

Table 6: Effect of intra spacing on mean Plant height, Number of leaves and branches of Basella alba-Kabuchai

Intra spacing	Mean Plant height (cm)	Mean number of leaves	Mean number of branches	Average DM ton/ha
15 cm (I_1)	54b	34b	13b	7.1c
20 cm (I_2)	50a	30a	18a	28b
25 cm (I_3)	48a	29a	16a	21a
CV%	26.1	23.1	31	25.7
Lsd	3.2	1.96	2.1	1.9

Means with same letters in the column are not significantly different.

Table 7: Effect of intra spacing on mean Plant height, Number of leaves and branches of Basella alba-Bumula

Intra spacing	Mean Plant height (cm)	Mean number of leaves	Mean number of branches	Average DM ton/ha
15 cm (I1)	50b	32b	12.5b	5.3c
20 cm (I2)	46a	29a	16.5a	22.8b
25 cm (I3)	47a	27a	15.4a	20.6a
CV%	20.1	24.1	22.5	29.2
Lsd	2.91	2.2	2.7	1.2

Means with same letters in the column are not significantly different.

Intra-row spacing of 20 cm (I_2) yielded highly interms of dry matter compared to Intra-row spacing of 15 cm (I_1) and Intra-row spacing of 25 cm (I_3) in both Kabuchai and Bumala (Table 6 and 7) respectively.

The highest yield on dry matter basis (28 ton/ha) were recorded from Intra-row spacing of 20 cm (I_2) while the lowest dry matter per hectare was recorded from Intra-row spacing of 15 cm (I_1) with 7.1 tons/ha, which was statistically different from Intra-row spacing of 25 cm (I_3) (21 tons/ ha) at Kabuchai.

In Bumala, analysis of variance also showed significant differences among intra-row spacing in relation to dry matter (Table 7). The highest dry matter (22.8 tons/ ha) was recorded from Intra-row spacing of 20 cm (I_2) which was statistically different from intra-row spacing of 15 cm (I_1) (5.3 tons/ha) and intra-row spacing of 25 cm (I_3) i.e. 20.6 tons/ha.

Effect of the Interaction between Training, Pruning and Intra-row spacing on mean plant height, number of leaves, Number branches and dry matter of *Basella alba* in Kabuchai and Bumula

Plant height (mean cm)

Analysis of variation Figure 4 show significant interaction of training, pruning and intra-row spacing. No staking interacting with no pruning and intra-row spacing of 25 cm (39 cm) recorded the lowest plant height while trellising interacting with double stem pruning and intra-spacing of 20 cm recorded the highest plant height (54 cm) at Kabuchai.

A similar trend was observed in Bumala as the analysis of variance also showed positive interaction between training and pruning, training and intra-row spacing, intra-row spacing and pruning then training with pruning with intra-row spacing. The highest plant height recorded at trellising interacting with double stem pruning and intra-spacing of 20 cm recorded the highest plant height (5 cm) which was statistically similar to one stake per plant interacting with pruning and intra-spacing of 15 and 20 cm respectively Fg 5 and Appendix 1

Number of leaves and branches (Mean)

The interaction between training and pruning, training and intra-row spacing, intra-row spacing and pruning was significant at $P \leq (0.005)$ α levels (Appendix 2) and Fg 1. The highest interaction (3 ways) i.e. was obtained at tresllising with double stem pruning and intra- row spacing of 20 cm. However this was not significantly different from one stake per plant, double stem pruning and inter-row spacing of 25 cm at Kabuchai (F1 and F6).

