Germination and seedling growth response of mango (*Mangifera Indica* L.) cultivars to different nursery potting media

Gebresmon Gebregiorgs1, Negasi Tekeste2* and Berhan Mengesha3

**Abstract**

**Background:** Mango is an important cash crop greatly contributing for food security of fruit growers in northwestern parts of Tigray region, northern Ethiopia. However, information was critically lacking with respect to germination and growth response of mango rootstock to varying compositions of growing media in the region. Thus, an experiment was conducted during 2018 to evaluate germination and seedling growth response of mango cultivars to different combinations of nursery potting media in a net house at Indasellassie. Seeds of Local, Dodo and Keitt cultivars of mango were sown in full top soil (M1); top soil: sawdust: sand (3:2:1)(M2); top soil: FYM (Farmyard manure): sand (3:2:1) (M3); and top soil: FYM: sawdust: (3:2:1)(M4). Randomized complete block design in a factorial arrangement with three replications were used. Data on germination and growth parameters were collected and analyzed using GenStat software.

**Results:** The findings of the experiment revealed that mango cultivar had significantly affected most of the germination and growth parameters except shoot number. Moreover, potting media affected most of the parameters except days to germination, germination percentage, stem diameter, root number, and shoot number. Interaction effects of cultivar and growing media significantly affected all parameters except internode length, shoot number and stem diameter. Accordingly, interactions of local mango cultivar and M3 media combination gave the highest for most of the parameters with the order of M3 = M1 = M4 > M2 for germination percentage, M3 > M1 > M4 = M2 for plant height, M3 > M1 > M2 = M4 for leaf number, M3 > M1 > M4 > M2 for leaf area, M3 = M1 > M2 = M4 for stem diameter, M3 > M1 > M2 > M4 for root number, M3 > M2 > M1 = M4 for root length, M3 > M1 > M2 = M4 for fresh weight, M3 > M1 = M2 = M4 for dry weight and Vigorosity II of mango.

**Conclusion:** Considering better mango performance on seed germination, seedling growth and establishment in the study area, mango growers should use Local mango cultivar with soil potting media combinations of top soil: FYM: sand in the ratio of 3:2:1 for improving productivity and food security.

**Keywords:** Farmyard manure, Mango, Monoembryonic, Rootstocks

---

**Background**

Mango (*Mangifera indica* L.) is a tropical fruit known as “king of fruits” belongs to genus Mangifera, family Anacardiaceae which is grown almost all parts of the world. It is believed to have originated from South East Asia and more than 1000 varieties have been identified all over the world [1]. Currently, mango is produced in tropical and sub-tropical climates, in more than 85 countries...
worldwide [2]. Mango is known as the king of the fruits due to its excellent flavor, delicious taste and high nutritive values that makes the crop valued for both food and nutritional security especially for developing countries like Ethiopia where the realization of food and nutritional security is still a challenge [3]. The crop can be consumed as a raw, canned, or juice which provides sufficient amount of dietary antioxidants, such as ascorbic acid, carotenoids, and phenolic compounds and additionally a remarkable amount of dietary fiber, and vitamin A [4]. Mango is one of the most widely grown among the fruit crops cultivated in Ethiopia preceded only by banana in terms of economic importance [5]. In Tigray region, the potential area for mango production is in estimated at about 118.2 hectare [4]. According to Mekonnen [6], an attractive and delicious tropical and temperate fruits including mango are much in demand in the local markets in Tigray (Additional file 1).

The productivity of mango in Ethiopia is very low compared to the crop potential, about 20–30 ton/ha [7, 8]. Various factors govern crop productivity but, genetic and environmental are well known. Nowadays, the government has been introducing new improved varieties in Ethiopia. However, as compared to different mango growing nations, varieties of improved mango seedlings distributed to farmers for commercial production in Ethiopia are few [9]. Moreover, the supply of suitable root-stock mango seedlings in Tigray region is very limited [10]. Consequently, nursery potting media believed to have contributed to low viability and productivity of mango in the region. Mango plants are multiplied asexually through grafting and each plant is made up of the rootstock which provide root system and the scion forming the tree canopy. Both of these parts play an equally vital role in the life of a tree. The rootstock has great influence on the vigour, longevity and productivity of the scion variety [11]. Moreover, quality and composition of fruits also been affected by the root stock [11]. Thus, raising good quality rootstocks is very important for sustainability of the orchard. Similarly, nursery potting medium is most important input for healthy, uniform and quality rootstock seedling production. Apart from the selection of proper ingredients, it is also necessary to maintain the porosity of the potting mixture so that proper development of roots takes place [12]. In North-western zone of Tigray region orchard owners usually use varied levels and types of nursery potting media although majority use top soil: FYM: sand in the ratio of (3:2:1) together with local cultivar mango seedling root stock. Likewise, in the study area, there was limited research based information on germination and growth performance of existing and available mango rootstock cultivars to different nursery potting media compositions. Hence, it was high time to consider the evaluation of nursery potting media combinations on germination, seedling growth and establishment of mango cultivars in the study area. Therefore, the experiment was aimed at evaluating germination and seedling growth response of mango root stock cultivars to different potting media combinations and identifying the best combinations of cultivar and potting medium that had good germination and growth performance.

Materials and methods
Description of the study area
The experiment was conducted from April to September 2018 at a net-house in Indaselassie (ATVET) College farm, Northwestern zone of Tigray region, Ethiopia. The area is located at about “300 km” from Mekelle city which is the capital of the region. The site is located at 130 88′36″ to 140 08′57″ N latitude and 380 04′30″ to 380 17′02″ E longitudes at an altitude of 1915 m above sea level [13].

According to the agro-climatic classifications of Ethiopia, the climatic zone of the study area is generally subtropical with an extended dry period of 9–10 months. A maximum effective rainy season of 50–60 days with average annual rainfall of 885 mm which varies between 758 and 1440 mm. The area has average temperature of 20.92 °C with a mean maximum temperature of 30.97 °C in April and minimum temperature of 11.4 °C in January [13]. The soil type of the district is sandy clay loam with pH of 6.57 [14]. The major crops grown include are Onion, Tomato, Teff, Maize, Sorghum, and Finger millet [13] (Fig.1).

