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IMPACT OF FARMING SYSTEMS ON MORPHOLOGICAL MULTIPLE-TRAITS FOR YIELD, OF PARSLEY (*PETROSELINUM CRISPUM*) GENOTYPES

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ABSTRACT

The study was carried out to determine the morphological variation of seven genotypes of parsley grown under four different farming system. An assortment of seven genotypes of parsley was studied in experiment to evaluate morphological characteristics and yield parameter grown under different hydroponics system (NFT, DFT and Dutch Bucket) and polyhouse condition. Study showed significance difference in morphological parameters, among the parsley genotypes, and different farming systems during 2022-2023 and 2023-2024. The pooled data showed that plant height (cm) was highest in genotype Gigante Italian (26.00 cm) in Nutrient Film Technique (NFT) followed by naturally ventilated polyhouse (23.66 cm), Dutch Bucket (22.66 cm) and Deep Floating Technique (DFT) (22.50 cm). The leaflet length and width (cm) were highest in genotype Giant Plain (4.25 cm, 4.38 cm) under polyhouse condition and lowest in genotype Kruasa curled (1.738 cm, 2.037 cm). In polyhouse total three, in NFT total six, Dutch Bucket total four and DFT total three harvesting was done throughout the season. After all, harvesting the fresh weight were measured. The fresh weight (gm) was varied from 680-898 gm in NFT, 349-517 gm in Dutch Bucket, 257-394 gm in DFT and 486-634 gm in polyhouse condition. Study found that the genotype Gigante Italian and farming system NFT had highest fresh weight (898 gm/plant) and dry weight (149.907 g). Correlation coefficient analysis estimates the relationship between different plant morphological parameters. The plant height had positive and significant correlation with the number of branches and yield per plant.

The variation in morphological parameters and yield of parsley genotypes studied that the Gigante and Giant genotypes showed highest morphological traits compared to other genotypes. If we compared all farming system for the production of parsley the Nutrient Film Technique (NFT) as well as polyhouse condition

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were best farming system for morphological growth of parsley genotypes.

Keyword: Morphological characters, parsley, soilless culture, polyhouse and correlation

1. INTRODUCTION

Petroselinum crispum known as parsley, belongs to the family Apiaceae, and is a native herb that occurs in many temperate countries. In temperate region, parsley grows as biennial, in the first season, forms a rosette of tripinnate leaves with number of leaflets and a taproot which used as a reserve food over the winter. In the 2nd year and season, it grows as a blossoming plant with scattered leaves and umbels with numbers of yellowish-green flowers (Cramer et al., 1960). The common types of parsley are the plain leaf type belong to ssp. *neapolitanum*, Danert, and the curly leaf type belong ssp. *crispum*, which are cultured for their foliage, and the turnip-rooted also called 'Hamburg' belong to ssp. *tuberosum*, primarily grown for its roots (Petropoulos et al., 2010). Variations are occurred in different genotypes of parsley i.e., morphology character, growth habit, leaves shape, flower colour, stem, leaves size and biochemical constituents. Parsley is considered a major source of vitamins, mineral furthermore it has chemical components such as phenols, flavonoids, carotenoids and vitamin c (Maodaa et al., 2016), which are active compounds having antioxidant capacity (Lako et al., 2007). The quality of phenotypic diversity is a worthwhile method to monitor the morphological traits that contribute to the entire diversity in a germplasm collection (Mehmood et al., 2014). Apart from being a vegetable parsley has many medicines uses due to presences of many biochemical in its various parts. Parsley is known for its antidiabetic (Manderfeld et al., 1997), antimicrobial (Ouis et al., 2014), antioxidant, antihypertensive, anticoagulant, antihyperlipidemic, anti- hepatotoxic, membrane protective and protection against DNA damages effects (Nielsen et al., 1999). Herbs and vegetables can be grown hydroponically in many different ways, but the deep-flow technique (DFT) and nutrient-film (NFT) are common techniques for their production (Currey and Flax, 2016).

Hydroponics has emerged as one of the most popular methods in today agriculture production. Hydroponics, soilless growth system, use minerals solution directly to nourish plants without using the soil (Jones, 2016). In this technique root is suspending in nutrient solution, plant absorb nutrient with less effort use their energy for growth and development of plants (Sardare and Admane, 2013). Consequently, growth rate and yield of plants hydroponics system are expected to increase as compared to soil based system. Hydroponics also reduce soil-borne problems, such as seed decay, seedling blight etc (Geilfus, 2019). The current issues of land and water scarcity have been inflaming by changing and unpredictable weather condition throughout time, which has also continued to have a negative impact on agriculture. Utilization of the latest technologies coupled with advanced method of crop production without a doubt will increase our capacity to deal with this modern technique of the shortages of resources. Hydroponics gardening is an ideal growing method for producing culinary and medicine herbs. Not only do hydroponics herbs grow faster, but also, they have significant more flavour and aroma than herbs grow in soil. The hydroponics system faces many environments related problem and it also helps out in the oversight of production system for better use of natural resources and reducing the malnutrition (Butler and Oebker, 1962). With hydroponics there is a greater chance to place the fresh produces in the market since their average nutritional status and consumers acquiring are higher (Mehra et al., 2018). The present study evaluates the morphological variations between

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the seven different genotypes of parsley grown under the different farming system. Present study also aimed to evaluate the production components of parsley plants subjected to hydroponics i.e., nutrient film technique (NFT), deep floating technique (DFT), Dutch Bucket and polyhouse condition during year 2022-2023 and 2023-2024.

2. MATERIALS AND METHODS

Plant material collection and establishment

The seeds of parsley genotypes collection from different sources. Seven parsley (*Petroselinum crispum*) genotypes were collected, including five curled leaves i.e., Forest green, Triple curled, Cress curled, Moss curled and Kruasa curled (*Petroselinum crispum spp. crispum*) and two plain leaves i.e., Gigante Italian, Giant Plain (*Petroselinum crispum spp. neaopolitnum*). This research was conducted during September 2022 to February 2023 and September 2023 to February 2024 at experimental farm of Vegetable Science and Floriculture Department, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur. The experimental farm was situated at 32°C 6′ North latitude and 76°C 3′East longitude at an elevation of 1290.8 meters above mean sea level. It is located in mid hill region of Himachal Pradesh.

Experimental design

The study was carried out in polyhouse condition and hydroponics system using a completely randomized block design (RBD) with replicates for each treatment and each replicate consisting seven genotypes. The experiment consisted of four treatments: (1) Hydroponic installation of the NFT (Nutrient Film Technique), (2) Hydroponic installation of the DFT (Deep floating technique), (3) Hydroponic installation of the Dutch Bucket and (4) polyhouse condition, soil with pH of 5.7 which is acidic in nature. The seeds of the different parsley genotypes were sown in cocopeat, vermiculite and perlite in plug trays with ratio 3:1:1 under high-tech nursery production unit. Seeding with 3-4 leaves was removed from plug trays, along with the growing media, and then placed in hydroponic channels and soil condition. Irrigation was started immediately after transplanting. For hydroponics, the Hoagland nutrient solution was used as the main source of nutrients.

Observations recorded

Observation was recorded on selected plants for the horticultural traits. Data was recorded on plant height (cm) which was measured with the help of scale from the base of the stem (at the soil surface) to the top, or the highest part of the plant, leaflet size (cm) was calculated by measuring the length and breadth of the leaflet by using scale, number of branches was measured from base to the centre of the plant and counted after every harvesting, stem diameter (mm) were measured with the help of vernier caliper and their values were averaged, shoot-root length (cm) of the plants was measured from plant surface from base to tip of shoot and root with the help of the scale or tread, plant fresh (gm) weight per plant was calculated by pooling the weight of the branches from each harvesting and then added these values was worked out and dry weight (g) per plant by shade dries in dark room. Observations were recorded for all the characters on randomly tagged plants.

