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Seedling Growth Rate of Korarima (*Aframomum cororima* (Braun) P.C.M. Jansen) Response to Soil Resource and Seed Treatment

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ABSTRACT

*Korarima (Aframomum corrorima) or Ethiopian cardamom is herbaceous, perennial and aromatic spice and medicinal crop. It is economically important food preservative, to flavor coffee and bread, as source of income from local and export markets. Seed treatments are commonly used in different crops to make hard seed coats permeable to water or gases. Growth soil media have organic sources which are more easily available and inexpensive to reduce production costs. Among all production constraints, farmers emphasized that lack agronomic practices like seed treatment and nursery media. The objective of this study was undertaken to evaluate the influence of different seed treatment methods and organic nursery media compositions on growth parameters of korarima. **E**xperiment had two factors soil media& Seed treatment factorial arrangement RCBD with three replications. Analysis of Variance using statistical analysis system software. Treatment means were separated using LSD at 0.05 probability level. The results of this experiment indicated that there were interaction effect of the factors highly significant (P<0.1) among growth parameters. The interaction effect of seed treatment by soil media was highly significant in respect of total leaf area, total dry weight and relative growth rate. Based on these outcome, pre-sowing seed treatment of Korarima seed soaked in pure water and sown in mixed soil media enhanced growth of korarima seedlings total leaf area, total dry weight and relative growth rate.*

Keywords: *Korarima (Aframomum corrorima), Ssoil Media, Seed treatment, seedling growth, Relative Growth Rate*

INTRODUCTION

Korarima (Aframomum corrorima) or called Ethiopian cardamom is herbaceous, perennial and aromatic spice and often of large size medicinal crop of the species (Jansen, 2002).It is economically important food preservative, to flavor coffee and bread, as source of income from local and export markets, for soil conservation and as substitute of Indian cardamom (Eyob *et al*., 2007).Southwestern Ethiopia, where natural (montane) forests found, is an important centre of spice crops production and collection (Agize and van der Zouwen, 2008). Korarima grows naturally at an altitude of 1700–2000 m.a.s.l (Ravindran 2002). Korarima requires 55 to 63% shade level for its proper development and hence grows in the lower strata of natural forests of Ethiopia (EIAR, 1999). Usually, these areas are located at altitudes ranging from 1000 to 2300 m.a.s.l. and receive an average annual rainfall of 1500mm and more. Korarima generally grown in forest loamy soils rich in available phosphorus and potassium, but well drained deep loamy soils abundant in humus are believed to be ideal (KAU, 1996).

Seed treatments is commonly used in different crops (Bhattacharya and Khuspe, 2001) to make hard seed coats permeable to water or gases and hasten germination and subsequent growth of seedlings. According to Kordali *et al.*, (2007) inhibitory effects of high constituents of hydro-carbon monoterpenes on germination and growth of seedling have been investigated in different plants

According to Mitchell et al., (1991) growth media may have the basic properties such as proper drainage, water holding capacity, lack of weed seeds, pests and diseases and other harmful materials, preferably have organic sources which are more easily returned to nature and be relatively inexpensive or available to reduce production costs (Delshad et al., 2011).

The Relative Growth Rate (RGR) of a plant at an instant in time (t) is defined as "the increase of plant material per unit of material present per unit of time (Britt er al. 1991). Low potential growth rate and tissue turnover rates are presumed to be adaptations to habitats characterized by low resource availability, with the low RGR, SLA, LAR (Reich, Walters *et al*. 1998) Among all production constraints, farmers emphasized that lack of improved varieties and agronomic practices like propagation techniques seed treatment and nursery media for effective seed germination and seedling growth are the basic activities emphasized by farmers. The agronomic practices which need major emphasis involve appropriate (Eyob *et al.*, 2008). The objective of this study was undertaken to evaluate the influence of different seed treatment methods and organic nursery media compositions on growth parameters of korarima

