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Improving The Efficiency of Irrigation Rates by Using Soil Conditioners on The Growth Rates of *Paulownia hybrid* Seedlings Planting in Sandy Soil

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ABSTRACT

The study was conducted during the 2020 and 2021 seasons at Alexandria University Alexandria, Egypt, in the Department of Flowers, Ornamental Plants, and Landscape Gardens Nursery, Faculty of Agriculture (El-Shatby). This study examined Paulownia hybrids (*Paecownia elongate×Paulownia tomentosa*) cultivated in 30-cm-diameter plastic pots. The study aimed to determine how different irrigation levels (40, 60, 80, and 100% of the field capacity) and chitosan ratios (0.0, 0.1, 0.2, and 0.3%), the transactions amount to sixteen, would affect the roots production, vegetative growth, flowering characteristics, and some chemical constituents of Paulownia hybrid seedlings grown in sandy soil. The irrigation level was found to have a greater effect on all of the features of Paulownia hybrid seedlings that were investigated than chitosan (soil conditioners -ratios). Additionally, the most important characteristics of the plant, include its height, number of leaves, leaves dry weight and leaves area, stem diameter and stem dry weight, number of flowers per plant, and length and dry weight of its roots. To determine the amount of carbohydrates in the leaves, the proline, chlorophyll, and relative water content, the largest amount of moisture (100 % of the field capacity) was combined with 0.1% chitosan (soil conditioners). According to the results, it is generally advised, to irrigate the cultivated Paulownia hybrid daily in sandy soil at a rate of at least 80% of the field's capacity. While, adding chitosan (soil conditioners (at a rate of 0.2% improved the vegetative growth, flowering characteristics, and root production. Also, adding chitosan at a rate of 0.1% improves some chemical analysis of the seedlings grown in sandy soil.

INTRODUCTION

Paulownia sp. is a deciduous tree that is native to China and is a member of the Paulowniaceae (Scrophulariaceae) family. It is characterized by a short rotation, huge leaves that are grouped in opposing pairs on the stem of this incredibly fast-growing plant, which can withstand a wide range of weather and soil conditions, including poor soil (Freeman *et al.*, 2012). It is found growing around the world, including China, Japan and Southeast Asia, Europe, North and Central America, and Australia (Rahman *et al.*, 2013). This extremely valuable wood has been crafted into transport containers, musical instruments, beautiful mouldings, laminated structural beams, and ceremonial furniture by skilled artisans.

In many parts of the world, particularly the semi-arid and arid zones, water is rapidly becoming a limited resource. Therefore, conserving irrigation water and improving water use efficiency are crucial objectives. However, water stress can still arise in plant tissues even with sufficient soil moisture, leading to significant changes in the majority, if not all, of the physiological and biochemical processes. According to (Misra and Srivastava's, 2000, El-Shanhorey and Soffar 2014) findings, Mentha arvensis essential oil output and leaf chlorophyll content was significantly reduced in response to water stress. (Mohamed, 2002; El-Shanhorey *et al.*, 2010) discovered a progressive rise in fresh and dry weights/plant with increasing irrigation level in *Rosmarinus officinalis* and *Pelargonium graveolens*. Drip watering was used to get the highest fresh and dry weights per plant and per feddan at the rate of 8L/h.

Generally, a lot of water is needed for cultivation on arid sandy soil. This soil's low water-holding capacity leads to deep percolation beneath the root zone and quick penetration. Hydrophilic polymers that produce gels have been studied for years as potential solutions to this kind of issue. For the agriculture sector to remain competitive over the long run, water usage resource optimisation is crucial. One of the biggest issues facing society in the near future is water management (Saguy *et al.*, 2013 and El-Shanhorey 2015). In fact, it is predicted that by 2030, there will be a scarcity of water due to withdrawals exceeding natural renewal by more than 60% and a 50% increase in water demand above current levels (Nestlé, 2011).

In order to boost the supply of secondary metabolites in herbs and plants, chitosan compounds—a kind of polysaccharide—are widely employed, according to studies on marjoram (Yin *et* *al.*, 2011) and artemisia (Lei *et al.*, 2011). They further suggest that the substance served as a strong inducer of enhanced overall terpine content and secondary metabolite production. Furthermore, there is growing interest in chitosan as a crop biostimulant that can be used in sustainable agriculture (Pichyangkura and Chadchawan, 2015; Sharp, 2013). Chitosan is a biocompatible, biodegradable, environmentally benign, and commercially available substance in large amounts. It has been shown to improve the growth and productivity of a variety of horticulture crops. Ornamental, fruit, and vegetable crops, for instance However, chitosan was used topically in the majority of the studies (El-Miniawy *et al.*, 2013; Farouk and Amany, 2012; Pichyangkura and Chadchawan, 2015; Pirbalouti *et al.*, 2017). One of the most significant salad vegetables in the US is lettuce (*Lactuca sativa*), which is high in vitamins, carotenoids, and other phytochemicals (Humphries and Khachik, 2003; Nicolle *et al.*, 2004). This study set out to evaluate how chitosan, applied as a soil amendment, affected the growth, gas exchange, and fluorescence of lettuce.

The purpose of this study was to investigate the effects of varying percentages of field capacity (irrigation levels), ratios of soil conditioners (chitosan), and their combinations on the vegetative growth, root growth, and flowering characteristics.
In addition, some chemical analysis of Paulownia hybrids grown in sandy soil in Alexandria was investigated.

