Research Article

Optimization of Light Intensity for Olive Propagation under Greenhouse Condition through Semi-Hardwood Cuttings

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Abstract | Olive cultivation in Pakistan is being commercialized at a fast pace in selected agro-climatic regions. The demand for local plants is increasing and no scientific study has been previously carried out to standardize propagation technology concerning optimization of light intensity under greenhouse conditions. The current study was conducted at Izhar farms (Pvt.) Ltd. under the collaboration with Barani Agricultural Research Institute (BARI) Chakwal to find out the appropriate light intensity for successful olive propagation under greenhouse conditions. The data regarding days to root initiation, number of roots, root length, days to shifting, rooted cutting percentage and callus percentage were collected under four different treatments. Cutting under the only green net (5944 lux), white net (11428 lux) only upper side white net (8484 lux) and both green and white net (5538). The results were found significant regarding the interaction between varieties and treatments; however, non-significant variation in varieties was found regarding the number of roots, days to root, and days to shift. The important observations regarding the results were found that minimum light intensity delayed the rooting percentage and increased the callus formation while higher light intensity increased mortality with increased root length in both varieties with moderate callus formation. Up to three weeks, there was no root development under all treatments. The cuttings under light intensity (8484 lux) produced more numbers of roots, with early initiation in both varieties. Variation in varietal performance was observed under different treatments however 8000 lux light gave better results in all the parameters.

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Introduction

Olive (*Olea europaea* L.) is long-lived and evergreen plant that belongs to the Oleaceae family, that has been originated in the Mediterranean region (Isfendiyaroglu, *et al*., 2009). The Oleaceae family contains about 26 genera and 700 species. Spain, Italy, Turkey, and Greece are the largest producers of olive oil followed by Portugal, Algeria, Tunisia, and Morocco. In addition to the Mediterranean region, olives are also grown in the United States, the Middle East, Australia and Argentina (Seyhan and Gezerel, 2005). The demand for olive sampling has increased in Asian markets due to its vast prospective and climatic adaptability in the region (Mehri, 2009).

There are several asexual propagation methods like budding, grafting cuttings and air layering but propagation through cuttings is considered the easiest and economical method for olive

multiplication (Dvin *et al.*, 2011; Hartmann *et al.*, 2002). Rooting ability of olive cuttings is subjective to several factors concerning rooting media (Awan *et al.*, 2003; Isfendiyaroglu *et al.*, 2009), cuttings types, olive varieties (Loreti and Hartmann, 1964; Turkoglu and Durmus, 2005), source of cutting material (Ahmed *et al.*, 2002; Sebastiani and Tognetti, 2004) and the growth hormone with its concentration (Asl-Moshtaghi and Shahsavar, 2011; Hartmann *et al.*, 2002). Light intensity is an important phenomenon for the successful propagation of rooted cuttings. The complementary effects of light intensities on the propagation of many plant species are well understood (Aminah *et al.*, 1997; Currey *et al.*, 2012; Lopez and Runkle, 2008; Park *et al.*, 2011; Zaczek *et al.*, 1997; Zobolo, 2010). The light intensity on the higher side is considered harmful for cuttings, as it increases the transpiration and temperature of the leaf and accelerates the leaf drying of cuttings. The roots of many woody and herbaceous species are affected due to high light (Aminah *et al.*, 1997; Zaczek *et al.*, 1997; Zobolo, 2010). There is a positive correlation between the high light intensities, the number of roots, and length (Currey *et al.*, 2012; Lopez and Runkle, 2008; Park *et al.*, 2011). The light intensity is recommended to keep low in the greenhouse usually to minimize the leaf transpiration and burning effects.