Materials and Methods

The experiments were executed at Jimma Agricultural Research Center nursery site. It is located within tepid to cool humid highland agro-ecological zone of the country at an altitude of 1750 m.*a.s.l.*, at latitude of 7^0, 46" N, and longitude of 30^0, 50 "E in the sub humid tropical belt of south western Ethiopia. The area receives an average total annual rain fall of 1530 mm, and mean minimum and maximum temperatures of 11.6^0C and 26.3^0C, respectively. The experiment was carried out in the nursery from May to September 2012. Seed pretreatments and media, variety of Korarima Jimma local landrace was used. Fresh seeds subjected to one of the following treatments: Control, soaked in tap water for 24 hrs, for 48 hrs, for 72 hrs; and soaked in 50% sulfuric acid (H_2SO_4) for 60 minutes (Eyob *et al.*, 2008). Growth media**.** The growth medium were forest soil and top soil alone and mixture of forest and top soil in 1:1 ratio, forest soil and compost in 1:1 ratio, top soil and compost in 1:1, forest soil, top soil and compost in 1:1:1 ratio, and top soil and compost in 3:1 ratio. Design was carried out in a 7x5 factorial using RCBD with three replications., the attributes of non-destructive parameters leaf area (cm^2), leaf numbers, dry weight of leaves, stems, roots; were recorded. Growth rate of seedlings was determined by measuring initial and final total dry matter yield Relative growth rate (RGR)is the product of SLA and LWF, defined as LA/W and known as leaf area ratio (LAR, total leaf area: total dry weight), NAR (net assimilation rate: rate of increase in plant mass per unit leaf area), specific leaf area (SLA, leaf area: leaf dry weight), LWF (leaf dry weight: plant dry weight). using the formula Agboola (1996): RGR= NAR x SLA x LWF

Data Analysis

The collected data was processed and analyzed using SAS computer software Version 9.2 (SAS, 2008). The analysis of variance (ANOVA) was employed for each parameter in order to identify the difference among the factors of seed pre-treatment, soil media and watering frequency and Significant differences among the treatments were compared using Fisher's Least Significance Difference (LSD) at < 5 % probability level.

Results and Discussion

Leaf Number

The interaction of seed treatment by soil media was highly significant ($P<0.01$) for leaf number. The highest Leaf number (8.17) was recorded for seeds soaked 24hrs in pure water and sown in media ratio of 1:1 forest soil to top soil (T_2M_3) and seeds soaked for 60 minutes in 50% sulphuric acid sown in forest soil and compost in 3:1 ratio (T_5M_4). Even if T_2M_3 and T_5M_4 had higher values statically there were no different for most treatments (Table 1). The lowest value of leaf number (6.50) was recorded for seeds soaked for 48 hrs in pure water sown in top soil with compost ratio of 3:1 (T_3M_7) (Table 1). Different results recorded in leaf number may be due to the water holding capacity which is needed for plant growth that may be affected by seed treatment. Different seeds need seed treatments for germination as well as for growth. The increase in leaf number due to supplied of more nutrient from the media and this could be attributed to a greater number of leaves.

Mean Leaf Area Per Leaf

The response of Leaf area (cm^2) to seed treatment by soil media was highly significant ($p<0.01$). The leaf area of seeds soaked and sown in mixed forest and Top soil media in 1:1 ratio (T_2M_3) was found the highest during four months of growth stage after sowing, (Table 1) and their values was 15.03 cm^2. Korarima seeds soaked for 24 hrs in pure water and sown in forest soil, top soil and compost in 1:1:1 ratio (T_2M_6) (14.78) also seeds not treated and sown in forest soil and compost soil media in 1:1 ratio (T1M4) (14.37 cm^2) shown higher Leaf area at the four months of growth stage. On the other hand, the least leaf area was observed

from seeds soaked for 72 hrs in pure water and sown in forest and compost soil media in 1:1 ratio (T_4M_4) (8.7cm^2) at four months of growth stages. The influence of the different proportions of media on leaf area at growth stage showed highly significant response. There were also non-significant leaf area growth variations within the proportions of each media source and seed pretreatment. However, the lowest value of leaf area was noted from those seedlings grown on the different proportions of media and seed pretreatment. This may be due to the age or early stage of seedling not used more compost blended of the media improve the soil condition in physical and nutrient availability. This contrary with the findings of Wosen et al., (2010) who reported growth parameters of leaf area has also increase with increasing soaking time.

Total Leaf Area

Total Leaf Area (cm^2) was significantly ($P<0.01$) affected by the interaction of seed treatment and media. The highest value 201.09 cm^{2}was observed for seeds soaked for 60 minutes in 50% sulfuric acid and sown in forest and top soil in 1:1 ratio (T_5M_3), while the smallest values (73.09) for seeds soaked 72 hrs in pure water and sown in forest soil alone (T_4M_1) was recorded four months of seedling growth stages (Table 1).This is because of combined effect of the media seed treatment provide more nutrients than single media for increasing specific leaf area. This is consistent with the findings of Ahmadi et al., (2007) who reported pre sowing seed treatment in concentrated sulfuric acid increase imbibition's and improve growth characteristics parameters such as total leaf area.

