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ABSTRACT

Hot pepper is one of the most important vegetable crops produced in Ethiopia. However, the average production and productivity of the crop is low in Humbo District, mostly associated with a lack of high yielding varieties, transplanting dates and inappropriate agronomic practices. An experiment was conducted to evaluate the effects of variety and seedling age on the growth, yield and quality of pepper during 2023/2024 main cropping season using supplementary irrigation in Humbo District. Treatments consisted of three pepper varieties (Mareko fana, Melka awaze, and Melka shote) and four seedling ages (35, 45, 55, and 65 days), laid in a Randomized Complete Block Design (RCBD) in a 3x4 factorial arrangement with three replications. Phenological, growth, yield, and quality parameters of pepper were collected and analyzed using SAS version 8.1 and mean separation was carried out using the Least Significant Difference (LSD) test at 5% and 1% level of significance. Seedlings transplanted at 55-day-old highest number of fruits per plant (31.89), total dry yield (2.57 t ha⁻¹) and oleoresin content (18.33%). Hence, using Melka awaze variety and 55-day seedling ages old can be recommended for the production of pepper in the study area using supplementary irrigation.

Keywords: Leaf area index; Number of seeds per pod; Seed weight; Total leaf area

1. INTRODUCTION

Hot pepper (*Capsicum annuum* L.) is an herbaceous plant belonging to the Solanaceae family. It is believed to have originated in the Andes of South America before migrating to tropical lowland areas of the Americas (Bosland *et al.*, 2012). It is cultivated in warm climates including Asia, northern America, and tropical and subtropical regions of Africa (Baenas *et al.*, 2019). In Ethiopia, among vegetable crops of the Solanaceae family, the genus *Capsicum* is the second most important vegetable crop next to tomato (Berhanu *et al.*, 2011; Hunde, 2020). “Datta” is common in South Ethiopia and developed from ground fresh peppers species alone and in combination with some Ethiopian spices (Gemechu, 2021). Mature green pods known as ('karia') are consumed as salads (Getahun and Habtie, 2017). It is widely accepted in the Ethiopian diet, and an essential traditional crop mainly used for its pungency and color (Chernet and Zibelo, 2019).

According to CSA (2021) 3.718 million hectares of land were used to produce 42.282 million tons of pepper in both dry and green fruits in the world. In this year's production of dry and green peppers, productivity was 2.57 and 17.8 t ha⁻¹ respectively. According to CSA (2021) Ethiopia produces 307,457.1 tons of dry pepper on around 172,142.2 ha, while 62,247.6 tons of green peppers on approximately 10,473.1 ha. The planting of red peppers occupies 180,701.46 ha of land and produced 1.8 t ha⁻¹ dry pepper and 6.31 t ha⁻¹ green pepper, respectively (CSA, 2023). The productivity of pepper in the south region, the average dried yield obtained in research conditions was 1.8-2.5 t ha⁻¹ (Gebre, 2015). According to Wolaita Zone Agricultural Development Office 2023, the average productivity of pepper in the Wolaita zone is 1.35 t ha⁻¹ for dry pepper.

In Ethiopia, there are different factors that contribute to the lower yields in the production of pepper. Those factors include lack of suitable high-yielding varieties, seedling age at transplanting time, the use of unreliable seed sources, poor irrigation systems, a lack of knowledge about soil fertility, poor cultural practices, lack of access to the market center (Bekele, 2022).

The Ethiopian Institute of Agricultural Research (EIAR) has so far released the following hot pepper varieties for the fresh and dry markets: Melka Awaze, Melka Shote, Mareko Fana, Bako Local, Melka Zala, Melka Dima, and Melka Eshete (MoARD, 2016). Different pepper varieties

respond differently to biotic and abiotic factors and have varying yield potentials. Local and Melka awaze yields of green pods were 5.366 and 14.529 t ha⁻¹, respectively (Getahun and Habtie, 2017). According to Getahun and Habtie (2017) reported that the variety ‘Melka Awaze’ produced the maximum yields in Woreta, Northwestern Ethiopia.

The age of the seedlings is another important factor that influences pepper production. A higher output of pepper can be achieved by using seedlings that are at the right age. According to earlier studies, seedlings transplanted at 60 and 75 days after sowing produced more fruits and had a higher fresh fruit output per hectare than those planted at 85 and 100 days (Ibrahim *et al.*, 2013). However, Essilfie *et al.* (2017) who, reported that on chili peppers when compared to seedlings that were 30, 37, and 60 days old, 44-day-old transplants had the highest yield, tallest plant, and highest number of branches. Similarly, Shukla *et al.* (2011) reported that middle seedling age transplants produced more fruits than younger and older transplants in sweet pepper. However, the research conducted so far has not considered the effects of varying seedling ages on pepper varieties. Therefore, it is imperative to investigate how different seedling ages influence pepper varieties.

Pepper is extensively produced in the Wolaita Zone for both household consumption and market supply. However, according to the Wolaita Zone Agricultural Office WZAO, 2023 (unpublished), the average productivity of dry pepper in the Wolaita Zone is only 1.35 t ha⁻¹, which is significantly lower than the national average 1.8 t ha⁻¹. This low productivity may be due to a lack of suitable high-yielding varieties and incorrect seedling age at transplanting. To address this, transplants are being made at different seedling age in the field to observe the growth, yield and quality of pepper. Farmers often transplant pepper seedlings either too early or too late compared to the recommended seedling age. This improper seedling age may significantly affect the growth, yield, and quality of peppers. To increase pepper productivity in the study area, it is crucial to determine the optimum seedling age for pepper. Farmers in the study area often do not adhere to the recommended seedling age for transplanting. Furthermore, it is hypothesizing that pepper varieties will respond differently to the age of seedlings. Hence, the objective of this study is:

- To determine the effects of seedling ages on the growth, yield, and quality of pepper varieties in Humbo District, South Ethiopia.

2. MATERIALS AND METHODS

2.1. Description of the Experimental Site

A field experiment was conducted on a farmer field in Wolaita Zone at Humbo District Ompo-Koysha Peasant Association in the 2023/2024 main cropping season under supplementary irrigation. Humbo District is located in 6° 39' 59.99" N latitude 37° 49' 59.99" E longitude. Besides, the woreda is located at an altitude of 1100 – 2335 meters above sea level. The district receives an average annual rainfall of 1120 mm and the temperature ranges between 15°C to 29°C. The soils of the district are mainly brownish red predominated by clay soil types (Labiso and Yagaso, 2021) .