MATERIALS AND METHODS

The 2020 and 2021 study seasons were used for this research. This study was conducted at Alexandria University in Alexandria, Egypt, in the Department of Flowers, Ornamental Plants, and Landscape Gardens nursery inside the Faculty of Agriculture (El-Shatby).

The study employed *Paulownia hybrid* plants *(Paulownia elongate* Paulownia tomentosa),* which were chosen based on their ability to adapt to the Egyptian environment. On April 1st, 2020 and 2021, respectively, first- and second-season seedlings were planted in 30-cm plastic pots. The pots were filled with 10 kg of sandy soil each. The examination of the sandy soil utilised, as detailed in Table (1) by Jackson (1958).

Four irrigation levels were employed to keep the soil moisture at the 40%, 60%, 80%, and 100% field capacity of the used sandy soil. The daily drop in each treatment's moisture level was measured during the growth seasons using the Moisture Tester Model KS-DI (Gypsum Block).

Using tap water as an irrigation source, the various treatments' amounts of water were added to each pot on a daily basis to maintain the soil moisture content at the corresponding percentage; at the conclusion of the experiment, the total amount of irrigation water for each treatment was computed and shown in Table (2).

Commercially known as "Chitosan," this natural polymer is a white granular substrate containing 97% chitosan (S.C.), has the ability to retain water, and was once utilized as a source of soil conditioners (S.C.). Based on the weight of the soil (w/w), four concentrations of this polymer were used: 0.0 (control), 0.1, 0.2, and 0.3%. Just before planting, every level of this polymer was thoroughly combined with the applied soil, according to Devitt *et al.*, (1991).

The plants were fertilized 30 days following agriculture. The quality of the generated flowers and roots was improved and the vegetative growth was accelerated by the use of two types of compound fertilizers (N: P_2O_5: K_2O).

Table 1: Some chemical analysis of the used sandy soil for the two successive seasons 2020 and 2021.

Season	pH	EC (mmohs/cm)	Soluble cations (mg/l)				Soluble anions (mg/l)		
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_2^{--}
2020	8.25	1.63	3.4	4.3	6.7	1.5	3.7	6.6	2.4
2021	8.08	1.17	3.6	2.7	6.2	1.1	3.2	6.1	2.1

Table 2: Total amount of the water used for each plant (L/pot) in each treatment during the growing two seasons of 2020 and 2021.

Field Capacity(%)	Total water amount / plant (L)									
	Chitosan added to soil (w/w)									
	2020					2021				
	0.0%	0.1%	0.2%	0.3%	Mean	0.0%	0.1%	0.2%	0.3%	Mean
100	126.0	124.5	123.6	122.0	496.1	127.6	126.0	125.3	123.7	502.6
80	106.0	104.5	103.6	102.0	416.1	107.6	106.0	105.3	103.7	422.6
60	86.0	84.5	83.6	82.0	336.1	87.6	86.0	85.3	83.7	342.6
40	66.0	64.5	63.6	62.0	256.1	67.6	66.0	65.3	63.7	262.6

According to Yadav and Maity (1989), these fertilizers were 19:19:19 for vegetative growth and 12:12:36 for flowering and root development. Each plant in the study received 16g of fertilizer. This quantity was split into four equal doses, one for each kind of fertilizer. Every two weeks, each dosage was applied as a top dressing on the soil's surface. On 13th of November ~~13th~~ in the both two seasons, the plants wre harvested.

Data gathered:

(1) The following vegetative growth characteristics were measured: plant height (cm), number of leaves per plant, leaves area (cm^2) as calculated by Koller (1972), leaves dry weight per plant (g), stem diameter (cm), stem dry weight (g), flowers number per plant, root length (cm), and root dry weight (g).

(2) Chemical analysis determination:

- According to Yadava (1986), total chlorophyll content was measured using a Minolta (chlorophyll meter) SPAD 502 at the conclusion of the season for the various treatments included in the experiment. According to the method of (Moran and Porath, 1980)
- The percentage of total carbohydras content (%) in the dried leaves was calculated based on Dubios *et al.* (1956).
- The proline content (mg/g) of the leaves was calculated based on Bates *et al.* (1973).
- Leaves Relative Water Content of leaves (%) in the fresh leaves was determined according to Ritche (1974) and Singh *et al.*, (1997).

There were sixteen treatments for each season, utilizing four chitosan concentrations and four irrigation field capacity levels. Three replicates, each comprising three plants, made up the split plot design. The irrigation levels were the main plots, while the chitosan concentrations were the subplots. According to Snedecor and Cochran (1974), the L.S.D. test was used to compare the means of the individual components and their interactions at a 5% level of probability.

RESULTS

1.Vegetative growth:

1.1 Plant height and Leaves parameters

Data displayed in Table (3), when applied to plants that were irrigated to 100% of their field capacity (control), showed that irrigation levels reduced the height of Paulownia hybrid plants in both seasons. The highest mean values of plant height (64.70 and 65.58 cm), number of leaves per plant (32.12 and 32.45), dry weight of leaves (4.82 and 4.88 g), and area of leaves (157.05 and 164.85 cm^2) were recorded in plants watered with 100% field capacity in the first and second seasons, respectively. Moreover, reducing the watering level led to a consistent and noteworthy decrease in the parameters related to leaves. The plants that received the lowest irrigation level (40 % of the (field capacity), mean heights of (45.37 and 46.08 cm), numbers of leaves per plant of (22.37 and 22.78), leaves dry weight of (3.37 and 3.42 g), and leaf area of (76.22 and 79.67 cm^2) in the first and second seasons had, respectively. These plants had significantly fewer leaves than those receiving any other irrigation level.

