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Effect of Rooting Media, Cutting Types and Watering Frequency on Shoot Parameters of Long Pepper *(Piper cappense)* at Jimma

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Abstract

The present study was conducted at Jimma Agricultural Research center (JARC) to investigate the effect of rooting media, cutting types and watering frequency on nursery performance of long pepper cuttings to identify best alternatives for production of adequate planting material. Four types of media, composed of sub soil(Ss), top soil(Ts), farm yard manure(FYM) and Fine sand with the following proportion, 2Top soil + 1Farm yard manure + 2fine sand recommended for coffee cutting, 6top soil + 3farm yard manure + 2fine sand recommended for coffee nursery, 1/3rd SS upper + 2top soil + 1farm yard manure + 1fine sand recommended for tea media and 2top soil + 1farm yard manure + 1fine sand recommended for coffee nursery, three level of cutting type soft wood (SW), semi hard wood(SHW) and hard wood (HW) and four level of watering frequency were combined in split plot design with three replications, where four watering frequency levels were assigned to main plots, four media type levels were assigned to sub plot and three types of cutting (soft wood, semi hard wood and hard wood) levels were assigned to sub- sub plot were combined with factorial arrangement (4 x 4 x 3) with 48 treatments. Data was collected for shoot parameters after six months of planting. Highly significant ($P < 0.0001$) differences among interactions were observed for survival percent of stem cuttings. The highest percent survival percent (83%, 78%) was recorded for watering frequency every week, soft wood cutting grown in rooting media 2TS:1FYM:2FS. The highest shoot diameter recorded for semi hard wood cutting type grown in all media, indicating that increased shoot girth probably reflects balanced allocation of assimilates between root and shoot system and availability of essential in the media and growth promoting substances produced in semi hard wood cutting types which are suitable for the cutting to develop vigorous shoots. Attention should also be given in selecting the cutting position on the stock plant while preparing the cuttings.

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Media, soft wood, semi hard wood, hard wood and watering frequency.

Introduction

Long pepper (*Piper cappense*) is indigenous spice crop "Timiz". Long paper, is similar to korarima (*Aframum korarima*) and grows wild and semi wild under the natural forests of the South and Southwestern parts of Ethiopia. It grows best in forest areas of the mid to high altitudes in Keficho and Dawuro zones of the southern region (mainly around Bonga, Wushwush and Waka areas) Jimma and areas that have comparable climatic conditions to Jimma are suitable for long pepper production. Long pepper and korarima, as a natural forest crops; require 50-63% shade level.

The commercial part of Long pepper is widely used by every Ethiopian in the preparation of 'Wot' and also serves as ingredient for other spice ingredients. In Ethiopia This spice is both the exotic species (by introducing the dried spike) and the locally produced long pepper spikes, apart from pepper (*P. nigrum L.*) are being utilized for seasoning and provide oil which to a certain extent is used as an aromatic in the drinks industry and for medicine. In Ethiopia, field surveys have shown both the utilized and the wild species of long paper found growing under story the natural forest area of Ethiopia.

The plant can be propagated using either by cutting or by seed. The first alternative, i.e., using cutting is preferably recommended. This type of propagation method as observed from other plant species helps to shorten the period from planting to the start of productive years. Cutting can be planted directly to the field. Relatively younger cutting (clumps) is suitable for propagation.

When the regular rain season starts and the soil gets reliable moisture, cutting (clumps) with two stems each can be planted in a well-prepared pit at least (20 x 20 cm) depth and width.

Plants are often subjected to periods of soil and atmospheric water deficit during their life cycle. Plant responses to water scarcity are complex, involving deleterious and/or adaptive changes, and under field conditions these responses can be synergistically or antagonistically modified by the super imposition of other stresses (Chaves *et al.*, 2002). Moreover, both physiological and growth responses to soil water stress vary with the species, the stage of the life cycle of the plant and with physiological mechanism through which it is mediated.

According to the reports of different authors (Etherington, 1975; Hale and Orcutt, 1987 and Salisbury and Ross, 1992) responses of plants to various soil water stresses could be reduction of leaf and shoot growth, photosynthetic rate, water potential and cell turgor pressures; alteration of spatial relations in the plasmalema, tonoplast and organelle membrane; change in structure or configuration of macromolecules, closing of stomata and differences in the distribution of roots. Long pepper cuttings are traditionally planted in a trench & covered with plastic sheet to get large number of transplantable seedlings. But the success of the transplant is often low hence; it is common to retain cuttings for more than a year to synchronize the transplanting time with the beginning of the rainy season. This requires extra costs for nursery operation & maintenance. This can be alleviated by identifying the best growing media, suitable type of cutting type & identifying appropriate watering frequency. However, no research work has been carried out on cutting propagation of long pepper and hence, much of the information on nursery practices and improved long pepper propagation technologies particularly on above ground parameters is lacking in the growing area of Ethiopia. Therefore, this study is designed to address the above-mentioned gaps with the following objectives indicated below.

Materials and Methods

Description of the Study Area

The study was conducted at Jimma Agricultural Research Center (JARC) located 365 km South West of Addis Ababa, and 12 km away from Jimma town. The Nursery site is located at $7^0$40' N latitude and $36^0$47'E longitudes with an altitude of 1753 meters above sea level. It is situated in the tepid to cool humid-mid highlands of south-western Ethiopia. The long-term (ten years) mean annual rainfall of the area is 1639 mm with a maximum and minimum air temperature 26.6 ^oC ^{and} 13.9^o C respectively. According to JARC 2010 meteorology data the relative humidity of the area ranges from 35 to 95 percent.

