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Plant protection and invasive plant *Melia azedarach* L.: Inhibition and delaying effects of fruit on seedling emergence compared with endocarp and seed

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Abstract
Melia azedarach is one of the broadleaved, perennial woody plant species and belongs to Meliaceae family. The plant is multipurpose and has few pests and diseases. Because of this reason, some of the plant parts may be used as plant protection agent. The plant can also become an invasive species under certain environmental factors whose growth demands must be known. One of the propagation methods of the plant is generative propagation and this study is aimed to find out seedling emergence ratio differences between sowed groups (fruit, endocarp and seed) under different water treatment durations as 1 day, 7 days and 14 days along, besides control (no water treatment) under non-sterile condition in laboratory before sowing in peat under greenhouse condition. At the end of the study, first and last emergence days (day and date), seedling emergence rate (%), shoot number per sowed part were revealed. Data showed that first seedling emergence days changed between 25-37 in seeds and 31-37 in endocarp in all water treatment and control. In fruits there is no emergence in control and first seedling emergence days changed between 53-78 in all water durations. Emergence ratios were very high with a ratio of 80-92,50% in endocarps, and very low with a ratio of 0-12.5% in fruits in all water treatments and control. According to the data this is emphasized that the planted parts (fruit, endocarp, seed) are more effective than water treatment in most parameters and the fruit pericarp has a strong emergence inhibiting and retarding effects on seedling emergence in *Melia azedarach.*

Keywords: *melia azedarach*, fruit, endocarp, seed, seedling, water treatment

Introduction
Melia azedarach L. is a member of family Meliaceae, natively found in some parts of Asia. The plant is one of the introduced or exotic species for some other countries in other continentals as Africa, Europe, North and South America [1-3]. The plant is used as fuel [4], ornamental and shade plant [5, 6], for production of furniture and some tools, reforesting or afforesting plant of drought areas [4, 7]. The plant has also ecological importance for soil aeration, enrichment the soil nutrients with deep roots [8, 9]. At the same time the plant parts, organs or tissues as bark, stem, root, leaves, flower, fruit, seed with their oil or infusions used for human or plant protection and cure aims [5]. Especially in plant protection, *M. azedarach* contain some active substances which lead to promising studies on the way to become insecticides [10-12], nematicides [13, 14], acaricides [15, 16], fungicides [17, 18], bactericides [19, 20] and herbicides [21]. These promising studies may become commercialized as botanical pesticides through an uninterrupted supply of plants. For this purpose serial production of seedlings can be done via seed as generative method which is one of the healthy seedling production techniques besides vegetative reproduction.
On the other hand, the plants are an invasive species that can cause problems in landcape and agricultural areas and require protection combat [22-26]. For this purpose to gain knowledge about its germination physiology and environmental requirements are become importance.
M. azedarach seeds in an endocarp [27] surrounded by pericarp. Pericarp of the drupe fruits are green and generally semi-fleshy in early developmental stage and non-fleshy in late stages. In some studies about generative propagation of woody species there are different unexpected results from endocarp or pericarp [28, 29] although they are responsible of mechanical or physical dormancy [30, 31]. Water is one of the pre-sowing treatments for dormancy breaking or accelerating seedling factor [32-35]. The study aimed to determine the effects of pre-treatment of water and water treatment duration on seedling growth from seed, endocarp and fruit under glasshouse condition.

Material and Methods
The experiment was conducted at greenhouse of Agriculture Faculty, Kocaeli University, Kocaeli City in Turkey. All used plant generative parts that planted in the substrate to germinate and emergence were: “Seed” (including endosperm+embryo+seed coat), “Endocarp” (=stone; including seed+endocarp) and “Fruit” (including seed+endocarp+pericarp (mesocarp+exocarp)). The all fruits manually collected from only one tree (Fig. 1a,b) approximately 18 years old, adapted naturally Kocaeli City ecological condition at February, 22nd, 2020 at pale, very mature stage (Fig. 2a) nearly 9 months after first fruit set which were occured in June, 2019. All sowed parts checked and healthy, similar parts prepared same day (Fig. 2b) and firstly 14 days water treatment, after a week 7 days water treatment after 6 days 1 day water treatment applied under laboratory condition with stagnant distilled water (Fig. 3a) without any extra treatment and all of them sowed at the same time under greenhouse condition at March, 9th, 2020

in 1 dm^3 pots filled with peat. Each pot consisted 10 sowing type material as a sub-plot (a repeat). Watering was done equally with hand as needed. The plants, each day of the experiment visited and daily recorded for first and last seedling emerging days, dates and emerged shoot numbers. At the end of the 120th day the study was completed although last emergence occured in 78th day, because there may be a new emergence.