Treatments and experimental design
The experiment consisted of 3 × 4 factorial combination of three mango cultivars vis-a-vis local cultivar/Kebabi mango in the local tigrina language (C1), Dodo (C2) and Keitt (C3) and four levels of soil potting media with full top soil (M1), (top soil: sawdust: sand (3:2:1) (M2)) (top soil: FYM(Farmyard manure): sand (3:2:1) (M3)) and (top soil: FYM(Farmyard manure): sawdust (3:2:1) (M4)). Randomized complete block design (RCBD) in a factorial arrangement with three replications was used. In the experiment, local mango cultivar together with full top soil was used as a control treatment as the top soil was considered to possess poor physical properties such as poor aeration, water holding capacity etc. compared to those treatments having FYM(Farmyard manure), sawdust and sand. The total area of the experimental was 70 m² (4 m by 17.5 m).

Experimental procedure
Fresh mango fruits of three cultivars were gathered in consultation with experts from the district office of
agriculture and rural development. About 360 healthy and mature mango fruits of each of the cultivars were selected from and taken to Indaselassie ATVET College nursery site. Immediately, freshly extracted seeds were cleaned with tap water then the healthy seeds within the same weight range were selected. The sowing of each cultivar seeds were done on the same day in the four different growing media combinations. One treatment within a block occupies 30 seedlings. Pot mixtures were prepared as per the ratio determined consisting of sand, soil, FYM and sawdust. FYM was obtained from dairy farm of Indaselassie Agricultural, Technical, Vocational, Educational and Training College. It was produced in a pit underneath shade to keep away from loss of nutrients through evaporation. The FYM was decomposed for about 6 months. Bi-product of Cordia africana wood saw-dust was collected from house furniture manufactures in Indaselassie town. Sand was collected from the upper river basin of the surrounding area. All media used for growing the seedlings were once sieved through mesh screen to obtain 1 mm to 5 mm ranged particles.

Physico-chemical properties of the nursery potting media were carried out. Media containing organic manures possess more available moisture or water holding capacity and some acids [15]. The seeds were sown at the depth of 2 cm in the media filled on black color polythene bags of 15 cm × 25 cm size [15]. Seeds were irrigated immediately after sowing and irrigation was continued every 2 days until the seeds start to germinate [16]. After start of germination, the seedlings were irrigated twice a week and allowed to grow for 120 days in the nursery. Moreover, simple shade structure was constructed using wood poles to support a roof of mesh wire upon which a thin layer of thatching grass to give protection against strong sunlight. Media were exposed to temperature/heat treatments to avoid nematode, insects and pathogens by putting 20 cm layer of media separately under a thin black plastic under the sun for a consecutive 3 days.

Data collection
Number of days for seed emergence: was recorded by counting the number of days taken from sowing till 50% of the seeds per plot start to emerge.

Germination percentage (%): The percentage of seeds germinated per plot was calculated by dividing number
of germinating seedlings to total number of seeds and expressed in percent.

Plant height (cm): Ten seedlings were randomly selected from each plot and plant heights were measured from the base to the tip of the shoot using a meter scale at 120 days after sowing seeds and the average height of ten plants were used for statistical analysis.

Number of leaves per plant: Numbers of leaves were recorded by counting leaves of ten randomly selected seedlings at 120 days after seeding and the average number of leaves were used for statistical analysis.

Number of stems per plant: Numbers of shoots per plant were counted at completion of germination from the ten randomly selected seedlings 120 days after planting and the average value was used for statistical analysis.

Internode length (cm): Internode length was recorded from all ten randomly selected seedlings using meter scale at 120 days after planting from node to another node of a seedling and it was summed up and the average of ten seedlings were used for statistical analysis.

Stem diameter (cm): Stem diameter was measured using digital caliper from ten randomly selected seedlings 120 days after sowing and their average value was used for statistical analysis.

Leaf area (cm): The leaf area was measured from ten randomly selected seedlings using meter scale at 120 days after seeding the seeds and computed using the formula developed by [17]:

\[
\text{LA} = 0.2452 \left( L \times W \right) \times N 
\]

where, LA = Leaf area, W = width, L = Length, N = number of leaves.

Number of roots per plant: Numbers of roots were measured by counting the number of roots (tap and fibrous) from ten randomly selected seedlings 120 days after sowing and the average was used for analysis.

Length of primary root (cm): Length of tap root was measured using a ruler at the end of 120 days after sowing from ten randomly selected seedlings of each plot which were carefully removed by cutting the polythene bags of seedlings and removing soil adhering to the roots of the seedlings.

Fresh weight of seedlings (g): Fresh weight of the whole parts of seedling (roots and shoots) was measured by weighing the weight of ten randomly selected seedlings per plot using sensitive balance at the end of the study period, 120 days after planting.

Dry weight (g): Dry weight of the whole parts of seedling was measured by drying ten randomly selected seedlings in an oven at 72 °C for 48 h [18] and dry biomass was weighted using sensitive balance and the average was used for statistical analysis.

Seedling vigour: Was determined according to the formula of [19];

\[
\text{Vigorindex(VI)} - I(\text{cm}) = \text{Mean seedling length} \times \text{percent germination}
\]

\[
\text{Vigorindex(VI)} - II(\text{g}) = \text{Dry weight of seedling} \times \text{percent germination}
\]

Media analysis

Top soil samples collected from a depth of 0–30 cm were taken before the implementation of the experiment. The collected samples were air dried, mixed and ground to pass through 2 mm sieve to remove large particles, debris, and stones. Then, the samples were taken to Mekelle soil testing laboratory. Particle size distribution was analyzed using hydrometer procedure [20]. The pH of the soil was measured in water at soil to water ratio of 1:2.5 using pH meter [21]. Organic carbon was determined using wet oxidation method [22]. Total nitrogen was analyzed by wet oxidation procedure of Kjeldahl method [23]. Available phosphorus was analyzed using the procedure of [24]. Cation exchange capacity (CEC) was analyzed using NH4 acetate method [25]. Farmyard manure and saw dust were also analyzed for the different parameters considered.