Experimental Treatments

The experimental materials used in this study include, rooting media composed of top soil, sub soil, farm yard manure, Fine sand, stem cutting obtained long pepper accession among from the 1979 collection batch and Watering frequency.

Rooting media proportions (types)

The basic media used for the preparation of the potting mixes were top soil, sub-soil, Farm yard manure and fine river sand. Top soil was collected from the upper 25 cm layer of uncultivated land and the sub soil next to the layer of the top soil at

about 30-35 cm depth was also collected from the same area. Well decomposed animal dung was collected from dairy farming privet enterprise around Jimma town, these materials were sun dried, crushed and also sieved through mesh before mixing with other media categories. Finally, a total of four rooting media types with the following proportion (v/v) were prepare.

Rooting media (1-4 types)

M1 = Top soil + Farm yard manure + Fine sand at 2:1:2 ratios recommended for coffee Cutting

M2 = Top Soil + Farm yard manure + Fine Sand at 6:3:2 ratios recommended for coffee Nursery

M3 = 1/3 sub soil upper +Top Soil +Farm yard manure + Fine Sand at 2:1:1 ratio Tea media

M4 = Top Soil + Farm yard manure + Fine Sand at 2:1:1 ratio recommended for coffee Nursery

Preparation of cutting types

Long pepper already established in the clone garden of Tepi Agricultural Research Center vertically grow orthotropic shoots was used as a source of stem cutting uniform and healthy cuttings with 2-4 nodes were harvested early in the morning when the shoot and the leaves are turgid from the soft wood (upper part of the shoot), semi hard wood (middle part of the shoot) and hard wood (nearer to the main stem) were taken using sharp and clean pruning shear cleaned with alcohol. The cuttings were placed immediately in the plastic bug to prevent dehydration and then transported to the actual propagation site where the whole operation is carried out under shaded condition to provide protection against sun light.

Double node cutting of soft wood, semi hard wood and hard wood cutting were prepared by cutting the shoot just above each node and the woody and young parts from the lower and upper ends of the shoot, respectively.

The leaves on both types of cutting were trimmed all in all to reduce the rate of transpiration. Slant cut at the base of each cutting were made before setting them in the rooting media. To maintain internal turgidity, all the cuttings were kept in a plastic bug. Finally, they were inserted to a depth of 3-4 cm into the potted media in February 2012 and watered up to field capacity. The polythene sheet was then buried along the edges of the bed to provide humidified environment for the cuttings.

Watering frequency

The quantity of water applied to a plot at a time (per irrigation) was Equivalent to the amount required to replenish or maintain the moisture content of the growth medium at field capacity. Entrance of water into adjacent plots upon irrigating a plot was controlled by carful application using fine-holed standard watering can. Water from external sources, particularly rain fall was prevented by white transparent plastic film spread over wooden poles and string to cover the whole main plot, the plastic film was closed all the time except during watering hours of the day. Propagator Structure. Eucalyptus wood, elephant grass and 30-micron thick white plastic sheet was used to contract the propagator. Raised nursery beds with 1.2m width x 10m length were prepared to arrange the treatments.

Then, simple and inexpensive non-mist propagator was made from wooden frame (eucalyptus tree post). The frame was covered with 30-micron thick white translucent plastic sheet. Artificial shade supported with wooden poles were made at a height of 2 meter above the ground level and covered with elephant grass to provide approximately 70 to 75% shade (Behailu *et al.*, 2006), and both sides of the propagator were also protected with the elephant grass to avoid direct sunlight.

Experimental Design and Treatment layout/arrangement

The Experiment was conducted in the nursery at melko (JARC) using stem cutting of long pepper in split plot design with three replications, where Four watering frequency levels were assigned to main plots, four media type levels were assigned to sub plot and three types of cutting (Soft wood, semi hard wood and hard wood) levels were assigned to sub- sub plot were combined with factorial arrangement (4 x 4 x 3) with 48 treatments (Table 1). Each treatment contains 12 cuttings and a total of 1728 cuttings were used for

the experiment. The cutting were inserted directly in the media filled in 16 cm wide and 25 cm long black polyethylene bags and randomly assigned in the propagator with in main plot with two rows and 10 cm spacing between treatments.

After Planting Care

To maintain the required level of moisture, temperature and relative humidity, water application manually using 10 L capacity plastic watering cane was done depending upon the time of watering Frequency (every Week, every Two Weeks, every Three Weeks and every Month) was carried out accordingly by opening and closing back the polyethylene sheet.

A daily minimum and maximum temperature inside the propagator were recorded using thermometer and the range was 22-23^{0}C, 20-21^{0}C, 21-22^{0}C and 29^{0}C under watering interval every week, every two weeks, every three weeks and every Month respectively. The relative humidity (RH) inside the propagator was also recorded daily and the average was 66-70 %, 80-81 %, 81-83 % and 87 % watering interval every week, every two weeks, every three weeks and every four weeks respectively.

Data Collection

Destructive data were collected 185 days after planting. Rooting percent was determined based on all survived cuttings per plot and the average was taken.

Five selected sample cutting from each plot were considered and separated in to root and shoot part and evaluated for the different parameters. The parameters measured and the methods used each are presented as follows.

Soil analysis

Prior to the nursery experiment, the soil was sampled from each rooting media and prepared before planting the cuttings and analysed for the physical and chemical properties. The analysis was determined in the laboratory using the procedure outlined by Sahlemedhin and Taye (2000). The analysis was carried out at JARC soil laboratory (Table2).