The properties of the leaves were also significantly impacted by the addition of chitosan to the ground. In both seasons, the studied leaf metrics increased gradually as the chitosan concentration increased from 0.0% (control) to 0.2%. Consequently, Table(3) data showed that Paulownia hybrid plants treated with 0.2% chitosan produced significantly higher mean values for plant height (59.16 and 57.45 cm) , number of leaves per plant (29.24 and 28.41), dry weight of leaves (4.40 and 4.27 g), and leaf area (133.50 and 128.34 cm^2) in the first and second seasons, respectively, when compared to the other concentrations.

The interaction between irrigation water and chitosan treatment on the analysed leaves parameter of Paulownia hybrid plants was recorded for two seasons. The results showed that in terms of mean values for plant height (71.66 and 75.50 cm), number of leaves per plant (35.50 and 37.50), leaves dry weight (5.34 and 5.63 g), and leaves area (191.44 and 216.81 cm^2) in the first and second seasons, respectively, the plants irrigated with water at 100% field capacity (control) and with chitosan at a 0.2% in the first and second seasons, respectively. On the other hand, the plant height (41.33 and 45.83 cm), number of leaves per plant (20.50 and 22.66), leaves dry weight (3.08 and 3.41 g), and area of leaves (63.45 and 77.96 cm^2) were the factors relating to leaves with the lowest values. These outcomes were attained when 40% of the field capacity and 0.0% chitosan were used to water the plants.

1.2. Stem parameters

Table (4) presents data on the stem parameters of Paulownia hybrid plants over two consecutive seasons. It indicates that lowering irrigation levels resulted in a drop in stem parameters when compared to plants that received 100% field capacity irrigation (control). With a mean diameter of (7.12 and 7.42 cm) and a stem dry weight of (15.45 and 16.10 g) in the first and second seasons, respectively, the plants irrigated with 100% field capacity had the thickest stems. Stem properties decreased steadily as irrigation levels were lowered.

Table 3: Means of vegetative growth characteristics of *Paulownia hybrid* plants as influenced by irrigation (F.C.) levels (field capacity percentage), chitosan (S.C.) percentage (%) and their combinations (F.C.×S.C.) in the two seasons 2020 and 2021.

Treatments		Plant height (cm)		Leaves number per plant		Leaf area (cm^2)		Leaves dry weight per plant (g)	
Field capacity (%)	Chitosan (%)	2020	2021	2020	2021	2020	2021	2020	2021
100%	0.0 %	61.66	58.50	30.66	28.83	142.60	130.15	4.59	4.36
	0.1 %	66.16	70.66	32.83	35.00	162.91	186.38	4.93	5.26
	0.2 %	71.66	75.50	35.50	37.50	191.44	216.81	5.34	5.63
	0.3 %	63.83	69.83	31.66	34.66	151.59	182.32	4.76	5.20
Mean (F.C,)		64.70	65.58	32.12	32.45	157.05	164.85	4.82	4.88
80%	0.0 %	53.16	50.33	26.50	25.00	106.40	94.38	3.96	3.75
	0.1 %	55.16	55.33	27.16	27.33	111.88	116.24	4.11	4.12
	0.2 %	60.00	57.50	29.66	28.50	134.42	122.64	4.47	4.28
	0.3%	52.83	56.16	26.16	27.83	103.12	117.00	3.93	4.18
Mean (F.C,)		55.28	54.83	27.37	27.16	113.95	112.56	4.11	4.08
60%	0.0 %	45.33	47.00	22.50	23.33	77.33	83.56	3.38	3.50
	0.1 %	48.50	47.66	24.00	23,66	87.90	84.79	3.61	3.55
	0.2 %	56.50	49.33	28.00	24.33	121.93	89.84	4.21	3.67
	0.3 %	44.83	47.50	22.16	23.33	74.63	84.34	3.34	3.54
Mean (F.C,)		48.79	47.87	24.16	23.66	90.44	85.63	3.63	3.56
40%	0.0 %	41.33	45.83	20.50	2266	63.45	77.96	3.08	3.41
	0.1 %	44.33	46.33	21.83	23.00	72.32	82.39	3.30	3.45
	0.2 %	48.50	47.50	23.83	23.33	86.21	84.07	3.61	3.53
	0.3 %	47.33	44.66	23.33	22.16	82.93	74.27	3.52	3.32
Mean (F.C,)		45.37	46.08	22.37	22.78	76.22	79.67	3.37	3.42
Mean (S.C.)	0.0 %	50.37	50.41	25.04	24.95	97.44	96.51	3.75	3.75
	0.1 %	53.53	54.99	26.45	27.24	108.75	117.45	3.98	4.09
	0.2 %	59.16	57.45	29.24	28.41	133.50	128.34	4.40	4.27
	0.3 %	52.20	54.53	25.82	26.99	103.06	114.48	3.88	4.06
L.S.D. at 0.05	F.C.	6.22	8.13	3.24	4,04	29.07	36.15	0.46	0.60
	S.C.	1,95	2.65	0.97	1.26	8.03	10.51	0.14	0.19
	F.C.* S.C.	2.25	3.06	1.11	1.45	9.25	12.11	0.13	0.27

In comparison to the irrigation levels 40%field capacity, which produced stem diameters of (4.90 and 4.98 cm) and stem dry weights of (10.63 and 10.80 g) in the first and second seasons, respectively.