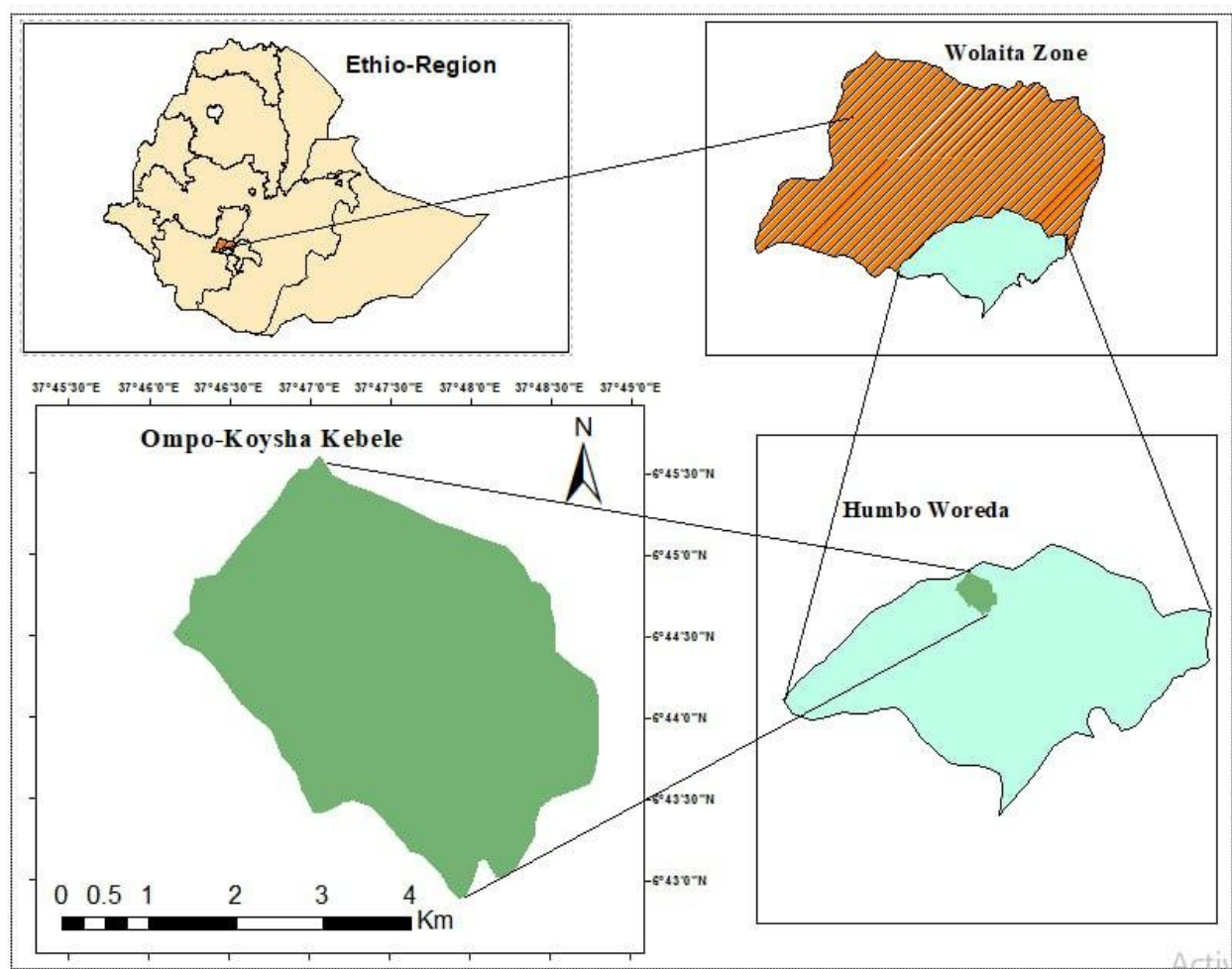


Figure 1. Map of the study area

2.2. Description of Experimental Materials

Seeds of three hot pepper varieties, namely Melka shote, Mareko fana, and Melka awaze, had 95% germination were used. The seeds of the varieties were obtained from the Melkassa Agricultural Research Center, Horticulture Division (MARC). The detailed characteristics of these three varieties are described below (Table 1).

Table 1: Description of the hot pepper varieties used for the experiment

Pepper Varieties	Mareko fana	Melka awaze	Melka shote
Maintainer	MARC	MARC	MARC
Adaptation (m.a.s.l)	1400–2200	1200–2200	1000–2200
Temperature (°C)	20/29	18/29	15/27
Rain Fall (mm)	600–1337	900–1300	900–1300

Source: MARC, 2005

2.3. Treatments and Experimental Design

The treatments consisted of three pepper varieties (Mareko fana, Melka awaze, and Melka shote) and four seedling ages (35-, 45-, 55-, and 65-day's old seedlings). The experiment was laid out in a randomized complete block design with a 3x4 factorial arrangement and replicated three times.

The gross size of each plot was 8.4 m² (2.4 m x 3.5 m). The spacing between plants and rows was 0.3 m and 0.7 m respectively. The distance between adjacent plots and blocks was between 0.5 m and 1 m respectively. Each plot comprised 5 rows, and each row comprised 8 plants. There was a total of 40 plants per plot. Plants in the central rows were used for data collection, leaving plants in the outer rows as well as those at both ends of each row to avoid border effects. Thus, the net plot size was 428.75 m².

2.4. Experimental Procedure and Crop Management

Pepper seeds were sown in May 26/ 2023 G.C on a seed bed size of 3 m x 1 m. The seed bed was covered with dry grass for 12 days. Then, beds were covered by raised shade to protect the

seedling from strong sun shine and heavy rainfall until the plants were ready for transplanting. The seedlings were irrigated and kept weed-free until the time of transplanting. Transplanting to the actual field was done when the seedlings attained 35 days after being sown and continued for a ten-day interval between transplants. Only vigorous and pest- and disease-free seedlings of equal size were transplanted.

In the main field seedlings were spaced 30 cm between plants and 70 cm between rows. The seedlings were transplanted late in the afternoon to prevent the seedlings from getting scorched by intense sunlight or dehydrated due to high temperatures. After transplanting the seedlings, light watering has been provided to settle the soil around the roots, eliminating air pockets that can dry out roots and impede their contact with the soil. The first weeding was done two weeks after transplanting, while subsequent weeding was done when it was needed. Fertilizer in the forms of urea (46% N) and NPS (19% N, 38% P₂O₅ and 7% S), hand weeding, and all other agronomic practices were applied uniformly to the entire plots as recommended for pepper production (Kitila and Olana, 2024). The entire 200 Kg NPS ha⁻¹ as a side dressing during the transplanting operation and 46 kg N ha⁻¹, half of it was applied when the seedlings become 45 days after transplanting was applied (Gelu *et al.*, 2024).

2.5. Data Collected

2.5.1. Phenological parameters

Days to 50% flowering (days): The number of days where 50% of the selected plants started blooming beginning from the days of transplanting.

Days to 50% maturity (days): Days to 50% maturity were record by counting the days from transplanting up to the date when 50% of the plants in a plot showed redness of fruits.

2.5.2. Growth parameters

Plant height (cm): Plant height was measured during the flowering stage from the soil surface to the top most growth points of the above-ground plant part. The measurement was taken as the length from 5 plants of central rows of each plot at the last harvesting time.

Total leaf area (cm²): It was determined from 5 randomly taken plants at complete pod setting and the mean value of them was taken. Total leaf area was obtained by measuring the length and width of 5 leaves for each five plants and counting the total number of leaves with respect to the

plant. The total leaf area was calculated and then multiplied by respective plant's total number of leaves to obtain the total leaf area using the formula developed by (Swart *et al.*, 2004).

$$LA = L \times W \times 0.69 \dots\dots\dots (1)$$

$$TLA = LA \times TNL \dots\dots\dots (2)$$

Where: LA = Leaf area, L= Leaf length, W= Leaf width, and TNL = Total number of leaves

Leaf area index (LAI): Is the amount of leaf area (cm²) in a canopy per unit ground area (cm²) of plants (Yildirim *et al.*, 2018). The values were obtained by the number of plants and their respective ground area (30 cm x 70 cm).

$$\text{Leaf area index} = \frac{\text{Total leaf area of a plant (cm}^2\text{)}}{\text{Ground area covered by the single plant (2,100 cm}^2\text{)}} \dots\dots\dots (3)$$

Canopy diameter (cm): The mean values were taken at fruit maturity by measuring the diameter of the plant (North to South and East to West dimensions of the above-ground part of sample plants).

