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EFFECT OF MAGNETIC FIELD ON PAULOWNIA SEEDS

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INTRODUCTION

It was shown that magnetic field was effective on the normal functions of livings. At the research done on the cell level, it was determined that at the G1 phase of the cell cycle, RNA and protein synthesis were effected by the magnetic field strength. At cells exposed to magnetic field strength, it was determined that cell division was effected by the magnetic field and was also seen that there was an increase on the rate of cell division [1,2,3,4].

At the studies done with various crops like cotton, sunflower, soybean, it was determined that there were positive effects of the magnetic field on the seedling growing [5,6,7,8]. In addition, at a lot of plants, an increase was obtained on the yield parameters and yield of the plants [9,10,11,12].

Generally, the investigations regarding the magnetic field were done on the various crops. In return for this, there is not any study in this subject with trees. Paulownia is a fast growing timber tree which is indigenous to Chine. By accepting this tree as a model one, it has been planned to do research on the effect of the magnetic field on trees.

MATERIAL and METHOD

Plant material:
In this research, the seeds belonging to P.elongata, P.tomentosa and P.fortunei were used. Paulownia has a very wide range of disribution in China. The seeds for P.elongata I and II were collected from Henon and Hepeh, for P.tomantosa I and II were collected from Hepeh and Beijing and for P.fortunei I and II were collected from Guangzhou. These Paulownia seeds were taken from UNITEK company.

Magnetic field treatment:
For magnetic field experiments, we used 10 magnets of 0.45 x 0.065 x 0.022 m dimensions. In JINR laboratories, these magnets prepared by magnetic field group were mounted onto the belt system which rotated with a rate of 1 m/second in our laboratories. The magnet height from the belt system could be adjusted. In this research two magnetic field strength values were used. The seeds were passed 1, 3 and 9 times for first experiment and 1, 3, 9 and 15 times for second experiment through a magnetic flux density of 4.7-5.7 mT for 2.2, 6.6, and 19.8 seconds on 17 th of May, 1999 and 3.8-4.8 mT for 2.2, 6.6, 19.8 and 33 seconds on 2nd of August, 1999. Magnet heights were determined for the first experiment as h= 0.050 m and for the second experiment as h= 0.055 m [6,7,13].

Seed germination and growth of plant material:
The seeds which were exposed to magnetic field were soaked before sowing. At this method, wet seed were taken and soaked in warm water (40°C) for 10 minutes. Then they were soaked for 24 hours in water at normal room temperature. The seeds whose surfaces were dried up, were germinated on filter papers in petri dishes under controlled conditions [14,15].

In the plant growth chamber whose was 27°C, seed coat was opened at the micropyler end and revealed the radicle in 3-5 days. Then the germinated seeds were transferred on the agar in petri dishes and about 10-14 day-old Paulownia seedlings were planted into plastic pods which were filled with standard experimental soils. Until the seedling became two-month-old, they were grown at the plant growth chamber.

Chlorophyll content:

Chloroplasts were extracted from the leaves of 2-month-old Paulownia species seedling. An extraction of leaf pigments was done with 80 % acetone and the absorbance was mesured at 663 and 645 nm with UV-160 Schmadzu spectrophotomether. Chl a, Chl b and total Chlorophyll were calculated according to the method of Arnon [16].

RESULTS

In this research, the seeds belonging to Paulownia species were exposed to two different magnetic field strength values and at each magnetic fields, they were kept at different periods. Germination rate of Paulownia species, seedling number and heights and chlorophyll content for magnetic treatment and control were determined. At the first experiment, seed belonging to P. elongata I, P. tomentosa I and P. fortunei I were passed 1, 3 and 9 times through a magnetic field of 4.7-5.7 mT. Germination rate and number of the young seedlings were shown at table 1.

