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*Short Communication*

# Effect of seed soaking and drying on germination, growth and vigour of Macadamia (*Macadamia integrifolia Maiden & Betche*)

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## ABSTRACT

Macadamia nut is one of the world's finest nuts, and it has recently gained popularity among the growers in India due to its high market value. The germination is very poor and time taking due to the presence of hard shell, which remains intact for 5-6 months of sowing. Hence to overcome this problem, the present study was formulated to know the effect of seed soaking and drying treatments on seed germination and growth attributes of macadamia nut. The early germination (47 days), high germination (88.13 %), plant height (16.16 cm), stem girth (0.47 cm), number of leaves per plant (11.22), fresh weight (10.73 g), dry weight (4.66 g), vigour index-I (1429.11 cm) and vigour index-II (411.40 g) were recorded in seeds soaked for three days followed by oven drying for 18 hours compared to control. The correlation studies showed that initiation of germination had a positive correlation with days taken for 50% and complete germination. In conclusion, soaking macadamia seeds in water for three days followed by oven drying at 40ºC for 18 hours will help to early germination, improve germination percentage, growth and vigour of the seedlings.

## INTRODUCTION

Macadamia nut (*Macadamia integrifolia Maiden & Betche*), family Proteaceae, is considered as one of the finest nuts of the world. It is the first and only native crop from Australia to achieve commercial fruit crop status. South Africa is the leading producer of macadamias followed by Australia, Kenya and China (International Nut and Dried Fruit Council, 2021). This nut is a rich source of proteins (9%), carbohydrates (9.30%), vitamins and minerals (Ricks, 1991). The high carbon per cent and cracking pressure of macadamia shells are utilized in producing durable activated charcoals by different physical and chemical activation methods (Poinern et al., 2011). The kernels are versatile due to their delicate taste and texture (Bueno, 2009), which can be eaten raw, roasted, fried, salted and caramelized form. It is also found useful as an ingredient of various cookies, cakes and ice creams (Piza & Moriya, 2014). It is a high oil yielding nut crop compared to other nut crops with more than 75% oil recovery. Macadamia oil is beneficial by lowering cholesterol levels and favorably altering risk factors for coronary artery disease (Garg et al., 2007).

Macadamia has not gained a commercial importance in India but few farmers are started cultivating, particularly in high altitude regions of Karnataka (Usha et al., 2018). In general, macadamia can be propagated through seeds or grafting but production of rootstocks for grafting takes more time due to poor and delayed germination. It is mainly due to the existence of hard shell which does not allow imbibition of water (Tripathi et al., 2022). Studies have proved that presowing treatments helps in quick germination and high seedling vigour in fruit crops like phalsa and white sapote (Muralidhara et al., 2017 & 2023). But the effect of pre sowing treatments on germination and vigour of macadamia is not studied. Hence, the present study was undertaken to know the effect of pre sowing treatments on seed germination and growth attributes of macadamia.

The present experiment was carried out under polyhouse conditions at Central Horticultural Experiment Station, Chettalli, Kodagu, Karnataka during 2022 and 2023. Uniform sized nuts weighing 8-9 g were selected for imposing seven treatments *viz*., $T_1$: control (no treatment), $T_2$: 1 day water soaking followed by 6 hours sun drying, $T_3$: 2 days water soaking followed by 12 hours sun drying, $T_4$: 3 days water soaking followed by 18 hours sun drying, $T_5$: 1 day water soaking followed by 6 hours oven

drying at 40º C, $T_6$: 2 days water soaking followed by 12 hours oven drying at 40º C, $T_7$: 3 days water soaking followed by 18 hours oven drying at 40ºC. The seeds were sown in 5 x 6-inch black polythene covers that were filled with standard potting mixture (2:1:1). The experiment was carried out using completely randomized block design replicated thrice with 30 seeds per replication. The replicated means were analyzed statistically using WASP 2.0 software (Web Agri Statistical Package). The Pearson's correlation test was performed to determine the association between the traits.

Daily observations were recorded for germination parameters such as, days taken for initiation of germination, days to 50% germination, days taken for complete germination. Ten months after sowing, the seedling growth parameters *viz*., plant height (cm), stem girth (cm), number of leaves, fresh weight (g), and dry weight (g) of the plants were measured. Using the formula provided by Bewley & Black (1982), germination percentage, germination rate, vigour index-I (cm) and vigour index-II (g) were determined.