The experiment laid out in Completely Randomized Design (CRD), consisted of 4X3 treatments with four water (0, 1, 7, 14 days) treatment, three sowing type (fruit, endocarp, seed) and four replicates for each treatment. Each sub-plot consisted with 10 sowed type, totally the study consisted with 480 sowed types. The recorded data were analysed through statistical software for observation the parameter were statically significant or not at 0.05% level.

Results and Discussion

The first seedling emergence days of *Melia azedarach* were not statistically affected by water treatment duration at seed and endocarp sowing. First seedling emergence days changed between 25-37 in seed and 31-37 in endocarp in all water duration and control. In fruit, there is no emergence at control and the first seedling emergence days changed between 53-78 in all water treatment after sowing date. Statistically 14 days water treated fruits sowing showed better result than 1 or 7 days water treatment in fruit for earliness. But in general first seedling emergence better in seed and endocarp sowing than fruit in all treatment (Table 1). In a study about salt stress on growth and physiology in *Melia azedarach* seedling from different provenences [36], seeds were collected in December and stored at 0-5^{0}C in cold storage warehouse until the end of March before soaking in warm water. After the presedure the seeds were sown field nursery and the seed germinated in mid-April. The results support us although our study included no cold or warm water treatment. The seeds and endocarps came to seedling at the first half of April in all treatments (Table 3) which is better than fruit sowing in our study. In another study on pre-sowing treatments on seed germination of *Melia azedarach* [33], the seeds treated with cold water, hot water, scarification, and H_2SO_4. In all the treatment germination started between 8.-11. day and germination completed within 20-21 days after sowing. They found that there are no statistical results about first and last germination in all the pre-sowing tratments. Similarly in our study water treatment duration showed no statistical results on first and last seedling emergence day from substrate to surface in seed and endocarp sowing. The last emergence days changed between 35-50 in seed sowing and 51-55 in endocarp sowing. According to all data (Table 2) last seedling emergence days are better in seed and endocarp sowing than fruit in all treatment. In a study [37] on seed germination of ponytail tree (*Beaucarnea recurvata* Lem.) with and without pericarp, emergence percentage were found 37% with pericarp and 60% without pericarp. Similarly in another study [38] on seed dormancy and seedling emergence of *Viburnum tinus*, a shrub plant, seed, stone and drupe (fruit) were sowed and was found that no shoot emergence occured in drupes. Mayer and Poljakoff-Mayber [39] emphasized that pulp responsible to preventing imbibition due to its impermeability, or by contining germination inhibitors. The studies supported our experiment that fruit in control gave no seedling emergence, in addition; water treated fruit gave the lowest results with 2.5-12.5% than seed and endocarp. Endocarp gave the highest emergence rate in all treatment with 80-92.5% than seed and fruit (Table 4; Fig. 5) because of each endocarp consisted more than one seed (in average 5 seed per endocarp) and the condition has insured emergence rate. The emerged shoot number supported to the opinion with 1.42-1.65 shoots per sowed endocarp while 1 shoot per seed or 0-1.1 shoots per fruit sowing (Table 5; Fig. 3b).

Conclusion

By analyzing our data water duration treatment did not show statistical significance on measured parameters of sowing types (seed and endocarp) except fruit. In fruit, water treatment showed better results than control in which there were no emergence. In water treatment; 1 day treatment is better than 7 or 14 days. This may be due to the fruit rotting effect of prolonged soaking in stagnant water as our observation. On the other hand, the removing pericarp (fruit pulp) can cause faster and synchronous germination. Although endocarp sowing started to seedling emergence a little late than seed but their seedling capacity is remarkable and statiscally higher (80-92.5%) than seed (17.5-20%) and fruit (0-12.5%) in all treatment included control, in addition it takes less effort than reaching seed inside. Thus, when it is necessary to combat with in agricultural areas the study taught that prolonged exposure to water may not be an essential requirement, and after pericarp removing or rotting the seedling easily occured from endocarp. On the other hand when it is necessary to establish a plantation for plant protection products to be made in the future, endocarp planting can be recommended to obtain healthy, uniform and large number of seedlings without any treatment in *Melia azedarach* L.

Table 1: First seedling emergence days at seed, endocarp and fruit sowing in the treatments of *Melia azedarach* L.

Treatment	Seed	Endocarp	Fruit
Control	26 a* B**	37 a C	0 c A
1 day water	32 a A	35 a A	76 a B
7 days water	37 a A	32 a A	78 a B
14 days water	25 a A	31 a A	53 b B

*Different lowercase letters are within the same column showes significantly differences between treatments at the same sowed type at $p \leq 0.05$

** Different capital letters are within the same line showes significantly differences between sowed seed, endocarp and fruit at the same treatment at $p \leq 0.05$

Table 2: Last seedling emergence days at seed, endocarp and fruit sowing in the treatments of *Melia azedarach* L.