For P. elongata, young seedling were seen firstly on the 6th day at all seeds passed through the magnets and on the 7th day of the germination period at control seeds. But on the 12th day, both germination rate and seedling number decreased according to control. For P. tomentosa, young seedling were firstly determined at those which were passed through the magnets on the 7th day, but control seedling were seen one day later. On the 12th day, at those which were passed through the magnets 9 times, the germination rate and seedling number were higher than control. For P. fortunei, young seedlings were firstly seen on the 10th days at those which were passed through once. But young control seedlings were firstly seen on the 12th day. The germination rate on the 10th day at those which were passed through magnet once was increased. At the period of germination, on the 12th and 16th days, when the germination rate was decreased, the seedling numbers which were passed through 1 and 9 times were increased according to control.

At the second experiment, Paulownia seeds were passed 1, 3, 9 and 15 times through the magnetic field of 3.8-4.8 mT. Germination rate and seedling numbers of Paulownia species were shown at table 2. For P.elongata II, at the germinated seeds radicule was seen on the 3rd day and its number was determined. At all the seeds which were passed through the magnets, more germination rate was determined according to control. When the germination rate was 23.33 percent at control, the germination rate of seeds which were passed through 3 times was increased 40 percent. Germination rate of all the magnet experiment period was also higher than control on the 4th day. While the germination rate was 40 percent at control, this rate was 50.67 percent at those which were passed once. But on the 10th day, the germination rate of the control was higher than the seeds which were passed through the magnets (Fig.1). On the 4th day when the first young seedling was seen, and on the 10th day the seedling number was a little bit higher than those which were passed through the magnet 3 times according to the control.

For P.tomentosa II, radicule was seen on the 3rd day of germination period and seeds which were exposed to magnetic field, had higher germination rate than control.