Vigor index-I (cm) = Mean seedling length × per cent germination

Vigor index-II (g) = Dry weight of seedling × per cent germination

The minimum number of days taken for initiation of germination and 50% of germination was found in the seeds soaked for 3 days followed by oven drying for 18 hours at 40ºC (47 and 77.67 days) which was on par with all other treatments except control (155 and 187.33 days) (Table 1). The early completion of germination was recorded in seeds soaked for three days followed by oven drying for 18 hours at 40ºC (137 days), however, seeds without any treatment ($T_1$) took more number of days for completion of germination (255.67 days). The faster germination in 3 days water-soaked seeds followed by 18 hours of oven drying at 40ºC due to long time soaking and drying of the seeds leads to shell cracking, which helps for early germination. The oven dried seeds will receive uniform temperature throughout treatment period compared to sun drying. So, there is faster germination in oven dried seeds compared to sun dried seeds. The late and poor germination in control is due to the presence of hard shell in macadamia nut (Tripathi et al., 2022), which remains unbroken even after 6 months of sowing (Andrade et al., 2002). The quicker germination was reported in different nuts crops *viz.*, walnut (Lamichhane et al., 2021) and almond (Masilamani et al., 2014) through pre-sowing treatments. Similar results were also reported in mango, aonla and white sapote (Muralidhara et al., 2016; Chiranjeevi et al., 2017; Muralidhara et al., 2023).

The highest germination per cent was recorded in 3 days water soaking followed by 18 hours oven dried seeds (88.33%) and lowest was recorded in control (33.33%). The rate of germination was recorded

**Table 1 : Effect of pre-sowing treatments on germination parameters of macadamia nut**

| Treatment | Days to initiation of germination | Days to 50% germination | Days to complete of germination | Germination (%) | Rate of germination |
|---|---|---|---|---|---|
| $T_1$ | 155.00 | 187.33 | 255.67 | 33.33 | 0.004 |
| $T_2$ | 55.67 | 80.00 | 176.33 | 81.67 | 0.006 |
| $T_3$ | 54.33 | 101.67 | 188.33 | 78.33 | 0.005 |
| $T_4$ | 56.33 | 94.67 | 144.00 | 46.67 | 0.007 |
| $T_5$ | 54.33 | 103.00 | 185.00 | 73.33 | 0.005 |
| $T_6$ | 51.00 | 101.67 | 171.67 | 81.67 | 0.006 |
| $T_7$ | 47.00 | 77.67 | 137.00 | 88.33 | 0.007 |
| CD (P=0.01) | 20.98 | 27.34 | 36.76 | 13.27 | 0.01 |
| CV (%) | 12.75 | 10.55 | 8.41 | 7.91 | 6.48 |

$T_1$: control, $T_2$: 1-day water soak and 6 hours sun drying, $T_3$: 2-day water soak with 12 hours sun drying, $T_4$: 3-day water soak with 18 hours sun drying, $T_5$: 1-day water soak with 6 hours oven drying at 40ºC, $T_6$: 2-day water soak with 12 hours oven drying at 40ºC, $T_7$: 3-day water soak with 18 hours oven drying at 40ºC

**Table 2 : Effect of pre-sowing treatments on growth and vigour attributes of macadamia nut**

| Treatment | Plant height (cm) | Plat girth (cm) | No. of leaves plant | Fresh weight of plant (g) | Dry weight of plant (g) | Vigour index-I (cm) | Vigour index-II (g) |
|---|---|---|---|---|---|---|---|
| $T_1$ | 11.78 | 0.36 | 6.89 | 8.02 | 3.47 | 392.85 | 117.47 |
| $T_2$ | 15.58 | 0.40 | 10.22 | 10.04 | 4.30 | 1272.11 | 351.33 |
| $T_3$ | 13.87 | 0.41 | 9.89 | 9.26 | 3.96 | 1086.00 | 309.85 |
| $T_4$ | 14.84 | 0.42 | 10.78 | 9.58 | 3.99 | 669.28 | 186.75 |
| $T_5$ | 14.32 | 0.41 | 10.44 | 10.04 | 4.11 | 1089.33 | 301.68 |
| $T_6$ | 13.90 | 0.36 | 9.56 | 7.90 | 3.20 | 1137.50 | 261.87 |
| $T_7$ | 16.16 | 0.47 | 11.22 | 10.73 | 4.66 | 1429.11 | 411.40 |
| CD (P=0.01) | 1.33 | 0.05 | 2.55 | 0.75 | 0.50 | 228.11 | 66.63 |
| CV (%) | 3.80 | 4.99 | 10.64 | 3.31 | 5.17 | 9.28 | 9.89 |

$T_1$: control (no treatment), $T_2$: 1-day water soak with 6 hours sun drying, $T_3$: 2-day water soak with 12 hours sun drying, $T_4$: 3-day water soak with 18 hours sun drying, $T_5$: 1-day water soak with 6 hours oven drying at 40ºC, $T_6$: 2-day water soak with 12 hours oven drying at 40ºC, $T_7$: 3-day water soak with 18 hours oven drying at 40ºC

maximum in 3 days water soaking followed by 18 hours oven dried seeds (0.007) and 3 days soaked and 18 hours sun dried seeds (0.007) and minimum was recorded in control (0.004) compared to other treatments. Increased germination percentage in hard coat seeds of *Caesalpinia sappans* by alternate soaking and drying was also reported by Rusmin & Hasanah (1993). The easy absorption of water in cracked seeds increases the α-amylase activity which helps in early plumule initiation. The similar results were also reported in white sapote (Muralidhara et al., 2023) when seed coat was removed.