Leaf Dry Weight

The interaction of seed treatment by soil media was highly significant ($p<0.01$) for leaf dry weight. The highest mean values of leaf weight (g) 0.786 and 0.787 were recorded for seeds not soaked and sown in forest soil and compost in 1:1 ratio (T_1M_4) and seeds soaked for 24hrs in pure water and sown in mixed forest and compost soil media in 1:1 ratio (T_2M_4) at four months of growth stages after sowing, respectively (Table 1). The lowest value 0.373g and 0.376g were recorded for seeds soaked for 48 hrs in pure water sown in top soil (T_3M_2), and seeds soaked for 60 minutes in 50% sulfuric acid sown in top soil (T_3M_2), respectively. In respect to leaf dry weight, it was significantly influenced by the various seed treated and ratios of soil media with highly significant effects by sources and proportion including their interactions (Table1). As a result, the value for leaf dry weights ranged from 0.0039g to 0.786g was observed at different growth stage. In general, leaf growth responses indicate the influences of wide C: N ratio in the media and hence inadequate nitrogen nutrition due to limited mineralization. This supports the findings of Franco and Munns (1982), who demonstrated the temporary shortage of nitrogen under a similar setting. This support the combined of the media of forest and compost soil combination Vineeta *et al* (2005) reported that soil structural stability increased due to straw addition with better aggregate size distribution and reduction in soil disturbance. He further added that soil organic matter acts as a reservoir for plant nutrients and prevents leaching of elements, necessary for seedling growth.

Stem Dry Weight

The highest mean values of stem weight (g) 0.513 were recorded seeds not soaked and sown in mixed forest and compost soil media in 1:1 ratio (T_1M_4) at four months of growth stages after sowing (Table 1). The lowest value recorded for stem weight(g) was 0.170, for seeds soaked for 24 hrs in pure water and sown in top soil and compost in 3:1 ratio (T_2M7). The result indicate un soaked seed (wihout seedtreatment) and the equal combination of soil media improve the soil physical structure and media nutrient, and this give high dry stem weight.On the other hand, less compost combination of the soil give less weight of stem dry weight(g).

Root Dry Weight

Interaction of seed treatment by soil media on root dry weight was highly significant ($p< 0.01$). Among the treatments tested, highest root weight per plant was recorded from seeds soaked for 24hrs in pure water and sown in mixed forest and compost soil media in 1:1 ratio (T_2M_4) treatments, which was 0.511 gat four months of growth stages. On the other hand, the seeds soaked for 48 hrs in pure water and sown in top soil media (T_3M_2) gave the lowest root weight during the growth stages four months and the values was 0.124 g (Table 1). This is may be due to combined effect of the soil improve the soil water holding capacity and nutrient uptake for growth. Hafeez-ur-Rahman *et al*., (2007) reported that mixed soil media improve soil structure and texture, which, in turn, increases metabolic activity in germinating seeds, leading to better germination of seed and growth of seedling.

Total Dry Weight

Interaction of seed treatment and media on weight total dry matter per plant showed highly significant

($p< 0.01$). The highest total dry weight per plant of 2.386g and 2.219g were obtained from seeds soaked for 24hrs in pure water and sown in mixed forest and compost soil media in 1:1 ratio (T_2M_4) and seeds soaked for 60 minutes in 50% sulphuric acid and sown in top soil and compost in 1:1 ratio soil media (T_5M_5), respectively, followed by seeds not soaked and sown in forest soil and compost in 1:1 ratio (T_1M_4) (2.033g). On the other hand, seeds soaked for 48 hrs in pure water and sown in top soil media (T_3M_2) (0.846g) and seeds soaked for 60 minutes in 50% sulfuric acid and sown in top soil media (T_5M_2) (0.845g) showed the lowest values at the four after sowing months seedling growth stage (Table 1).

Dry matter production in any crop depends upon the leaf area index (LAI), the structure of the canopy, photosynthetic rate per unit of leaf area, and the strength of the metabolic sinks in attracting assimilates, which is may been hanced by seed treatment and blended media combination and this particularly important in sin seedling growth. This result is in agreement with previous finding of Wooton *et al.*, (1981) as reported that media blends with compost were to found be best for optimum seedling growth.