Data analysis

Collected data were subjected to Analysis of Variance (ANOVA) using standard procedure [26]. Fisher’s LSD test at 5% probability level was used to separate the means. Pearson’s correlation was done to examine the degree of association among the different parameters. Data analysis carried out using GenStat discovery 16th edition statistical software.

Results and discussion

Characteristics of the experimental nursery potting media

Table 1 highlighted the characteristics of the experimental nursery soil, FYM and sawdust before planting. The textural class of the experimental soil was sandy clay loam having pH of 6.8 and classified as neutral as per the ratings of Horneck et al. [27]. The total nitrogen (N) content of the soil was 0.30%, which was high based on the rating of Hart et al. [28] which is in contrary to the reports where the soil of the study area are characterized with poor in fertility [29, 30]. Available phosphorus (P) content was 6.10 ppm which is low as per the ratings of Olsen [24] which is similar with the reports where soils of the study area are poor
soil fertility [29, 30]. Moreover, the available potassium (K) content of the experimental soil found to be 193 ppm which is rated as medium based on the ratings of Khan et al. [31] and is in line with the existing notion that Ethiopian soils are rich in potassium [32]. The cation exchange capacity was 49.57 meq/100 g of soil which is rated high based on the ratings of Hazelton and Murphy [33] and the organic carbon content was 1.08%, which is deficient according to Maria and Yost [34]. Generally, it is reported that soils in Tigray region where the study area is located, are characterized to be shallow, low in fertility, with high run-off, and low infiltration capacity which is attributed to high nutrient losses through soil erosion, and extremely low use of external nutrient inputs [29, 30]. 

Except organic carbon, EC and available phosphorus of the experimental soil are suitable for the growth and development of mango seedlings. The addition of well decomposed FYM and sawdust can improve soil physical properties and there by enhance root development of mango seedling through improved aeration [31, 35].

Similarly, Usman et al. [36] suggested on the use and positive of organic input on citrus seedlings. Therefore, soil fertility management in the study should focus on conditions that improve soil organic carbon and potassium through application of optimum levels of organic manure which thus improve soil physico-chemical properties [35].

### Germination and growth response of mango to soil growing media and cultivar

#### Days to germination

Days to germination had significantly affected by the main effect of cultivar and its interaction of growth media while main effect of growing media did not Table 2. Local cultivar in combination with full top soil germinated earlier (22 days) although statistically at par with the combinations of local cultivar together with soil media composition in the ratio of Top soil: FYM: Sand (3:2:1). Conversely, Keitt cultivar in combinations with media composition in the ratio of Top soil: Sawdust: Sand (3:2:1) germinated late (32 days) and is

### Table 1 Physico-chemical properties of the experimental top soil, FYM and Sawdust before sowing

| Physico-Chemical Properties | Soil | Rating | FYM | Rating | Sawdust | Rating |
|-----------------------------|------|--------|-----|--------|---------|--------|
| Particle size | | | | | | |
| Sand (%) | 48% | 40 | | | | |
| Silt (%) | 22% | 25–40 | | | | |
| Clay (%) | 30% | 40–50 | | | | |
| Chemical Properties | | | | | | |
| pH | 6.80 | Neutral | 8.00 | Moderately alkaline | 6.70 | Neutral |
| Organic carbon (%) | 1.08 | Low (1.5–2.5%) | 3.64 | High (1.5–2.5%) | 3.67 | High (1.5–2.5%) |
| CEC (meq/100 g) | 49.57 | very high (> 40) | 41.1 | Very high (> 40) | 22.2 | Moderate (12–25) |
| EC (ms/cm) | 0.50 | Low salinity | 2.95 | Low salinity (0–2) | 1.27 | Low salinity (0–2) |
| Nutrient availability | | | | | | |
| Total N (%) | 0.30 | High (0.25–0.50) | 0.50 | Very-high > 0.5 | 0.59 | Very high > 0.5 |
| Available P(ppm) | 6.10 | Low < 20 | 372.4 | Excessive (> 100) | 106.1 | Excessive (> 100) |
| Available K(ppm) | 193.0 | Medium (150–250) | 865.0 | Excessive (> 250) | 775.00 | Excessive (> 250) |

CEC Cation Exchange Capacity, EC Electrical Conductivity

### Table 2 Interaction effect of soil media and cultivar on days to germination and germination percentage of mango

| Potting media | Days to germination | Germination percentage |
|---------------|---------------------|------------------------|
|               | C1 | C2 | C3 | C4 | C5 | LSD | CV% |
| M1            | 22.00f | 28.88c | 30.44b | 97.80a | 52.20de | 61.13c |
| M2            | 23.33e | 27.7 cd | 32.40a | 90.00b | 61.13c | 53.33de |
| M3            | 22.00f | 27.04d | 32.00a | 95.53ab | 57.77cde | 56.67cde |
| M4            | 22.67ef | 27.31d | 32.33a | 92.23ab | 58.90 cd | 51.13e |
| LSD           | 1.27 | 2.7 | 6.5 |
| CV%           | | | |

c1: local cultivar, c2: dodo, c3: keitt, m1: full top soil, m2: top soil: sawdust: sand (3:2:1), m3: top: FYM: sand (3:2:1), m4: top soil: FYM sawdust (3:2:1) LSD least significant difference at 5%, and CV% coefficient variance
statistically at par with combinations of Keitt cultivar with Top soil: FYM: Sawdust (3:2:1) (Table 2). Parasana et al. [37] reported similar findings where a combination of Soil: FYM: Sand (2:1:1) soil media with Master royal local cultivar of mango which resulted in early days to germination of 24.0 days. Moreover, Abdul [38] indicated similar findings. The probable reason for such findings in mango could be due to genetic differences and different media compositions [19, 39].