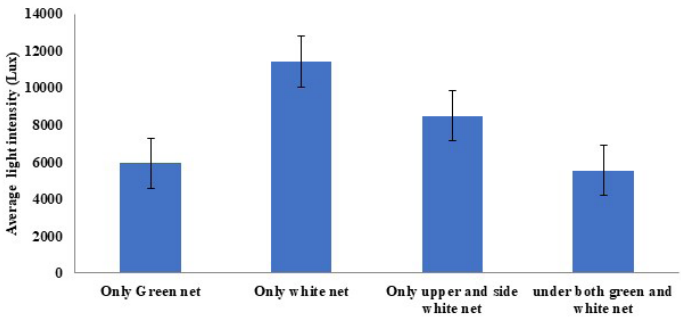

Figure 1: *Average light intensities data of all the four treatments during the study.*

The cultivation of olive in Pakistan has no longer history however the olive plantation is being increased day by day from the last decade due to its health and economic importance. Olive has been cultivated on more than 5966 acres of land in the Pothwar region (Anonymous, 2018). The results of five olive varieties namely, Gemlik, Nabali, Coratina, Hamdi, and Moraiolo were found satisfactory regarding fruit and oil yield under the environmental conditions of Pothwar, Pakistan (Iqbal *et al.*, 2019). The studies on propagation through cuttings were conducted on a very limited scale regarding the standardization of media, hormonal concentration, varietal behavior, and cutting length and thickness (Hussain *et al.*, 2020; Rehman *et al.*, 2013; Ali *et al.*, 2019) but no study was conducted regarding the standardization of light intensity for successful olive propagation in Pakistan. Hence, the main purpose of the study was to determine the optimum level of light intensity for appropriate rooting under the greenhouse condition.

Materials and Methods

Experimental location and cutting material

The research experiment was conducted at "Izhar Farms (Pvt.) Ltd." located in tehsil Kallar Kahar district Chakwal, Pakistan at 460 m altitude (32^0 46'33 N and 72^0 4231 E). The cutting material of two olive varieties (Coratina and Frantoio) was collected from an olive orchard planted with 6 x 6 m spacing under a high-efficiency irrigation system at the age of seven years. The semi-hardwood cuttings (7 cm in length) were collected with one pair of leaves near the tip and a round cut at the base. Cuttings were treated with IBA (3000ppm) solution for 10 seconds then planted in sand media in bed formation (Figure 2) under greenhouse condition with sprinkler irrigation system controlled by a timer with an interval of every 25 minutes for 10 seconds (day time) in such a way to keep the cuttings wet. The cuttings were planted under four different treatments for variability in light intensities i.e. cutting under the green net T_1 (5944 lux), white net T_2 (11428 lux) upper side, sides white net T_3 (8484 lux), and both green and white net T_4 (5538 lux)(Figure 1). The temperature inside the greenhouse was maintained at 25 (±2) °C by heating constantly through the basal heating system. Relative humidity was maintained at 70-80 % through proper misting. Fungicide spray-applied continuously with a gap of 7 days to prevent the attack of fungus in humid conditions.

Parameters understudy

The data of days to root initiation was recorded as the first root appeared, length of the root was measured from base to tip of the root, numbers of roots were counted after washing, and after gaining the appropriate root length the numbers of days to shifting were calculated. The percentage of callus formation was counted and the percentage was calculated. The overall success rate was recorded by shifting all the rooted cuttings from sand media to polythene containers.