Statistical analysis

The statistical significance was done by analysis of variance (ANOVA) using OPSTAT. Later the morphological data were used for correlation analysis by using Pearson's correlation coefficient method.

3. RESULT

Plant height (cm)

The plant height of parsley genotypes varied under different farming system and genotypes. The significant differences were observed for plant height among all the genotypes and growing system. In most of farming system pooled data showed that genotype Gigante Italian

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showed highest plant height in NFT (26.00 cm) farming system, polyhouse (23.66 cm) condition, Dutch Bucket (22.66 cm) system and DFT (22.50 cm) farming system shows in figure 1. In case of Nutrient Film Technique (NFT) farming system and polyhouse condition most of genotypes showed highest plant height.

Number of branches per plant

The number of branches were measured after the all harvesting was done in all farming system. The pooled data showed that in genotype Gigante Italian showed highest number of branches in NFT farming system (36.056), polyhouse condition (28.17) and Dutch Bucket (21.485) farming system. DFT farming system genotype Kruasa curled (16.865) showed highest number of branches per plant. The significant variation was occurred in number of branches per plant in different genotypes and farming system. In the most of farming system genotype Gigante Italian shows highest number of branches per plants showed in figure 2.

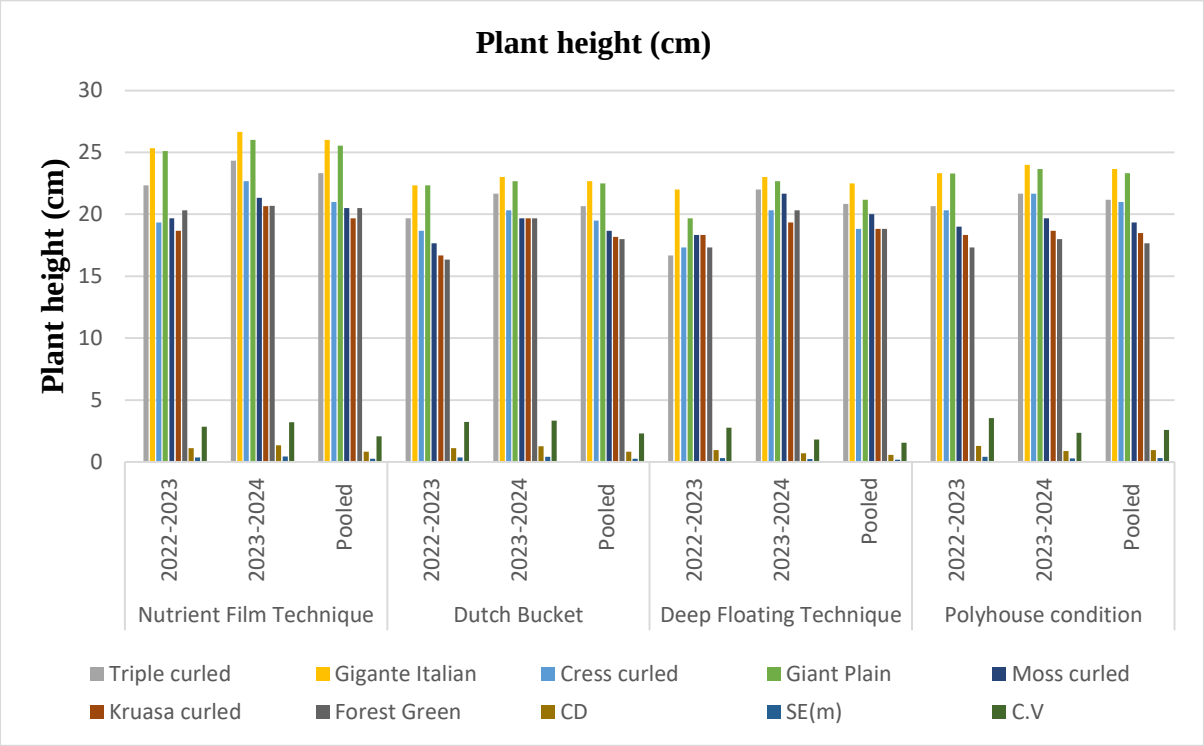

Figure 1: Plant height of different genotypes of parsley under different farming system

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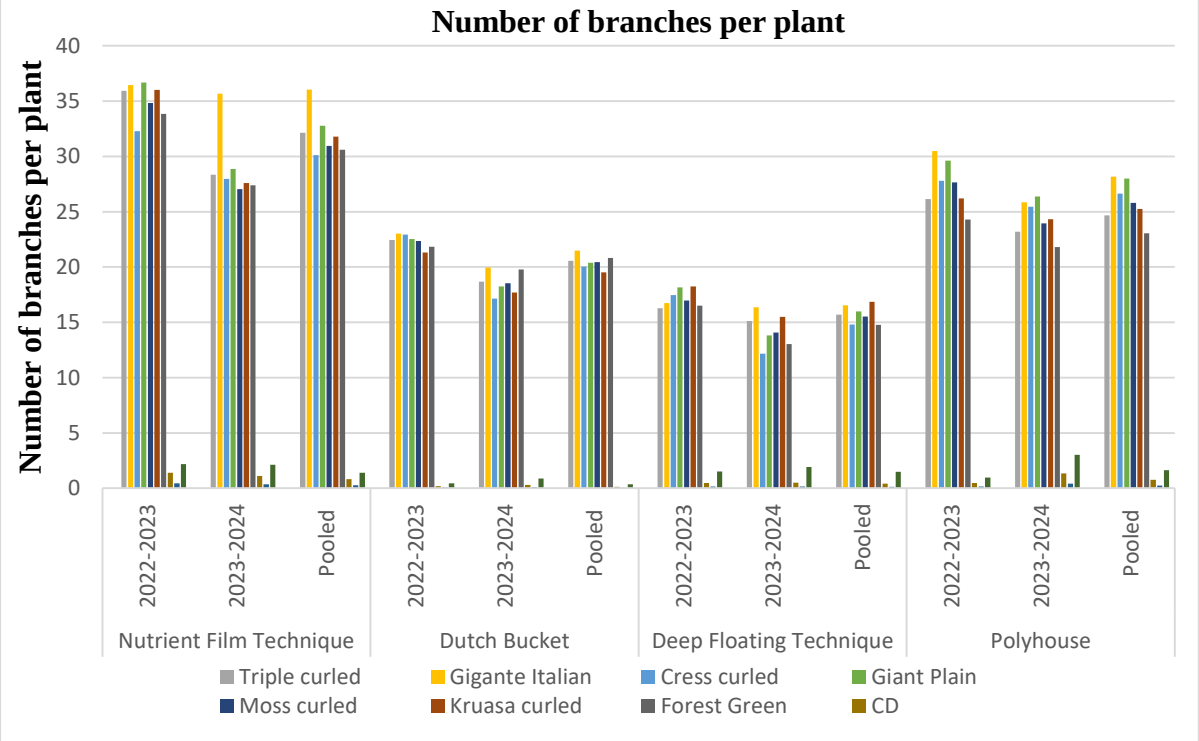

Figure 2: Number of branches per plant of different parsley genotypes under different farming system

Stem diameter (mm)

The experimental data on stem thickness showed significant variation among the different parsley genotypes and farming systems. The pooled data showed that the stem diameter (mm) was highest in genotype Giant plain (16.710 mm) in polyhouse condition, DFT (2.652 mm) farming system, Moss curled (6.373 mm) in NFT farming system and Forest green (3.877 mm) in Dutch Bucket system. In most of farming system polyhouse condition in genotype Gigante Italian (16.710 mm) showed highest stem diameter showed in figure 3.