Physical Properties (before planting)

Texture

Media texture was determined by the modified Bouyucous Hydrometer method

Bulk density (g/ml)

Mass of dried media (g)/volume of dried media (ml) was calculated and taken for analysis

Water holding capacity (%)

It was calculated using the following formula

$$WHC = \frac{\text{Weight water in the saturated media(g) X 100}}{\text{Weight of saturated media (g)}}$$

Chemical properties

P^H

The P^H of the rooting media was determined by meters, from a 1:2.5 soil-water suspension.

Organic carbon (%)

Organic carbon content of the soil was determined by the wet combustion procedure of walkley and Black method (1934)

Total nitrogen (%)

Total nitrogen content of the rooting media was determined by wet-oxidation procedure using modified kjeldahl method

Available phosphorus (ppm)

The available phosphorus content of the rooting media was determined by 0.5M sodium bicarbonate extraction solution (PH 8.5) method of Olsen (1954)

Available potassium (ppm)

The available potassium content of the rooting media was determined by using atomic absorption or flame photometer.

Shoot parameters

Shoot sprouting

Total number of cutting with newly growing shoots was counted and the average value was used for analysis.

Shoot Height (cm)

The length of each newly developed shoots of the sample was measured from the point of attachment on the cutting to the tip of the shoot using a ruler and the average of plot was taken for each treatment.

Leaf number

The newly growing leaves were counted for each sample cutting and the average was calculated for each treatment.

Shoot fresh weight (g)

The weight of newly growing shoots detached from the sample cutting was measured using sensitive balance and the average was taken for each treatment.

Shoot dry weight (g)

After drying the shoots in an oven drier (at a temperature of 100 ^{o}C to constant weight) weight was measured using a sensitive balance and the average was calculated for each treatment.

Leaf Area (cm^2)

Sample leaves from five randomly selected sample cutting were taken and leaf area was calculated as length X width. Then average value per cutting was taken.

Stem Girth (mm)

The diameter 0f the new shoot growth was measured by digital calliper 10cm from the point of attachment and average was taken and multiplied by 3.14(π).

Data analysis

Data collected for various root and shoot parameters were checked for meeting the assumption for ANOVA. Except for percentage of sprouted cuttings, the results are presented for discussion per plant basis.

The percentage data (percentage of sprouting) was transformed using the Arc sign transformation method before analysis. Data were analyzed using SAS software (SAS version 9.2, 2008). Mean comparison were perform using the Duncan's Multiple Range Test (DMRT) method. A significant level of 5% was used for all statistical analysis.
Linear statistical model for split-split-plot design

$$y_{ijkh} = \mu + A_i + \beta_j + d_{ij} + B_k + (AB)_{ik} + f_{ijk} + C_h + (AC)_{ih} + (BC)_{kh} + (ABC)_{ikh} + \varepsilon_{ijkh}$$

Where

y_{ijkh} = *The response measurement for the ijkhth* observations

μ = the experiment means

A_i = the main plot treatment effect

β_j = the block effect

dij = the main plot error (error a)

B_k = the subplot treatment effect
$(AB)_{ik}$ = the treatment interaction effect

fijk = the subplot error (error b)

C_h = the sub subplot treatment effect

$(AC)_{ih}$ = the treatment interaction effect

$(BC)_{kh}$ = the treatment interaction effect

$(ABC)_{ikh}$ = the treatment interaction effect

ε_{ijkh} = the sub subplot error (error c)
i, k, h = a particular treatment

j = a particular block

Results and Discussion

In present study different shoot growth parameters were considered and the analysis of variance (ANOVA) was performed, accordingly (Appendix Table 1-5).

Survival percent of cuttings (%)

The analysis of variance for survival percent of stem cutting was significantly influenced by watering frequency, rooting media and cutting type. The interaction effect between watering frequency and rooting media, watering frequency and Cutting types, Media and cutting types, three-way interaction watering frequency, rooting media and cutting types were also significant. Also, the main effect of rooting media and cutting type recorded significant differences. However, main effect of watering frequency did not show significant differences for survival percent of stem cuttings (Appendix Table 1). Highly significant ($P < 0.0001$) differences among interactions were observed for survival percent of stem cuttings (Table 3). The highest percent survival percent (83%, 78%) was recorded for watering frequency every week, Soft wood cutting grown in rooting media 2TS:1FYM:2FS and watering frequency every three weeks, Soft wood cutting grown in rooting media 2TS:1FYM:2FS Respectively (Table 3).The least Survival percent (34-43 %,) on the other hand, was recorded for rooting media 1/3 SS + 2TS:1FYM:1FS with watering frequency every three weeks, hard wood cutting (HW)and semi hard wood cutting(SHW) with watering frequency every week and planting in rooting media 2TS: 1FYM: 1FS proportion with semi hard wood cutting type respectively.

However, this value was statistically similar with the survival percent (71) obtained for the same type of cutting and rooting media composition of 6TS: 3FYM: 2FS. Furthermore, Soft wood cutting type and watering frequency every week and every three weeks had shown better survival percent when they were grown on 2TS:1FYM:2FS media proportion However, highest improvement in survival percent of cutting was recorded from soft wood cutting type, while the death rate of cuttings from hard wood cutting type was high. In general, the observed differences among the main effects of cutting type, soft wood could be due to the accumulation of growth hormone in the succulent part.

The variation among the cutting types might possibly be duo to variation in size of cutting and the accumulation of carbohydrates and growth regulating substance at the base of cutting types (Hartmann *et al.,* 1997).