Number of branches: The sum of numbers of primary, secondary, and tertiary branches per stem of randomly selected 5 middle-row plants at final harvest were counted.

2.5.3. Yield and yield-related parameters

Number of fruits per plant: Mean number of red ripe fruits of individual plants from central rows for each plot at each harvest was recorded.

Number of seeds per pod: The number of seeds of 5 randomly select marketable pods harvested from the net plot area was counted at each harvest and mean values were computed.

Seed weight per pod (g): Seed extract from 5 marketable pods were weighted using a sensitive balance and mean values determined.

Marketable yield (t ha⁻¹): The marketable yield of plants was determined at each harvesting by sorting dried fruits according to color, shape, shininess, firmness and size of the fruits. After drying, the dried marketable fruits were separated, the weight of the respective categories were recorded and converted to ton per hectare.

Unmarketable yield (t ha⁻¹): Is the yield obtained by sorting the diseased, discolored, shrunken shape and small sized, totally unwanted pods by consumers from marketable dried pods were recorded at each harvest and converted to ton per hectare.

Total dry fruit yield (t ha⁻¹): Weight of total (marketable and unmarketable) fruits harvested at each successive harvesting from the plants was recorded and summed up to estimate yield per hectare.

2.5.4. Quality Parameters

Fruit dry weight content (g): Five pods from each plot were taken, and samples were dried in an oven at 105 °C for 24 hours.

Fruit pericarp thickness (mm): Pericarp of five marketable fruits from each plot was measured using venire caliper and mean values were recorded.

Fruit length (cm): Length of five marketable fruits from each plot for each variety were measured at red and dried stage using venire caliper and mean values were taken.

Fruit diameter (cm): Fruit wall was measured from five marketable fruits of sample plants from each plot at red ripe and dried stage using venire caliper and mean values were recorded.

Oleoresin content (W/W %): The sample pods were collected from each plot, shade-dried, and ground into powder. 50g of this powder were used for oleoresin extraction. The flask was cooled in a desiccator, weighed, and the oleoresin content was quantified on a percent weight-to-weight basis according to the formula described (Daniel *et al.*, 2008).

$$\text{Oleoresin content (\%)} = \frac{\text{Weight of oil (g)}}{\text{Weight of samples (g)}} \times 100 \dots\dots\dots (4)$$

2.6. Data analysis

The collected data were subjected to analysis of variance (ANOVA) using Statistical Analysis Software (SAS) version 8.1 (SAS Institute, 2003). Mean separation was carried out using the Least Significant Difference (LSD) test at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1. Phenological Parameters

3.1.1. Days to 50% flowering

Days required to reach to 50% flowering was significantly ($P < 0.05$) influenced by the main effects of pepper varieties and seedling age as well as their interaction effects (Appendix Table 1). The longest (74.33) days required to reach 50% flowering were recorded in the response to the Melka shote variety transplanted at 35 days old seedling. However, the earliest (45.33) days required to reach to 50% flowering were recorded in the response of the Mareko fana pepper variety transplanted at 65 days old seedling. The longest days required to reach to 50% flowering were statistically at par with Melka awaze variety transplanted at 35 days seedling ages. The earliest days required to reach to 50% flowering were statistically at par for all pepper varieties planted at 55- and 65-days old seedlings (Table 2).

The results indicated that transplanting older seedlings may have allowed them to acclimate to the environment more successfully, establish themselves effectively, and utilize soil nutrients from the soil solution. Consequently, these older seedlings exhibited increased vegetative growth and began flowering faster than younger transplants. According to Sana *et al.* (2003) showed that the plant's hereditary characteristics, genetic potential, and early acclimation to the growing environment can all be factors in how early or late a plant, measured in days 50% flowering.

This finding is in agreement with the results of Ndagana (2021), who reported that the Rocoto pepper variety transplanted on 120-day-old seedlings was required (100.74 days) to reach 50% flowering compared to other varieties, whereas the Tabasco variety transplanted on 30-days-old seedlings took the longest (131.65 days) to attain 50% flowering.

3.1.2. Days to 50% maturity

Days to 50% maturity was significantly ($P < 0.05$) influenced by the main effects of pepper varieties and seedling age as well as their interaction effects (Appendix Table 1). The longest (134.33) days required to reach to 50% maturity was recorded in the response to planting of Melka shote variety using 35 days old seedlings. However, the earliest (104.33) days required to reach to 50% maturity was recorded in the response to Mareko fana variety using 65 days old seedlings (Table 2).

The earliest days required to reach to 50% maturity in response to planting Mareko Fana variety using 65 days old seedlings might be due to inherent genetic variation of the varieties as well as reduced transplanting shock and shorter lag time, allowing photosynthesis to continue uninterrupted after transplanting. This result is supported by Teferi *et al.* (2015) who reported that earliness or lateness in the days to maturity might have been due to their inherited characters, and early acclimatization to the growing area.

This result agrees with the finding of Ndagana (2021) who reported that the Rocoto pepper variety transplanted in 120 day old seedlings was required to reach 50% maturity earlier (135 days). However, Tabasco pepper variety transplanted in 30 days seedling ages took the longest (173.38 days) to reach to 50% maturity.

Table 2: Phenology of pepper as influenced by interaction effects of Variety and Seedling age in Wolaita Zone Humbo District, South Ethiopia during the main cropping season of 2023/2024

Variety	Seedling age (days)	Days to 50% flowering (days)	Days to 50% maturity (days)
Mareko fana	35	57.33 ^{bcd}	117.33 ^{bcd}
	45	56.66 ^{bcd}	115.33 ^{bcde}
	55	54.00 ^{efg}	111.33 ^{efg}
	65	45.33 ^g	104.33 ^h
Melka awaze	35	70.00 ^a	129.00 ^a
	45	59.66 ^{bc}	120.33 ^{bc}
	55	53.66 ^{def}	115.33 ^{cde}
	65	48.33 ^{fg}	108.33 ^{gh}
Melka shote	35	74.33 ^a	134.33 ^a
	45	61.33 ^b	121.33 ^b
	55	54.33 ^{cde}	114.33 ^{def}
	65	49.66 ^{efg}	109.33 ^{fgh}
LSD (0.05)		5.93	5.48
CV (%)		6.18	2.77

Where; Treatment means followed by the same letter(s) within the same column are not significantly different, CV = Coefficient of variation, LSD= Least Significant Difference.

3.2. Growth Parameters

3.2.1. Plant height

Plant height was highly significantly ($P < 0.01$) influenced by the main effects of variety and seedling age. However, it was not significantly influenced by the interaction effect of treatments in pepper (Appendix Table 1). The tallest (72.96 cm) and (79.66 cm) plant height were obtained in responses to Melka shote variety and 55 days seedling ages, respectively. However, the shortest (62.71 cm) and (48.59 cm) plant height were recorded in responses to Mareko fana and 35 days seedling ages, respectively (Table 3). The highest (72.96 cm) plant height was recorded in response to Melka shote variety, which is also statistically at par with Melka awaze variety. And also, the highest (79.66 cm) plant height was recorded in response to 55 days seedling age, which is statistically at par with 65 days old seedling ages (Table 3).

This could be due to the genetic makeup of the varieties and the difference in plant height between pepper varieties in 55 days seedling age transplants may also be attributed to their higher biomass, especially to their well-established and developed root system, which facilitated better cellular elongation and enhanced uptake of water and nutrients from the soil. Older transplants with sufficient number of true leaves might be responsible for manufacturing a sizable amount of photosynthesis required to establish vigorous plant and complete its life cycle more comfortably (Shukla *et al.*, 2011).