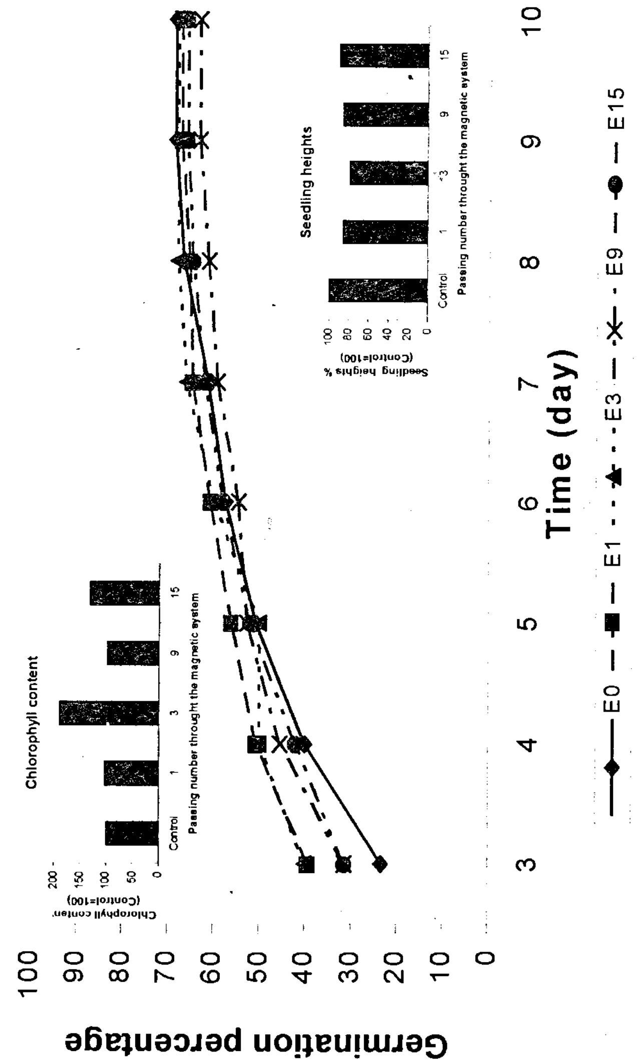

Fig 1: Effects of magnetic field on Paulownia elongata

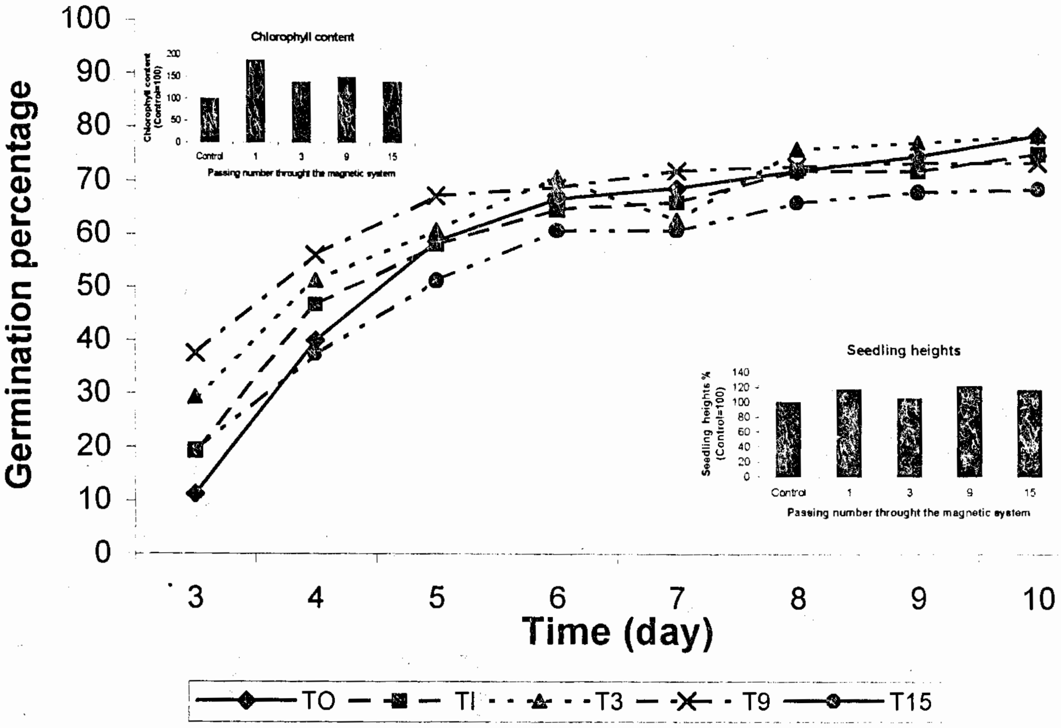

Fig 2: Effects of magnetic field on Paulownia tomentosa

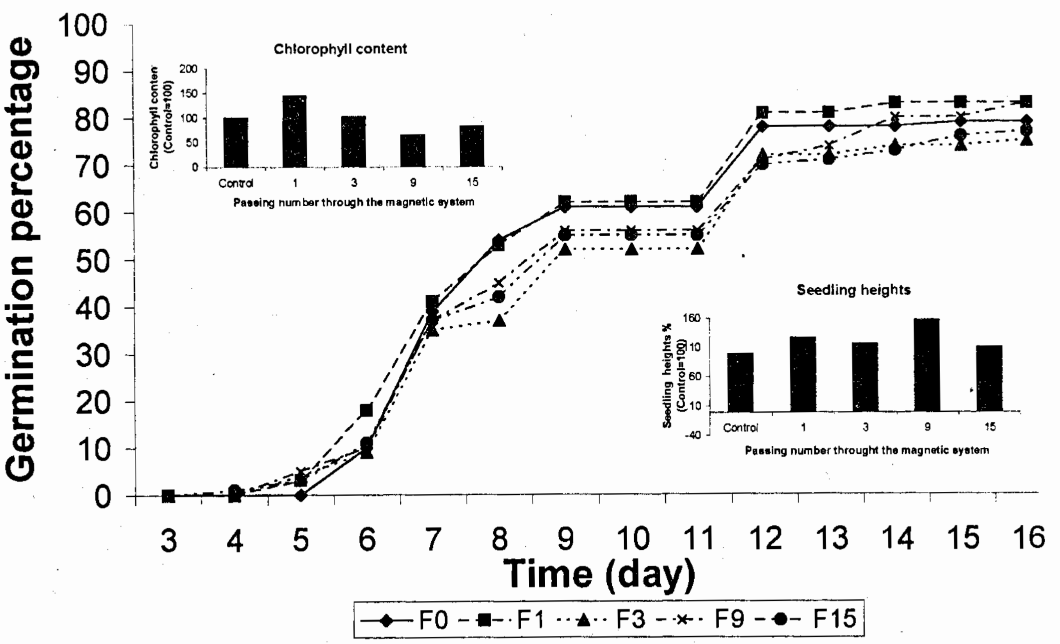

Fig 3: Effects of magnetic field on Paulownia fortunei

While this rate was 11.33 percent at control, it was 37.60 percent at those which were passed through 9 times. On the 5th day, while germination rate of those which were passed through the magnets 3 and 9 times was higher than control, on the 10th day, the control had higher germination rate than all seeds which were exposed to magnetic field (Fig.2). On the 5th day, all times of exposed to magnetic field, rate of young seedling was found higher than control. On the 10th day, when only seedling number which was passed 3 times was increased, others were decreased according to control.

For P. fortunei II, on the 5th day, radicule was seen and germination rate was also higher than control. On the 10th day, it was a little bit higher than control only at those which were passed through the magnets once (Fig. 3). On the 8th day, when the young seedling was seen, the control has not any seedling. From the seedling number on the 10th day, and seedling numbers which were transferred into soil on the 14th day, we found that a positive result was obtained only at those which were passed through magnetic field once.

2-month-old seedling heights were determined and average seedling heights were shown in table 3. While P.elongata II, seedling heights were decreased according to control, seedling heights at P. tomentosa II and P. fortunei II which were all periods of exposed to magnetic field, were increased (Fig 1,2 and 3).