Shoot length (cm)

Length of new shoot emerged from stem cutting was highly significantly ($P<0.001$) influenced by the interaction of watering frequency, rooting media and cutting type. The interaction effect between watering frequency and rooting media, watering frequency and Cutting types, Media and cutting types were also significant. Although the main effect of watering frequency media and cutting type Shows Significant difference on shoot length of long pepper (Appendix Table 2).

Highly Significant ($P<.001$) variation were observed among treatments, were the longest shoot length (361cm and 350 cm) was Showed for water application every week, Soft wood (SW) cutting and hard wood (HW) cutting grown in rooting media 6TS: 3FYM: 2FS proportion (Table 3).The least value (77cm and 93cm) was also recorded from watering frequency every month, soft wood cutting grown on media composed 2TS: 1FYM: 2FS and 2TS: 1FYM: 1FS.In the present study soft wood and hard wood cutting type grown in 6TS: 3FYM: 2FS proportion show better shoot length than semi hard wood cutting grown in same media proportion.

This could be the physical-chemical nature of rooting media blends (Table 2) especially, those having high percent of OC, OM and N might have favored good rooting and shoot growth. On the other hand, the highest shoot growth recorded for soft wood and hard wood cutting could be duo to relatively the high accumulation of growth hormones and accumulation of carbohydrate respectively.

Shoot Girth (mm)

Girth of newly emerged shoots from stem cutting of long pepper was highly significant ($P < 0.0001$) influenced by the interaction of watering frequency, media and watering frequency and cutting type. The interaction effect of media by cutting type and the main effect of watering frequency, rooting media and cutting type showed non-significant difference (Appendix Table 3). The highest average shoot girth (2.23 mm) was recorded for semi hard wood cutting type and watering frequency every week grown in (6TS: 3FYM:2FS) media proportion (Table 3). On the

other hand (2.03 mm and 2mm) was recorded for watering frequency every month and every week by hard wood and semi hard wood cutting type grown in (2TS: 1FYM:1FS) media proportion. However, the lowest shoot girth (1.23mm) was recorded for watering frequency every month on different rooting media and soft wood and semi hard wood cutting type.

Generally, the highest shoot diameter recorded for watering frequency every week, semi hard wood cutting type grown in (6TS: 3FYM:2FS) media proportion, indicating that increased shoot girth probably reflects balanced allocation of assimilates between root and shoot system and availability of essential in the media and growth promoting substances produced in semi hard wood cutting types which are suitable for the cutting to develop vigorous shoots.

Leaf number

In this study, number of leaves growth on long pepper stem cutting was highly significantly ($P<0.0001$) difference affected by the main effect of watering frequency, watering frequency interaction with cutting type, media interaction with cutting type and watering frequency, media and cutting type interaction. However, not significant difference was recorded for watering frequency interaction with media, media and cutting types alone (Appendix Table 4).

As indicated in (Table 3), the highest average number of leaves with values (20) per stem cuttings were counted for hard wood cutting types for water frequency every week grown on media proportion (2TS:1FYM:1FS).

Table.1 Details of treatment combination with in main plot

Treatment No	Watering Frequency	Media	Cutting types
1.	Every week	TS : FYM : FS (2:1:2)	SW
2.	Every week	TS : FYM : FS (2:1:2)	SHW
3.	Every week	TS : FYM : FS (2:1:2)	HW
4.	Every week	TS: FYM : FS (6:3:2)	SW
5.	Every week	TS: FYM : FS (6:3:2)	SHW
6.	Every week	TS: FYM : FS (6:3:2)	HW
7.	Every week	1/3 SS+TS: FYM : FS (2:1:1)	SW
8.	Every week	1/3 SS+TS: FYM : FS (2:1:1	SHW
9.	Every week	1/3 SS+TS: FYM : FS (2:1:1	HW
10.	Every week	TS : FYM : FS (2:1:2)	SW
11.	Every week	TS : FYM : FS (2:1:2)	SHW
12.	Every week	TS : FYM : FS (2:1:2)	HW

Media; TS= top soil, FYM= farm yard manure, FS= fine sand. Cutting type; SW=soft wood, SHW=semi hard wood, HW=hard wood

Table.2 Physical and chemical properties of different rooting media used in the present study

Rooting media	Chemical properties						Physical properties
	P^H water(1:2.5)	P (ppm)	% OC	% OM	% N	Available K(Meq k/100	Bulk density(g/cm^3)
TS : FYM : FS (2:1:2)	5.8	90.31	4.10	7.06	0.27	2.69	1.48
TS : FYM : FS (6:3:2)	5.67	153.95	5.29	9.12	0.41	3.32	1.44
TS : FYM : FS (2:1:1)	5.6	153.95	5.06	8.73	0.33	3.32	1.49
FYM	6.44	441.62	23.96	41.30	0.52	11.64	1.54
Top soil(TS)	5.2	3.11	3.93	6.77	0.25	1.41	1.36
Sub soil(SS)	5.3	13.06	2.68	4.62	0.21	1.53	1.33
Fine Sand(FS)	5.74	15.43	0.75	1.30	0.02	0.56	1.64

OC=organic carbon, OM=organic matter, P=Phosphorus, N=nitrogen, K=Potassium

Table.3 Interaction effect of watering frequency, rooting media and cutting types on various *Shoot*