The result of the present experiment agrees with the finding of (Kahsay, 2017) who reported that the tallest plant height was recorded Melka zala variety (83.47 cm) and the shortest was Melka eshet (60.93 cm) varieties. Furthermore Manna and Ray (2015) who reported that the average plant height was highest (47.58 cm) in the capsicum crops which were transplanted at the 60 days seedling age and the plant height was lowest (21.67 cm) in the capsicum crops transplanted at the 30 seedling ages.

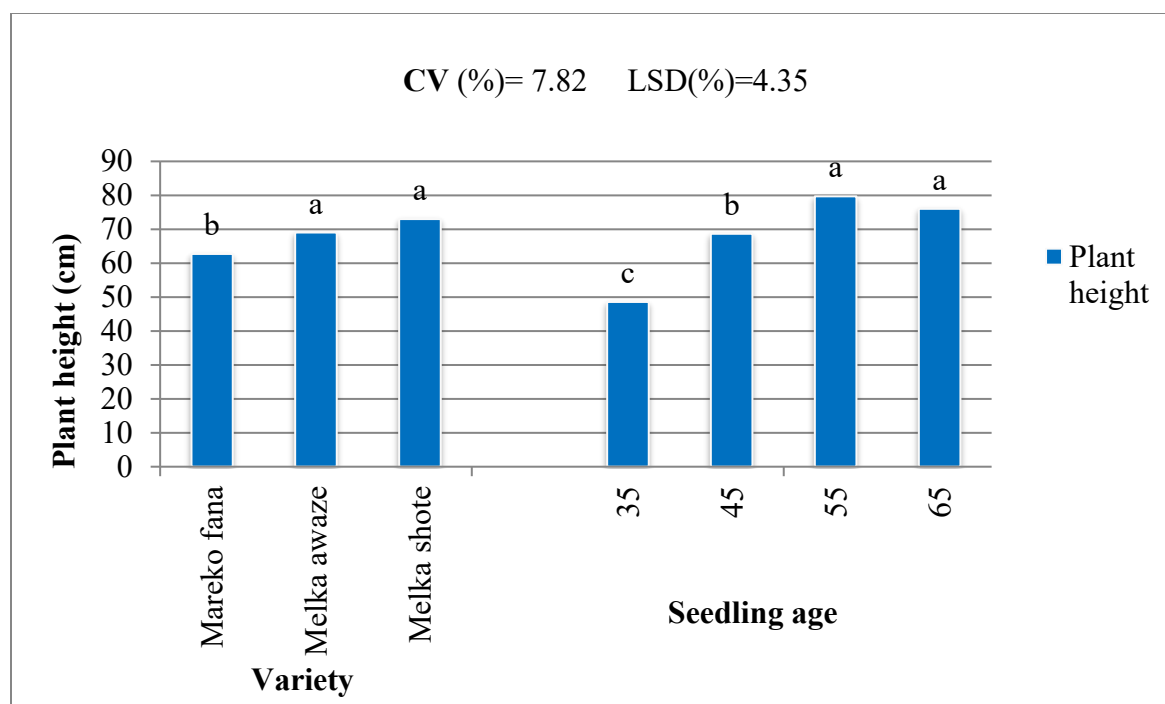


Figure 2: Effect of varieties and seedling ages on plant height of hot pepper.

Where; CV = Coefficient of variation and LSD= Least Significant Difference

3.2.2. Total leaf area

Total leaf area was highly significantly ($P < 0.01$) influenced by the main effects of variety and seedling age. However, there was no interaction effect between variety and seedling age in total leaf area of pepper (Appendix Table 1). The highest (3118.2 cm^2) and (3855.1 cm^2) total leaf area were recorded in the Mareko fana variety and 55 days seedling ages, respectively. However, the lowest (2282.7 cm^2) and (1721.3 cm^2) total leaf area were obtained in the Melka shote variety and 35 days seedling ages, respectively. The lowest ($1.2282.8 \text{ cm}^2$) total leaf area was recorded in response to the Melka shote variety, which is also statistically at par with Melka awaze variety with the result of 2608.7 cm^2 . The lowest (2282.8 cm^2) total leaf area was recorded in response to 35 days seedling ages, which is also statistically at par with 65 days seedling ages with the result of 2250.2 cm^2 .

The highest total leaf area was recorded in the Mareko fana variety at 55 days of seedling age. This might be due to genetic variations like the size and shape of leaf characteristics of pepper varieties, and an increased leaf area at middle seedling ages indicates that good growth and development of pepper at the nursery help to establish early on the field successfully and

seedlings make photosynthesis. The warmer soil and air temperature during middle transplanting date provides sufficient time for vegetative growth thereby increasing leaf area while later transplanted crop have to face cold winters during early stage of the growth.

The result of this experiment agrees with the finding of Hinsermu *et al.* (2022) who reported that the highest (38.12 cm²) leaf area was recorded by Mareko Fana while, the lowest (34.12 cm²) leaf area was recorded in Melka shote.

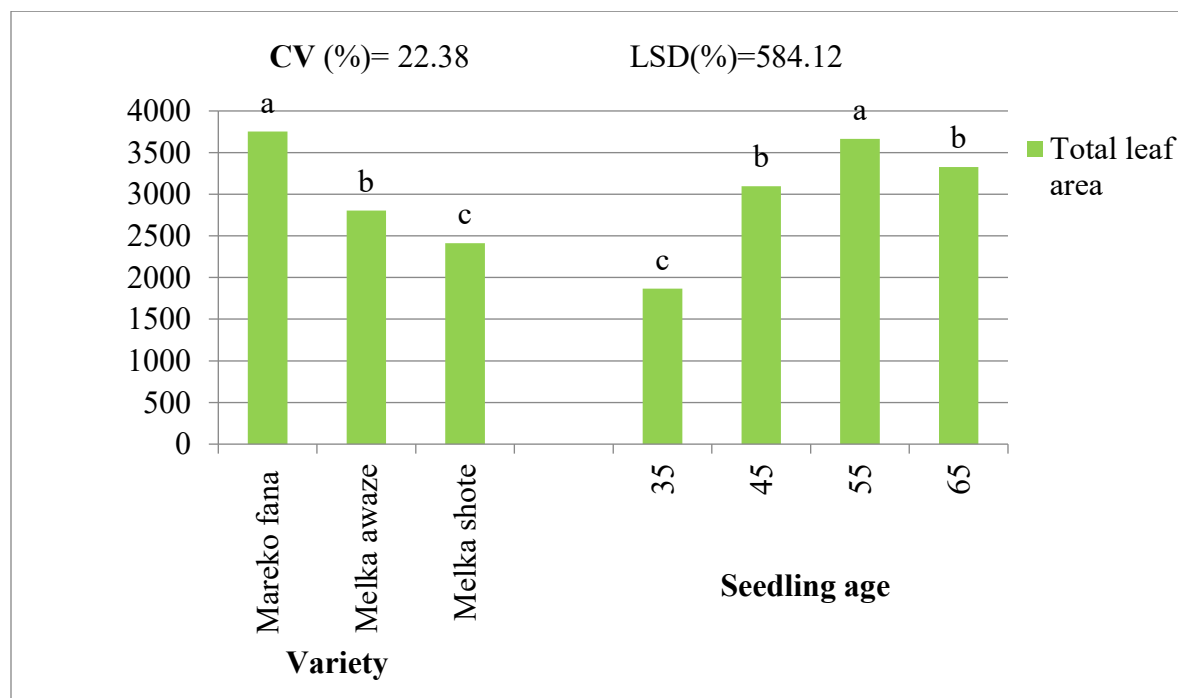


Figure 3: Effect of varieties and seedling ages on total leaf area of hot pepper.