Leaflet length & width (cm)

The leaflet length and width of parsley genotypes show significant difference in all four-farming system i.e., NFT, DFT, Dutch Bucket and polyhouse condition in figure 4 and 5. Pooled data showed that the leaflet length & width was highest in genotype Giant plain (3.098 cm, 3.255cm) in NFT farming system, genotype Gigante Italian (3.053 cm, 3.235 cm) in Dutch Bucket system, genotype Giant plain (3.062 cm 3.167 cm) in DFT system and polyhouse (4.252 cm, 4.388 cm) condition. In most of the farming system genotype Gigante Italian and Giant Plain showed higher leaflet length and width

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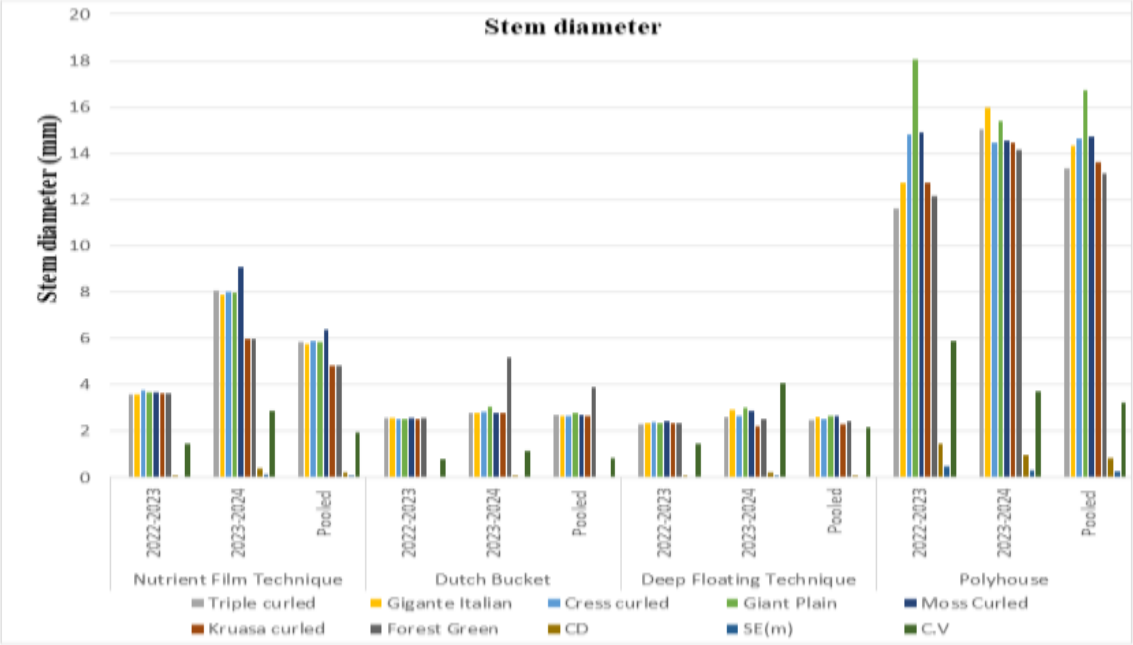

Figure 3: Stem diameter of different genotypes of parsley under different farming system

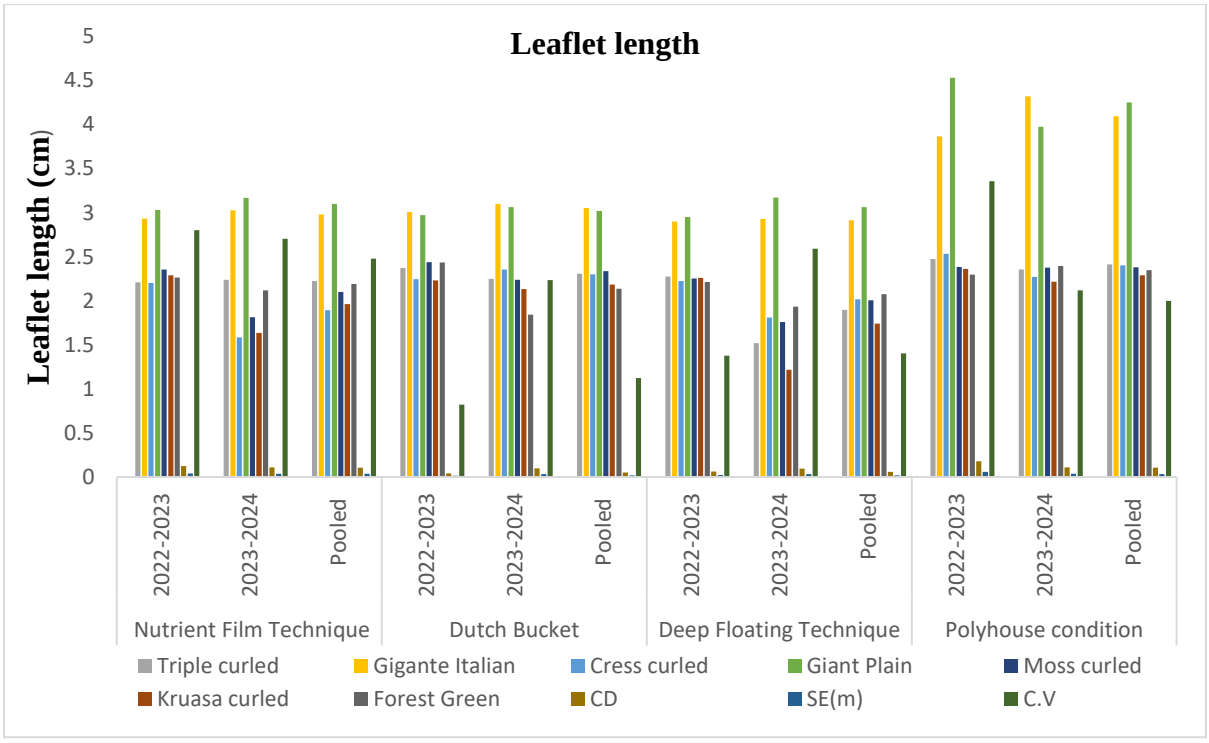

Figure 4: leaflet length of different genotypes of parsley under different farming system

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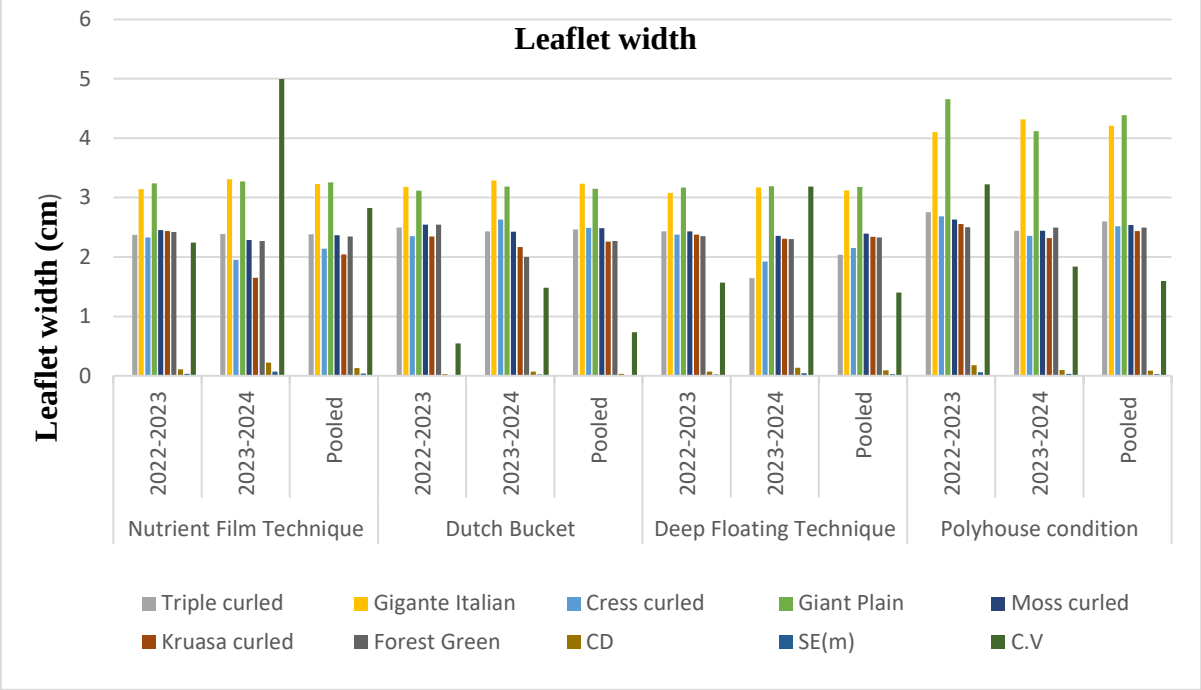