Chitosan treatments, in contrast to other treatments, enhanced the stem parameters of Paulownia hybrid plants in comparison to the control. Furthermore, in comparison to the other concentrations, plant treated with 0.2% chitosan had significantly higher mean stem diameter (6.40 and 6.21 cm) and stem dry weight (13.87 and 13.47 g) in the first and second seasons, respectively.

The recorded results for the two seasons are presented in Table (4), which demonstrates the interaction between irrigation water and chitosan on stem parameters of Paulownia hybrid plants. It was found that there were significant differences between the values obtained from plants receiving the various treatment combinations. The plants were watered at 100% (field capacity) and with 0.2% chitosan in the first and second seasons, respectively, had the highest values of stem diameter (7.75 and 8.17 cm) and stem dry weight (16.82 and 17.72 g). Conversely, plants watered with 40% (field capacity) and chitosan at 0.0 % produced the lowest values of stem diameter (4.47 and 4.96 cm) and stem dry weight (9.69 and 10.74 g) in the first and second seasons, respectively.

1.3. Root parameters

Table (5) presents data on the root parameters of *Paulownia hybrid* plants during two consecutive seasons. It indicates that lowering irrigation levels resulted in a drop in root parameters relative to plants that received 100% field capacity irrigation (control).

Table 4: Means of stem characteristics of *Paulownia hybrid* plants as influenced by irrigation (F.C.) levels (field capacity percentage), chitosan (S.C.) percentage (%) and their combinations (F.C.×S.C.) in the two seasons of 2020 and 2021.

Treatments		Stem diameter (cm)		Stem dry weight (g)	
Field capacity (%)	**Chitosan (%)**	**2020**	**2021**	**2020**	**2021**
100%	0.0 %	6.67	6.33	14.47	13.72
	0.1 %	7.16	7.65	15.52	16.58
	0.2 %	7.75	8.17	16.82	17.72
	0.3 %	6.90	7.56	14.99	16.39
Mean (F.C,)		7.12	7.42	15.45	16.10
80%	0.0 %	5.75	5.44	12.47	11.80
	0.1 %	5.97	5.98	12.94	12.97
	0.2 %	6.49	6.22	14.07	13.48
	0.3 %	5.716	6.07	12.39	13.17
Mean (F.C,)		5.98	5.92	12.96	12.85
60%	0.0 %	4.90	5.08	10.63	11.02
	0.1 %	5.24	5.15	11.37	11.18
	0.2 %	6.116	5.33	13.24	11.57
	0.3 %	4.85	5.14	10.51	11.14
Mean (F.C,)		5.27	5.17	11.43	11.22
40%	0.0 %	4.47	4.96	9.69	10.74
	0.1 %	4.79	5.01	10.39	10.86
	0.2 %	5.25	5.13	11.37	11.13
	0.3 %	5.12	4.83	11.09	10.47
Mean (F.C,)		4.90	4.98	10.63	10.80
Mean (S.C.)	0.0 %	5.44	5.45	11.81	11.82
	0.1 %	5.79	5.94	12.55	12.89
	0.2 %	6.40	6.21	13.87	13.47
	0.3 %	5.64	5.90	12.24	12.79
L.S.D. at 0.05	F.C.	0.67	0.88	1.46	1.91
	S.C.	0.21	0.28	0.45	0.62
	F.C.* S.C.	0.23	0.32	0.52	0.71

Plants irrigated at 100% field capacity in the first and second seasons, with mean root lengths of (44.06 and 45.89 cm) and root dry weights of (6.11 and 6.32 g), respectively. Root parameters steadily decreased as irrigation levels were lowered. In comparison to the irrigation levels 40%field capacity, which resulted in root diameters of (30.41 and 30.91 cm) and root dry weight of (4.58 and 4.63 g) in the first and second seasons, respectively, were obtained for the plants irrigated with the water lowest 40 % (field capacity), respectively.

Table (5) displays data indicating that the application of chitosan boosted root parameters in comparison to plants that received chitosan 0.0 % (control). In the first and second seasons, respectively, the maximum values of root length (39.62 and 38.49 cm) and root dry weight (5.61 and 5.48 g) was observed in the case of increased chitosan 0.2 % concentration with all irrigation levels. Conversely, a progressive decrease in root parameter was observed when the content of chitosan in irrigation water was reduced. Even at the lowest chitosan 0.0% concentration, which produced root length (33.74 and 33.76 cm) and root dry weight (4.95 and 4.96 g) in the first and second seasons, respectively, these decreases in root parameters were noteworthy.