Watering Frequency	Rooting media	Cutting type	SUR %	*ShL (cm)*	ShG (mm)	*LN*	*L A (cm^2)*	ShFw(g)
Every week	2TS:1FYM:2FS	SW	83 ^{a}	285 ^{cd}	1.83 $^{a-g}$	14 $^{g-n}$	2101 $^{d-l}$	121.33 $^{a-j}$
Every week	2TS:1FYM:2FS	SHW	70 ^{bcd}	247 $^{e-i}$	1.93 $^{a-e}$	15 $^{f-k}$	1560 $^{j-m}$	124.67 $^{a-g}$
Every week	2TS:1FYM:2FS	HW	34 ^{p}	178 $^{m-p}$	1.7 $^{b-k}$	17 ^{bcd}	1300 ^{klm}	79.33 ^{jkl}
Every week	6TS:3FYM:2FS	SW	71 ^{bcd}	361 ^{a}	1.66 $^{b-l}$	16 $^{c-g}$	2278 $^{c-l}$	107.33 $^{d-l}$
Every week	6TS:3FYM:2FS	SHW	66 $^{c-g}$	223 ^{ijk}	2.23 ^{a}	13 $^{j-p}$	1933 $^{g-m}$	122.67 $^{a-h}$
Every week	6TS:3FYM:2FS	HW	42 $^{m-p}$	350 ^{a}	1.5 $^{f-m}$	13 $^{j-p}$	1574 $^{j-m}$	143.67 $^{a-d}$
Every week	1/3 SS+2TS:1FYM:1FS	SW	67 ^{cde}	256 $^{e-h}$	1.63 $^{b-m}$	15 $^{e-j}$	1963 $^{f-m}$	93.67 $^{e-l}$
Every week	1/3 SS+2TS:1FYM:1FS	SHW	55 ^{hij}	258 $^{d-g}$	1.53 $^{e-m}$	15 $^{e-j}$	1889 $^{h-m}$	90.67 $^{g-l}$
Every week	1/3 SS+2TS:1FYM:1FS	HW	48 $^{i-n}$	198 $^{k-n}$	1.4 $^{h-m}$	15 $^{e-j}$	1239 ^{klm}	106 $^{d-l}$
Every week	2TS:1FYM:1FS	SW	63 $^{d-h}$	231 $^{g-j}$	1.73 $^{b-j}$	15 $^{e-j}$	3259 $^{b-j}$	160 ^{a}
Every week	2TS:1FYM:1FS	SHW	47 $^{j-o}$	205 $^{j-m}$	2 abc	12 $^{n-t}$	1614 $^{j-m}$	114.33 $^{b-k}$
Every week	2TS:1FYM:1FS	HW	41 $^{m-p}$	168 $^{n-r}$	1.49 $^{d-m}$	20 ^{a}	1863 $^{h-m}$	125.67 $^{a-g}$
Every two week	2TS:1FYM:2FS	SW	58 $^{e-i}$	224 $^{h-l}$	1.91 $^{a-g}$	14 $^{g-n}$	1828 $^{h-m}$	134.67 $^{a-f}$
Every two week	2TS:1FYM:2FS	SHW	67 ^{cde}	191 ^{lmn}	1.76 $^{b-i}$	17 $^{b-e}$	2141 $^{c-l}$	112.67 $^{b-k}$
Every two week	2TS:1FYM:2FS	HW	45 $^{j-o}$	231 $^{g-j}$	1.96 $^{a-d}$	16 $^{c-g}$	1063 ^{lm}	152.33 ^{abc}
Every two week	6TS:3FYM:2FS	SW	54 ^{hij}	319 ^{b}	1.8 $^{b-h}$	15 $^{e-j}$	2164 $^{c-l}$	100.33 $^{e-l}$
Every two week	6TS:3FYM:2FS	SHW	66 $^{c-g}$	132 st	1.5 $^{f-m}$	18 ^{ab}	1454 ^{klm}	115.67 $^{b-k}$
Every two week	6TS:3FYM:2FS	HW	66 $^{c-j}$	247 $^{e-i}$	1.5 $^{f-m}$	16 $^{c-g}$	2162 $^{c-l}$	130 $^{a-g}$
Every two week	1/3 SS+2TS:1FYM:1FS	SW	43 $^{l-p}$	253 $^{e-h}$	1.6 $^{c-m}$	16 $^{c-g}$	2058 $^{e-l}$	154.33 ^{ab}
Every two week	1/3 SS+2TS:1FYM:1FS	SHW	46 $^{j-o}$	244 $^{f-i}$	1.46 $^{g-m}$	16 $^{c-g}$	1155 ^{lm}	128.67 $^{a-g}$
Every two week	1/3 SS+2TS:1FYM:1FS	HW	75 ^{abc}	197 $^{k-n}$	1.46 $^{g-m}$	18 ^{ab}	2263 $^{c-l}$	153.67 ^{abc}
Every two week	2TS:1FYM:1FS	SW	57 ^{ghi}	265 ^{def}	1.26 ^{lm}	15 $^{e-j}$	1873 $^{h-m}$	136 $^{a-e}$
Every two week	2TS:1FYM:1FS	SHW	52 $^{i-l}$	257 $^{d-h}$	1.3 ^{klm}	17 $^{b-e}$	1102 ^{lm}	120.67 $^{a-j}$
Every two week	2TS:1FYM:1FS	HW	52 $^{i-l}$	197 $^{k-n}$	1.5 $^{f-m}$	15 $^{e-j}$	1038 ^{lm}	122.33 $^{a-i}$