Figure 5: leaflet width of different genotypes of parsley under different farming system

Shoot and Root length (cm)

Hydroponics offer controlled nutrient distribution, possibly leading to denser but shallower roots, while polyhouse soil allows for greater root expansion in search of nutrients. The pooled data shows that the root length was highest in genotype Gigante Italian in Dutch Bucket system (25.500 cm), DFT system (23.667 cm), and genotype Triple curled in polyhouse condition (21.500 cm), and NFT farming system (20.167 cm) showed in figure 7. Root length differences observed between hydroponic and polyhouse parsley may arise from the growing medium. Among different growing systems significantly longer roots were recorded in plants of Dutch Bucket system, DFT system followed polyhouse condition and then NFT system. The shoot length was highest in genotype Gigante Italian (8.347 cm) in NFT system, genotype Giant Plain in Dutch bucket system (10.288 cm), genotype Gigante Italian (9.548 cm) in DFT system and genotype Triple curled (9.802 cm) in polyhouse condition showed in figure 6.

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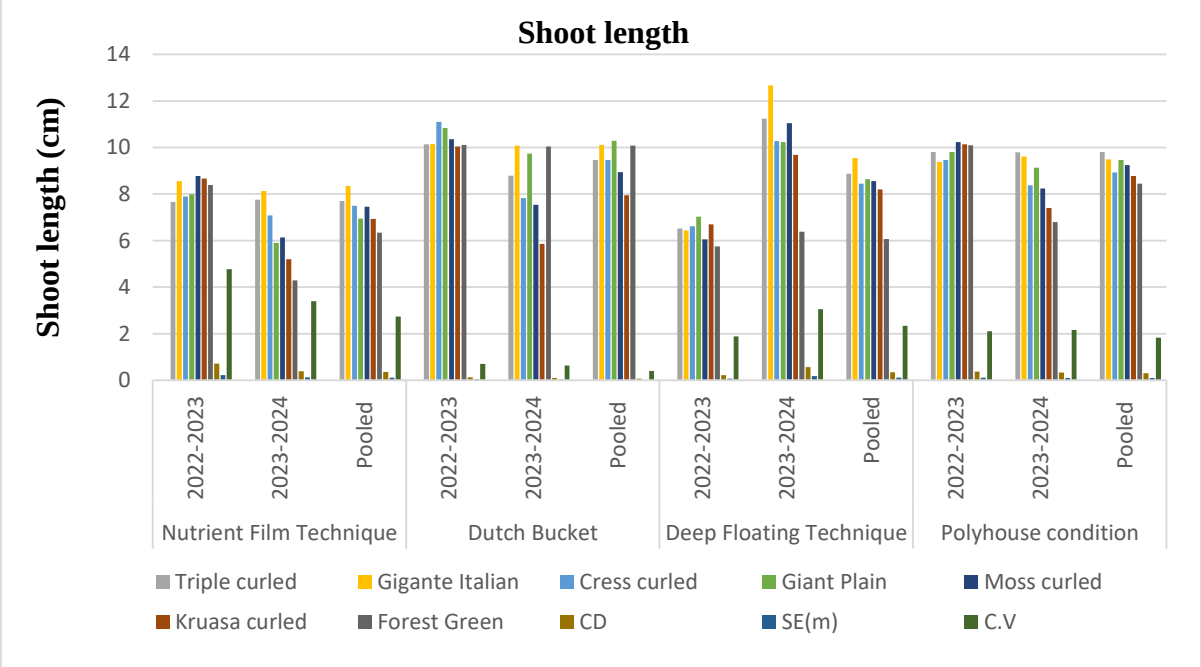

Figure 6: Shoot length of different genotypes of parsley under different farming system

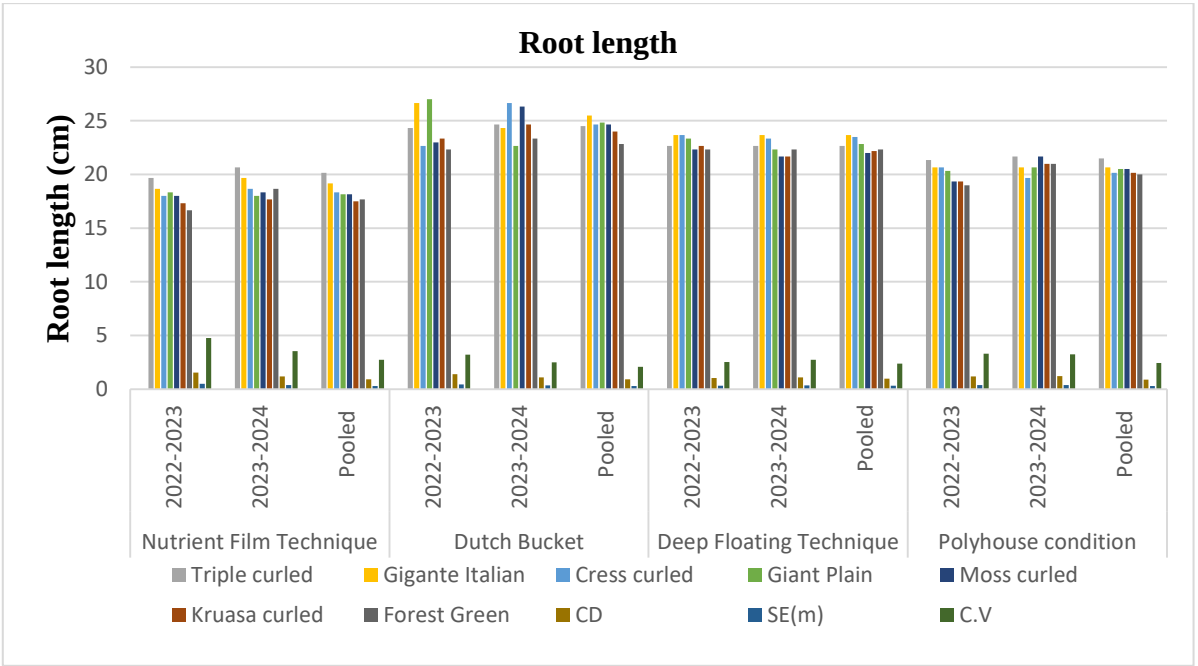

Figure 7: Root length of different genotypes of parsley under different farming system

Fresh and dry (gm) weight of plant

Fresh weight per plant of parsley genotypes showed significant difference in all four different

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farming systems. The NFT system pooled data shows that the genotype Gigante Italian (898 gm) shows highest and genotype Triple curled (680 gm) shows lowest fresh weight of plant. The Dutch Bucket farming system the genotype Gigante Italian (517 gm) showed highest and genotype Cress curled (349 gm) showed lowest fresh weight. In DFT farming system pooled data showed that the genotype Gigante Italian (394 gm) shows highest and genotype Moss curled (257 gm) had lowest fresh weight per plant. In polyhouse condition data showed that the genotype Gigante Italian (634 gm) show highest and genotype Kruasa curled (486 gm) show lowest fresh weight per plant shows in table 8. The dry weight highest in genotype Gigante Italian (149.907 gm) and lowest in genotype Kruasa curled (122.867 gm) in NFT farming system. In Dutch Bucket farming system, the dry weight was highest in genotype Giant Plain (0.944 gm) and lowest in genotype Forest Green (0.653 gm). Dry weight was highest in genotype Giant Plain (0.328 gm) and lowest in genotype Cress curled (0.268 gm) in DFT farming system. The dry weight was highest in genotype Forest Green (147.057 gm) and lowest in Cress curled (103.38 gm) in polyhouse condition. Most of the farming system the genotype Gigante Italian Showed highest fresh as well as dry weight per plant shows in table 9.