Again, at the 2-month-old seedling leaves, chlorophyll a, chlorophyll b and total chlorophyll contents were shown at table 4. At P. elongata II, while chlorophyll a showed an increase at those which were passed through the magnets 3 and 15 times in accordance with control, chlorophyll b and total chlorophyll content increased at those which were passed through the magnets 1, 3 and 15 times according to control (Fig 1). For P.tomentosa II, chlorophyll a, chlorophyll b and total chlorophyll content showed increased at all periods of exposed to magnets (Fig 2). For P. fortunei II, an increase was determined only at those which were passed through the magnets 1 and 3 times (Fig 3).

DISCUSSION

Seedling production from seed is an important method of Paulownia propagation and it has many advantages. The roots are better developed in seedling than in those propagated by root or stem cuttings. Seedlings which are produced from seeds also grow stronger and faster [14].

During the early stages of germination, seeds imbibe water, the formation of enzymes begins, growth resumes, seed coat ruptures and the young root emerges first. So the embryonic root is the first structure to break out of germination.

In our research, after being exposed to the magnetic field, the seeds of P.elongata II and P.tomentosa II species, the appearing day of the young roots in the germination period was the 3rd day and for P. fortunei this was the 5th day. For each variety, the germination rates were determinated on these days. The germination rate of fast germinated P.elongata and P.tomentosa species were higher than control on the 3rd day. P.fortunei seeds were germinated slower than other two Paulownia species, while control seeds of P.fortunei were not showing any germination at all the seed which passed through magnets, the germination was started by the appearing of the root tip. The rates of the germination on this day showed the effect of the magnetic field in a clear way.