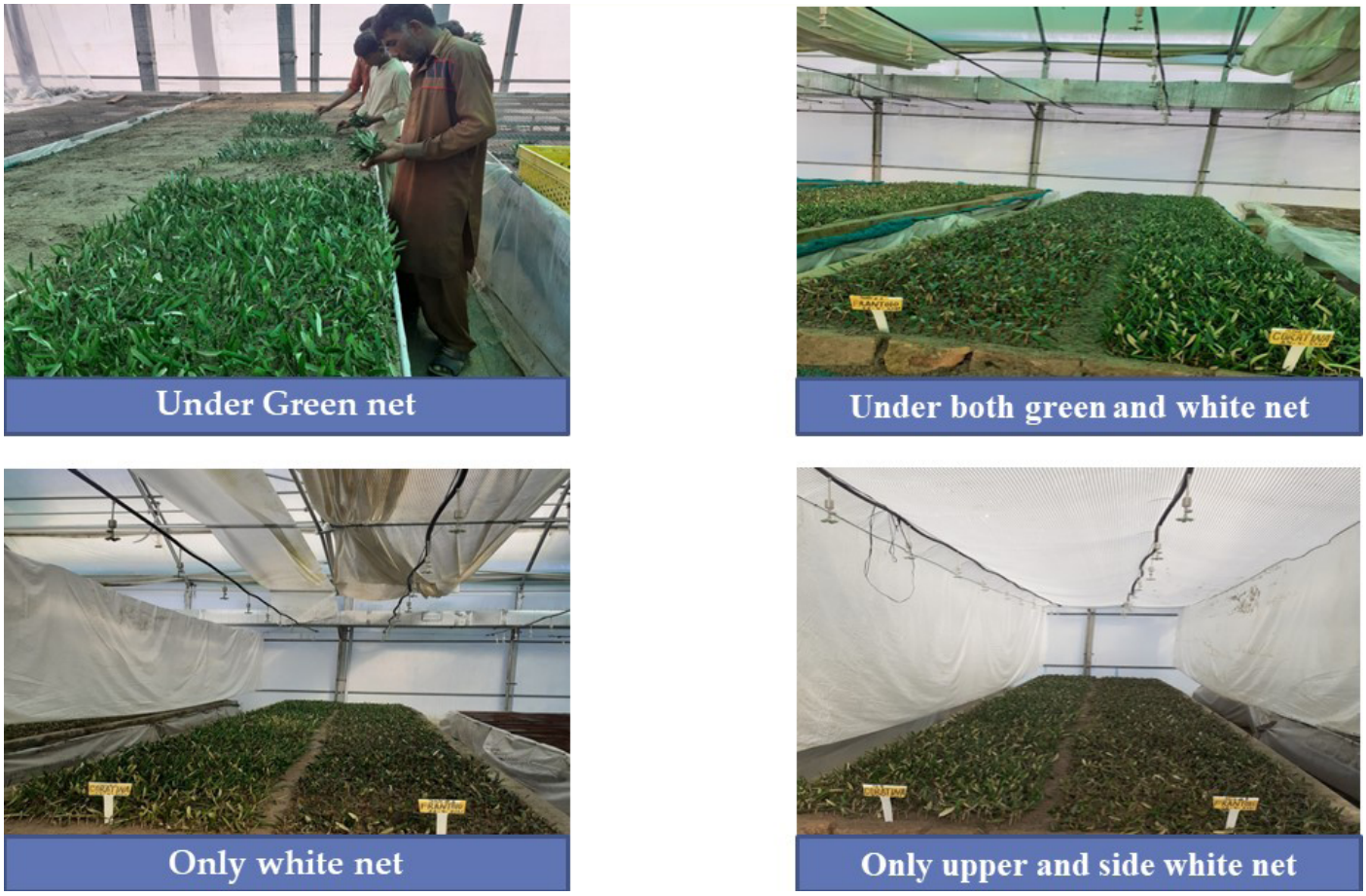

Figure 2: *Different light intensities for olive propagation under greenhouse conditions.*

The data of temperature, humidity, and light intensity were recorded on daily basis with the help of a hygrometer and lux meter respectively.

Statistical analysis

The experiment was laid out according to a randomized complete block design with three replications. The data for two varieties with six parameters were analyzed to determine minimum, maximum, means, cumulative variance. The Least Significant Difference (LSD) was utilized to compare the means at $P \leq 0.05$ (Statistics 8.1).

Results and Discussions

Days to root initiation

Light intensities varied under various treatments which resulted from the difference in days to root initiation under each treatment. Statistically significant results were found in the treatments while the non-significant result was observed in days to root initiation among varieties. The results presented in the Table 1 showed that both the varieties Frantoio (35.33) and Coratina (33.66) has taken the average maximum number of days for root initiation under T4 where the average light was 5538 lux while minimum time for root initiation was observed under T3 (8484 lux). Overall T3 was found for better forb early root initiation in both the varieties.