Table1. *Interaction effects of seed treatment and media on leaf number, mean leaf area, total leaf area dry weight of leaf, stem, root and total dry weight*

Treatment	Leaf number	Leaf area(cm^2)	Total Leaf Area(cm^2)	Leaf weight (g)	stem weight (g)	Root wt(g)	Total Dry weight (g)
T1M1	7.00^{b-d}	11.50^{m-o}	144.21^{f-j}	0.586^{e-h}	0.383^{c-g}	0.342^{c-f}	1.470^{gh}
T1M2	7.17^{b-d}	12.17^{j-m}	142.26^{g-j}	0.569^{f-j}	0.290^{j-n}	0.292^{d-h}	1.254^{i-k}
T1M3	6.83^{cd}	10.73^{pq}	121.59^{jk}	0.600^{d-h}	0.324^{g-l}	0.296^{d-h}	1.618^{e-g}
T1M4	7.67^{a-c}	14.37^{a-c}	139.49^{g-j}	0.786^{a}	0.513^{a}	0.411^{bC}	2.033^{b}
T1M5	7.500^{a-c}	10.54^{q}	138.09^{g-j}	0.665^{b-f}	0.412^{b-f}	0.290^{e-i}	1.856^{b-d}
T1M6	7.33^{a-d}	13.22^{e-g}	125.75^{i-k}	0.701^{a-d}	0.366^{d-i}	0.358^{c-e}	1.675^{d-f}
T1M7	7.500^{a-c}	13.07^{e-h}	147.81^{e-i}	0.476^{i-n}	0.307^{h-m}	0.245^{g-k}	1.293^{h-k}
T2M1	7.67^{a-c}	13.44^{de}	121.09^{jk}	0.600^{d-h}	0.371^{d-h}	0.371^{cd}	1.482^{gh}
T2M2	7.17^{b-d}	12.05^{k-n}	136.33^{g-j}	0.573^{f-i}	0.335^{g-k}	0.337^{c-f}	1.332^{h-j}
T2M3	8.17^{a}	15.03^{a}	118.73^{jk}	0.527^{h-m}	0.324^{g-l}	0.298^{d-g}	1.297^{h-k}
T2M4	7.17^{b-d}	10.22^{q}	173.88^{bd}	0.787^{a}	0.443^{bc}	0.511^{a}	2.386^{a}
T2M5	7.50^{a-c}	12.6^{f-k}	147.04^{e-i}	0.436^{mn}	0.422^{bcd}	0.286^{e-i}	1.576^{fg}
T2M6	7.67^{a-c}	14.78^{ab}	158.34^{c-g}	0.422^{mn}	0.416^{b-e}	0.380^{bc}	1.680^{d-f}
T2M7	7.17^{b-d}	10.95^{o-q}	157.87^{c-g}	0.552^{g-l}	0.170^{q}	0.397^{bc}	1.282^{h-k}
T3M1	7.50^{a-c}	13.45^{de}	169.19^{b-e}	0.454^{k-n}	0.185^{pq}	0.280^{e-i}	1.035^{l-n}
T3M2	7.50^{a-c}	11.35^{n-p}	154.67^{d-h}	0.373^{n}	0.255^{l-o}	0.124^{n}	0.846^{n}
T3M3	7.83^{ab}	12.49^{g-k}	183.87^{ab}	0.496^{hm}	0.335^{g-k}	0.249^{g-j}	1.306^{h-j}
T3M4	7.50^{a-c}	12.27^{i-m}	138.31^{g-j}	0.560^{f-k}	0.345^{f-j}	0.286^{e-i}	1.441^{g-i}
T3M5	7.33^{a-d}	13.01^{e-i}	168.30^{b-f}	0.764^{ab}	0.372^{d-h}	0.449^{ab}	1.978^{bc}
T3M6	7.50^{a-c}	13.27^{e-g}	105.3^{kl}	0.736^{a-c}	0.349^{e-j}	0.412^{bc}	1.810^{c-e}
T3M7	6.50^{d}	10.40^{q}	185.3^{ab}	0.553^{g-k}	0.352^{e-j}	0.220^{g-m}	1.198^{j-l}
T4M1	7.17^{b-d}	14.14^{b-d}	73.09^{m}	0.463^{j-n}	0.199^{o-q}	0.180^{j-n}	1.004^{l-n}
T4M2	7.17^{b-d}	10.64^{pq}	123.67^{i-k}	0.596^{d-h}	0.308^{h-m}	0.265^{f-i}	1.315^{h-j}
T4M3	7.83^{ab}	11.87^{k-n}	181.65^{a-c}	0.446^{l-n}	0.268^{kl-n}	0.147^{mn}	0.994^{mn}
T4M4	6.83^{cd}	8.70^{r}	119.34^{jk}	0.467^{i-n}	0.250^{m-p}	0.222^{g-m}	1.101^{k-m}
T4M5	7.67^{a-c}	14.16^{b-d}	177.55^{a-d}	0.689^{a-e}	0.343^{f-ij}	0.215^{h-m}	1.593^{fg}
T4M6	7.50^{a-c}	10.43^{q}	156.99^{c-g}	0.433^{mn}	0.299^{i-m}	0.234^{g-l}	1.012^{l-n}
T4M7	7.00^{b-d}	10.63^{pq}	86.55^{lm}	0.549^{g-l}	0.343^{f-j}	0.209^{i-m}	1.375^{h-j}
T5M1	7.50^{a-c}	13.72^{c-e}	90.66^{lm}	0.460^{k-n}	0.242^{m-p}	0.218^{g-m}	1.056^{lm}
T5M2	7.50^{a-c}	11.66^{lo}	187.18^{ab}	0.376^{n}	0.227^{n-q}	0.166^{k-n}	0.845^{n}
T5M3	7.50^{a-c}	12.39^{h-l}	201.09^{a}	0.426^{mn}	0.256^{l-o}	0.160^{l-n}	0.929^{mn}
T5M4	8.17^{a}	12.97^{e-j}	108.00^{kl}	0.518^{h-l}	0.266^{k-o}	0.273^{f-i}	1.282^{h-k}
T5M5	7.00^{b-d}	13.33^{f}	138.97^{g-j}	0.653^{c-g}	0.479^{ab}	0.356^{c-e}	2.219^{a}
T5M6	7.00^{b-d}	13.10^{e-h}	130.05^{h-k}	0.643^{c-g}	0.366^{d-i}	0.225^{g-m}	1.697^{d-f}
T5M7	7.50^{a-c}	13.48^{de}	179.33^{a-d}	0.666^{b-f}	0.424^{b-d}	0.333^{c-f}	1.965^{bc}
Cv%	6.47	3.47	9.04	9.83	11.07	14.55	7.39
LSD 5%	0.78	0.70	21.16	0.09	0.06	0.07	0.17