Where; CV = Coefficient of variation and LSD= Least Significant Difference

3.2.3. Canopy diameter

Canopy diameter was highly significantly ($P < 0.01$) influenced by the main effects of variety and seedling age of pepper. However, the interaction effects of the two factors did not influence canopy diameter of pepper (Appendix Table 1). The widest (14.56 cm) and (14.75 cm) canopy diameter were recorded in Melka awaze variety and 55 days seedling ages, respectively. The lowest (12.45 cm) and (12.04 cm) canopy diameters were recorded in Mareko fana variety and 35 days seedling ages, respectively. The widest (14.56 cm) canopy diameter was recorded in response to Melka awaze variety, which is also statistically at par with Meka shote variety. The lowest (12.45 cm) canopy diameter was recorded in response to Mareko fana variety, which is

also statistically at par with Meka shote variety. The widest (14.75 cm) canopy diameter was recorded in response to 55 days seedling age, which is also statistically at par with 45 days seedling age with the result of 14.45 cm. The lowest (12.04 cm) canopy diameter was recorded in response to 35 days seedling age, which is also statistically at par with 65 days seedling age (Table 3).

The widest canopy diameter was recorded in the Melka awaze variety and 55 days of seedling ages. The difference in canopy diameter among pepper varieties might be due to genetic variations and increased canopy diameters from middle seedling ages due to the presence of good initial vegetative growth in middle seedlings at the time of transplanting. This result supported by Essilfie *et al.* (2017) who observed that the period of vegetative growth, light conversion efficiency, and canopy diameter can all be impacted by plant density.

The result of the present experiment agree with the finding of Essilfie *et al.* (2017) who reported that the 56 days seedling ages transplant produced the widest (25 cm) canopy width from 48 to 80 days after transplanting at the same cropping period. But, the 30 days seedling ages transplant was the least (12 cm) canopy diameter from 32 – 80 days after transplanting during the 2013 cropping season.

3.2.4. Number of branches

Number of branches was significantly highly ($P < 0.01$) influenced by the main effects of variety and seedling age of pepper. However, the interaction effects of the two factors did not influence number of branches of pepper in the treatment (Appendix Table 1). The highest (11.96) and (12.02) number of branches were produced in Melka awaze variety and 55 days seedling ages, respectively. However, the least (9.54) and (9.45) number of branches were produced Mareko fana variety and 35 days seedling ages, respectively. The highest (12.02) number of branches was recorded in response to 55 days seedling ages, which is also statistically at par with 45 days seedling ages. The least (9.45) number of branches was recorded in response to 35 days seedling ages, which is also statistically at par with 65 days seedling ages (Table 3).

The Melka awaze variety and 55 days of seedling age produced the most branches. This result shows that, due to the genetic variation of the variety and variable environmental conditions, when compared to young or too-old seedlings, middle seedling age increases plant growth and

the number of branches at the optimum time for transplanting. The least number of branches were produced in the Mareko fana variety and 35-day seedling ages.

This finding is in agreement with the results of Daudu *et al.* (2020) reported that, in terms of number of branches per plant, the highest number of branches (9.25) was produced by 32 days seedling ages while the lowest number of branches (4.75) was produced by 48 seedlings. This result contradicts with the finding of Awel (2017), who reported that the number of branches per plant shows no significant difference among all pepper varieties.

Table 3: Main effect of variety and seedling age on growth parameter of pepper in Wolaita zone Humbo District, South Ethiopia during the main cropping season of 2023/2024

Variety	Canopy Diameter (cm)	Number of Branch.
Mareko fana	12.45 ^b	9.54 ^b
Melka awaze	14.56 ^a	11.96 ^a
Melka shote	13.5 ^{ab}	10.81 ^a
LSD (0.05)	1.24	1.02
Seedling age		
35	12.04 ^b	9.45 ^c
45	14.45 ^a	11.51 ^{ab}
55	14.75 ^a	12.02 ^a
65	12.77 ^b	10.1 ^{bc}
LSD (0.05)	1.43	1.18
CV (%)	10.85	11.24

Where; Means with in column followed by the same letter (s) are not significantly different. CV= coefficient of variation, LSD= Least significant Difference.

3.3. Yield and yield related parameters

3.3.1. Number of fruits per plant

The main effects of variety and seedling age highly significantly ($P < 0.01$) influenced the number of fruits per plant of pepper. However, there was no their interaction effect between variety and seedling age in number of fruits per plant of pepper (Appendix Table 1). The highest (34.08) and (32.32) number of fruits were recorded in Melka awaze variety and 55 days seedling

ages, respectively. The least (22.78) and (27.06) number of fruits per plant were recorded in Mareko fana variety and 35 seedling ages, respectively. The Melka awaze variety was greater than the Melka shote and Mareko fana varieties by 1.37 and 11.3 fruits, respectively. The highest (34.08) number of fruits per plant was recorded in response to Melka awaze variety, which is also statistically at par with Melka shote variety. The least (27.06) number of fruits per plant was recorded in response to 35 seedling ages, which is also statistically at par with 65 seedling ages (Table 4).

The highest number of fruits per plant was obtained in the Melka awaze variety and 55-day seedling ages might be due to the variety's inherited differences, such as canopy diameter, branch number, and vegetative growth, which restrict the number of fruit yields. Because as the number of branches increased, there was the potential that the number of fruit-producing buds would also increase, resulting in increased fruit yield. The 55 days seedlings age were the favorable soil moisture and temperature for pepper growth with optimum seedling age compared to younger seedling ages. As a result of their better vegetative growth over other aged seedlings, the middle-aged seedlings produced more heavy fruits, with the largest fruits (Ahmed *et al.*, 2022).

This finding is in agreement with the results of Jankauskienė and Laužikė (2023) who reported that the 50-days-aged seedlings were found in a heavier and higher number of fruits because their vegetative growth was better than other aged seedlings. This result contradicts with Ahmed *et al.* (2022) who reported that the highest (13.55) fruits per plant were recorded in 28 days seedling age transplants, whereas the lowest (7.22) fruits per plant were obtained in 48 days seedling age transplants in sweet pepper.

3.3.2. Number of seeds per fruit

Number of seeds per fruit was highly significantly ($P < 0.01$) influenced by variety and seedling age. However, there was no significant effect on its interaction with the number of seeds per pod in pepper (Appendix Table 1). The highest (125.4) and (128.3) number of seed per fruit were recorded in Melka awaze variety and 55 days seedling ages, respectively. Whereas, the least (112.03) and (110.27) number of seed per fruit were recorded in Melka shote variety and 35 seedling ages, respectively. The highest (125.4) number of seed per fruit was recorded in response to Melka awaze variety, which is also statistically at par with Marko fana variety. The least (112.03) number of seed per fruit was obtained in response to Melka shote variety which is

also statistically at par with Marko fana variety with the result of 118.69 (Table 4). The least (110.27) number of seed per fruit was recorded in response to 35-day seedlings age, which is also statistically at par with 65 days seedling ages with the result of 115.65 (Table 4).

The highest number of seeds per fruit was recorded in the Melka awaze variety and 55 days of seedling ages. This variation is due to the genetic makeup of the varieties and the effects of the seedling age. Pepper plants that showed strong vegetative growth also achieved higher photosynthetic capacity, which led to a larger pod size and a higher number of seeds per pod. The differential response by different varieties may be due to differences in genetic constituents of the varieties and variable environmental condition (Bergefurd *et al.*, 2011).