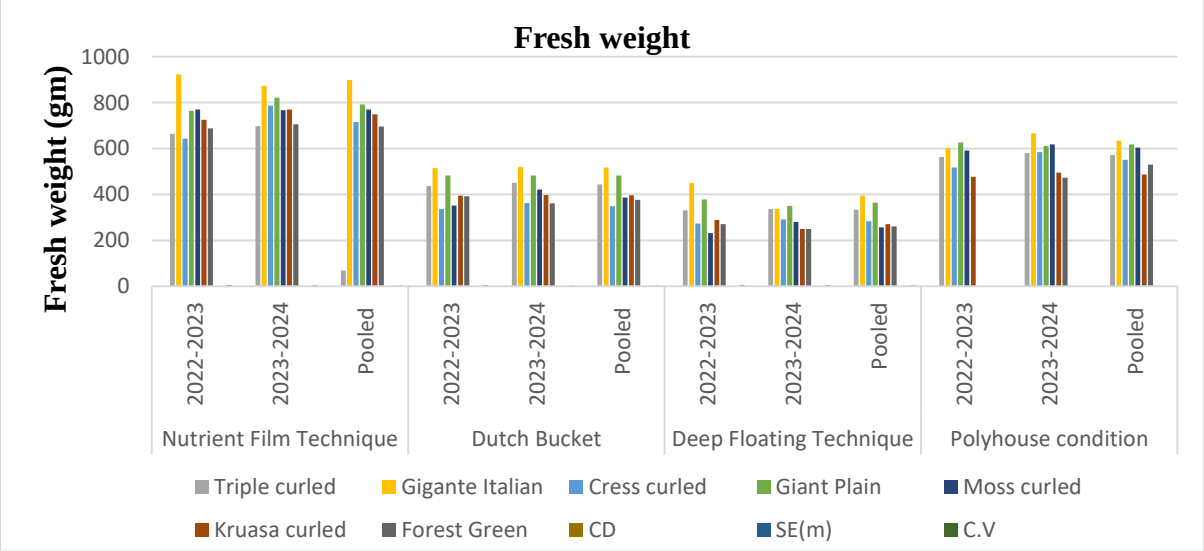

Figure 8: Fresh weight per plant of different genotypes of parsley under different farming system

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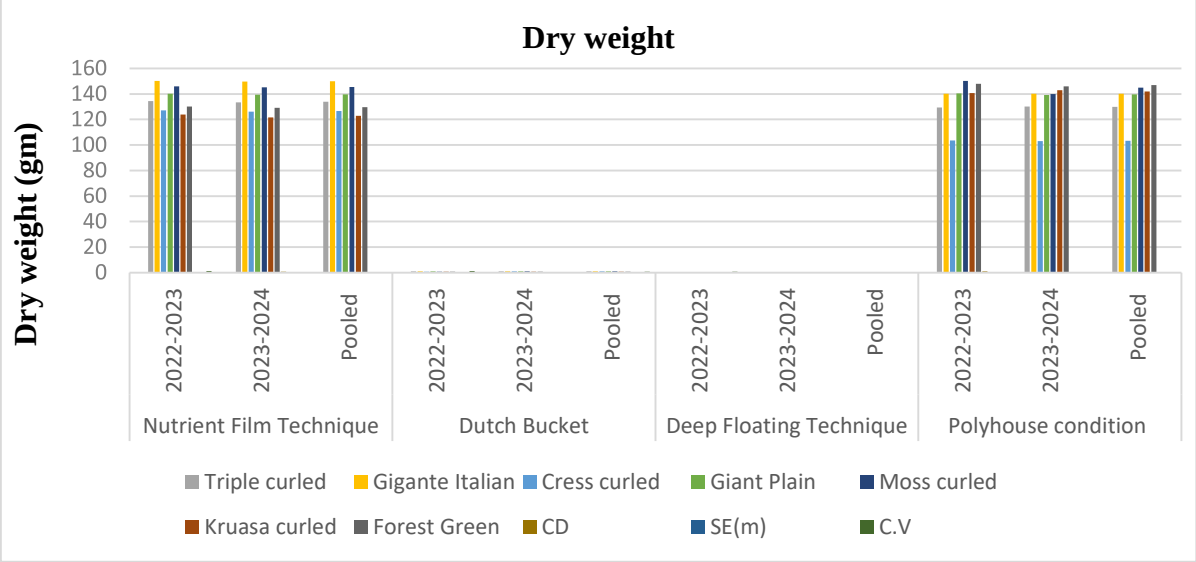

Figure 9: Dry weight per plant of different genotypes of parsley under different farming system

Correlation coefficient analysis

Correlation coefficient analysis estimates the relationship between various plant morphological characters. The correlation between two traits is positive and significant, advance in one trait will exert a positive impact on the other. In this study, plant height had positive and significant correlation with the number of branches per plants and yield per plant (table1-4). In NFT system plant height shows positive and significant correlation with leaflet length & width and number of branches respectively, shoot length shows non-significant relationship with fresh weight. The leaflet length and width observed positive and significant correlation with each other and with fresh weight and dry weight per plant (table 1). Number of branches per plant shows positive, significant correlation with fresh weight and dry weight per plant. In polyhouse condition and Dutch bucket system most of the traits shows positive correlation with each other (table 2 & 4). The plant height show, non-significant correlation with the dry weight and significantly correlated with the fresh weight per plant under polyhouse condition. In DFT system plant height, leaflet length and width show positive correlation with most of traits and shoot length show negative correlation with number of branches per plant (table 3).

Table 1: Pearson's correlation coefficient between different traits of parsley genotypes in Nutrient Film Technique (NFT) farming system

Traits	PH	LL	LB	NB	SL	SD	RLR	FWP	DWP
PH	1								
LL	0.943** (0.001)	1							
LB	0.943** (0.001)	0.991** (0.001)	1						
NB	0.753 (0.051)	0.782* (0.039)	0.780* (0.038)	1					
SL	0.526 (0.225)	-0.243 (0.599)	-0.268 (0.561)	-0.281 (0.542)	1				

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SD	0.344 (0.450)	0.196 (0.674)	0.298 (0.516)	0.094 (0.842)	-0.331 (0.469)	1			
RLR	0.446 (0.316)	0.233 (0.615)	0.238 (0.608)	0.370 (0.414)	-0.474 (0.283)	0.462 (0.297)	1		
FWP	0.600 (0.154)	0.714 (0.072)	0.750 (0.052)	0.842* (0.018)	-0.047 (0.921)	0.242 (0.601)	-0.27 (0.954)	1	
DWP	0.620 ((0.137)	0.675 (0.096)	0.748 (0.053)	0.656 (0.110)	-0.019 (0.968)	0.638 (0.123)	0.361 0.426	0.738 (0.058)	1

*p <0.01 level (2-tailed), ** p <0.05 level (2-tailed), respectively

PH: plant height, LL: leaflet length, LB: leaflet breath, NB: number of branches per plant, SL: shoot length, SD: stem diameter, RLR: root length, FWP: fresh weight per plant, DWP: dry weight per plant.