The germination rates of the "Komatsuna" (Brassica sp.) plants which were exposed to the electromagnetic field (EMF) of 5 Gauss was increased according to the control [17]. In a study done with Allium cepa L. and Oryza sativa L. germination rates of the seeds which were exposed to EMF of 108 Oe for 30 minutes increased [8]. The pollen grain of Caria papaya were exposed to an EMF of 96 Gauss, for 10 minutes and higher germination rates than control and longer pollen tubes were obtained [18]. ATP content in germination seeds of Phaseolus aureus Poxb. which were exposed to EMF of 0.2 T for 60 minutes was increased [19]. Apart from this, plants in the condition of the geomagnetic field (GMF) and this ~ 10^5-10^6 fold screening have been investigated. It was shown that in condition of screening the capacity for germination of seed and growth of the seedling was delayed and inhibited respectively, growth of seedling in GMF condition was faster [5].

According to experiments showing biological effects of magnetic field, the rate of cell proliferation was increased. Cell processes could be influenced by magnetic field. Significant change in the duration of the presythetic phase of cell cycle was determined and during this period was intensive RNA and protein synthesis. The level of some mRNA was altered by EMFs. Total RNA and mRNA in cell exposed to a pulse magnetic field with a peak flux density of 3.5 mT was also increased. But the relevance of extremely low frequency (ELF) type of magnetic field interaction to the functions of living cells is not clear at the present time. However, magnetic field of the order of 10^{-3} to 10^{-2} T can affect chemical reactions by influencing the electronic spin states of reaction intermediates. Such effects have the potential to lead to biological consequences [2,3,4,20].

In this research, seeds which were exposed to magnetic field had higher germination rate in accordance with control at the beginning of the germination period. On the 10th and 12th days of germination period the determined differences at the beginning of the germination rate disappeared.

It was seen that the determined differences of germination at first 24 and 48 hrs at the Calland soybean variety which was exposed to magnetic field of 7.1-8.9 mT disappeared at 72 hrs. But there wasn't any difference for germination rate of J-357 soybean variety of first 24 hrs [7].

Because of the thin and weak young Paulownia seedlings, their survival rate has been decreased according to germination rate. But early germination or accelareted germination can prolong the time for growth and improve the quality of seedlings.

The number of the young seedlings of Paulownia varieties which were exposed to magnetic field was more than control on the first day of seedlings or at control not any seedlings were encountered. On the 10th and 12th days, difference in seedling numbers either continued or disappeared depending on the magnetic field exposed at Paulownia varieties. Finally, differences were found due to the magnet treatment, at the number of seedlings which were transplanted into soil according to the control. While seedling number at P.tomentosa I and II increased according to control at the rate of 11.99 and 16.41 percent respectively, these increases at P.fortunei I and II were at the rates of 4.16 and 7.14 percent. As to P.elongata II, an increase at the rate of 5.56 percent in seedling number was obtained.

The positive effects of magnetic field on Paulownia's seedling heigths were seen at the magnetic field of 3.8-4.8 mT. At P.tomentosa II and P.fortunei II, the difference on the seedling heights were determined according to control. For P.tomentosa II an increase at the rate of 21.60 percent and P.fortunei II at the rate of 58 percent was obtained.

The previous studies regarding the effects of magnetic field on seedling heights of various plants were available [3,6,7,8].

Chlorophyll is a large molecule which has very important effects in photosynthesis which takes part in chloroplast called organels.

It was determined that magnetic field of 3.8-4.8 mT increased the chlorophyll content in Paulownia species. The determined increases at chlorophyll a, chlorophyll b and total chlorophyll contents especially appeared in the expose to magnetic field for a short time. Compared to control, there was 89.27 % increase of chlorophyll content with magnetic treatment for P.elongata and 87.48 percent and 45.26 percent increase for P.tomentosa and P.fortunei respectively.

In research made in China, it was observed that irrigated plants with magnetic water increased leaf chlorophyll content [12]. It was also shown that screening natural electromagnetic fields on chlorophyll content of Phaseolus vulgaris leaves were effected and found lower contents of chlorophyll a and chlorophyll b than unshielded plants [21].