Number of roots

An analysis of the variance of the results indicated that statistically significant variations were found in the treatments while the non-significant result was observed in between the varieties (Table 1). The maximum average number of roots was recorded under T_3 followed by T_2in both varieties. However, Variety Coratina performed better (7.33) than Frantoio (6.66) under $T_3$and similarly under T_2. Both varieties depicted poor performance under T_4.

Root length

The results of root length were significantly affected under different treatments in both varieties (Table 1). The overall maximum root length was recorded in the variety of Coratina (6.89 cm) while the minimum was noted in the variety Frantoio (5.78 cm). The finding of an interaction between variety and treatment showed that maximum root length was recorded in the variety Coratina (8.76 cm) under T_2 followed by

Table 1: *Impact of varieties and treatments on days to root initiation, number of roots and root length.*

Treatments	Days to Root Initiation			Number of Roots			Root Length		
	Varieties V X T		Mean (T)	Varieties V X T		Mean (T)	Varieties V X T		Mean (T)
	Coratina	Frantoio		Coratina	Frantoio		Coratina	Frantoio	
Only green net	27.33 bc	29.66 b	28.5 b	4.66 bc	4.33 bc	4.5 b	6.36 b	5.71 b	6.04 b
Only white net	26.66 ± 1.03 bc	27.66 ± 1.10 bc	27.16 bc	6 ± 0.30 abc	5.33 ± 0.20 abc	5.66 ab	8.76 ± 0.38 a	6.83 ± 0.31 b	7.8 a
Only upper and side white net	24.66 ± 1.09c	25.66 ± 1.08 c	25.16 c	7.33 ± 0.31 a	6.66 ± 0.30 ab	7.0 a	8.63 ± 0.33 a	7.20 ± 0.31 ab	7.91 a
under both green and white net	33.66 ± 1.11a	35.33 ± 1.06 a	34.5 a	4.33 ± 0.20 bc	3.66 ± 0.14 c	4 b	3.8 ± 0.16 c	3.4 ± 0.11 c	3.6 c
Mean (V)	29.58 a	28.08 a		5.58 a	5.0 a		6.89 a	5.78 b	

Table 2: *Impact of varieties and treatments on days to shifting, rooted cutting % and callused cutting %.*

Treatments	Rooted cutting %			Callused cutting %		
	Varieties V X T		Mean (T)	Varieties V X T		Mean (T)
	Coratina	Frantoio		Coratina	Frantoio	
Only green net	41.74 a	17.84 c	29.79 b	7.65 ab	2.37 c	5.01 ab
Only white net	28.08 ± 1.40 b	24.38 ± 1.21 bc	26.23 b	8.51 ± 0.42 ab	3.34 ± 0.16 c	5.92 ab
Only upper and side white net	44.85 ± 2.24 a	31.43 ± 1.57 b	38.14 a	5.04 ± 0.25 bc	2.66 ± 0.13 c	3.85 b
under both green and white net	31.42 ± 1.57 b	26.73 ± 1.33 b	29.07 b	9.38 ± 0.46 a	5.67 ± 0.28 bc	7.52 a
Mean (V)	36.52 a	25.09 b		7.64 a	3.51 b	

the same variety (8.63 cm) under T_3. The treatment T_4 resulted from poor root length and was found at the bottom regarding both varieties.

Rooted cutting %

After 7 weeks from cutting plantation, the majority of cuttings were callused or rooted (Table 2). The higher and lower light intensities (T_2 & T_4) treatments had the highest fraction of mortality, whereas both varieties showed different behavior under lower and higher regimes. A statistically significant difference was found in both varieties under all treatments (Table 2). In comparison of performance between varieties, Coratina performed better under low light intensity T_1 (41.74 %) & higher light intensity T_2 (31.42 %) as compared to variety Frantoio (17.84 %) & (24.38 %) respectively. The results depicted that variety Coratina was found more resistant to higher and lower light intensities than variety Frantoio. However, both the varieties have non-significant variation at the light intensity under (T_3). The minimum rooted cutting percentage was recorded in variety Frantoio (17.84 %) under only green net treatment (5538 lux).