Table 2: Pearson's correlation coefficient between different traits of parsley genotypes in polyhouse condition

Traits	**PH**	**LL**	**LB**	**NB**	**SL**	**SD**	**RLR**	**FWP**	**DWP**
PH	1								
LL	0.855* (0.014)	1							
LB	0.854* (0.140)	1.000** (0.001)	1						
NB	0.872* (0.100)	0.805* (0.290)	0.797* (0.032)	1					
SL	0.756* (0.490)	0.485 (0.270)	0.498 (0.256)	0.523 (0.228)	1				
SD	0.631 (0.129)	0.693 (0.084)	0.691 (0.086)	0.769* (0.430)	0.343 (0.452)	1			
RLR	0.450 (0.312)	0.136 (0.772)	0.153 (0.743)	0.099 (0.832)	0.891** (0.007)	-0.710 (0.879)	1		
FWP	0.785* (0.036)	0.738 (0.580)	0.742 (0.056)	0.683 (0.091)	0.710 (0.074)	0.597 (0.157)	0.425 (0.342)	1	
DWP	-0.236 (0.610)	0.185 (0.691)	0.197 (0.673)	-0.209 (0.653)	-0.730 (0.877)	-0.081 (0.863)	-0.470 (0.920)	0.910 (0.846)	1

*p <0.01 level (2-tailed), ** p <0.05 level (2-tailed) level, respectively

PH: plant height, LL: leaflet length, LB: leaflet breath, NB: number of branches per plant, SL: shoot length, SD: stem diameter, RLR: root length, FWP: fresh weight per plant, DWP: dry weight per plant.

Table 3: Pearson's correlation coefficient between different traits of parsley genotypes in Deep Floating Technique (DFT) system.

Traits	**PH**	**LL**	**LB**	**NB**	**SL**	**SD**	**RLR**	**FWP**	**DWP**
PH	1								
LL	0.861* (0.013)	1							
LB	0.742 (0.056)	0.943** (0.001)	1						
NB	0.324 (0.478)	0.531 (0.220)	0.458 (0.302)	1					
SL	0.687 (0.088)	0.367 (0.417)	0.357 (0.432)	-0.291 (0.525)	1				
SD	0.625 (0.133)	0.705 (0.077)	0.594 (0.159)	0.285 (0.535)	0.467 (0.290)	1			

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RLR	0.557 (0.194)	0.123 (0.792)	-0.073 (0.877)	0.147 (0.753)	0.588 (0.165)	0.229 (0.622)	1		
FWP	0.555 (0.196)	0.701 (0.079)	0.639 (0.122)	0.871* (0.011)	0.111 (0.812)	0.661 (0.106)	-0.292 (0.525)	1	
DWP	0.390 (0.387)	0.529 (0.222)	0.308 (0.501)	0.732 (0.061)	-0.106 (0.820)	0.698 (0.081)	0.278 (0.546)	0.782* (0.038)	1

*p <0.01 level (2-tailed), ** p <0.05 level (2-tailed), respectively

PH: plant height, LL: leaflet length, LB: leaflet breath, NB: number of branches per plant, SL: shoot length, SD: stem diameter, RLR: root length, FWP: fresh weight per plant, DWP: dry weight per plant.

Table 4: Pearson's correlation coefficient between different traits of parsley genotypes in Dutch Bucket farming system.

Traits	PH	LL	LB	NB	SL	SD	RLR	FWP	DWP
PH	1								
LL	0.932** (0.002)	1							
LB	0.942** (0.002)	0.996** (0.001)	1						
NB	0.535 (0.216)	0.538 (0.213)	0.576 (0.176)	1					
SL	0.624 (0.134)	0.591 (0.162)	0.628 (0.131)	0.750 (0.052)	1				
SD	-0.399 (0.376)	-0.327 (0.474)	-0.328 (0.473)	0.264 (0.567)	0.380 (0.400)	1			
RLR	0.674 (0.097)	0.580 (0.173)	0.632 (0.128)	0.433 (0.332)	0.531 (0.220)	-0.273 (0.553)	1		
FWP	0.888** (0.008)	0.877** (0.010)	0.859* (0.013)	0.597 (0.157)	0.472 (0.285)	-0.276 (0.549)	0.405 (0.367)	1	
DWP	0.804* (0.029)	0.647 (0.116)	0.685 (0.090)	0.308 (0.502)	0.428 (0.338)	-0.632 (0.128)	0.570 (0.182)	0.538 (0.213)	1

*p <0.01 level (2-tailed), ** p <0.05 level (2-tailed), respectively

PH: plant height, LL: leaflet length, LB: leaflet breath, NB: number of branches per plant, SL: shoot length, SD: stem diameter, RLR: root length, FWP: fresh weight per plant, DWP: dry weight per plant.

DISCUSSION

Morphological traits used to assess the genetic diversity within parsley different genotypes and related species. When compared plant height of soil-based system with the different hydroponic system, the NFT system showed highest plant height followed by Dutch Bucket and DFT system. Morphological studies show clear separation between the seven different genotypes of parsley. Plant height was highest in Gigante Italian genotype (26.00 cm) in NFT system and lowest in polyhouse Forest Green (17.66 cm). Indira and Sabitha (2024) study revealed that for NFT hydroponic and soil-based systems, the plant height and root length of plants at the end of the growth period higher in NFT system then the soil-based condition. The greater plants height due to the efficient and direct absorption of nutrients provided by the hydroponic system. There was significance variation in plain leaf parsley and curled leaf parsley on basis of the morphological character including leaflet length, leaflet width and yield. The leaflet length (4.53 cm) and width (4.65 cm) were higher in flat leaf parsley (*Petroselinum crispum spp.*

neapolitanum) i.e., Gigante Italian and Giant Plain. It may be due to broader, larger, plain leaf, without curled, and leaves surface area was higher in plain leaf parsley. In curly leaf parsley more curled, more ruffled and compact leaves. Kmiecik and Lisiewska (1999**)** have indicated the significant difference between the productivity, size of plain and curly- leafed of parsley planted in northern Europe. The number of branches were measured after the all harvesting was done in all the farming system. The genotypes grown in NFT farming system had highest numbers of branches as compared to other farming system. More the number of branches in parsley genotypes grown NFT farming system, which was directly proportional to the yield. More branches mean more leaf production and ultimately higher overall yield (Dorota Jadczak et al. (2019). Stem thickness (mm) and shoot length of parsley is vital for structural support, efficient nutrient transport, disease resistance, water management and harvest quality, impacting overall crop yield and market suitability. The stem diameter (mm) was highest in polyhouse condition followed by NFT, Dutch Bucket and then DFT system and, shoot length was highest in Dutch Bucket system, NFT, DFT and polyhouse condition. This may because in polyhouse farming the increase the width of plant rather the length, but hydroponically stem length increases of parsley rather than the width. The root length was highest in Dutch Bucket system, followed by polyhouse condition and NFT farming system. Moraes et al. (2018), Agacaoili (2019), and Santos et al. (2021) in their respective studies demonstrated that hydroponics offer controlled nutrient distribution, possibly leading to denser but shallower roots, while polyhouse soil allows for greater root expansion in search of nutrients. The fresh and dry weight was highest in NFT farming system compared with all farming system. Kumar et al. (2018) and Santos et al. (2021) studied that the fresh and dry weight of per plant was measured highest in NFT farming (Nutrient Film Technique) system compared to other farming. NFT system provided the ideal conditions for the absorption of available nutrients and water, which resulted in the crop develop fully early as compared to the other systems which is directly proportional to the yield of the plant (Kumar et al. (2010). In our study, the most of morphological traits was highest in Nutrient Film Technique (NFT) as compared to other farming system. On the basis of morphological traits genotypes Gigante Italian show best morphological characters then other genotypes.