Germination percentage
Main effect of cultivar and soil medium as well as their interactions had significantly ($P \leq 0.05$) affected germination percentage of mango seedlings (Table 2). Germination percentage was highest (97.8%) at the treatment combinations of local mango cultivar with full top-soil and is statistically at par with local mango cultivar in combination with top soil: FYM: sand (3:2:1). However, treatment combinations of Keitt cultivar and soil media composition of Top Soil: Sawdust: Sand (3:2:1) gave minimum (51.13) percent germination (Table 2). In contrary, Parasana et al. [37] indicated highest germination percent of 81% at treatment combination of Master royal mango stone cultivar together with top soil: sand: FYM (2:1:1). Genetic variation, content of cotyledons /endosperm weight and hard nature of seed coat might affect the percent germination of mango. Many researchers reported varietal difference on seedling performance of mango [19, 39, 40].

Plant height
There was a significant difference in plant height of mango seedlings due to cultivar, soil media and their interactions (Table 3). Full top soil in combination with local cultivar of mango gave the highest plant height of 37.90 cm although statistically similar with treatment combinations of local mango cultivar and potting media compositions of Top soil: FYM: Sawdust: Sand (3:2:1) (Table 3). However, Keitt cultivar in combination with Top soil: Sawdust: Sand (3:2:1) potting media compositions gave the shortest plant height of 15.78 cm although statistically at par with treatment combination of Keitt cultivar and potting media composition of Top soil: FYM: Sawdust: Sand (3:2:1) which gave 17.29 cm plant height (Table 3). In line with the findings, local Nekkare cultivar in combinations with potting media composition of Soil: Sand: Compost: Coir pith (1:1:1) gave the highest plant height of 29.60 cm [38]. Meena et al. [41] similarly, reported maximum plant height of 28.48 cm at soil potting media compositions of Soil: FYM: Sand (1:1:1). This could be due to the nutrient supply of the different combinations of soil potting media which might have helped in improving the rooting zone soil physico-chemical properties and thus increased nutrient assimilation initiate cell division, differentiation and enhanced nutrient availability leading to higher production of photo synthetically functional leaves and growth of plant [19, 41].

Number of leaves
Number of leaves had significantly ($P \leq 0.05$) affected by the main effect of cultivar, soil potting media as well as their interaction effects (Table 3). Local mango cultivar in combination with soil media composition of Top soil: FYM: Sand (3:2:1) gave the highest (18) number of leaves while Keitt cultivar in combination with soil media composition of Soil: FYM: Sawdust (3:2:1) gave the lowest (8) number of leaves (Table 3). Master-royal mango cultivar in combination with soil potting media of composition of Soil: Sand: FYM (2:1:1) resulted in higher number of leaves [37]. Many researchers reported similar findings on different mango cultivars [17, 42, 43]. High soil nutrient availability in the potting media can improve nutrient availability and water for growth of mango seedlings [31].

| Potting media | Cultivar | Plant height (cm) | Leaf number | Leaf area (cm) | Stem diameter (cm) |
|---------------|----------|-------------------|-------------|----------------|-------------------|
|               | C1       | C2                | C3          | C1             | C2              | C3               | C1       | C2     | C3               |
| M1            | 37.90a   | 27.57bc           | 24.32 cd    | 15.07b         | 13.47bc         | 9.87efg          | 67.14b   | 31.06efg | 33.85efg         |
| M2            | 29.27b   | 22.25d            | 15.78e      | 11.47defg      | 10.60defg       | 9.20fg           | 28.40efg | 25.50fg | 24.08g           |
| M3            | 37.46a   | 24.67 cd          | 18.42e      | 17.6a          | 12.00cde        | 11.67cde         | 86.68a   | 59.77bc | 40.23de          |
| M4            | 29.43b   | 26.00bc           | 17.29e      | 11.40defg      | 12.60 cd        | 8.40g            | 49.35 cd  | 38.19def | 23.11g           |
| LSD           | 3.55     |                   |             | 2.45           |                 | 13.46           | 0.06     |         |                  |
| CV (%)        | 8.1      |                   |             | 12.1           |                 | 18.8            | 5.9      |         |                  |

C1 local cultivar, C2 dodo, C3 keitt, M1 full top soil, M2 top soil: sawdust (3:2:1), M3 top: FYM: sand (3:2:1), M4 top soil: FYM sawdust (3:2:1), means with the same letter(s) are statistically similar at $P \leq 0.05$, LSD least significant difference at 5%, and CV% coefficient variance
**Leaf area**
Cultivar, soil potting media and their interactions had significantly ($P \leq 0.05$) affected leaf area of mango seedlings (Table 3). Maximum leaf area of 86.68 cm was observed at the treatment combinations of soil media with compositions of Top soil: FYM: Sand (3:2:1) and local cultivar. However, the minimum leaf area of 23.11 cm was observed at combinations of Keitt cultivar together with soil media of composition of Top soil: Sawdust (3:2:1) (Table 3). Abbas et al. [44] reported similar findings where combination of soil media with a composition of sand: peat moss: vermiculite (1:2:1) and local cultivar of mango gave the highest leaf area of 101.56 cm$^2$. Better nutrient availability might led to improved production of functional leaves [37].

**Stem diameter**
Mango cultivar showed significant difference on stem diameter while, main effect of soil media and its interaction with cultivar did not (Table 3). Maximum stem diameter of 0.75 cm was obtained at combinations of soil media composition with Soil: FYM: Sand (3:2:1) and local cultivar while combinations of soil media composition of Top soil: FYM: Sawdust (3:2:1) and Keitt cultivar gave the minimum stem diameter of 0.44 cm (Table 3). In line with the findings, maximum stem diameter of 0.79 cm was reported at 120 days after germination at combinations of Nekkare mango cultivar and soil media composition of Soil: Sand: Compost: Coir pith (1:1:1:1) [38]. Moreover, Parasana et al. [37] indicated maximum stem diameter at combinations of Master royal cultivar of mango and soil media composition of Soil: FYM (2:1:1) at 180 days of germination. Difference in mango rootstock performance might have resulted in differences stem diameter characteristics [45, 46].