Table (5) presents the findings of the interaction between the chitosan concentration treatments and irrigation water on the root characteristics of *Paulownia hybrid* plants. The values obtained for plants receiving different treatment combinations varied significantly from one another. When plants were irrigated with 100% (field capacity) water and 0.2% chitosan in the first and second seasons, respectively, the greatest values of root length (48.00 and 50.50 cm) and root dry weight (6.55 and 6.84 g) were obtained. On the other hand, the plants irrigated with the irrigation water at the lowest 40% (field capacity) and with chitosan at 0.0 % treatment had the lowest values of root length (27.75 and 30.66 cm) and root dry weight (4.28 and 4.62 g) in the first and second seasons, respectively.

Table 5: Means of root production of *Paulownia hybrid* Plants as influenced by irrigation (F.C.) levels (field capacity percentage), chitosan (S.C.) percentage (%) and their combinations (F.C.×S.C.) in the two seasons of 2020 and 2021.

Treatments		Root length (cm)		Root dry weight (g)	
Field capacity (%)	**Chitosan (%)**	**2020**	**2021**	**2020**	**2021**
100%	0.0 %	41.25	39.16	5.80	5.57
	0.1 %	44.25	47.25	6.14	6.48
	0.2 %	48.00	50.50	6.55	6.84
	0.3 %	42.75	46.66	5.96	6.41
Mean (F.C.)		44.06	45.89	6.11	6.32
80%	0.0 %	35.58	33.66	5.17	4.95
	0.1 %	36.91	37.00	5.32	5.32
	0.2 %	40.16	38.50	5.68	5.49
	0.3 %	35.41	37.66	5.14	5.39
Mean (F.C.)		37.01	36.70	5.32	5.28
60%	0.0 %	30.41	31.58	4.58	4.71
	0.1 %	32.50	31.91	4.82	4.76
	0.2 %	37.83	33.08	5.41	4.88
	0.3 %	30.08	31.83	4.55	4.75
Mean (F.C.)		32.70	32.10	4.84	4.77
40%	0.0 %	27.75	30.66	4.28	4.62
	0.1 %	29.75	31.16	4.50	4.66
	0.2 %	32.50	31.91	4.82	4.74
	0.3 %	31.66	29.91	4.73	4.53
Mean (F.C.)		30.41	30.91	4.58	4.63
Mean (S.C.)	0.0 %	33.74	33.76	4.95	4.96
	0.1 %	35.85	36.83	5.19	5.30
	0.2 %	39.62	38.49	5.61	5.48
	0.3 %	34.97	36.51	5.09	5.27
L.S.D. at 0.05	F.C.	4.16	5.24	0.46	0.60
	S.C.	1.31	1.78	0.14	0.19
	F.C.* S.C.	1.51	2.06	0.13	0.21

1.4. Flowering parameters

Table (6) presents data indicating a significant decrease in the flowering parameters per plant of *Paulownia hybrid* plants under all tested irrigation levels treatments compared to plants irrigated at 100% field capacity (control). Plants that were irrigated to 100% of the field capacity in the first and second seasons, respectively, had the highest mean bloom number per plant (21.58 and 22.62). Conversely, when irrigation levels were decreased, the number of flowers per plant steadily decreased as well. For plants were irrigated using the 40% field capacity, this value peaked (14.79 and 14.99) in the first and second seasons, respectively.

The plants' ability to flower was likewise greatly impacted by the addition of varying concentrations of chitosan. The chitosan concentration was gradually raised from 0.0% (control) to 0.3% in both seasons. As a result, Table (6) demonstrated that, in comparison to the other concentrations, *Paulownia hybrid* plants grown in soil containing 0.2% chitosan had significantly higher values of number of flowers per plant (19.33 and 18.83) in the first and second seasons, respectively.

The results of the two seasons' results regarding the interaction between the chitosan and irrigation water treatments revealed that the plants treated with chitosan 0.2% and 100% (field capacity) yielded the highest values in terms of the number of flowers per plant (23.50 and 25.00) in the first and second seasons, respectively. Conversely, the plants that were irrigated with water at 40% field capacity with the lowest chitosan concentration of 0.0% had mean values of (13.33 and 14.50) blooms per plant in the first and second seasons, respectively.

2. Chemical composition

According to Table (7) results of plant irrigated with 100% field capacity produced the highest chemical composition, which may have an impact on the amounts of chlorophyll (36.24 and 34.96 SPAD), carbohydrates (36.78 and 37.99%), and relative water content (85.69 and 78.82%) in the first and second seasons, respectively.

Table 6: Means of flowering characteristics of *Paulownia hybrid* plants as influenced by irrigation (F.C.) levels (field capacity percentage), chitosan (S.C.) percentage (%) and their combinations (F.C.×S.C.) in the two seasons of 2020 and 2021.