Ten months after sowing, maximum plant height was noticed in three days water soaked and 18 hours oven dried seeds (16.16 cm) which was on par with 1 day-soaked seeds with 6 hours sun drying (15.58 cm) and 3 days soaked with 18 hours sun drying (14.84 cm) and minimum was recorded in control (11.78 cm) (Table 2). Maximum plant girth (0.47 cm) and number of leaves (11.22) were also recorded in 3 days water soaked and 18 hours oven dried seeds. All the treatments were statistically on par with respect to number of leaves except control (6.89). Seeds soaking in water for 3 days followed by 18 hours oven drying

**Table 3 : Correlation matrix for different germination and seedling growth characters of macadamia nut**

| Trait | DIG | DFG | DCG | GP | RG | PH | SG | NL | FW | DW | VI-I | VI-II |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIG | 1 | | | | | | | | | | | |
| DFG | 0.96 | 1 | | | | | | | | | | |
| DCG | 0.88 | 0.91 | 1 | | | | | | | | | |
| GP | -0.79 | -0.79 | -0.58 | 1 | | | | | | | | |
| RG | 0.58 | 0.55 | 0.46 | -0.60 | 1 | | | | | | | |
| PH | -0.82 | -0.92 | -0.83 | 0.76 | -0.59 | 1 | | | | | | |
| SG | -0.56 | -0.65 | -0.73 | 0.44 | -0.77 | 0.79 | 1 | | | | | |
| NL | -0.93 | -0.95 | -0.94 | 0.65 | -0.64 | 0.91 | 0.79 | 1 | | | | |
| FW | -0.57 | -0.69 | -0.63 | 0.47 | -0.71 | 0.86 | 0.91 | 0.79 | 1 | | | |
| DW | -0.45 | -0.61 | -0.55 | 0.42 | -0.69 | 0.81 | 0.91 | 0.69 | 0.98 | 1 | | |
| VI-I | -0.80 | -0.83 | -0.64 | 0.98 | -0.62 | 0.86 | 0.56 | 0.72 | 0.60 | 0.56 | 1 | |
| VI-II | -0.74 | -0.81 | -0.62 | 0.93 | -0.73 | 0.89 | 0.69 | 0.73 | 0.73 | 0.72 | 0.97 | 1 |

DIG: days to initiation of germination, DFG: days to 50% of germination, DCG: days to complete germination, GP: germination percentage, RG: rate of germination, PH: plant height, SG: stem girth, NL: number of leaves, FW: fresh weight, DW: dry weight, VI-I: vigour index-I, VI-II: vigour index-II

($T_7$) increases the vigour of seedlings due to early initiation of germination, good nutrient uptake by development of a good root system, which also increases the photosynthetic activity due to early exposure of leaves to sunlight. The simillar results were also reported in different fruit crops (Muralidhara et al., 2016 & 2023).

The highest fresh weight, dry weight, vigour index-I and vigour index-II was recorded in the seeds soaked in water for 3 days and 18 hours oven drying (10.73 g, 4.6 g, 1429.11 cm and 411.40 g, respectively) and minimum were noticed in control (8.02 g, 3.47 g, 392.85 cm and 117.47 g, respectively) (Table 2). The results were further strengthened with studies done in white phalsa and writs as white sapote (Muralidhara et al., 2017 & 2023). The maximum fresh weight, dry weight and vigour index in seeds soaked in water for 3 days and oven dried for 18 hours may be due to the early initiation of seedlings and development of a good root system which helps for sufficient nutrient uptake.

The correlation analysis indicates the association between different parameters (Table 3). Early seedling initiation recorded negative correlation for all growth and vigour characteristics and a positive correlation with the number of days required for 50% and complete germination. The characteristic related to seedling growth and vigour had a positive association between the rate of germination and germination percentage. The vigour index I and II had positive association between the fresh and dried weight of the seedlings. The correlation data unequivocally demonstrated that seedlings that emerge early will have more plant vigour and reach an early graftable stage. The similar association was reported for different germination and growth parameters in mango and white sapote (Muralidhara et al., 2016 & 2023).

## CONCLUSION

Soaking macadamia seeds for 3 days followed by oven drying at 40ºC for 18 hours helped in improving the germination percentage, growth and vigour of seedlings of Macadamia nut.

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