No positive effect of magnetic field of 4.7-5.7 mT was seen at P.elongata I. As for P.tomentosa I, it caused an increase in seedling number and germination percentage at those which were passed through 9 times according to control. At P.fortunei I, it has positive effect from seedling number point of view at those which were passed through once.

With regard to magnetic field of 4.7-5.7 mT, when the seeds for Paulownia varieties were exposed to magnetic field of 3.8-4.8 mT, better results were obtained. Seedlings which were transferred into soil and chlorophyll contents of P.elongata II were increased at this magnetic field. Also, at all periods exposed to magnetic field, germination percentages on the 3rd day, seedling numbers on the 5th day, seedling heights and chlorophyll contents of P.tomentosa are higher than control. At P.fortunei II, again germination percentage on the 5th day, seedling numbers on the 8th day and seedling heights are higher than control at all procedures. Apart from this, germination percentage, seedling number and transferred plant number on the 10th day and chlorophyll content were also higher at this magnetic field which were passed through magnets once.

The experiment showed that influence of magnetic field of 3.8-4.8 mT by short time was positive for P.fortunei II.

According to the observations during the first two months from the first appearance of roots and to the analysis results, it showed that Paulownia varieties gave different responds to the magnetic field. For this reason, if a new research is made with magnetic field, it is necessary to determine on appropriate magnetic field strength for the variety. At the preliminary experiment to be done for the determination of the appropriate magnetic field strength for P.varieties, germination percentage on the first day which the seed coat opens at the micropylar end and reveals the radicle will be determined. Also the numbers on the first seen day of the young seedling and seedling heights are taken into consideration.

The height of saplings in their first year should exceed 4 m. Under optimum conditions a 5-year-old or 6-year-old Paulownia tree can produce useful timber. For this reason, observation and neccessary analysis must also be continued within this period.

Table 1: Germination percentages and seedling numbers on the 12th day and the day when the first young seedling belonging to Paulownia varieties was exposed to magnetic field of 4.7- 5.7 mT.

Variety	Magnetic field influence[1]	Seed number	The day first young seedling seen[2]			12th day		
			Germination %	Seedling number	Seedling %	Germination %	Seedling number	Seedling %
P. elongata	Control	60	68.33	-	-	73.33	44	73.33
	1	60	55.00	1	1.67	60	34	56.67
	3	59	52.54	1	1.69	59.32	32	54.12
	9	60	56.67	3	5	61.67	36	60
P. tomantosa	Control	61	91.80	-	-	93.44	50	81.97
	1	61	86.89	7	11.48	91.80	54	88.52
	3	62	85.48	1	1.61	90.32	54	87.10
	9	61	93.44	11	18.03	98.36	56	91.80
P. fortunei	Control	60	47.67	-	-	88.33	7	11.67
	1	60	50	1	1.67	78.33	16	23.33
	3	61	29.51	-	-	68.85	2	3.28
	9	62	41.94	-	-	77.42	20	24.19

[1] Passing number through magnetic field.
[2] After being exposed to the magnetic field, it was determined that young seedling for P. elongata, P. tomentosa and P. fortunei the 6th, 7th and 10th day respectively.

Table 2: Germination percentages, seedling numbers and seedling numbers transferred into soil beloning to Paulownia varieties exposed to magnetic field of 3.8- 4.8 mT.