Treatment	Seed	Endocarp	Fruit
Control	50 a* B**	53 a B	0 c A
1 day water	37 a A	55 a B	76 a C
7 days water	43 a A	51 a A	78 a B
14 days water	35 a A	51 a B	53 b B

*Different lowercase letters are within the same column showes significantly differences between treatments at the same sowed type at p≤0.05

** Different capital letters are within the same line showes significantly differences between sowed seed, endocarp and fruit at the same treatment at p≤0.05

Table 3: First-Last seedling emergence dates at seed, endocarp and fruit in the treatments of *Melia azedarach* L. after sowing March, 9th, 2020.

Treatment	**First-Last Emergence Dates**		
	Seed	**Endocarp**	**Fruit**
Control	April, 4- April, 28	April, 15- May, 1	-----_-----
1 day water	April, 10- April, 15	April, 13- May, 3	May, 24-May, 26
7 days water	April, 15- April, 21	April, 10- April, 29	May, 26-May, 26
14 days water	April, 3- April, 13	April, 9- April, 29	May, 1-May, 1

Table 4: The seedling emergency rate (%) at seed, endocarp and fruit sowing in the treatments of *Melia azedarach* L.

Treatment	**Seed**	**Endocarp**	**Fruit**
Control	17.5 a* B**	82.5 a A	0.0 b B
1 day water	20.0 a B	80.0 a A	12.5 a B
7 days water	17.5 a B	92.5 a A	2.5 b C
14 days water	17.5 a C	90.0 a A	2.5 b C

*Different lowercase letters are within the same column showes significantly differences between treatments at the same sowed type at p≤0.05

** Different capital letters are within the same line showes significantly differences between sowed seed, endocarp and fruit at the same treatment at p≤0.05

Table 5: Emerged shoot number per seed, per endocarp or per fruit in the treatments of *Melia azedarach* L.

Treatment	**Seed**	**Endocarp**	**Fruit**
Control	1.00 a B	1.61 a A	0.00 b C
1 day water	1.00 a B	1.52 a A	1.10 a B
7 days water	1.00 a B	1.42 a A	1.00 a B
14 days water	1.00 a B	1.65 a A	1.00 a B

*Different lowercase letters are within the same column showes significantly differences between treatments at the same sowed type at p≤0.05

** Different capital letters are within the same line showes significantly differences between sowed seed, endocarp and fruit at the same treatment at p≤0.05

Fig 1: *Melia azedarach* L. **a)** A view from the mother tree, **b)** A view from the used mature fruits on the tree just before the fruits are picked on 22nd of February, 2020

Fig 2: *Melia azedarach* L. **a)** Fruits taken to the laboratory for measurement, counting, and preperation immediately after picking, **b)** Representative sample of fruits, endocarps and seeds from left to right that used

Fig 3: *Melia azedarach* L. **a)** Seeds (bottom row), endocarps (middle row), and fruits (top row); untreated, 1 day water treatment, 7 days water treatment, and 14 days water treatment from left to right for each sowed types (the photograph taken just before sowing), **b)** Multiple shoot emergency from endocarp treatment

Fig 4: *Melia azedarach* L. seedling growth after 90 days from sowing at seeds (16 pots on the left), endocarps (16 pots in the middle), and fruits (16 pots on the right)

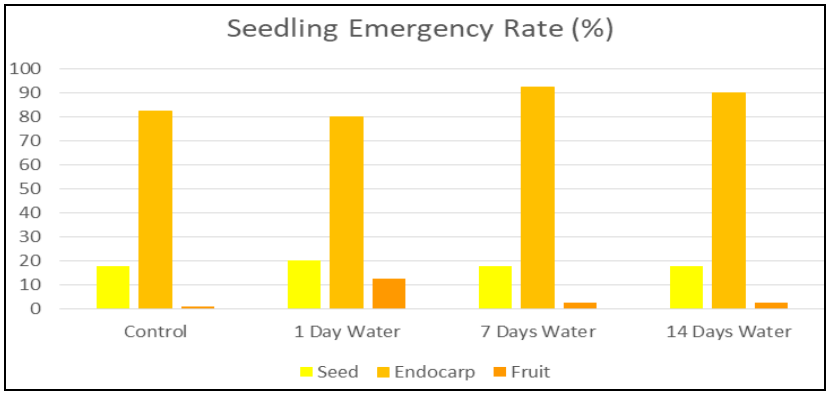

Fig 5: The seedling emergency rate (%) at seed, endocarp and fruit sowing in the treatments of *Melia azedarach* L.

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