CONCLUSIONS

Hydroponic system can enhance the morphological character, leaf production, number of branches and the potentially increase the plant height in parsley cultivation. Hydroponic system offers advantages in terms of controlled growth condition and potential for increased plant size and uniformity; they also result in morphological difference compared to the soil grown parsley. These morphological differences may be attributed to the controlled nutrient availability and the environmental condition in hydroponic setup. The study demonstrates the variation in morphological traits in different farming system and select the most promising farming system for parsley production. Understanding these variations is curial for the optimizing cultivation practices and select the appropriate system based on specific plant species. The morphological diversity also shows a clear separation between the plain leaf and the curly leaf parsley. It should be pointed out that the hydroponic NFT system demonstrated higher fresh and dry weight per plant as compared to other farming system. Morphological traits plant height, leaflets size, branches, root shoot length, fresh and dry weight per plants demonstrated considerable diversity between the genotypes. The two-parsley curly leaf and flat leaf exhibited distinct and consistent morphological patterns, which can be useful for classification, selection of best genotypes and breeding purpose. These morphological variations are not a taxonomic and botanical interest but also show, and medicinal application.

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CONFLICT OF INTEREST

The authors declare no Conflict of Interest.

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Supplementary Tables

Table 1 (Figure 1): Plant height of different genotypes in different growing condition

Plant Height (cm)												
System	**NFT (Nutrient Film Technique)**			**D.B (Dutch Bucket)**			**DFT (Deep Floating Technique)**			**P.H (Polyhouse)**		
Years / Genotypes	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**
Triple curled	22.333	24.333	23.333	19.667	21.667	20.667	16.667	22.000	20.833	20.667	21.667	21.167
Gigante Italian	25.333	26.667	26.000	22.333	23.000	22.667	22.000	23.000	22.500	23.333	24.000	23.667
Cress curled	19.333	22.667	21.000	18.667	20.333	19.500	17.333	20.333	18.833	20.333	21.667	21.000
Giant Plain	25.117	26.000	25.510	22.333	22.667	22.500	19.667	22.667	21.167	23.300	23.667	23.333

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Moss curled	19.667	21.333	20.500	17.667	19.667	18.667	18.333	21.667	20.000	19.000	19.667	19.333
Kruasa curled	18.667	20.667	19.667	16.667	19.667	18.167	18.333	19.333	18.833	18.333	18.667	18.500
Forest Green	20.333	20.677	20.500	16.333	19.667	18.000	17.333	20.333	18.833	17.333	18.000	17.667
CD	1.110	1.350	0.840	1.110	1.262	0.833	0.948	0.698	0.567	1.292	0.892	0.965
SE(m)	0.356	0.433	0.270	0.356	0.405	0.267	0.304	0.224	0.182	0.415	0.286	0.310
C.V	2.836	3.217	2.072	3.232	3.348	2.312	2.781	1.820	1.564	3.541	2.357	2.595

Table 2 (Figure 2): Number of branches per plant of different genotypes in different growing condition

Number of branches per plant												
System	**NFT (Nutrient Film Technique)**			**D.B (Dutch Bucket)**			**DFT (Deep Floating Technique)**			**P.H (Polyhouse)**		
Years / Genotypes	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**
Triple curled	35.927	28.349	32.138	22.430	18.687	20.558	16.277	15.120	15.698	26.133	23.200	24.667
Gigante Italian	36.450	35.662	36.056	23.030	19.940	21.485	16.747	16.353	16.550	30.497	25.857	28.177
Cress curled	32.270	27.967	30.118	22.937	17.147	20.042	17.450	12.160	14.805	27.797	25.453	26.625
Giant Plain	36.677	28.863	32.769	22.540	18.233	20.387	18.163	13.827	15.995	29.627	26.370	27.998
Moss curled	34.837	27.039	30.938	22.350	18.543	20.447	16.967	14.087	15.527	27.647	23.950	25.798
Kruasa curled	36.020	27.588	31.802	21.307	17.707	19.507	18.250	15.480	16.865	26.200	24.307	25.253
Forest Green	33.847	27.378	30.611	21.840	19.787	20.813	16.497	13.020	14.758	24.300	21.797	23.048
CD	1.387	1.103	0.814	0.175	0.297	0.132	0.471	0.497	0.420	0.483	1.332	0.764
SE(m)	0.445	0.354	0.261	0.056	0.095	0.042	0.151	0.160	0.135	0.155	0.427	0.245
C.V	2.195	2.115	1.411	0.435	0.890	0.359	1.523	1.933	1.484	0.978	3.031	1.638

Table 3 (Figure 3): Stem diameter of different genotypes in different growing condition

Stem diameter (mm)												
System	**NFT (Nutrient Film Technique)**			**D.B (Dutch Bucket)**			**DFT (Deep Floating Technique)**			**P.H (Polyhouse)**		
Years / Genotypes	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**
Triple curled	3.590	8.067	5.828	2.580	2.797	2.688	2.320	2.593	2.457	11.620	15.043	13.332
Gigante Italian	3.587	7.900	5.743	2.550	2.803	2.677	2.327	2.920	2.623	12.713	15.950	14.332
Cress curled	3.747	8.033	5.890	2.513	2.817	2.665	2.400	2.673	2.537	14.803	14.470	14.637
Giant Plain	3.690	7.967	5.828	2.520	3.047	2.783	2.333	2.990	2.662	18.043	15.377	16.710
Moss curled	3.663	9.083	6.373	2.553	2.807	2.680	2.413	2.890	2.652	14.900	14.520	14.710
Kruasa curled	3.647	6.000	4.823	2.520	2.790	2.655	2.363	2.233	2.298	12.722	14.470	13.596
Forest Green	3.647	6.000	4.823	2.553	5.200	3.877	2.340	2.507	2.423	12.140	14.137	13.138
CD	0.097	0.395	0.198	0.037	0.066	0.043	0.062	0.196	0.098	1.469	0.989	0.829
SE(m)	0.031	0.127	0.064	0.012	0.021	0.014	0.020	0.063	0.032	0.472	0.317	0.266
C.V	1.469	2.894	1.960	0.812	1.153	0.835	1.472	4.063	2.171	5.899	3.702	3.211

Table 4 (Figure 4): leaflet length per plant of different genotypes in different growing condition

Leaflet length per plant (cm)												
System	**NFT (Nutrient Film Technique)**			**D.B (Dutch Bucket)**			**DFT (Deep Floating Technique)**			**P.H (Polyhouse)**		
Years / Genotypes	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**
Triple curled	2.210	2.237	2.223	2.370	2.247	2.308	2.273	1.517	1.895	2.473	2.353	2.413
Gigante Italian	2.930	3.027	2.978	3.007	3.100	3.053	2.900	2.927	2.913	3.867	4.320	4.093
Cress curled	2.200	1.583	1.892	2.243	2.353	2.298	2.223	1.807	2.015	2.530	2.270	2.400
Giant Plain	3.030	3.167	3.098	2.973	3.063	3.018	2.950	3.173	3.062	4.530	3.973	4.252
Moss curled	2.353	1.813	2.098	2.437	2.237	2.337	2.253	1.757	2.005	2.383	2.377	2.380

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Kruasa curled	2.287	1.633	1.960	2.230	2.133	2.182	2.260	1.217	1.738	2.360	2.217	2.288
Forest Green	2.263	2.117	2.190	2.433	1.840	2.137	2.213	1.933	2.073	2.297	2.393	2.345
CD	0.124	0.108	0.105	0.037	0.097	0.050	0.060	0.095	0.056	0.176	0.108	0.104
SE(m)	0.040	0.035	0.034	0.012	0.031	0.016	0.019	0.031	0.018	0.057	0.035	0.033
C.V	2.802	2.702	2.478	0.820	2.235	1.121	1.377	2.590	1.400	3.356	2.117	1.998

Table 5 (Figure 5): leaflet width per plant of different genotypes in different growing condition