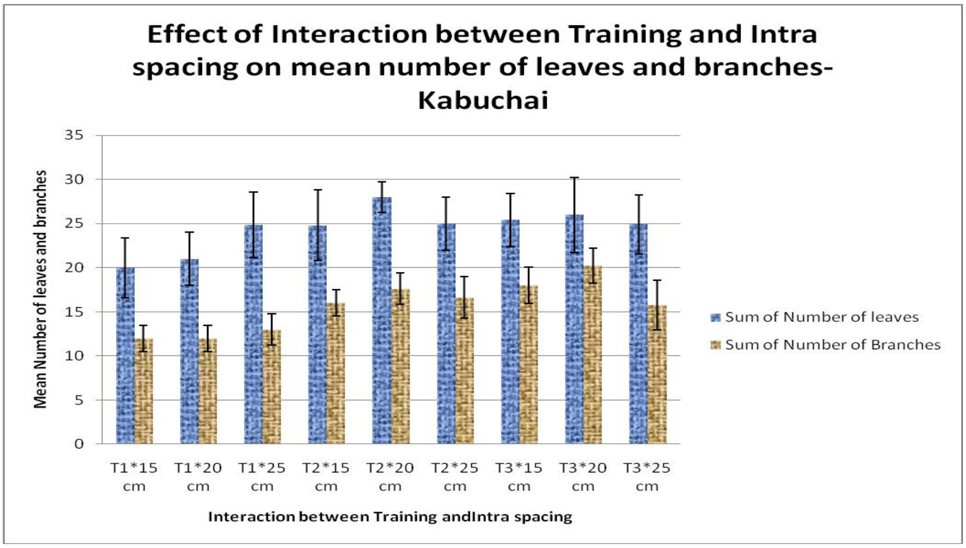

Figure 1: Effect of Interaction between training and Intra-row spacing on mean number of leaves and branches-Kabuchai

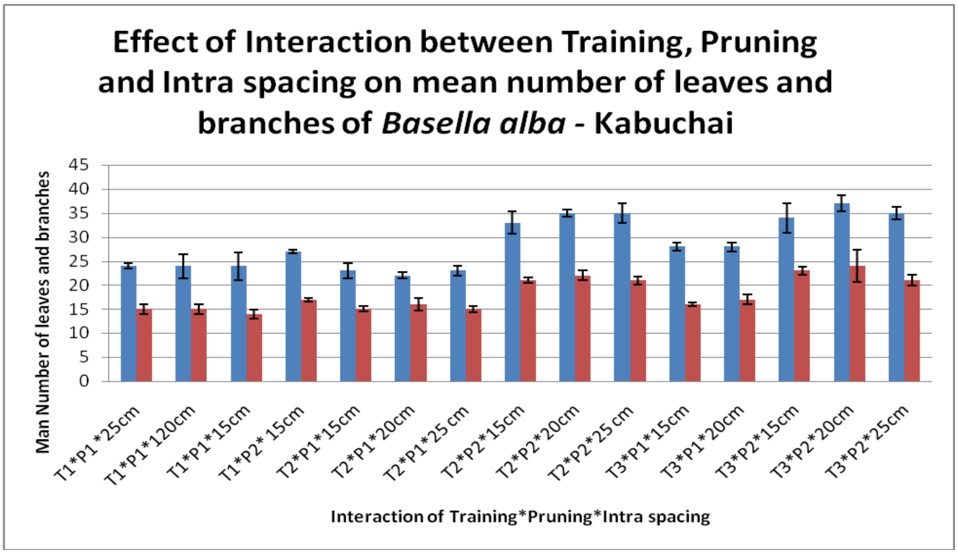

Figure 2: Effect of Interaction between training, pruning and Intra-row spacing on mean number of leaves and branches-Kabuchai

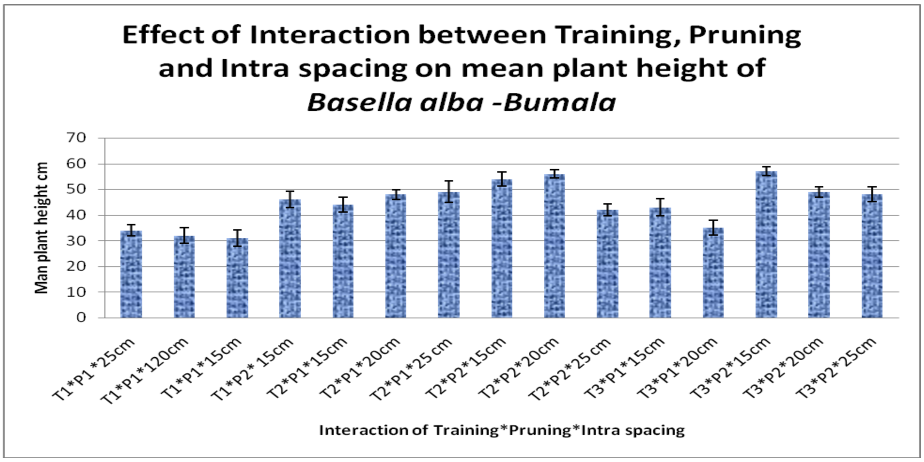

Figure 3: Effect of Interaction between training, pruning and Intra-row spacing on mean plant height –Bumala