This finding is in agreement with the results of Ahmed *et al.* (2022) reported that the maximum (80.04) number of seeds per fruit was recorded in 28 days seedling age transplants whereas, the lowest (40.09) was observed in 14 days seedling age transplants. It contradicts the present result the finding of Daudu *et al.* (2020) who observed that the highest (143.00) number of seeds was produced by 24 days seedling ages while the lowest (108.80) number of seeds was produced by 40 days seedling ages.

3.3.3. Seed weight per pod (g)

Seed weight per pod was highly significantly ($P < 0.01$) influenced by the main effects of variety and seedling age. However, there was no significant effect on its interaction with the seed weight per pod in pepper (Appendix Table 1). The maximum (1.87 g) and (1.83 g) weight of seed per pod were recorded in Melka awaze variety and 55 days seedling ages, respectively. The minimum (1.53 g) and (1.54 g) seed weight per fruit were obtained in the Melka shote variety and 35 days seedling ages, respectively (Table 4). The maximum (1.83 g) seed weight per fruit was obtained in response to 55 days seedling ages which is also statistically at par with 45 days seedling ages with the result of 1.72 g. The least (1.54 g) seed weight per fruit was obtained in response to 35 days seedling ages which is also statistically at par with 65 days seedling ages with the result of 1.67 g (Table 4).

The maximum weight of seed per pod was recorded in the Melka awaze variety at 55 days of seedling age. This might be due to the fact that there is a positive relationship between seed number and pod size, where increasing the seed number, pod size, and seed size linearly

increases the weight of the seed per pod. As a result, pods with larger seed weights are thought to assimilate at a higher rate.

The present result is similar to the finding of Daudu *et al.* (2020) who reported that the weight of 100 seeds recorded the highest (0.41 g) in 40-day seedling ages and the lowest (0.20 g) in 48-days seedling age. It contradicts the present result; the finding of Ahmed *et al.* (2022) reported that the heaviest (8.17 g) average seed weight was recorded at 28 days of seedling age transplants and the thinnest (6.60 g) weight was recorded at 42 days of seedling age transplants.

Table 4: Main effect of variety and seedling age on number of fruits per plant, number of seeds per pod and seed weight per pod of pepper in Wolaita Zone Humbo District, South Ethiopia

Variety	Number of fruits per plant	Number of seeds per pod	Seed weight per pod (g)
Mareko fana	22.78 ^b	118.69 ^{ab}	1.67 ^b
Melka awaze	34.08 ^a	125.54 ^a	1.87 ^a
Melka shote	32.71 ^a	112.03 ^b	1.53 ^c
LSD (0.05)	1.73	7.04	0.11
Seedling age (days)			
35	27.06 ^c	110.27 ^c	1.54 ^c
45	30.18 ^b	120.79 ^{ab}	1.72 ^{ab}
55	32.32 ^a	128.3 ^a	1.83 ^a
65	29.87 ^b	115.65 ^{bc}	1.67 ^{bc}
LSD (0.05)	2.00	8.13	0.13
CV (%)	6.86	7.01	7.94

Means with in column followed by the same letter (s) are not significantly different. CV= coefficient of variation, LSD= Least Significant Difference.

3.3.4. Marketable yield (t ha⁻¹)

Marketable yield was highly significantly ($P < 0.01$) influenced by the main effects of variety and seedling age, and their interaction (Appendix Table 1). The highest (2.38 t ha⁻¹) marketable dry yield was obtained in the Melka awaze variety with 55-day-old seedling ages, which is also statistically at par with the Melka shote variety with 55-day-old seedling ages, with a result of

2.21 t ha⁻¹. On the other hand, the lowest (1.06 t ha⁻¹) marketable dry yield was recorded on the Mareko fana variety with younger transplanted 35 days' seedling ages (Table 5).

The highest marketable dry yield was recorded due to the combination of the higher yielder variety and transplanting at the optimum seedling age, which has been shown to the best fruit color and size of pepper yields that are marketable. It was indicated that the presence of significant variation among pepper varieties in terms of growth characteristics was influenced by the inherent characteristics of the cultivars and affected the marketable yield of pepper. In order to maximize light and favorable temperatures and yield a high-quality crop, the planting date should be chosen so that the crop has the necessary time for germination, flowering, and seeding, as well as the proper synchronization of flowering with temperatures (Nahardani *et al.*, 2013).

This study is agreeing with the finding of Jankauskienė and Laužikė (2023) who showed that middle seedling ages (55 days) gave the highest marketable yields compared to the 40-day seedling ages. Similar results were obtained by Koner *et al.* (2015), who showed that the variety Mekong in combination with 60 seedling age were recorded the maximum (23.08 t ha⁻¹) fruit yield.

3.3.5. Unmarketable yield (t ha⁻¹)

The main effects of variety and seedling age and their interaction effects were highly significantly ($P < 0.01$) influenced by unmarketable dry yield of pepper (Appendix Table 1). The highest (0.94 t ha⁻¹) unmarketable dry yield was recorded in the response to Melka shote variety with younger seedling ages (35 days). Melka awaze variety with 35 days seedling ages (0.91 t ha⁻¹) statistically at par with Mareko fana variety with the younger 35 seedling ages 0.82 t ha⁻¹. On the other hand, the lower (0.47 t ha⁻¹) unmarketable dry yield was recorded in the Mareko fana pepper variety with the 55 days seedling ages (Table 5).

The highest unmarketable dry yield was recorded in the response to Melka shote variety with younger (35 days) seedling ages. This result might be the lower yielder variety with too younger seedling age resulted small sized pods, which leads to the production of a greater number of small-sized pods, large plants with few early fruits, and reduced firmness by reducing wall thickness, a greater number of branches and other vegetative organs. Younger seedlings appeared to require less food storage for vegetative extension, whereas older transplants were developed enough to control vegetative extension and so produced lower yields (Akinrotimi, 2018).

The present result agree with the finding of Teferi *et al.* (2015) who showed that the result of unmarketable yield the variety Melka shote had the highest unmarketable yield (0.1053 t ha⁻¹) while the least unmarketable yield was recorded from variety of Melka awaze (0.088 t ha⁻¹).

Table 5: Interaction effects on variety and seedling age on marketable and unmarketable dry yield of pepper in Wolaita Zone Humbo District, South Ethiopia during the main cropping season of 2023/2024.

Variety	Seedling age (days)	Marketable yield (t ha ⁻¹)	Unmarketable yield (t ha ⁻¹)
Mareko fana	35	1.06 ^h	0.74 ^b
	45	1.51 ^{ef}	0.57 ^{def}
	55	1.7 ^{cd}	0.47 ^{gh}
	65	1.62 ^{de}	0.49 ^{fgh}
Melka awaze	35	1.35 ^{fg}	0.91 ^a
	45	2.11 ^b	0.56 ^{def}
	55	2.38 ^a	0.43 ^h
	65	1.86 ^c	0.64 ^{cd}
Melka shote	35	1.22 ^{gh}	0.94 ^a
	45	2.05 ^b	0.67 ^{bc}
	55	2.21 ^{ab}	0.52 ^{efg}
	65	1.83 ^c	0.58 ^{de}
LSD (0.05)		0.17	0.08
CV (%)		5.83	7.6

Where; Treatment means followed by the same letter(s) within the same column are not significantly different, CV = Coefficient of variation, LSD= Least Significant Difference.