Variety	Magnetic field influence [1]	Seed number	The day root seen [2]	The day first young seedling seen [3]			10[th] day				
			Germination %	Germination %	Seedling number	Seedling %	Germination %	Seedling number	Seedling %	The number of seedling transferred into soil [4] Number	%
P. elongata	Control	150	23.33	40	7	4.66	68.67	83	55.33	72	48
	1	150	39.33	50.67	5	3.33	67.33	82	54.67	74	49.33
	3	150	40	50	10	6.67	68	87	58	74	49.33
	9	150	31.33	45.33	3	2	63.33	80	53.33	73	48.67
	15	150	31.33	42	3	2	66	84	56	76	50.67
P. tomentosa	Control	150	11.33	58.67	3	2	78.67	94	62.67	67	44.67
	1	150	19.33	58	10	6.67	75.33	88	58.67	57	38
	3	150	29.33	60.67	13	8.67	78.67	96	64	78	52
	9	150	37.60	67.20	22	17.60	73.60	76	60.8	47	37.60
	15	150	19.33	51.33	8	5.33	68.67	83	55.33	55	36.67
P. fortunei	Control	100	-	54	-	-	78	49	49	70	70
	1	100	3	53	3	3	81	54	54	75	75
	3	100	4	37	2	2	72	42	42	64	64
	9	100	5	45	5	5	71	46	46	70	70
	15	100	3	42	2	2	70	39	39	61	61

1 Passing number through magnetic field.
2 At germination period. root for P.elongata and P.tomantosa was seen on the 3[rd] day for P.fortunei. it was seen on the 5[th] day.
3 After the seeds were exposed to magnetic field. it was seen that young seedling for P.elongata was the 4[th]. P.tomentosa was the 5[th] and P.fortunei was the 8[th] day.
4 P.fortunei seedlings were transferred into soil on the 14[th] day.

Table 3: Seedling numbers and average heights of 2-month seedling belonging to Paulownia varieties which
were exposed to magnetic field of 3.8- 4.8 mT

Variety	Magnetic field influence*	Seedling number	Seedling height (cm)	Seedling %
P.elongata	Control	86	5.70 ± 1.18	100
	1	96	4.90 ± 1.99	85.96
	3	95	4.50 ± 1.69	78.95
	9	84	4.86 ± 1.90	85.96
	15	103	5.11 ± 1.60	89.64
P.tomentosa	Control	86	3.24 ± 0.76	100
	1	83	3.81 ± 0.92	117.59
	3	68	3.39 ± 0.83	104.63
	9	72	3.94 ± 0.87	121.60
	15	76	3.78 ± 0.88	116.67
P.fortunei	Control	63	3.06 ± 0.77	100
	1	61	3.91 ± 1.19	127.80
	3	62	3.58 ± 0.84	117
	9	67	4.86 ± 1.16	158
	15	58	3.41 ± 0.70	111.40

* Passing number through magnetic field.

Table 4: Chlorophyll contents of 2-month old Paulownia seedlings which were exposed to magnetic field of 3.8- 4.8 mT.

Variety	Magnetic field influence*	Chl a	Chl b	Total chlorophyll mg/gfw
P.elongata	Control	0.362±0.020	0.227±0.018	0.587±0.025
	1	0.335±0.032	0.248±0.030	0.603±0.045
	3	0.858±0.035	0.386±0.070	1.111±0.194
	9	0.353±0.017	0.220±0.042	0.574±0.032
	15	0.428±0.022	0.343±0.029	0.772±0.027
P.tomentosa	Control	0.320±0.013	0.215±0.015	0.535±0.004
	1	0.641±0.064	0.322±0.035	1.003±0.064
	3	0.462±0.016	0.277±0.089	0.739±0.121
	9	0.521±0.095	0.280±0.096	0.801±0.192
	15	0.446±0.045	0.290±0.022	0.744±0.066
P.fortunei	Control	0.475±0.021	0.326±0.420	0.802±0.063
	1	0.750±0.050	0.414±0.087	1.165±0.038
	3	0.489±0.017	0.327±0.036	0.817±0.039
	9	0.295±0.028	0.213±0.055	0.509±0.070
	15	0.387±0.038	0.270±0.056	0.657±0.038

* Passing number through magnetic system

Then, we may have some ideas to say about the effects of magnetic field on the wood properties of Paulownia trees.

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