Treatments		Flower number per Plant	
Field capacity (%)	**Chitosan (%)**	**2020**	**2021**
100%	0.0 %	20.16	19.16
	0.1 %	21.66	23.33
	0.2 %	23.50	25.00
	0.3 %	21.00	23.00
Mean (F.C.)		21.58	22.62
80%	0.0 %	17.33	16.66
	0.1 %	18.00	18.33
	0.2 %	19.50	18.83
	0.3 %	17.33	18.16
Mean (F.C.)		18.04	17.99
60%	0.0 %	14.66	15.16
	0.1 %	15.83	15.66
	0.2 %	18.50	15.16
	0.3 %	14.66	15.50
Mean (F.C.)		15.91	15.62
40%	0.0 %	13.33	14.50
	0.1 %	15.50	15.16
	0.2 %	15.83	15.33
	0.3 %	14.50	15.00
Mean (F.C.)		14.79	14.99
Mean (S.C.)	0.0 %	16.37	16.37
	0.1 %	17.74	18.12
	0.2 %	19.33	18.83
	0.3 %	16.87	17.91
L.S.D. at 0.05	F.C.	2.02	2.75
	S.C.	0.63	0.90
	F.C.* S.C.	0.73	1.04

In contrast, plant irrigated with 40% field capacity produced higher proline contents (2.51 and 2.63 mg/g). However, lower proline contents (1.50 and 1.56 mg/g) were obtained in plant irrigation with 100% field capacity, the reduction of irrigation levels by 40% field capacity led to gradual and significant decreases in the both total chlorophyll content, which reached its lowest values (27.02 and 25.75 SPAD), the carbohydrates content (22.62 and 23.33 %), and the relative water content (60.14 and 58.21 %) in the first and second seasons, respectively.

Table (7) provided additional evidence that chitosan treatments may have affected the total chlorophyll content (35.83 and 34.54 SPAD), total carbohydrates (30.91 and 31.71 %), and relative water content (75.03 and 71.34 %) in plants grown in soil containing a chitosan at 0.1% and in the first and second seasons, respectively. Conversely, plants grown in soil containing a chitosan at 0.3% yielded higher proline contents (2.03 and 2.12 mg/g).

In relation to the interaction between the chitosan treatment and irrigation levels, the plants irrigated at 100% field capacity and treated with chitosan at 0.1% had the highest total chlorophyll contents (40.51 and 39.23 SPAD), total carbohydrates (38.09 and 39.22 %), and relative water content (89.26 and 80.85%) in the first and second seasons, respectively. While, the higher proline contents (2.57 and 2.69 mg/g) were resulted for the plants irrigated with 40% field capacity, chitosan treatment at 0.3%.

DISCUSSION

The majority of commercial chitin, which is the source of chitosan, is made from the waste of prawns, prawns and crabs. Chitin creates structures that support internal mollusk body parts, insect skeletons, crustacean shells, and cell walls. Findings showed that chitosan has potential.

Table 7: Means of chemical constituents of *Paulownia hybrid* plants as influenced by irrigation (F.C.) levels (field capacity percentage), chitosan (S.C.) percentage (%) and their combinations (F.C.×S.C.) in the two seasons of 2020 and 2021.

Treatments		Total chlorophyll content (mg/g fresh weight)		Proline content (mg/g)		carbohydrates content of leaves (%)		Relative Water Content (%)	
Field capacity(%)	Chitosan (%)	2020	2021	2020	2021	2020	2021	2020	2021
100%	0.0 %	30.75	29.47	1.55	1.62	35.72	36.93	80.17	77.17
	0.1 %	40.51	39.23	1.45	1.52	38.09	39.22	89.26	80.85
	0.2 %	38.14	36.87	1.46	1.52	37.16	38.42	86.71	78.71
	0.3 %	35.58	34.30	1.54	1.61	36.18	37.41	86.64	78.55
Mean (F.C.)		36.24	34.96	1.50	1.56	36.78	37.99	85.69	78.82
80%	0.0 %	30.82	29.53	1.83	1.91	31.08	32.12	76.33	72.79
	0.1 %	39.08	37.80	1.76	1.84	33.09	34.22	79.53	76.19
	0.2 %	37.38	36.10	1.77	1.85	32.57	33.49	77.37	74.76
	0.3 %	36.32	35.03	1.85	1.93	31.87	32.62	76.34	73.87
Mean (F.C.)		35.90	34.61	1.80	1.88	32.15	33.11	77.39	74.40
60%	0.0 %	28.30	27.03	2.14	2.24	26.52	26.87	66.85	64.48
	0.1 %	34.01	32.73	2.07	2.16	28.77	28.91	70.03	68.26
	0.2 %	30.77	29.50	2.04	2.14	27.78	28.19	69.40	65.94
	0.3 %	30.12	28.83	2.17	2.27	26.62	26.64	68.04	65.78
Mean (F.C.)		30.80	29.52	2.10	2.20	27.42	27.65	68.58	66.11
40%	0.0 %	25.01	23.73	2.55	2.67	21.54	22.07	58.46	56.00
	0.1 %	29.72	28.43	2.47	2.59	23.71	24.51	61.31	60.08
	0.2 %	27.04	25.77	2.46	2.58	23.14	23.89	60.47	58.60
	0.3 %	26.34	25.07	2.57	2.69	22.12	22.86	60.33	58.18
Mean (F.C.)		27.02	25.75	2.51	2.63	22.62	23.33	60.14	58.21
Mean (S.C,)	0.0 %	28.72	27.44	2.01	2.11	28.71	29.49	70.45	67.61
	0.1 %	35.83	34.54	1.93	2.02	30.91	31.71	75.03	71.34
	0.2 %	33.33	32.06	1.93	2.02	30.16	30.99	73.48	69.50
	0.3 %	32.09	30.80	2.03	2.12	29.19	29.88	72.83	69.09
L.S.D. at 0.05	F.C.	2.34	2.34	0.014	0.016	0.86	1.69	2.17	0.71
	S.C.	0.79	0.79	0.009	0.010	0.33	0.30	0.45	0.47
	F.C.* S.C.	0.91	0.91	0.009	0.009	0.37	0.35	0.72	0.54