3.3.6. Total yield (t ha⁻¹)

Total dry yield was highly significantly ($P < 0.01$) influenced by variety and seedling age of pepper. But Its interaction has not shown a significant effect on total dry yield of pepper (Appendix Table 1). The highest (2.56 t ha⁻¹) and (2.57 t ha⁻¹) total dry yield were recorded in the Melka awaze variety and 55 days seedling ages, respectively. On the other hand, the lowest (2.02 t ha⁻¹) and (2.05 t ha⁻¹) total dry yield were obtained in the Mareko fana variety and 35 seedling ages, respectively (Table 6). The highest (2.56 t ha⁻¹) total dry yield was recorded in

response to Melka awaze variety, which is also statistically at par with Melka shote variety with the result of 2.51 t ha⁻¹. The highest (2.57 t ha⁻¹) total dry yield was recorded in response to 55 days seedling age, which is also statistically at par with 45 days seedling ages with the result of 2.49 t ha⁻¹ (Table 6).

The Melka awaze variety and 55 days seedling ages were recorded the highest dry yield might be due to the yield difference among these varieties, good vegetative growth, wide canopy diameter, the highest branch number and the highest leaf area and better root development of in middle transplanting days might has utilized plant nutrients and soil moisture in sufficient amount throughout life period, thus improved plant growth, yield attributes and finally produced higher fruit yield per unit area.

The present study similar with the finding of Ahmed *et al.* (2022), who indicated that the highest (26.8 t ha⁻¹) yield was recorded at 28 days seedling age transplants whereas, the lowest (7.76 t ha⁻¹) yield was recorded at 48 days seedling age transplants in sweet pepper.

Table 6: Effects of seedling age and varieties on total dry yield of pepper in Wolaita Zone Humbo District, South Ethiopia during the main cropping season of 2023/2024.

Variety	Total dry yield (t ha ⁻¹)
Mareko fana	2.02 ^b
Melka awaze	2.56 ^a
Melka shote	2.51 ^a
LSD (0.05)	0.9
Seedling age (days)	
35	2.05 ^c
45	2.49 ^a
55	2.57 ^a
65	2.34 ^b
LSD (0.05)	0.1
CV (%)	4.52

Means with in column followed by the same letter (s) are not significantly different at 0.05% level of significance; LSD (0.05) = Least Significant Difference at 0.05% level; CV= coefficient of variation.

3.4. Quality Parameters

3.4.1. Fruit dry weight (g)

The main effects of variety and seedling age highly significantly ($P < 0.01$) influenced by fruit dry weight content of pepper. However, the interaction effects of the two factors did not influence fruit dry weight content of pepper (Appendix Table 1). The highest (2.14 g) and (1.94 g) fruit dry weight content were recorded in Melka awaze variety and 55 days seedling ages, respectively. The least (1.47 g) and (1.51 g) fruit dry weight content per fruit were obtained from Melka shote variety and 35 days old seedling ages, respectively. Mareko fana variety was statistically similar value (1.52 g) with Melka shote variety (1.47 g). The least (1.47 g) fruit dry weight content was recorded in response to 35 days old seedling ages, which is also statistically at par with 65 days old seedling ages (Table 7).

The highest fruit dry weight content was recorded from the Melka awaze variety and 55- days' seedling ages. The variations in fruit dry weight among varieties may be due to the genetic makeup of the varieties. At the optimum seedling ages the rate of photosynthesis increased with increasing doses of chlorophyll content as a result, a greater amount of dry weight accumulated in the fruit. According to Tesfaw and Dechassa (2013) who showed that fruits vary in the percentage of dry matter they contain, most likely due to photosynthetic products that are transferred from leaves to fruits accumulate nutrients differently.

This result agrees with the findings of Kahsay (2017) who, showed that the highest Fruit Weight was obtained from Melka eshet (2.36 g) pepper variety. However, the lowest was from Melka Shote (0.65 g) variety. The present result contradict with the finding of Ahmed *et al.* (2022), who reported that the highest (6.6 g) individual fruit weight was recorded at 28 days seedling age transplants whereas, the lowest (3.7 g) average individual fruit weight was found in at 48 days seedling age transplants.

3.4.2. Fruit pericarp thickness (mm)

Fruit pericarp thickness was highly significantly ($P < 0.01$) influenced by the main effects of variety and seedling age of pepper. However, the interaction effects of the two factors did not influence fruit pericarp thickness of pepper (Appendix Table 1). The thickest (1.2 mm) and (1.09 mm) pericarp thickness were recorded in Mareko fana variety and 55 days seedling ages, respectively. The thinnest (0.74 mm) and (0.89 mm) pericarp thickness were recorded in Melka

shote variety and 35 days seedling ages, respectively. The thickest (1.09 mm) pericarp thickness was recorded in response to 55 days old seedling ages, which is also statistically at par with 45 days old seedling ages with the result of 1.02 mm. The thinnest (0.89 mm) pericarp thickness was recorded in response to 35 days old seedling ages (Table 7). One of the key factors affecting pepper growth, productivity, and quality is the ideal seedling's age (Islam *et al.*, 2010).

The thickest pericarp thickness was recorded in the Mareko fana variety at 55 days of seedling age. This might be due to the difference in fruit pericarp thickness among the pepper varieties, the difference in genetic makeup, and the varieties assimilation partitioning capacity that might result in the thickest or thinnest fruit pericarp. The increased pericarp thickness from middle seedling ages observed in the present study might be due to the presence of good initial vegetative growth and high photosynthesis of seedlings at the time of transplanting.

This finding is in agreement with the results of Saxena and Singh (2019), who reported that 33 days old seedling ages produced maximum value (4.36 mm) for pericarp thickness whereas, minimum value (4.06 mm) was recorded in 18 days old seedling ages in sweet pepper.

3.4.3. Fruit length

Fruit length was highly significantly ($P < 0.01$) influenced by the main effects of variety and seedling age. However, there was no interaction effect between variety and seedling age in fruit length of pepper (Appendix Table 1). The longest (8.95 cm) and (9.41 cm) fruit length were obtained in Melka awaze variety and 55 days seedling ages, respectively. The lowest (7.29 cm) and (6.9 cm) fruit length of pepper recorded in Mareko fana variety and 35 days seedling ages, respectively. The lowest (7.37 cm) fruit length was recorded in response to Mareko fana variety, which is also statistically at par with Melka shote variety with the result of 8.07 cm. Fruit length was transplanted at 45-day seedling ages (8.26 cm), which is also statistically at par with 65-day seedling ages (Table 7).

The longest fruit length was obtained in the Melka awaze variety and 55 days of seedling age. This might be due to the pepper varieties' inherited traits, and the fruit length difference observed among the seedling ages might be due to better vegetative growth in the middle seedlings ages. Seedlings with high vegetative growth and better fruit development have the longest fruit length. This result is supported by Essilfie *et al.* (2017), who that the longest fruit length in the middle-

aged seedling transplants may have been caused by the period of high temperature and rainfall during the cropping period, which led to vigorous plant growth.

This result is in line with the findings of Abebe *et al.* (2017), who observed that a higher fruit length (10.62 cm) was obtained by Melka awaze. However, lower fruit length (9.18 cm) was obtained by the Mareko fana variety. This result contradicts with the findings of Sibhatu *et al.* (2016) reported that Melka shote possessed the highest fruit length (11.00 cm) while the lowest was recorded on local (4.67 cm) variety.