Leaflet Width per plant (cm)												
System	**NFT (Nutrient Film Technique)**			**D.B (Dutch Bucket)**			**DFT (Deep Floating Technique)**			**P.H (Polyhouse)**		
Years / Genotypes	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**
Triple curled	2.373	2.390	2.382	2.493	2.433	2.463	2.430	1.643	2.327	2.757	2.443	2.600
Gigante Italian	3.143	3.310	3.227	3.180	3.290	3.235	3.077	3.170	3.123	4.100	4.317	4.208
Cress curled	2.327	1.950	2.138	2.350	2.630	2.490	2.377	1.923	2.150	2.683	2.353	2.518
Giant Plain	3.240	3.270	3.255	3.113	3.183	3.148	3.167	3.193	3.178	4.657	4.120	4.388
Moss curled	2.453	2.283	2.368	2.543	2.423	2.483	2.433	2.357	2.395	2.633	2.440	2.537
Kruasa curled	2.437	1.647	2.042	2.347	2.167	2.257	2.377	2.307	2.342	2.553	2.320	2.437
Forest Green	2.420	2.267	2.343	2.543	2.000	2.272	2.350	2.303	2.037	2.503	2.493	2.498
CD	0.106	0.220	0.129	0.026	0.069	0.035	0.073	0.138	0.090	0.181	0.097	0.087
SE(m)	0.034	0.071	0.041	0.008	0.022	0.011	0.024	0.044	0.029	0.058	0.031	0.028
C.V	2.243	4.997	2.827	0.546	1.483	0.735	1.569	3.185	1.400	3.225	1.840	1.596

Table 6 (Figure 6): Shoot length per plant of different genotypes in different growing condition

Shoot length (cm)												
System	**NFT (Nutrient Film Technique)**			**D.B (Dutch Bucket)**			**DFT (Deep Floating Technique)**			**P.H (Polyhouse)**		
Years / Genotypes	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**
Triple curled	7.657	7.757	7.707	10.143	8.790	9.467	6.520	11.233	8.877	9.803	9.800	9.802
Gigante Italian	8.563	8.130	8.347	10.150	10.083	10.117	6.433	12.663	9.548	9.377	9.617	9.497
Cress curled	7.903	7.090	7.497	11.107	7.830	9.468	6.613	10.280	8.447	9.470	8.377	8.923
Giant Plain	7.997	5.900	6.948	10.840	9.737	10.288	7.037	10.233	8.635	9.803	9.130	9.467
Moss curled	8.780	6.140	7.460	10.357	7.540	8.948	6.057	11.043	8.550	10.233	8.243	9.238
Kruasa curled	8.663	5.200	6.932	10.047	5.863	7.955	6.707	9.690	8.198	10.140	7.403	8.772
Forest Green	8.393	4.290	6.342	10.107	10.047	10.077	5.757	6.390	6.073	10.093	6.803	8.448
CD	0.712	0.389	0.360	0.132	0.097	0.068	0.219	0.561	0.352	0.374	0.331	0.301
SE(m)	0.229	0.125	0.116	0.042	0.031	0.022	0.070	0.180	0.113	0.120	0.106	0.097
C.V	4.781	3.399	2.737	0.704	0.631	0.402	1.885	3.051	2.346	2.111	2.167	1.826

Table 7 (Figure 7): Root length of different genotypes in different growing condition

Root Length (cm)												
System	**NFT (Nutrient Film Technique)**			**D.B (Dutch Bucket)**			**DFT (Deep Floating Technique)**			**P.H (Polyhouse)**		
Years / Genotypes	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**
Triple curled	19.667	20.667	20.167	24.333	24.667	24.500	22.667	**22.667**	**22.667**	**21.333**	21.667	21.500
Gigante Italian	18.667	19.667	19.167	26.667	24.333	25.500	23.667	23.667	23.667	20.667	20.667	20.667
Cress curled	18.000	18.667	18.333	22.667	26.667	24.667	**23.667**	23.333	23.500	20.667	19.667	20.167
Giant Plain	18.333	18.000	18.167	27.000	22.667	24.833	23.333	22.333	22.833	20.333	20.667	20.500
Moss curled	18.000	18.333	18.167	23.000	26.33	24.667	22.333	21.667	22.000	19.333	21.667	20.500

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Kruasa curled	17.333	17.667	17.500	23.333	24.667	24.000	22.667	21.667	22.167	19.333	21.000	20.167
Forest Green	16.667	18.667	17.667	22.333	23.333	22.833	22.333	22.333	22.333	19.000	21.000	20.000
CD	1.554	1.199	0.906	1.397	1.110	0.914	1.038	1.110	0.975	1.199	1.220	0.899
SE(m)	0.499	0.385	0.291	0.448	0.356	0.293	0.333	0.356	0.313	0.385	0.392	0.289
C.V	4.773	3.544	2.731	3.211	2.502	2.079	2.515	2.740	2.383	3.318	3.246	2.439

Table 8 (Figure 8): Fresh weight per plant of different genotypes in different growing condition

Fresh Weight per plant (g)												
System	**NFT (Nutrient Film Technique)**			**D.B (Dutch Bucket)**			**DFT (Deep Floating Technique)**			**P.H (Polyhouse)**		
Years / Genotypes	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**
Triple curled	663	697	680	436	450	443	330	336	333	563	580	572
Gigante Italian	923	873	898	514	520	517	451	337	394	602	666	634
Cress curled	643	787	715	336	363	349	274	291	283	518	584	551
Giant Plain	764	821	792	482	483	483	378	350	364	626	611	618
Moss curled	770	767	769	352	421	387	232	281	257	590	618	604
Kruasa curled	725	770	748	394	398	396	289	250	270	477	495	486
Forest Green	687	705	696	392	361	377	271	250	261	587	473	530
CD	0.070	0.059	0.049	0.041	0.024	0.026	0.035	0.033	0.024	0.021	0.022	0.009
SE(m)	0.022	0.019	0.016	0.013	0.008	0.008	0.011	0.011	0.008	0.007	0.007	0.003
C.V	5.233	4.267	3.618	5.436	3.162	3.380	6.192	6.196	4.384	2.055	2.085	0.901

Table 9 (Figure 9): Dry weight per plant of different genotypes in different growing condition

Dry weight per plant (g)												
System	**NFT (Nutrient Film Technique)**			**D.B (Dutch Bucket)**			**DFT (Deep Floating Technique)**			**P.H (Polyhouse)**		
Years / Genotypes	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**	**2022-2023**	**2023-2024**	**Pooled**
Triple curled	134.300	133.297	133.798	0.870	0.995	0.932	0.250	0.288	0.269	129.407	130.160	129.783
Gigante Italian	150.147	149.667	149.907	0.904	0.911	0.908	0.260	0.298	0.279	140.140	140.280	140.210
Cress curled	127.013	126.073	126.543	0.786	0.988	0.887	0.227	0.309	0.268	103.660	103.113	103.387
Giant Plain	140.073	139.337	139.555	0.891	0.997	0.944	0.343	0.312	0.328	140.317	139.077	139.697
Moss curled	146.00	145.077	145.538	0.782	0.911	0.846	0.332	0.306	0.319	150.107	140.000	145.053
Kruasa curled	123.933	121.740	122.867	0.689	0.676	0.682	0.278	0.324	0.301	140.633	143.033	141.833
Forest Green	130.077	129.033	129.555	0.651	0.654	0.653	0.267	0.312	0.290	148.077	146.037	147.057
CD	0.284	0.744	0.391	0.019	0.004	0.010	0.003	0.002	0.002	0.873	0.200	0.418
SE(m)	0.091	0.239	0.126	0.006	0.001	0.003	0.001	0.001	0.001	0.280	0.064	0.134
C.V	1.327	0.307	0.161	1.327	0.229	0.656	0.603	0.420	0.372	0.357	0.083	0.172