**Internode length**
Local cultivar of mango gave longer internode length of 7.48 cm while Keitt cultivar gave the shortest with 3.63 cm. Moreover, full top soil gave longer internodes length of 6.84 cm while soil media composition of Top soil: Sawdust: Sand (3:2:1) gave the shortest with 4.15 cm (Table 4). However, there was no significant interaction effect of cultivar and growth media (Table 4). Higher (10.38 cm) internode length of mango seedlings were reported at soil media composition of Soil: Sand: Compost: Coir pith (1:1:1:1) with Neelum mango cultivar [38]. The relationship of media with seedling cultivar demonstrate massive growth in all vital plant growth parameters including, net plant growth, stem diameter, internode distance, number and size of leaves, root length and number of roots [36].

**Table 4** Effects of cultivar and media on internodes length and stem number of mango seedlings

| Potting media | Internode length (cm) | Stem number |
|---------------|-----------------------|-------------|
| M1            | 6.84a                 | 1.84b       |
| M2            | 4.15c                 | 2.44a       |
| M3            | 5.50b                 | 2.19ab      |
| M4            | 5.02b                 | 2.00ab      |
| LSD           | 0.71                  | 0.51        |

| Cultivar      | Internode length (cm) | Stem number |
|---------------|-----------------------|-------------|
| C1            | 7.48a                 | 2.33a       |
| C2            | 5.03b                 | 2.22ab      |
| C3            | 3.63c                 | 1.81b       |
| LSD           | 0.62                  | 0.44        |
| CV(%)         | 13.6                  | 24.6        |

Higher shoot number of 2.33 was observed at local mango cultivar while the lowest number of 1.81 was observed at Keitt cultivar of mango. Similarly, soil media combinations at compositions of top soil: Sawdust: Sand (3:2:1) gave higher shoot number of 2.44 while soil media combination with proportions of Top soil: FYM: Sawdust: Sand (3:2:1) gave the lowest (2.0) stem number (Table 4). The variation in stem number among mango seedlings could be due to seed polyembryonic nature that contains several embryos produced by nuclear embryos which grow to numerous plants commercially grown as cultivars [47].

**Root length**
Table 6 indicates response of primary root length as affected by the main effects of cultivar and soil potting media and their interactions. The maximum root length of 30.40 cm was observed at combinations of local mango cultivar and soil media combination of Soil: FYM: Sand (3:2:1) while combinations of Keitt cultivar and soil media of full top soil gave the shortest root length of 21.2 cm (Table 5). In conformity Abdul [38] indicated higher (27.86 cm) root length of mango seedlings at combinations of Nekkare cultivar and media composition of Soil: Sand: Compost (1:2:1). Damodarana et al. [48] reported similar findings. Soil media might have attributed to such findings and enhanced growth of the seedling, including enhanced root system development [49] (Table7).

**Root number**
Root number of mango seedlings had significantly affected by main effect of cultivar and its interaction with potting media while soil media did not (Table 5). Local
**Table 5** Interaction effect of soil media and cultivar on root number, root length, fresh and dry weight of mango

| Potting media | Cultivar | Root number | Root length | Fresh Biomass | Dry Biomass |
|---------------|----------|-------------|-------------|---------------|-------------|
|               |          | C1          | C2          | C3            | C1          | C2          | C3            |
| M1            | C1       | 5.00a       | 2.87bcde    | 2.27ef        | 26.39bc     | 23.07ef     | 21.20g        | 39.29b        |
| M2            | C2       | 3.60b       | 3.21bc      | 1.56f         | 27.33b      | 26.07bcde   | 22.14f        | 32.71bc       |
| M3            | C3       | 5.16a       | 2.40de      | 2.20ef        | 30.40a      | 25.47bcde   | 23.73defg     | 52.75a        |
| M4            | C4       | 3.47b       | 3.07bcd     | 2.60cde       | 24.87bcde   | 24.09cdef   | 24.13cdef     | 33.51bc       |
| LSD(5%)       |          | 0.79        |             | 2.64          |             |             |               |               |
| CV(%)         |          | 15          |             | 6.3           |             |             |               |               |

CT1 local cultivar, C2 dodo, C3 kett, M1 full top soil, M2 top soil: sawdust: sand (3:2:1), M3 top: FYM: sand (3:2:1), M4 top soil: FYM: sawdust (3:2:1), Means with the same letter within a column are statistically non-significant at \( p \leq 0.05 \), LSD least significant difference at 5%, and CV\% coefficient variance

**Table 6** Interaction effect of soil media and cultivar on vigour of mango

| Potting media | Cultivar | Vigour I | Vigour II |
|---------------|----------|----------|-----------|
|               |          | C1       | C2       | C3       | C1       | C2       | C3       |
| M1            | C1       | 37.05a   | 14.39d   | 13.74d   | 16.61b   | 5.48de   | 3.1ef    |
| M2            | C2       | 26.25c   | 13.60d   | 8.38e    | 13.8c    | 6.00d    | 2.66f    |
| M3            | C3       | 34.30b   | 14.31d   | 10.49e   | 21.34a   | 6.48d    | 3.14ef   |
| M4            | C4       | 27.10c   | 15.32d   | 9.48e    | 13.92c   | 6.67d    | 2.43f    |
| LSD           |          | 2.41     |           | 7.6      |           | 16.8     |

CT1 local cultivar, C2 dodo, C3 kett, M1 full top soil, M2 top soil: sawdust: sand (3:2:1), M3 top: FYM: sand (3:2:1), M4 top soil: FYM: sawdust (3:2:1), Means with the same letter are statistically significant at \( p \leq 0.05 \), LSD least significant difference at 5%, and CV\% coefficient variance