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$

T1 - Non-soaked,(T2-: 24 hrs,T3-: 48 hrs,T4 -72hrs) soaking seeds in pure water) , T5-:50% sulphuric acid soaking for 60 minutes, M1- Forest soil, M2- Top soil, M3- Forest & Top soil (1:1), M4- Forest & compost (1:1), M5-: Top & compost (1:1), M6- Forest l, Top & compost (1:1: 1), M7: Top & compost (3:1)

Growth Rate Components

The interaction of seeds pre sowing treatment and soil media showed highly significant P<0.01) difference in Relative Growth Rate (RGR), Absolute Growth Rate (AGR), Net Assimilate Rate (NAR), Leaf Area Ratio (LAR), Specific Leaf Area (SLA) and Leaf Weight Ratio (LWR). The data showed that different interaction of seeds pre sowing treatment and soil media had highly significant (P<0.01) effect on seedling relative growth rate (RGR). Mean values given in table 9 showed that the highest RGR (0.296g/g/d) was recorded in seeds soaked for 48 hrs in pure water and sowing in mixture of top soil and compost in 3:1 ratio (T3M7). A minimum value for seedling relative growth rate (RGR) (0.085 g/g/d) was observed in seeds soaked for 72 hrs in pure water and sown in forest soil (T_4M_1).