Every three week	2TS:1FYM:2FS	SW	78 ^{ab}	233 $^{g-j}$	1.33 $^{j-m}$	12 $^{n-t}$	2105 $^{d-l}$	93 $^{f-l}$
Every three week	2TS:1FYM:2FS	SHW	43 $^{k-p}$	231 $^{g-j}$	1.36 $^{i-m}$	12 $^{n-s}$	3926 ^{abc}	66 ^{l}
Every three week	2TS:1FYM:2FS	HW	66 $^{c-g}$	170 $^{n-r}$	1.53 $^{e-m}$	13 $^{j-p}$	4860 ^{ab}	73 ^{kl}
Every three week	6TS:3FYM:2FS	SW	67 ^{cde}	264 ^{def}	1.7 $^{b-k}$	14 $^{g-n}$	1393 ^{klm}	130 $^{a-g}$
Every three week	6TS:3FYM:2FS	SHW	47 $^{j-o}$	144 ^{rs}	1.66 $^{b-l}$	10 ^{t}	2405 $^{c-l}$	111.33 $^{c-k}$
Every three week	6TS:3FYM:2FS	HW	62 $^{d-h}$	183 ^{mno}	1.83 $^{a-g}$	11 $^{q-t}$	2517 $^{c-l}$	100 $^{e-l}$
Every three week	1/3 SS+2TS:1FYM:1FS	SW	53 $^{h-k}$	198 $^{k-n}$	1.63 $^{b-m}$	13 $^{j-p}$	3262 $^{b-j}$	99.67 $^{e-l}$
Every three week	1/3 SS+2TS:1FYM:1FS	SHW	58 $^{e-i}$	247 $^{e-i}$	1.53 $^{e-m}$	13 $^{j-p}$	3799 $^{a-e}$	128.33 $^{a-g}$
Every three week	1/3 SS+2TS:1FYM:1FS	HW	35 ^{p}	276 ^{cde}	1.73 $^{b-j}$	11 $^{q-t}$	2579 $^{c-l}$	144.33 $^{a-d}$
Every three week	2TS:1FYM:1FS	SW	63 $^{d-h}$	157 $^{o-s}$	1.76 $^{b-i}$	11 ^{qrst}	234 ^{m}	104.33 $^{d-l}$
Every three week	2TS:1FYM:1FS	SHW	38 ^{nop}	272 $^{c-f}$	1.5 $^{f-m}$	15 $^{e-j}$	5018 ^{ab}	163.33 ^{a}
Every three week	2TS:1FYM:1FS	HW	57 $^{f-i}$	275 ^{cde}	1.63 $^{b-m}$	11 $^{q-t}$	1155 ^{lm}	94.33 $^{e-l}$
Every Four Weeks	2TS:1FYM:2FS	SW	66 $^{c-g}$	77 ^{v}	1.26 ^{lm}	11 $^{q-t}$	3736 $^{a-f}$	81 $^{h-l}$
Every Four Weeks	2TS:1FYM:2FS	SHW	38 ^{op}	247 $^{e-i}$	1.3 ^{klm}	17 ^{bcd}	3345 $^{b-j}$	105 $^{d-l}$
Every Four Weeks	2TS:1FYM:2FS	HW	42 $^{m-p}$	109 ^{tu}	1.43 $^{g-m}$	13 $^{j-p}$	5513 ^{a}	77.33 ^{kl}
Every Four Weeks	6TS:3FYM:2FS	SW	62 $^{d-h}$	234 $^{g-j}$	1.26 ^{lm}	14 $^{g-n}$	3732 $^{a-g}$	112.33 $^{b-k}$
Every Four Weeks	6TS:3FYM:2FS	SHW	57 $^{f-i}$	147 ^{qrs}	1.23 ^{m}	14 $^{g-n}$	3908 ^{abc}	79.67 $^{i-l}$
Every Four Weeks	6TS:3FYM:2FS	HW	67 $^{c-f}$	178 $^{m-p}$	1.46 $^{g-m}$	14 $^{g-n}$	3446 $^{b-i}$	79 ^{jkl}
Every Four Weeks	1/3 SS+2TS:1FYM:1FS	SW	75 ^{abc}	181 ^{mno}	1.6 $^{c-m}$	14 $^{g-n}$	1659 $^{i-m}$	114.67 $^{b-k}$
Every Four Weeks	1/3 SS+2TS:1FYM:1FS	SHW	49 $^{i-m}$	295 ^{bc}	1.9 $^{a-f}$	14 $^{g-n}$	891 ^{lm}	95.33 $^{e-l}$
Every Four Weeks	1/3 SS+2TS:1FYM:1FS	HW	43 $^{k-p}$	175 $^{n-q}$	1.73 $^{b-j}$	14 $^{g-n}$	3358 $^{b-j}$	100.67 $^{e-l}$
Every Four Weeks	2TS:1FYM:1FS	SW	70 ^{bcd}	93 ^{uv}	1.8 $^{b-h}$	14 $^{g-n}$	3888 $^{a-d}$	128 $^{a-g}$
Every Four Weeks	2TS:1FYM:1FS	SHW	48 $^{i-m}$	176 $^{m-q}$	1.36 $^{i-m}$	14 $^{g-n}$	3489 $^{b-h}$	103.33 $^{d-l}$
Every Four Weeks	2TS:1FYM:1FS	HW	40 $^{m-p}$	149 $^{p-s}$	2.03 ^{ab}	14 $^{g-n}$	2961 $^{c-k}$	81.67 $^{h-l}$
C.V %			10.8	8.20	15.67	8.30	19.83	22.16
LSD 0.05% level			9.03	28.49	0.62	2.18	20.72	42.84