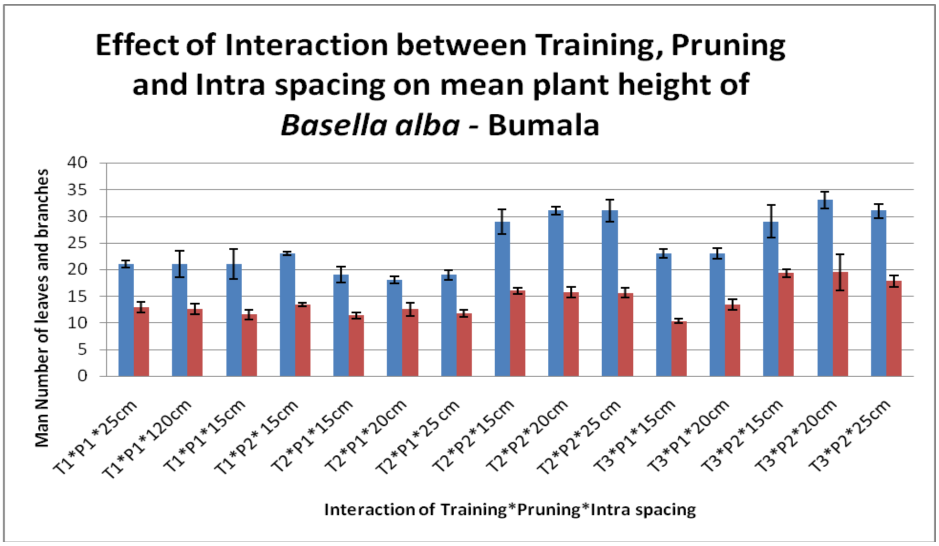

Figure 4: Effect of Interaction between training, pruning and Intra-row spacing on mean number of leaves and branches-Bumala

Dry matter (tons/ha)

Analysis of variation show significant interaction of training, pruning and intra-row spacing in Bumala Figure 8. No staking interacting with no pruning and intra-row spacing of 25 cm (3.4 tons/ha) recorded the lowest dry matter while trellising interacting with double stem pruning and intra-spacing of 20 cm recorded the highest dry matter (31 tons/ha) at Bumala.

A similar trend was observed in Kabuchai as the analysis of variance also showed positive interaction between training and pruning, training and intra-row spacing, intra-row spacing and pruning then training with pruning with intra-row spacing. The highest dry matter recorded at trellising interacting with double stem pruning and intra-spacing of 20 cm (33 tons/ha) which was statistically similar to one stake per plant interacting with pruning and intra-spacing of 15 and 20 cm respectively Fg 9.

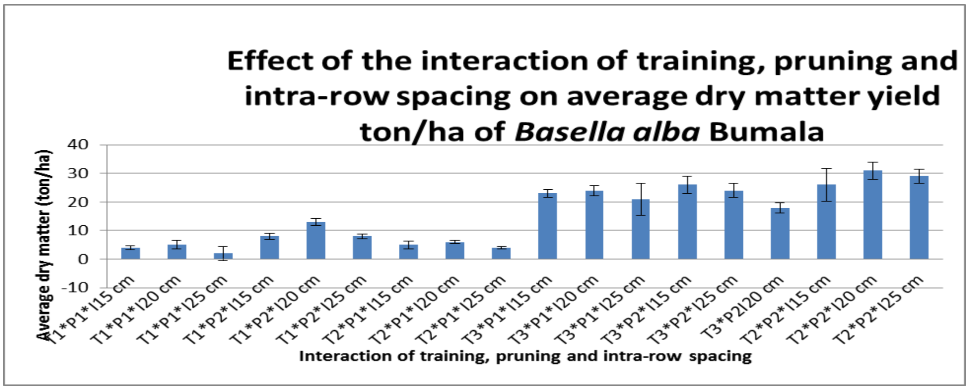

Figure 5: Effect of Interaction between training, pruning and Intra-row spacing on average dry matter in tons/ha-Bumala