The best performance of top soil and its combination with compost might be attributed to its richer nutritional status which enhanced photosynthetic activity resulted in more plant stored material, thereby increasing seedling relative growth rate. Similarly, minimum seedling relative growth rate in forest soil alone may be due to less soil nutrition than the combination soil media with compost which restricted plant growth. Among the treatments tested, the highest AGR per plant was recorded from seeds soaked for 24hrs in pure water and sown in mixed forest and compost soil media in 1:1 ratio (T_2M_4) treatments and seed soaked for 60 minutes in 50% sulfuric acid and sowing in mixture of top soil compost in 1:1 ratio (T_5M_5) which was 0.04g/dat four months of growth stages. On the other hand, the seeds soaked for 48 hrs in pure water and sown in top soil media (T_3M_2) and seeds soaked for 60 minutes in 50% sulfuric acid and sown in top soil (T_5M_2) gave the lowest value (0.037g/d) of AGR. Korarima seeds soaked for 24 hrs in pure water and sown in mixed Forest soil and compost in 1:1 ratio (T_2M4) gave the highest NAR 0.0039 g/cm^2/day,1.86, respectively at four months of growth stages after sowing. The seeds soaked for 60 minutes in 50% sulfuric acid and sown in top soil media (T_5M_2) and seeds soaked for 72 hrs in pure water and sown in Forest soil (T4M1) gave the lowest Net Assimilate Rate during the growth stages of four months growth stages with their respective values of 0.0012 g/cm^2/day (Table 2).The interaction of seed treatment by soil media was highly significant (P<0.01) for leaf area ratio. The highest value of LAR was observed for seed soaked for 60 minutes in 50% sulfuric acid and sown in top soil (T_5M_2) and for seeds soaked for 60 minutes in 50% sulfuric acid and sown in mixture of forest and top soil in equal ratio (T_5M_3) 220.31 and 218.55cm^2/g. While the lowest value (58.3 cm^2/g) was recorded for Korarima seeds soaked for 48 hrs in pure water and sown in blended forest, top soil and compost in 1:1:1 ratio (T_3M_6). Specific Leaf area was significantly affected by the interaction of seed pre-sowing treatments and soil media.

The highest SLA (507.87 cm^2/g) was obtained from seeds treated with 50% sulfuric acid (soaking for 60 minutes) and sown in top soil (T5M1). The minimum SLA was 143.43 cm^2/g for 48 hours soaking in pure water and sowing in mixture of forest, top soil and compost (T3M6) (Table2). Leaf weight ratio was significantly affected by the interaction of seed pre-sowing treatments and soil media. The highest LWR (0.46g/g) was obtained from seeds treated with 50% sulfuric acid (soaking for 60 minutes) and sown in mixture of forest and top soil (T5M3) , 48 hours soaking in pure water and sowing in blended top soil & compost 3:1 ratio(T3M7) and 72 hours soaking in pure water and sowing in forest soil (T4M1)or forest soil and compost mixture at 1:1 ratio (T5M4). The minimum LWR were 0.28 and 0.25g/g for 24 hours soaking in pure water and sowing in mixture of top & compost soil (T2M5) or sown in a blend of forest soil, top soil and compost in 1:1:1 ratio (T2M6) (Table 2)

The importance of a high RGR for a plant could be a high plant mass after a certain period of growth stages. The result is in agreement with that of Rafael. et al., (1998), who reported that the rate of increase in biomass per unit biomass have been identified due to cause of variation in RGR between growth stages can be associated with variation in LAR (total leaf area: total dry weight) or rate of increase in plant mass per unit leaf area. Either daily or two-day interval of water application increased the number of *Korarima* leaves when compared with the rest. The number of leaves is considered a measure of photosynthetic and transpiration area (Ritchie, 1984). The findings suggest that frequency of water improved photosynthetic and transpiration area due to increased number of leaves and hence, increased seedling height, and root.

Table2. *Interaction of seed treatment and soil media on on growth component of Korarima seedling at four months after sowing*