Growth parameters of long pepper

SUR = survival percent, *ShL=shoot length*,ShG =shoot girth, *LN=Leaf number*, LA=Leaf area, ShFW= shoot fresh weight.

Appendix Table.1 Analysis of Variance for percent survival of stem cutting of long pepper

Source	DF	Sum of Squares	Mean Square	F-Ratio	p-Value	Significant
rep	2	18.8862	9.4431	0.3014	0.7504	NS
WF	3	123.6933	41.2311	1.3160	0.3533	NS
Error(a)	6	187.9875	31.3312	.	.	
MEDIA	3	1464.0216	488.0072	27.2946	<.0001	*
WF*MEDIA	9	1523.0100	169.2233	9.4648	<.0001	*
Error(b)	24	429.1014	17.8792	.	.	
CUTTING	2	5084.4982	2542.2491	69.2644	<.0001	*
WF*CUTTING	6	6076.9773	1012.8295	27.5949	<.0001	*
MEDIA*CUTTING	6	1574.8438	262.4740	7.1512	<.0001	*
WF*MEDIA*CUTTING	18	6040.3958	335.5775	9.1429	<.0001	*
Error(c)	64	2349.0272	36.7035	.	.	
Total	143	24872.4422	.	.	.	

* - Significant at 5% (level of significance opted by user), NS – Non-Significant
p-Value < 0.05 - Significant at 5%, p-Value < 0.01 - Significant at 1%

Appendix Table.2 Analysis of Variance for Shoot length per cutting of long pepper

Source	DF	Sum of Squares	Mean Square	F-Ratio	p-Value	Significant
rep	2	97.7222	48.8611	0.3035	0.7490	NS
WF	3	113353.1319	37784.3773	234.6721	<.0001	*
Error(a)	6	966.0556	161.0093	.	.	
MEDIA	3	28961.0208	9653.6736	28.1448	<.0001	*
WF*MEDIA	9	77686.5625	8631.8403	25.1657	<.0001	*
Error(b)	24	8232.0000	343.0000	.	.	
CUTTING	2	12097.7639	6048.8819	18.9947	<.0001	*
WF*CUTTING	6	74366.6806	12394.4468	38.9210	<.0001	*
MEDIA*CUTTING	6	141836.2917	23639.3819	74.2323	<.0001	*
WF*MEDIA*CUTTING	18	72285.7083	4015.8727	12.6106	<.0001	*
Error(c)	64	20380.8889	318.4514	.	.	
Total	143	550263.8264	.	.	.	

* - Significant at 5% (level of significance opted by user), NS – Non-Significant
p-Value < 0.05 - Significant at 5%, p-Value < 0.01 - Significant at 1%

Appendix Table.3 Analysis of Variance for stem girth of long pepper

Source	DF	Sum of Squares	Mean Square	F-Ratio	p-Value	Significant
rep	2	3.5311	1.7655	3.3910	0.1034	NS
WF	3	0.7051	0.2350	0.4514	0.7256	NS
Error(a)	6	3.1239	0.5206	.	.	
MEDIA	3	0.0165	0.0055	0.0369	0.9903	NS
WF*MEDIA	9	4.1102	0.4567	3.0654	0.0136	*
Error(b)	24	3.5756	0.1490	.	.	
CUTTING	2	0.0208	0.0104	0.1622	0.8506	NS
WF*CUTTING	6	1.4860	0.2477	3.8634	0.0024	*

Source	DF	Sum of Squares	Mean Square	F-Ratio	p-Value	Significant
MEDIA*CUTTING	6	0.2561	0.0427	0.6658	0.6774	NS
WF*MEDIA*CUTTING	18	1.1768	0.0654	1.0199	0.4511	NS
Error(c)	64	4.1027	0.0641	.	.	
Total	143	22.1048	.	.	.	

* - Significant at 5% (level of significance opted by user), NS – Non-Significant
p-Value < 0.05 - Significant at 5%, p-Value < 0.01 - Significant at 1%

Appendix Table.4 Analysis of Variance for leaf number per cutting of long pepper

Source	DF	Sum of Squares	Mean Square	F-Ratio	p-Value	Significant
rep	2	16.0972	8.0486	3.0907	0.1195	NS
WF	3	306.9167	102.3056	39.2853	0.0002	*
Error(a)	6	15.6250	2.6042	.	.	
MEDIA	3	2.3056	0.7685	0.3484	0.7906	NS
WF*MEDIA	9	28.0833	3.1204	1.4145	0.2368	NS
Error(b)	24	52.9444	2.2060	.	.	
CUTTING	2	1.6806	0.8403	0.6020	0.5508	NS
WF*CUTTING	6	47.3750	7.8958	5.6567	<.0001	*
MEDIA*CUTTING	6	40.1528	6.6921	4.7944	0.0004	*
WF*MEDIA*CUTTING	18	167.4583	9.3032	6.6650	<.0001	*
Error(c)	64	89.3333	1.3958	.	.	
Total	143	767.9722	.	.	.	

* - Significant at 5% (level of significance opted by user), NS – Non-Significant
p-Value < 0.05 - Significant at 5%, p-Value < 0.01 - Significant at 1%

Appendix Table.5 Analysis of Variance for leaf Area (cm) per cutting of long pepper

Source	DF	Sum of Squares	Mean Square	F-Ratio	p-Value	Significant
rep	2	320.5672	160.2836	0.2240	0.8057	NS
WF	3	5055.4607	1685.1536	2.3549	0.1712	NS
Error(a)	6	4293.6581	715.6097	.	.	
MEDIA	3	669.2440	223.0813	2.3988	0.0929	NS
WF*MEDIA	9	4091.8764	454.6529	4.8889	0.0009	*
Error(b)	24	2231.9230	92.9968	.	.	
CUTTING	2	21.6483	10.8242	0.1251	0.8826	NS
WF*CUTTING	6	4090.9435	681.8239	7.8827	<.0001	*
MEDIA*CUTTING	6	837.1285	139.5214	1.6130	0.1580	NS
WF*MEDIA*CUTTING	18	4363.8465	242.4359	2.8029	0.0013	*
Error(c)	64	5535.7511	86.4961	.	.	
Total	143	31512.0474	.	.	.	