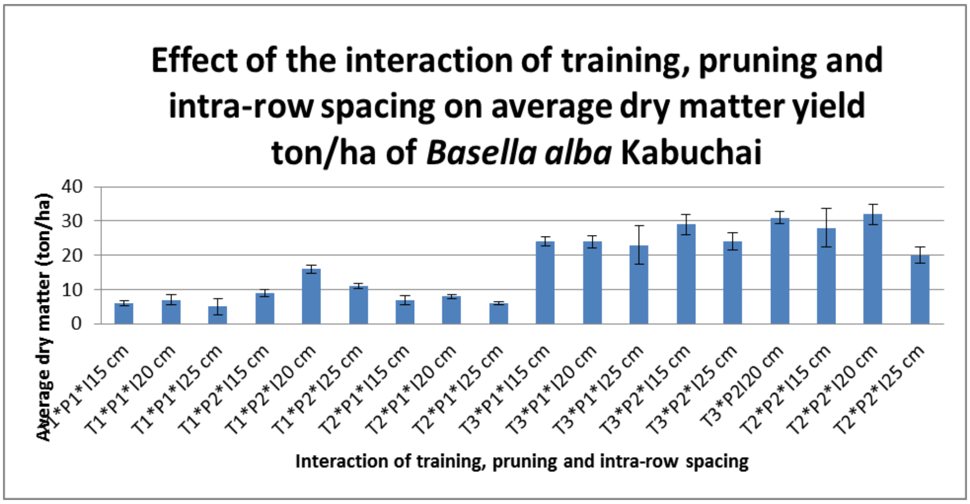

Figure 6: Effect of Interaction between training, pruning and Intra-row spacing on average dry matter in tons/ha- Kabuchai

DISCUSSION

Plant height

Vine length per plant was significantly influenced by training, pruning and intra-row spacing as well as their interaction in both Bumala and Kabuchai. The longest vine length was recorded at trellising and one stake per plant and lowest at no staking, no pruning and intra-row spacing of 25 cm. On overall the longest vine was recorded at intra-row spacing of 15cm and 20cm interacting with pruning and trellising and or one stake per plant. Narrow spacing led to high plant density per unit area that encourages competition leadingfor strives for vital resources especially light. It also leads to high interception of light for photosynthesis which directly relates to dry matter accumulation. Also training supported the plant and promoted epical growth. These findings are also in line with research done by Park *et al.*, (1993) whose results showed that highest vine length was found from closest spacing and lowest obtained from widest spacing.

Number of leaves

Number of leaves was significantly influenced by training, pruning and intra-row spacing as well as their interaction in both Bumala and Kabuchai. The number of leaves increased in treatments with trellises, double stem pruning and intra-row spacing of 20 cm. Interaction of trellises, double stem pruing and intra-row spacing 20 cm developed more branches that led to higher bearing of leaves thus more vegetative growth. Treatments with wider spacing (intra-row sapcing of 25) gave the lowest number of leaves. This was attributed to low plant population which is a determinant of yield. The findings agree with research done by Khan (2013).

Number of Branches

The combined effect of trellises, pruning and spacing had significant influence on the number of branches per plant in both sites. The highest number of branches per plant was recorded from treatments with trellises, double stem pruning and intra-row spacing of 20 cm. While no trellises, no pruning and intra-row spacing 15 gave the lowest number of branches per plant. The number of branches was more on treatments that were pruned because pruning (double stem pruning) encourages development of more buds and sprouting that eventually develop into branches. Spacing also influenced number of branches, wider intra-row spacing (25 cm) and medium spacing (intra-row spacing provided ambient environment and adequate resources such as sunlight, nutrients and water which are vital for vigorous branching Rahman *et al.,*(1985).