Despite being first produced using the glucose circle, chitosan also includes a class of free amino acids called glucose amino, or carbon atom number two, and is classified as a part of the carbohydrate family, which is composed of chains without branches. Additionally, it has been reported by (Boonlertnirun *et al.,* 2008) and (Guan et al., 2009) that chitosan is a naturally occurring biopolymer that is produced when chitin is deacted. Since it acts as a carbon source for soil microbes and speeds up the conversion of organic nutrients into inorganic nutrients that are easily absorbed by plant roots, its abundance of nitrogen molecules improves the germination index, shoot and root dry weight, and can significantly increase the microbial population (Bolto *et al.,* 2004). Furthermore, chitosan may improve the natural characteristics of sandy areas by attracting dirt.

Chitosan can be used in many different ways. It served as a plant booster and growth enhancer in agricultural production. Field crops, ornamentals, turf, household gardens and nurseries are all treated with chitosan. Other applications for chitosan include acting as a flocculant to precipitate proteins during the preparation of animal feed, controlling plant development in or on wheat, and treating seeds for particular crops. As stated by (Behboudi *et al.,* 2018), plant nutrients with a negative ionic charge formed a chemical connection with chitosan, which had a positive ionic charge. Plants were progressively exposed to this action, which greatly enhanced production. Furthermore, our results suggested that chitosan could increase endogenous cytokinin levels, which would encourage the synthesis and growth of chlorophyll, or it could increase the availability of amino compounds that chitosan produces, which would increase the amount of photosynthetic pigments and leaf area (Behboudi *et al.,* 2018). Applying organic soil conditioners on a regular basis can help compensate for sandy soil's well-known lack of fertility and ongoing need for supplementing.

According to (Bolto *et al.*, 2004), chitosan has the capacity to provide the soil with a carbon source, speed up the transformation of organic matter into inorganic matter, and facilitate the uptake of additional nutrients by the roots. Chitosan and all other chitin derivatives have a high nitrogen concentration of 6% to 9%, which makes them comparable to other organic fertilisers such dried blood and bone meal (Yen and Mau, 2007). Roberts and Jones (2012) state that in order for plants to access the nitrogen in chitin, they can either directly absorb monomers as organic nitrogen or use microbial breakdown to form inorganic nitrogen. Chitosan can be used to add organic matter to soils without changing the carbon to nitrogen ratio. Other than nitrogen, significant levels of calcium minerals, which provide structural stiffness to the exoskeletons of crustaceans, are also present in chitosan (Boßelmann *et al.,* 2007). Although chitosan contains calcium and nitrogen, these nutrients were not the only ones that contributed to its positive effects on crop growth and yield; in fact, in a number of trials, the chitosan's nutrients were balanced out in control plots that were treated with inorganic fertiliser. (Ohta *et al.,* 2004) demonstrated how chitosan significantly accelerated the growth of seedlings of several ornamental plants as well as Chinese cabbage, in contrast to traditional mineral fertiliser.

Chitosan improves abiotic stressors' detrimental effects and lessens their physiological reactions by activating stress transduction pathways in plants. The delivery mechanisms' intelligence and slowness can be partially ascribed to their ability to sustainably boost plant growth and development (Shinde *et al.,* 2024). Chitosan's mechanical, biological, and physical properties can all be altered chemically. The amino group, which is abundant in chitosan and has a high degree of deacetylation, is a common target for modifications (Issahaku *et al.*, 2023).

Chitosan can also be utilised as a vehicle for the delivery of additional, essential nutrients due to its cationic properties (Sharp, 2013). The synthesis of coordination compounds with ions of copper, zinc, iron, and other elements is facilitated by the functional hydroxyl and amino groups on deacetylated chitosan (Ramırez *et al.*, 2010), but not with those of alkaline metals or alkaline earth metals such as calcium or magnesium. Because they are poorly soluble, chitosan offers a sustainable alternative to synthetic chelation agents like ethylenediaminetetraacetic acid, which are widely employed to replenish nutrients and iron to calcareous/neutral soils (Bohn *et al.*, 2002). Because of its high molecular weight and porous structure, chitosan can form gels that can absorb large amounts of water to increase the water-holding capacity of soil (Jamnongkan and Kaewpirom, 2010; Tamura *et al.*, 2006). Plant growth may also be stimulated by the direct effects of chitosan as a soil additive on plant nutrition status, metabolism, and photosynthesis. When chitosan was applied to the soil, it increased the amount of total amino acids, total sugars, potassium, phosphate, and nitrogen in radish (Farouk *et al.*, 2011). Research has demonstrated that the application of chitosan topically enhances the activity of the enzyme leaf nitrate reductase in Indian spinach *(Basella alba)* and okra *(Abelmoschus esculentus)* (Mondal et al., 2011, 2012). It has been demonstrated that adding chitosan to the soil increases the amount of chlorophyll in the leaves of many crops (Chibu and Shibayama, 2003; Farouk *et al*., 2011; Sheikha and Al-Malki, 2011). Chitosan has the ability to act as a biostimulant and increase photosynthetic rate and chlorophyll fluorescence, as will be covered in more detail below.