Treatment	RGRII	AGR	NAR	LAR	SLA	LWR
T1M1	0.208g-j	0.024g-i	0.0021d-g	98.72e-j	248.82g-j	0.40d-i
T1M2	0.193h-k	0.021k-m	0.0017j-m	113.62ef	251g-j	0.45ab
T1M3	0.188i-l	0.027fg	0.0025c	75.3j-m	202.98i-l	0.37g-k
T1M4	0.161k-o	0.034b	0.0023cd	68.77k-m	180.81j-l	0.39e-j
T1M5	0.217e-i	0.031cd	0.0029b	74.72j-m	208.91i-l	0.36j-k
T1M6	0.158l-o	0.028ef	0.0021d-g	75.21j-m	180.05j-l	0.42a-g
T1M7	0.187i-l	0.021j-l	0.0016k-m	114.51ef	315.46e-g	0.37h-k
T2M1	0.149m-o	0.025gh	0.0018h-l	81.73i-m	202.12i-l	0.41b-h
T2M2	0.187i-l	0.022h-l	0.0018h-l	103.6e-i	240.75h-j	0.43a-e
T2M3	0.131op	0.021j-l	0.0015m-o	91.62f-k	227.3h-k	0.41a-e
T2M4	0.282ab	0.040a	0.0039a	73.03j-m	221.97h-k	0.33kl
T2M5	0.193h-k	0.026fg	0.0020e-h	93.52f-l	339.81d-f	0.28m
T2M6	0.177j-m	0.028ef	0.0019f-j	94.28f-l	375.00c-e	0.25m
T2M7	0.238c-g	0.021j-l	0.0019f-i	123.06de	285.92f-h	0.43a-e
T3M1	0.208g-j	0.017no	0.0013op	163.7bc	374.17c-e	0.44a-d
T3M2	0.225d-h	0.014p	0.0013op	184.2b	415.14bc	0.44a-d
T3M3	0.244c-f	0.022i-l	0.0017i-m	142.22cd	378.78c-e	0.38f-j
T3M4	0.187i-l	0.024g-i	0.0020f-h	96.17f-j	250.05g-j	0.39e-j
T3M5	0.215f-i	0.033bc	0.0025c	85.15h-l	220.68h-k	0.39e-j
T3M6	0.132op	0.030de	0.0023cd	58.3m	143.43l	0.41b-h
T3M7	0.296a	0.020l-n	0.0019f-j	155.04c	336.56ef	0.46a
T4M1	0.085q	0.016op	0.0012p	73.12j-m	158.5kl	0.46a
T4M2	0.192h-k	0.022i-l	0.0020e-h	95.25f-j	209.03i-k	0.45ab
T4M3	0.253b-d	0.017op	0.0014n-p	184.88b	411.66b-d	0.45ab
T4M4	0.227d-g	0.018m-o	0.0021d-g	110.16e-h	256.6g-i	0.43a-e
T4M5	0.208g-j	0.026fg	0.0019g-k	111.59e-g	257.74g-i	0.43a-e
T4M6	0.248c-e	0.016op	0.0016l-n	155.77c	365.66c-e	0.43a-e
T4M7	0.135n-p	0.023h-k	0.0021d-f	62.77lm	158.22kl	0.40d-i
T5M1	0.109pq	0.017no	0.0013op	85.83g-l	197.19i-l	0.44a-d
T5M2	0.264a-c	0.014p	0.0012p	220.31a	507.87a	0.45ab
T5M3	0.268a-c	0.016op	0.0012op	218.55a	474.14ab	0.46a
T5M4	0.140n-p	0.021j-l	0.0016k-m	84.53h-m	211.64i-l	0.40d-i
T5M5	0.173k-l	0.037a	0.0028b	62.64lm	213.37h-l	0.29lm
T5M6	0.165k-n	0.028d-f	0.0021d-f	76.89j-m	202.63i-l	0.38f-j
T5M7	0.221d-h	0.033bc	0.0024c	91.58f-k	269.79f-i	0.34k-l
Cv%	10.24	7.44	8.16	14.84	16.55	7.24
LSD 5%	0.0329	0.003	0.0003	26.26	73.11	0.05

Mean values followed by the same letter(s) with in a column are not significantly different at P < 0.05

T1 - Non-soaked,(T2-: 24 hrs ,T3-: 48 hrs T4 -72hrs) soaking seeds in pure water) , T5-:50% sulphuric acid soaking for 60 minutes, M1- Forest soil , M2- Top soil , M3- Forest & Top soil (1:1), M4- Forest & compost (1:1), M5-: Top & compost (1:1), M6- Forest l, Top & compost (1:1: 1), M7: Top & compost (3:1)

RGR - relative growth rate, AGR-absolute growth rate, NAR-net assimilate rate, SLA-specific leaf area, LWR- Leaf weight ratio, LAR- leaf area ratio

CONCLUSION

Based on these outcome, pre-sowing seed treatment and media applied by Korarima seeds soaked for 48 hrs in pure water, 50% sulphuric acid soaking for 60 minutes and 24 hrs in pure water and sown in top soil and compost in 3:1 ratios ($T3M_7$), Forest soil and Top soil in 1:1 ratios (T5M3), and Forest soil and compost in 1:1 ratios (T2M4),combinations improved RGR, total leaf area and total dry weight of korarima seedlings, respectively. Therefore, pre-sowing seed treatment pure water and media mixed in combinations of top soil and compost economically recommended for korarima nursery growers.

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