**Table 7** Simple liner correlation for germination and growth parameters of mango

|               | DG | GP | IN | LA  | LN  | PH  | RL  | RN  | SD  | SN  | V1  | V2  | WD  | WF  |
|---------------|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| DG            |    |    |    |     |     |     |     |     |     |     |     |     |     |     |
| GP            |    | 0.91** |    |     |     |     |     |     |     |     |     |     |     |     |
| IN            |    | 0.81** | 0.77** |    |     |     |     |     |     |     |     |     |     |     |
| LA            |    | -0.62** | 0.60** | 0.71** |    |     |     |     |     |     |     |     |     |     |
| LN            |    | -0.62** | 0.56** | 0.76** | 0.83** | -    |     |     |     |     |     |     |     |     |
| PH            |    | 0.48** | 0.86** | 0.73** | 0.79** |    |     |     |     |     |     |     |     |     |
| RL            |    | -0.56** | 0.64** | 0.57** | 0.50** | 0.50** | -    |     |     |     |     |     |     |     |
| RN            |    | -0.78** | 0.76** | 0.82** | 0.65** | 0.69** | 0.86** | 0.65** | -    |     |     |     |     |     |
| SD            |    | -0.79** | 0.72** | 0.88** | 0.64** | 0.66** | 0.91** | 0.50** | 0.77** | -    |     |     |     |     |
| SN            |    | 0.36** | 0.29** | 0.10** | 0.09** | 0.10** | 0.23** | 0.27** | 0.42** | 0.32** | -    |     |     |     |
| V1            |    | 0.92** | 0.95** | 0.90** | 0.70** | 0.69** | 0.93** | 0.57** | 0.87** | 0.83** | 0.26** | -    |     |     |
| V2            |    | 0.93** | 0.93** | 0.83** | 0.75** | 0.73** | 0.88** | 0.68** | 0.86** | 0.78** | 0.33** | 0.95** | -    |     |
| WD            |    | 0.92** | 0.83** | 0.84** | 0.75** | 0.76** | 0.89** | 0.71** | 0.85** | 0.81** | 0.36** | 0.90** | 0.96** | -    |
| WF            |    | 0.89** | 0.80** | 0.82** | 0.79** | 0.79** | 0.88** | 0.71** | 0.84** | 0.77** | 0.35** | 0.88** | 0.96** | 0.99** | -    |

* significance at \( p \leq 0.05 \), **highly significant at \( p \leq 0.1 \), and ns non-significant at \( p \leq 0.05 \), DG Date of Germination, GP Germination of percentage, PH plant height, SD seedling diameter, A Leaf area, LN Leaf number, RL Root length, RN Root number, SN Shoot number, FW Fresh weight, DW Dry weight, V1 Vigour I, V2 Vigour II
mango cultivar in combination with soil potting media at proportions of Soil: FYM: Sand (3:2:1) gave the highest root number of 5.16 while Keitt cultivar in combination with full top soil gave the lowest with 1.56 root number (Table 5). Nekkare mango cultivar in combination with soil media compositions of Soil: Sand: Compost (1:2:1) results in the highest number of roots of 7.6 [38]. The findings obtained at the current study might be due to the desirable effects of media combinations on retaining regular moisture supply, root respiration and encouraging growth of mango seedling [50].

**Biomass**

Main effect of cultivar and potting media as well as their interaction effects significantly ($P<0.05$) affected fresh and dry biomass of mango seedlings (Table 5). Maximum fresh and dry weight of 52.75 g and 22.35 g were observed at a combinations of local mango cultivar together with soil potting media of Soil: FYM: Sand (3:2:1) while the minimum fresh and dry weight of 9.57 g and 3.84 g, respectively, were obtained at combinations of Keitt cultivar and soil potting media of Top soil: FYM: Sawdust (3:2:1) (Table 5). Maximum fresh weight was reported at combinations of mango Master-royal cultivar and soil media compositions of Soil: Sand: FYM (2:1:1) at 180 days after germination [37]. Similarly, soil media combinations of Top soil: FYM: leaf mould (1:1:1) and local cultivar gave the highest (41.83 g) fresh weight at 90 days after germination mango [35]. Moreover, it was reported that the highest dry weight of 31.25 g was observed with combinations of soil media compositions of Soil: Sand: FYM (1:1:1) and Dusehri cultivar of mango [49]. In conformity, maximum dry weight of 23.23 g of mango seedlings were observed with combinations of soil media of Soil: Sand: FYM (2:1:1) and Master-royal cultivar at 180 days after germination of seeds [37]. Meena et al. [51] indicated that the positive effect proper media composition on soil physico-chemical properties might be due to increased dry biomass of the seedlings.

**Vigour index (VI)-I and II**

Table 6 indicates the interaction effect of mango cultivar and soil potting media on Vigour index (VI)-I and II. Vigour index (VI)-I was highest (37.05 cm) at combinations of mango local cultivar together with full top while the minimum (8.38 cm) was observed at combinations of Keitt cultivar of mango and Top soil: FYM: Sawdust soil potting media (3:2:1). Moreover, maximum vigour index (VI)-II of 21.34 g was observed at local cultivar of mango in combination with potting media proportion of Soil: FYM: Sand (3:2:1) while the minimum vigor index (VI)-II of 2.43 g was recorded at Keitt cultivar of mango in combination with soil potting media compositions of top Soil: FYM: Sawdust (3:2:1) (Table 6). Bappakka mango cultivar in combination with soil media composition of Sand: Red earth: FYM gave the highest vigor index [19]. Moreover, hormone GA$_3$—100 ppm in combination with Varikka mango cultivar gave higher vigour index (VI)-I and II of 36.37 cm and 22.99 g, respectively [52]. The difference might be due to poorness or richness of the soil potting media and weight of seeds. Many investigators suggested more favorable media containing organic manures possess organic acid that might help in making available moisture and some acids might have helped in yielding minimum days and better germination percentage and particularly good root system development [37].

**Conclusion and recommendation**

Mango is a potential fruit crop contributing greatly to the improvement of nutritional and health of the Ethiopian society. In the study area, the crop is contributing significantly to the livelihoods and food security of the local growers. Despite its potential for food and nutrition security its productivity is very low. However, suitable root stock cultivar and nursery potting media play a great lot in improving its productivity. Local mango cultivar in combination with growth media at a combination of top soil: FYM: sand (3:2:1) gave better mango seed germination, seedling growth and establishment in the study area. Accordingly, the treatment is recommended for improving productivity of mango in the study area.