Regarding the impact of irrigation levels, earlier findings showed that, for a given irrigation level, 100% field capacity greatly increased the output of *Jatropha curcas* fruits and seeds, with 20% field capacity producing the lowest yield. These outcomes are consistent with the research conducted by El-Shafie et al. (1994) on Roselle plants, which revealed that higher fruit yields, heavier fruits, and more fruits per plant were produced when irrigation was carried out more frequently at 100% field capacity as opposed to 90% field capacity, with 20% field capacity yielding the lowest values in this regard. El-Makawy (1999) reported similar findings for *Peganum harmala*. Reddy *et al.* (1996) on castor beans (Ricinus communis) demonstrated that water stress during the vegetative phase or early flowering stages significantly reduced seed yield. Other studies on castor varieties, such as seed yield Dinesh *et al.* (2001) on castor plants and Salem (2002) on *Simmonds chinensis*, also supported this finding. Water's function in photosynthesis, which affects both relative growth rate and flowering, may help to explain why it increases flower production. Also, Mohamed, et al. 2017 on thier study on Corymbia citriodora, Gmelina arborea and khaya senegalensis that adding polymers is very effective to hold moist in sandy soil for long time and to enhance vegetative growth.

It is possible to conclude from the data in the Tables that higher irrigation rates led to a higher concentration of total chlorophylls. In light of this, it may be concluded that the best irrigation strategy for encouraging the synthesis and accumulation of pigments was irrigation at 100% field capacity. The results of Ibrahim (2005) on jojoba seedlings, Mazher *et al.*, (2006) on *Taxodium distichum*, Kashiwagi *et al.*, (2004) on *Cicer arietinum*, and Mazher *et al.*, (2010) on *Jatropha curcas* were all in line with these findings.

The results of the single effect of water stress, according to the (Alshireefy and Bajlan, 2023) study, showed the superiority of the seedlings treated with light stress treatment, which increased their height by 100% of the field capacity value. Likewise, the individual impact of conventional and nano-chitosan biofertilizer shown that the seedlings treated at a concentration of 300 mg/l grew taller, had larger main stems, longer main roots, and more. Conversely, the findings of the study indicate that conventional and nano chitosan significantly lessen the detrimental impacts of environmental challenges on plants, including water stress. Additionally, it implies that using chitosan treatments can support stronger plant growth, enabling them to tolerate water stress at a reduced expense in a chemical-free, safe environment.

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الملخص العربي

تحسين كفاءة معدلات الرى بأستخدام محسنات التربة على معدلات نمو شتلات الباولونيا المزروعة فى التربة الرملية

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[٢] فرع بحوث الأشجار الخشبية بأنطونيادس – معهد بحوث البساتين – مركز البحوث الزراعية

أجرى هذا البحث فى مشتل قسم الزهور ونباتات الزينة – كلية الزراعة – جامعة الإسكندرية بالإسكندرية خلال عامي ٢٠٢٠ و ٢٠٢١ على شتلات أشجار البولونيا المنزرعة في أصص بلاستيك مقاس ٣٠ سم مملوءة بتربة رملية بهدف دراسة تأثير أربع مستويات من المحتوى المائي للتربة: هي ٤٠٪, ٦٠٪, ٨٠٪, ١٠٠٪ من السعة الحقلية للتربة الرملية وأربعة تركيزات من محسن التربة (شيتوزان) هي صفر, ٠.١٪, ٠.٢ %, ٠.٣٪ منفرده أو في جميع التباديل الممكنة بينهما لتعطى ١٦ معاملة على بعض صفات النمو الخضري والزهري والتحليل الكيماوي لنباتات البولونيا النامية فى التربة الرملية.

أظهرت النتائج المتحصل عليها أن مستويات الري كانت أكثر فاعلية في التأثير على جميع الصفات المدروسة لنبات البولونيا بمقارنتها بتركيزات الشيتوزان. وعموما استخدام أعلى مستوى من الرطوبة الأرضية (١٠٠٪ سعة حقلية) في وجود محسن التربة (شيتوزان) عند تركيز ٠.٢٪ أعطى أعلى زيادة معنوية في كل من أرتفاع النبات, عدد الأوراق, وزن الأوراق الجاف, المساحة الورقية, قطر الساق, الوزن الجاف للساق, طول الساق الجاف,عدد الأزهار. على الجانب الآخر فقد أعطى أعلى مستوى من الرطوبة الأرضية (١٠٠٪ من السعة الحقلية) ونسبة الشيتوزان المضاف للتربة الرملية بنسبة ٠.١٪ حيث يعطى أعلى نسبة من محتوى الأوراق من الكلوروفيل الكلى ومحتوى الكربوهيدرات وأعلى محتوى الماء النسبى وأقل محتوى من البرولين.

وعموما فإن النتائج المتحصل عليها توصى برى شتلات أشجار البولونيا المنزرعة في الأرض الرملية بمستوى رطوبى لا يقل عن ٨٠٪ من السعة الحقلية مع استخدام محسنات التربة بتركيز ٠.٢ % حيث يؤدى ذلك للحصول على معدلات جيدة للنمو الخضري والزهري تتمشى مع المواصفات العالمية والتحليلات الكيماوية لنباتات البولونيا النامية فى التربة الرملية.