***Basella alba* yield**

The yield of *Basella alba* expressed on dry matter basis in tons per hectare was significantly influenced by the interaction of trellises, intra-row spacing and double stem pruning in both Bumala and Kabuchai. The highest yield was recorded where there was interaction of trellises, double stem pruning and intra-row spacing of 20 cm followed by followed by trellises , pruning and intra-row spacing of 25 cm and trellises, double stem pruning and intra-spacing of 15 cm. while the lowest yield was obtained from treatments with no trellises and no pruning and intra-row spacing of 15 and 25 cm respectively. Rahman *et al., (*1985) findings showed that spacing of (20 cm by 40 cm) gave the highest yield while the spacing of (40 by 40 cm) gave the lowest yields of green. Intra-row spacing of 20 cm with trellises and double stem pruning accommodates more plants per unit area and consequently increases yield per plot. Lesser number of plants per unit area caused less yield per plot in intra-row spacing of 25. The increased yield at intra-row spacing of 20 cm could be attributed to the increased number of plants per unit area which compensated and resulted in higher yield. Park *et al.,* (1993) reported that 24 cm by 24 cm was better than 15 cm by 15 cm or 30cm by 31 cm by 31 cm in consideration of growth and yield of the crop.Akunda, (2001) noted that narrow spacing has advantage because plants achieve canopy closure more quickly and intercept more light throughout the growing season. Canopy development is a function of spacing, and environment. The relative equidistant plant distribution leads to increased leaf area development and greater light interception early in the season.

Double stem pruning encourages growth of more branches from sprouts that bear leaves which ultimately influences dry matter accumulation. Yield positively correlates with number of branches and leaves. Pruning increases cell division (mitotic activity) and enlargement resulting in many branches and leaves. Through photosynthesis there was accumulation of carbohydrates in the leaves thus increasing their weights (Basela and Mahaden, 2008). Combination of trellises, pruning and intra-row spacing of 20 cm not only had more branches and leaves but supporting the branches through trellises and or one stake per plant led to more interception of light a resource for photosynthesis hence accumulation of more dry matter compared to those without trellis.

Treatments without staking or trellising and no pruning had low dry matter accumulation in general. These could be attributed to a number of factors including minimum exposure to light that essential for photosynthesis a function of dry matter accumulation, logging on the ground predisposes the plants to pests and diseases which limit plant development and productivity. Abiotic and biotic stresses can reduce yield of crops when not well managed for example, moisture stress has been documented to reduce the yield benefit from narrow row spacing in Kansas by more than 20% (Heitholt *et al.,* 2005).

Trellising seems to be the best option of staking *Basella alba when* compared to use of one stake per plant as it gives higher dry matter compared to the later. One stake per plant yields relatively lower than trelliising because stakes often lodge due to wind and termite attack. This disturbs growth and more often causes injury to plants unlike string and poles. The string also environmentally friendly and it is also convenient and easy to implement.

Although the research was not comparing sites, Kabuchai seems to be performing well than Bumala and this could be attributed to favourable soil P^H of 6.1 compared to lower P^H of 4.8 in Bumala. The P^H of 6 allows for easier absorption of nutrients especially Phosphorus and Nitrogen which are essential in root development and vegetative growth respectively (Okalebo *et al.,* 2003). Kabuchai also had reliable and well distributed rainfall which is necessary for dry matter accumulation and other metabolic activities.

CONCLUSION

Basella alba requires appropriate agronomic practices for optimum yields. For optimum yields proper combination of trellises, pruning and intra-row spacing must be adhered to. Training is an important aspect of *Basella alba* dry matter production. It enhances light interception that is necessary for photosynthesis, a determinant to dry matter accumulation. It also minimizes logging that predisposes the vines to pests and diseases among other yield limiting factors. From the findings of this research it is clear that growth and yield of *Basella alba* is a function of training, pruning and intra-row spacing in combination although training and intra-row spacing seems to influence more *Basella alba* performance than pruning.

Interaction of trellising/ one stake per plant, double stem pruning and intra-row spacing of 20 cm greatly influenced growth and biomass accumulation of *Basella alba*. This interaction allows for more plants per unit area with relatively adequate nutrients which enhances more branches and consequently number of leaves per plant components which determine dry matter accumulation. It also exposes the plant to light interception a component necessary for photosynthis that influences dry matter accumulation. In contrast intra-spacing of 25 cm spacing without training and or pruning yields lowly because of low plants per unit area. Wider spacing results into low plant density which is a major determinant of yield.