**Abbreviations**

FYM: Farmyard manure; ATVET: Agricultural Technical Vocational and Educational Training.

**Supplementary Information**

The online version contains supplementary material available at https://doi.org/10.1186/s40066-021-00316-7.

**Acknowledgements**

The authors would like to thank Indaselasie ATVET College for allowing the nursery site, facilities and equipment for the research.

**Authors’ contributions**

GG contributed in research proposal writing, data collection, data analysis and interpretation. NT contributed in research proposal writing, data analysis, data interpretation and article writing. BM contributed in research proposal writing, data analysis, and data interpretation. All authors read and approved the final manuscript.

**Funding**

The authors declare that the research was supported by the first author's own financial source.

**Availability of data and materials**

The datasets are used and/or analyzed during the current study available from the corresponding author on request.
Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Author details
1 Department of Plant Science, Endasellassie Agricultural, Technical, Vocational and Educational Training College, Shire, Tigray, Ethiopia. 2 Department of Plant Science, College of Agriculture, Aksum University, Shire, Tigray, Ethiopia. 3 Department Dry Land Crop and Horticultural Science, College of Agriculture and Natural Resources Mekelle University, Mekelle, Tigray, Ethiopia.

Received: 2 May 2020 Accepted: 15 October 2020 Published online: 07 November 2021