* - Significant at 5% (level of significance opted by user), NS - Non Significant
p-Value < 0.05 - Significant at 5%, p-Value < 0.01 - Significant at 1%

Appendix Table.6 Analysis of Variance for Shoot Fresh Weight (g) per cutting of long pepper

Source	DF	Sum of Squares	Mean Square	F-Ratio	p-Value	Significant
rep	2	5991.6060	2995.8030	3.1263	0.1174	NS
WF	3	21196.7456	7065.5819	7.3733	0.0195	*
Error(a)	6	5749.5719	958.2620	.	.	
MEDIA	3	7887.3012	2629.1004	4.1395	0.0169	*
WF*MEDIA	9	18315.3050	2035.0339	3.2042	0.0109	*
Error(b)	24	15242.9052	635.1210	.	.	
CUTTING	2	1203.9760	601.9880	0.9643	0.3867	NS
WF*CUTTING	6	6554.7626	1092.4604	1.7500	0.1238	NS
MEDIA*CUTTING	6	5766.6632	961.1105	1.5396	0.1797	NS
WF*MEDIA*CUTTING	18	22924.5380	1273.5854	2.0401	0.0195	*
Error(c)	64	39953.3676	624.2714	.	.	
Total	143	150786.7423	.	.	.	

* - Significant at 5% (level of significance opted by user), NS – Non-Significant
p-Value < 0.05 - Significant at 5%, p-Value < 0.01 - Significant at 1%

Fig.1 Propagator structure frame work

The least number of leaves (10) per stem cutting was recorded for watering frequency every three weeks with semi hard wood cutting type grown under (6TS: 3FYM:2FS) media proportion (Table 3).

Leaf area (cm^2)

Total leaf area obtained from the present study revealed that interaction effect of watering frequency, rooting media and cutting types, watering frequency by rooting media and watering frequency by cutting type were showed highly significant ($P< 0.01$) difference where as the main effect of watering frequency, rooting media and cutting type and the interaction effect of rooting media by cutting showed no significant difference (Appendix Table 5).

Larger leaf area (5513 cm^2)was recorded for hard wood cutting with watering application every month grown in *2TS:1FYM:2FS* media proportion and the lowest value of leaf area per stem cuttings(234cm^2) was recorded under watering frequency every three weeks, soft wood cutting type grown under *2TS:1FYM:1FS* media proportion (Table3).

In general, both cutting types grown in *2TS:1FYM:2FS* media proportion and watering interval every three weeks and every month had exhibited better performance than those grown in other media and watering frequency every week and every two weeks. The difference revealed between the three types of cutting could be attributed to the variation in their size and the number of leaves retained on them. The larger leaf area produced by hard wood cutting type could be due to higher total carbohydrate content.

Shoot fresh weight (g)

The analysis of variance for Average fresh shoot weight of stem cutting was significantly influenced by watering frequency, rooting media and cutting type. The main effect of watering frequency, rooting media and the interaction effect between watering frequency and rooting media. Watering frequency, rooting media and cutting type was significant($P \leq 0.05$). However, main effect of Cutting types, the interaction effect between watering frequency and cutting types and rooting media by cutting types did not show significant differences for average fresh shoot weight of stem cuttings of long pepper (Appendix Table 6). The highest average fresh shoot weight(163g and 160 g) was recorded for watering frequency every three weeks, semi hard wood cutting grown in rooting media 2TS:1FYM:1FS and watering frequency every week, Soft wood cutting grown in rooting media 2TS:1FYM:2FS Respectively (Table 3).The least average fresh shoot weight(66 g) on the other hand, was observed for rooting media 2TS:1FYM:2FS with watering frequency every three weeks, semi hard wood cutting (SHW) grown in rooting media 2TS: 1FYM: 1FS proportion(Table 3).

The results of the present investigation suggested that the rooting and shoot growth of leafless hard wood cuttings of long pepper is related to all the factors studied: rooting media, cutting type and watering frequency of the stock plant at the time of taking cuttings. In this experiment, cutting type significantly affected survival percent, shoot length, shoot girth, leaf number, leaf area and average fresh shoot weight of long pepper cutting. Cuttings obtained from the soft wood cutting type showed greater performance regarding survival percent and shoot length, as compared to those cuttings collected from semi hard and hard wood portions of the stock plant. In general, soft wood cuttings gave rise to the best and well-developed long pepper seedlings. The other major factor affecting shoot growth of long pepper stem cuttings was the growth media type.

Although growth media type have considerable effect on leaf number, average fresh shoot weight, leaf area and stem girth of long pepper, all other shoot development and growth parameters were highly influenced by the type of media used.

In most shoot growth and development characters evaluated, better results were obtained from long pepper cuttings grown on a 1/3 sub soil (SS) upper + 2 top soil (TS), 1Farmyard manure (FYM) and 1fine sand (FS) and 6 top soil(TS), 3Farmyard manure (FYM) and 2fine sand(FS).

The current result had also revealed the need for considering, watering interval was significantly affected shoot development and growth parameters survival percent, shoot length and leaf number of long pepper cutting.

Watering interval every two week and every week showed greater performance regarding all shoot growth and development parameters considered, as compared to watering interval every month and every three weeks. In general, watering interval

every week and watering interval every two weeks gave rise to the best and well-developed long pepper seedlings.

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