Pruning enhances more sprouts that develop into branches and number of branches has a great influence on number of leaves which intercept photo-synthetically active radiation (PAR) hence photosynthesis and dry matter accumulation.

From agronomic point of view, it would be wise to adopt combination of trellising, double stem pruning and intra-row spacing of 20 cm for higher *Basella alba* yields.

RECOMMENDATIONS

From this study I recommend the adoption of trellising, double stem pruning and intra-row spacing of 20 cm for optimum dry matter yield.

Further studies in the following areas are recommended;

i. A study should be done on the most economical and appropriate training method to establish most economical viable and farmer and environmentally friendly method.
ii. A long term experiment on training methods, pruning and spacing be conducted to ascertain the best combination and optimum Days After transplanting for dry matter accumulation.

REFERENCES

Abukutsa-onyango, M.O., 2007. The Diversity of cultivated African leaf vegetables in three communities In western Kenya .*African Journal of FDood Agriculture ,Nutrition and Development*

Akunda, E.M.W.,(2001).Improving Food Production by understanding the effects of intercropping andplant population on soybean Nitrogen fixing attributes.*The Journal of Food Technology in Africa. Vol 6.No.4.*

Basela O and Mahaden A (2008)., Effect of fertilzers on growth, yield, yield components, quality and certain nutrient content in broccoli (*Brassica oleracea) Journal Agricultutre Biology 10: 627-632*

Duke, J A. and Ayensu, E,S 1985. Medicinal plants of china Reference publications, inc ISBN O-917256-20-4.

Government of Kenya [GOK] 2008. Food security and Nutrition strategy 2nd Graft world health organization/international A Consultative Group. Vitamin A supplements; a guide to their use in the treatment and prevention of vitamin A Deficiency. Geneva; world health organization,2000.

Grubben,G.J.H. 1997.Tropical Vegetables and their Genetic Resources. Royal Tropical institute, Amsterdam ,Netherlads.453pp.

Grubben, G,J,H. and Denton,O.A.2004. Plant Resources of Tropical Africa 2.Vegetable.PROTA Foundation Wageningen.44; 103-111.

Heitholt, J.J., Farr, J.B. and Eason, R., (2005). Planting configuration x cultivar effectson soybean production in low environments.*Crop Science* 45: 1800-1808.

Lucas 1988: soil and water conservation at Langley Hall in Maumee,Journal of soil and water conservation:Volume 4, Number 1 January / February 1990.

Okalebo, J.R.,Woomer,P. L.,Mukhwana, E. J.,Musyoka,M.W.,Ndungu, K.W.,Kifuko and M.N.,Kiraithe, C. K.,(2003). Evaluation of Soil Fertility management Technologies (Best Bets) on Yield and Uptakeof Nitrogen and Phosphorus by Maize and LegumesinWesternKenya:Asix Ngo study. .*African Crop Science Conference Proceedings*, Vol.6: 480-488.

Palada ,M. C. and , Chang, L,C. 2003. Suggested cultural practices for*Basella*.AVRDC International cooperators Guide . AVRDC pub No 03-553.

Park K W, Han K S and Won JH 1993: Effect of propagation method, planting density and fertilizer level on growth of water Spinach (*Impomoea aquatica*). *Journal of Korean Society of Horticultural Science 34 (4) 241-247*

SAS InstituteInc,2012.SAS/STAT 9.3 User’s Guide, 2nd edn.ed. SAS InstituteInc, Cary, NC.

Rahman AKMM, Hossain SMM 1985: Effect of spacing and harvesting interval on growth and yield and yield of Indian Spinach. In: Horticulture Research Report on Vegetable Crops. BARI, Joydebpur, Gazipur. P28.

Rop., N.K., Mutui., T.M. and Kiprop E., K. (2012). Influence of nitrogen fertilizer on the growth ,yield and quality of Indian spinach [*Basella alba L.]. African Journal of . Horticultural Science 6:111-117.*