3.4.4. Fruit diameter

Fruit diameter was highly significantly ($P < 0.01$) influenced by the main effects of variety and seedlings age. However, there was no interaction effect between variety and seedling age in fruit diameter of pepper (Appendix Table 1). The highest (2.21 cm) and (1.97 cm) fruit diameter were obtained in the Mareko fana variety and 55-day-old seedlings age, respectively. However, the lowest (1.23 cm) and (1.37 cm) fruit diameter were recorded in Melka shote variety and 35 days seedlings age, respectively (Table 7).

The highest fruit diameter was obtained in the Mareko fana variety and 55-day-old seedling ages. This might be due to the capacity of Marko fana to absorb a lot of solar radiation, which may have contributed to the variations in fruit diameter by causing a greater buildup of photosynthetic assimilates. The fruit diameter difference observed among the seedling age groups might be due to better vegetative growth. During fruit development, the fruit vary in size and this is said to be determined by the cultivar and by cell elongation during anthesis and post-anthesis (Bosland *et al.*, 2012).

This result is agree with the finding of Kahsay (2017) showed that the highest (2.82 cm) fruit diameter was recorded from Marko fana and lowest (0.9 cm) fruit diameter was observed in Melka Shote. Similarly, the finding of Simon and Tesfaye (2014) showed that Marko fana variety produced the highest (1.98 cm) fruit diameter.

3.4.5. Oleoresin content (%)

Oleoresin content was significantly highly ($P < 0.01$) influenced by the main effects of varieties of pepper. However, the interaction effects of the treatments, as well as the main effect of seedling age were not revealed significant variation on oleoresin content of pepper (Appendix

Table 1). The highest (18.33%) oleoresin content was obtained in the Melka awaze variety whereas; the lowest (12.25%) oleoresin content was recorded in Melka shote variety (Table 7). This could be due to the genetic makeup of the varieties. This result supported by Sharma *et al.* (2021), who reported that the content of oleoresin presents in different varieties of capsicum fruits mainly depend upon many factors such as geographical origin, environmental condition, soil characteristics as well as extraction conditions. This result is in line with the finding of Jyothi *et al.* (2008), who reported that the highest (21.8%) oleoresin content was obtained in the PBC-380 variety whereas, the lowest (9.0%) oleoresin content was recorded in ‘PBC-776’.

Table 7: Main effect of variety and seedling age on fruit dry weight, fruit thickness, fruit length, fruit diameter and oleoresin content of pepper in Wolaita Zone Humbo District, South Ethiopia during the main cropping season of 2023/2024.

Variety	Fruit Dry Weight (g)	Fruit Thickness (cm)	Fruit Length (cm)	Fruit Diameter (mm)	Oleoresin Content (%)
Mareko fana	1.52 ^b	1.2 ^a	7.29 ^b	2.21 ^a	15.58 ^b
Melka awaze	2.14 ^a	1.01 ^b	8.95 ^a	1.61 ^b	18.33 ^a
Melka shote	1.47 ^b	0.74 ^c	8.07 ^b	1.23 ^c	12.25 ^c
LSD (0.05)	0.17	0.05	0.77	0.14	1.78
Seedling age (days)					
35	1.51 ^c	0.89 ^b	6.9 ^c	1.37 ^c	14.66
45	1.71 ^b	1.02 ^a	8.26 ^b	1.72 ^b	15.44
55	1.94 ^a	1.09 ^a	9.41 ^a	1.97 ^a	15.77
65	1.69 ^{bc}	0.93 ^b	7.85 ^b	1.67 ^b	15.66
LSD (0.05)	0.2	0.06	0.89	0.16	Ns
CV (%)	12.23	7.09	11.35	9.88	13.66

Means with in columns followed by the same letter (s) are not significantly different; CV= coefficient of variation, LSD= Least Significant Difference, Ns= none significant

4. CONCLUSIONS AND RECOMMENDATION

High yielder variety and seedling ages are two of the important agronomic practices that influence the growth, yield and quality of pepper. Days to 50% of flowering, days to 50% of maturity, marketable yield, and unmarketable yield of pepper were all affected by the seedling age and variety in the interaction effect. Compared to other varieties, Mareko fana combined with 65-day-old seedlings early flowering (45.33 days) and matured (104.33 days). The treatment combination of Melka awaze variety and 55-days-old seedling ages recorded the highest dry yield (2.38 t ha^{-1}) with acceptable quality, according to the study's results. This combination can be recommended for the economically and agronomically acceptable production of dry peppers under supplementary irrigation in Humbo Woreda, Ompo-Koysha Peasant Association and other areas with similar agroecology's. Repetition of the study across other representative agroecology's and seasons in the study area, both under rain-fed and irrigated conditions, is also recommended since the study was carried out at a single location for a single season.

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Consent to publication

The original research project's authors all agreed to share it with the public.

Data availability statement

All data supporting the findings of this study are included in the manuscript and its supplementary information.

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Authorship contribution

Desalegn Asmare: Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ashenafi Woldeselassie:** Writing – review & editing, Visualization, Validation, Supervision, Project administration, Investigation.

Declarations

Ethics approval and consent to participate

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Competing interests

The authors declare that there is no conflict of interest.

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6. APPEDICES

Appendix Table 1. Mean squares of the analysis of variance for phenology, growth, yield, and quality of pepper as influenced by varieties and seedlings age in Wolaita Zone Humbo District, South Ethiopia during the main cropping season of 2023.

Source of variation	Replication	Varieties	Seedling age	Interaction	Error	CV (%)
Degree of freedom	2	2	3	6	22	
Days to 50% flowering	8.36	185.36**	638.85**	32.21*	12.27	6.18
Days to 50% maturity	23.861	195.111**	614.991**	30.63*	10.497	2.77
Plant height(cm)	15.87	320.35**	1732.74**	67.28 ^{ns}	28.44	7.82
Total leaf area (cm ²)	21682	2127413**	7542412**	822696 ^{ns}	356990	22.4
leaf area index	0.00484	0.47954**	1.71184**	0.18655 ^{ns}	0.0808	22.5
Canopy diameter (cm)	0.2655	13.3042**	15.4269**	1.914 ^{ns}	2.1469	10.8
Number of branches	11.4579	17.5932**	12.9665**	1.9251 ^{ns}	1.4658	11.2
Number of fruits per plant	1.502	456.486**	41.912 **	7.832 ^{ns}	4.194	6.86
Number of seed per fruit	280.014	547.327**	530.582**	65.857 ^{ns}	69.221	7.01
Seed weight per pod (g)	0.02470	0.34628 **	0.12474**	0.02579 ^{ns}	0.01809	7.94
Marketable dry yield (t ha ⁻¹)	0.02269	0.67887**	1.29787**	0.04617**	0.01035	5.83
Unmarketable dry yield (t ha ⁻¹)	0.00066	0.03847**	0.24821**	0.01054**	0.00229	7.6
Total dry yield (t ha ⁻¹)	0.01493	1.04466**	0.47269**	0.01992 ^{ns}	0.01144	4.52
Fruit dry weight content (g)	0.01367	1.6864**	0.28803**	0.11127 ^{ns}	0.04414	12.2
Fruit pericarp thickness (cm)	0.020550	0.6494**	0.0699**	0.00409 ^{ns}	0.00489	7.09
Fruit length (cm)	0.76668	8.2214**	9.7153**	0.84175 ^{ns}	0.84606	11.4
Fruit diameter (cm)	0.01361	2.9477**	0.5444**	0.06444 ^{ns}	0.02785	9.88
Oleoresin content (%)	9.361	111.361**	2.259 ^{ns}	9.176 ^{ns}	4.422	13.6

Where Ns= None-significant, * and **= significant at $P=0.05$ and $P=0.01$, respectively, and CV (%) = Coefficient of variation in percent.