Callused Cutting %

It was noted that statistically significant variation was found in varieties, treatments, and interaction between varieties and treatments (Table 2). The maximum callused cutting % (7.5%) was observed under T_4 treatment followed T_2 while minimum (3.85%) callused cutting percentage was recorded under T_3. The findings of interaction between varieties and treatments indicated that maximum callused cutting % was recorded in variety Coratina (9.38 %) under low light intensities treatments T_4 (5538 lux) and T_1 (5944 lux) while the minimum callused cutting % was recorded in variety Frantoio (2.37%) under T_1 (5944 lux) treatment. Overall it could be concluded that under low-intensity root initiation will take more time with higher callus formation.

Light intensity is an important phenomenon for the successful propagation of rooted cuttings. The complementary effects of light intensities on the propagation of many plants species were well described (Currey *et al.*, 2012; Lopez and Runkle, 2008; Park *et al.*, 2011; Zobolo, 2010). The results of the above-mentioned studies showed that light intensity plays an important role in photosynthesis up to the optimum level. It was observed that excessive light intensity increased the vapor pressure deficit (VPD) surrounding the cutting environment that ultimately caused the leaf dehydration in leafy cuttings while the moderate light regimes increased the photosynthetic activity.

The high intensity is considered harmful for cuttings, as it increases the transpiration and temperature of the leaf and facilitates leaf drying. The roots of many woody and herbaceous species are affected due to high light (Aminah *et al*., 1997; Zaczek *et al*., 1997; Zobolo, 2010). We have found a positive correlation between the high light intensities with the number of roots and length which were also confirmed by other scientists. (Currey *et al*., 2012, Lopez and Runkle, 2008; Park *et al*., 2011).

The light intensity is kept low in the greenhouse usually to minimize the leaf transpiration and burning effects. The leaf photosynthesis in cuttings can play a crucial role in the formation of roots by providing the food through carbohydrates where it required rooting development for several weeks. Environmental conditions surrounding the roots are crucial for successful rooting In particular; leaf temperature and air VPD play a pivotal role in leaf survival and activity (Hartmann and Kester, 1983). Optimization of mist apparatus and spray intervals can help to counterbalance undesired VPD increase caused by greater light regimes. It is generally recommended that the light intensity should be kept low for the rooting of vegetative cuttings to minimize the leaf wilting and we observed that over light intensity hampers the rooting process. Our results were in harmony with the study of Tombesi *et al*. (2015) who reported that higher light intensity increased leaf wilting which resulted from poor root formation.

Olive cultivation was other than Mediterranean countries gaining popularity, especially in Pakistan. The yield and oil quality were found better (Ali *et al*., 2020; Iqbal *et al*., 2019). The study on propagation was very limited especially the impact of light intensity under greenhouse conditions. So it was tried to find out the appropriate light intensity for successful olive propagation through semi-hardwood cuttings. We have found that lower light intensity resulted from more callus formation and higher light caused a higher mortality ratio as in most of the areas in Pakistan we received higher light intensities.

Conclusion and Recommendations

It could be concluded from this study that light intensity 8000 to 8500 lux is most suitable for the sucessful ropagation of olive semi-hardwood cuttings. However, we also observed that other management factors like misting, humidity, fluctuation of light, and varieties selection have a vital impact on final success for olive propagation. Therefore, it is suggested that experiments may be conducted upon more varieties, types of cuttings, and time of planting under greenhouse conditions with optimum light intensity.

Novelty Statement

Olive is a hard to root woody plant species which is propagated through cuttings under conventional screen house. This resulted in very limited rooting success. Therefore, this study was conducted to determine the optimum level of light intensity for appropriate rooting under greenhouse conditions. Resultantly, light intensity of 8000 to 8500 lux was proved as most suitable for successful propagation of olive semi-hardwood cuttings.

Author's Contribution

Muhammad Rafique: Overall management of the article.
Muhammad Azhar Iqbal: Conceived the idea, wrote abstract and methodology.
Inam Ul Haq: Data entry, analysis and technical input at every step.
Muhammad Ramzan Anser: Introduction and references.
Humara Umar: Collected data, result and discussion.
Muhammad Ashraf Sumrah: Conclusion and reviewed literature.

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