References
1. Rymbai H, Laxman RH, Dinesh MR, Sunoj VSJ, Ravishankar KV, Jha AK. Diversity in leaf morphology and physiological characteristics among mango (Mangifera indica) cultivars popular in different agro-climatic regions of India. Sci Hortic. 2014;176:189–93.
2. Birarra E, Berihun T. Mango value chain preliminary analysis in Bahir Dar Town. Ethiopia RA J Appl Res. 2017;3(3):2077–84.
3. Ullah H, Saeed A, Thompson AK, Ahmad W, Azher NM. Storage of ripe mango (Mangifera indica L.) cv. Alphonso in controlled atmosphere with elevated CO2 Pakistan J. Botany. 2010;42(3):1076–80.
4. Takele, H. Review of mango value chain in Ethiopia. J Bio, pp.230–239.
5. Fita T. White mango scale, Aulacaspis tubercularis, distribution and severity status in east and west wollega zones, western Ethiopia. Sci Tech and Educ Res J. 2014;3(3):1–10.
6. Fano M. Integrating seedling suppliers with fruit growers in Tigray. LIVES Ethiopia. 2014.
7. Griesbach J. Mango growing in Kenya. World Agroforestry Center (ICRAF). Nairobi, Kenya. 2003.
8. Tiwari R, Baghel BS. Effect of intercropping on plant and soil of Dashehari mango orchard under low productive environments. Asian J of Hort. 2014;9(2):439–42.
9. Dessalegn Y, Assefa H, Dero T, Tefera M. Mango Production Knowledge and Local Management Strategies in Tigray. IIED-dry lands Programme, Edinburgh (United Kingdom): Ethiopia; 2000.
10. Siber K, Harad SC. Effect of pre sowing seed treatments on growth pattern of guava variety l-49. Int J of Chem Studies. 2017;5(5):1735–40.
11. Srivastava R, R Nanhorya, Upadhyay JK. Indian Forestier. 1998;124(7):503–10.
12. Teklay, T, Girmay G. Impact of Mixed Fertilizer Applications under Different Planting Methods and Seed Rates on Yield, Yield Components and Nutrient Use Efficiency of Tef [Eragrostis tef (Zucc.) Trotter]. J of Bioteic and Agri.2015; 5: 2224–308.
13. Kiros G, Nigussie D. Agronomic and Economic Evaluation of Nitrogen Fertilizer Rates and Intra Row Spacing on Growth and Bulb Yield of Onion (Allium cepa L.) under Rainfall Condition. Environ. 2016;6(2), 621.
14. Bisla SS, Singhrot RS, Chauhan SS. Effect of growing media on seed germination and growth of Ber Haryana J Hort Sci. 1984;13(3–4):118–22.
15. Yadav D, Pal AK, Singh SP. Vegetative Methods of Plant Propagation: II-Grafting Cutting Layering and Budding in Mango. Int J Pure App Biosci. 2018;6(3):575–86.
16. Minja RP, Kimaro AA, Mpanda M, Moshy S, Mtawajande V, Ngereza A, Ambrose J, Ndete A, Khuliha B, Nyalius G. Effects of Rootstock Type and Scion Cultivar on Grafting Success and Growth of Mango (Mangifera indica L) Seedlings. J of Exper Agr Int. 2017;16(2): 1–9.
17. Bijuayehu, D. Effects of Removal of Buds and Younger Leaves on Growth, Tuber Yield and Quality of Potato (Solanum tuberosum L.) Under Hot Tropical Condition, Humbo, Southern Ethiopia. MSc. Thesis, Haramaya University, Ethiopia. 2007.
18. Murakihara BM, Reddy YTN, Srilatha V, Akshita HJ. Effect of Seed Coat Removal Treatments on Seed Germination and Seedling Attributes in Mango Varieties. Int J of fruit sci. 2016;16(1):11–9.
19. Bouyoucos GJ. Hydrometer method improved for making particle size analysis of soils. Agron. J. 1962;54:464–6.
20. Page AL. Methods of soil analysis. Chemical and Microbiological Properties. Part II. 1982.
21. Wallkey A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 1934;37:29–38.
22. Bremner JM, Mulvaney C. Total Nitrogen Methods of soil analysis. Part 2. Chemical and microbiological properties, 1982; 595–624.
23. Olsen SR. Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate Circ. 939. U.S. Dep. Agric., Washington, DC. 1954.
24. FAO (Food and Agriculture Organization of the United Nations). FAO fertilizer and plant nutrition bulletin: Guide to laboratory establishment for plant nutrient analysis. FAO, Rome, Italy. 2008.
25. Gomez AK, Gomez AA. Statistical Procedures for Agricultural Research. New York: John Wiley and Sons Inc., 1984.
26. Horneck DA, Sullivan DM, Owen JS, Hart JM. Soil test interpretation guide. Oregon State University Extension Publication. 2011.
27. Hart JM, Marx ES, Stevens RG. Soil test interpretation guide. 1996.
28. Corbeels M, Abebe S, Mitiku H. Farmers’ knowledge of soil fertility and local management strategies in Tigray. ILED-dry lands Programme, Edinburgh (United Kingdom): Ethiopia; 2000.
29. Corbeels M, Abebe S, Mitiku H. Farmers’ knowledge of soil fertility and local management strategies in Tigray. ILED-dry lands Programme, Edinburgh (United Kingdom): Ethiopia; 2000.
30. Corbeels M, Abebe S, Mitiku H. Farmers’ knowledge of soil fertility and local management strategies in Tigray. ILED-dry lands Programme, Edinburgh (United Kingdom): Ethiopia; 2000.
31. Khan N, Shah ST, Sajid M, Rab A, Iqbal A, Haq SU, Iqbal M, Rahman S, Ahmad R, Ali W, Rawan S. Propagating media affects mango seed germination at different depths; Pure Appl Biol. 2016;5(3):392.
32. Murphy HF. A Report on Fertility Status and Other Data on Some Soils of Ethiopia Experimental Station Bulletin No. 44. Hailieslassie College of Agriculture, Oklahoma State University 1968.
33. Hazeltin P, Murphy B. Interpreting soil test results: What do all the numbers mean?. CSIRO publishing. 2016.
34. Maria RM, Yost R. A survey of soil fertility status of four agroecological zones of Mozambique. Soil Sci. 2006;171(11):902–14.
35. Gholap SS, Polara ND. Effect of growth of media and storage of stone on the growth and development of mango (Mangifera indica L) rootstock cv. Local. HortFlora Res Spectrum. 2015;4(3):236–40.
36. Usman M, Shah MH, Badar A, Fatima B, Sabir M, Zaman Q. Media steam- ing and coco-coir enhance growth of rough lemon (Citrus jambhiri L.) stock Pakistan J of Agr Sci. 2014;51(3).
37. Parasaana JS, Leua HN, Ray NR. Effect of different growing Media mixture on the germination and seedling growth of mango (Mangifera indica L) cultivars under net house conditions. Bioscan. 2013;8(3):897–909.
38. Abdul Q. Effect of media composition on seed germination, seedling growth and its effect on grafting in Mango (Mangifera indica L). Msc. Thesis, University of Agricultural Sciences GKVK, Bangalore. 2011. http://krishikosh.egranth.ac.in/handle/1/89745. Accessed 17 February 2020.
39. Ajal J, Kizito EB. Performance of local variety mango grafted unions under nursery conditions. Bachelors Thesis, Agricultural Science and Entrepreneurship, Uganda Christian University. 2012.
40. Chavan PM. Effect of conditioner on days of storage and preparation of mango stone on germination and survival of mango (Mangifera indica L) rootstock. Msc thesis, Vasantrao Naik Marathwada Krishidyapeth, Parbhani. 2018. http://krishikosh.egranth.ac.in/handle/1/5810072140. Accessed 17 February 2020.
41. Bairwa S, Singh V, Mahawer LN, Regar AL. Effect of media and age of rootstock on epicotyl grafting of mango (Mangifera indica L) cv. amrapali. Int J Chem Studies. 2018;6(3):3239–43.
42. Baita H, Manga A, Mustapi A. Evaluation of different morphotypes of mango (Mangifera indica L) for use as rootstock in seedlings production. Bayero J Pure App Sci. 2010;3(1).
43. Roy RK, Robbani M, Ali M, Bhowal SK, Erfan ANM. Variations in salinity tolerance of selected mango rootstocks. Bangladesh Agron J. 2014;17(1):89–94.
44. Abbas MT, Seif MI, Gomaa AM, Nada EEM. Effect of seed husk, GA3, KNO3 and seed orientation in seedbed on germination characters of white succary mango seeds. Hortscience J Suez Canal Uni. 2015;3:55–60.
45. Smith MW, Bright JD, Hoult MD, Renfree RA, Maddern T, Coombes N. Field evaluation of 64 rootstocks for growth and yield of ‘Kensington Pride’ mango. Hortsci. 2008;43(6):1720–5.
46. Das B, Dhakar MK. Effect of interstock on growth of vigorous mango cultivars under eastern plateau and hill region of India. Vegetos-An Int J Plant Res. 2016;29(3):1–5.
47. Faroug MM. Effects of Different Germination Media and the Orientation of Mango Seedling Germination and Growth (Mangifera indica). Doctoral dissertation, UoFK. 2015.
48. Damodarana T, Rajanb S, Kumarb R, Sharmaa DK, Misraa VK, Jhaa SK, Raic RB. Post-tsunami collection of polyembryonic mango diversity from Andaman Islands and their ex situ reaction to high sodium in sodic soil. J Appl Hortic. 2013;15(1):21–5.
49. Kaur S. Effect of growing media mixtures on seed germination and seedling growth of different mango (Mangifera indica L.) cultivars under submountainous conditions of Punjab. Chem Sci Rev Lett. 2017;6(23):1599–603.
50. Deyeswari D, Rayaprolu S, Jone A. Effect of Potting Media on Seed Germination, Seedling Growth and Vigour in TNAU Papaya Co. 8 (Carica papaya L). Int J Pure App Biosci. 2017;5(3):505–12.
51. Meena AK, Garhwal OP, Mahawar AK, Singh SP. Effect of Different Growing Media on Seedling Growth Parameters and Economics of Papaya (Carica papaya L.) cv. Pusa Delicious. Int J Curr Microbiol App Sci. 2017;6(6):2964–72.
52. Reshma UR, Simi S. Correlation analysis of pre-sowing treatments, sowing positions and age of stones after extraction on germination of mango (Mangifera indica L.). J Pharmacognosy Phytochem. 2019;8(1):1133–8.

Publisher's Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.