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EFFECTS OF NANO SILVER PARTICLES AND GIBBERELLIC ACID ON GROWTH AND SOME PHYSIOLOGICAL CHARACTERISTICS OF *DALBERGIA SISSOO ROXB.*

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ABSTRACT:
Recent studies show that Nanotechnology can be effectively used to enhance the characteristics of many types of trees including forest trees. *Dalbergia Sissoo Roxb.*, which belongs to the *Fabaceae* family, is a forest tree that grows in dry land and water conservation areas. The aim of this study is to examine the effect of nano silver (NS) at (0, 30, 60 and 90 mg/L) and gibberellic acid (GA_3) at (0, 50, 100 and 200 mg/L) concentrations on seed performance and subsequent growth of *Dalbergia sissoo Roxb*. The results reveal the enhancement of germination rate and velocity by using GA_3 at 100 and 200 mg/L. NS90 treatment increased each of shoot and root fresh and dry weight, leaf area and plant height whereas GA50 treatment increased number of branches per plant and primary root length. Non-significant differences between treatments on *Peroxidase* enzyme activity and chlorophyll a content was observed whereas NS30 had the highest chlorophyll b and lowest total carotenoids. Shoot and root contents of some essential and non-essential elements differed between treatments. In roots, N90 treatment increased each of Cu and Mn elements, but it decreased Cl content. Although GA100 treatment increased Cl content, it decreased Mn. The paper concludes that the applications of nano-silver and GA_3 on *Dalbergia sissoo Roxb.* have significant effects on its growth and physiological parameters.

KEYWORDS: *Dalbergia sissoo Roxb.*, Germination, Gibberellin, Nano Silver, *Peroxidase* Enzyme and Vegetative Growth.

1. INTRODUCTION

Dalbergia sissoo Roxb. is an important legume tree belonging to family *Fabaceae* (Sehra and Sharma, 2021). It mainly grows along riverbanks below a height of 900 meters, but can naturally reach up to 1300 meters. The mean temperature in its natural range is 10-40 °C, but varies from just below freezing to almost 50 °C. It can survive annual average rainfall of up to 2,000 millimeters. It grows in the range of soils from perfect sand and gravel to rich alluvium of banks of the river; it can grow in slightly salty soils (Adenusi and Odaibo, 2009). *Dalbergia Sissoo* is among the most valuable tree species commonly recommended for afforestation and reforestation programs in dry land and water conservation areas (Joshi *et al.*, 2021). It is used as a wind break, shelter belt and nitrogen fixation. Also, its highly valued wood is used for making furniture and for constructional and general utility purposes (Naqvi *et al.*, 2019). Its leaves, young shoots and green pods, are important sources of fodder (Bhattacharya *et al.*, 2014), and its seed oil and roots which contain tectoridin used medicinally (Sehra and Sharma, 2018). The developments in agricultural science are continuous especially in plant physiology and throughout the last century developed from plant hormones to nanotechnology. Thus, Nanotechnology as a revolutionary contemporary science can play an enormous role in improving the quality of *Dalbergia Sissoo Roxb*. and increasing their production (Singh *et al.*, 2021).

Many studies have been conducted using nano silver on different plant species for improving seed performance and their subsequent growth such as in fenugreek (*Trigonella foenum-graecum*) where AgNPs enhanced seed germination and early seedling growth (Hojjat and Hojjat, 2015). In their study of bishop pine (*Pinnus muricata*) Sweet and Singleton (2015) found that after 1 month AgNP had significantly reduced the root length of pine seedlings. However, after 4 months growth, AgNP levels utilized had significantly reduced both pines root and shoot biomass. Stimulatory effects reported on root elongation, fresh weight, and evapotranspiration of poplars (*Populus tremula*) and arabidopsis (*Arabidopsis thaliana*) (Wang *et al.*, 2013).

Plant hormones are another practice used for improving plant growth and development where the plant hormone gibberellins are used for improving seed performance in many species such as horse gram (*Macrotyloma uniflorum*) where germination percentages were significantly accelerated by GA_3 (Lalitha *et al.*, 2016). According to Al-Hawezy (2013) who has studied seed germination of loquat (*Eriobotrya japonica*), GA_3 has a significant effect on increasing germination rate as compared to control. Another study was determined to reduce faba bean (*Vicia faba*) flowers abortion and increase seed production by GA_3 foliar spraying. Its results indicated that plant height, number of branches/plant, number of pods/plant, number of seeds/pod, number of seeds/plant as well as seed yield significantly exceeded (Kandil *et al.*, 2011).

Due to the dearth of research about effects of NS on *Dalbergia Sissoo Roxb*. growth, and the desire to increase the cultivated area of this important tree, this study has been conducted which is about the effects of NS and GA_3 in

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different concentrations on the growth and some physiological characteristics of *Dalbergia Sissoo*.

2. MATERIAL AND METHODS

2.1 Plant Material and Chemicals

The ripe pods of *Dalbergia Sissoo* tree which was 15 years old collected on July 19, 2018 from Mnara Park/Erbil. Pods with one seed was selected. The experiment for this study was conducted in a private field in Taqtaq city, Koysinjaq, Erbil located at 35º32'43"N, 44º4'8".

The nano silver made in US Research Nanomaterials, Inc (CAS: 7440-22-4, USA). For preparing 90 mg/L nano silver, 0.1809 g of nano silver (99.5%) dissolved in 5 ml of ethanol then completed to 2 L by distilled water, this treatment denoted as NS90 and as an original solution, whereas each of NS60 and NS30 were prepared from the original solution. The gibberellic acid made from Avonchem limited (CAS: 77-06-5, UK). For preparing 200 mg/L GA_3, 0.412 g of gibberellic acid (97%) dissolved in 5 ml of ethanol then completed to 2 L by distilled water, this treatment denoted as GA200 and as an original solution, whereas each of GA100 and GA50 were prepared from the original solution.

2.2 Treatment Procedure

On January 10, 2019, poly bags sized (10x10x30) cm was filled with soil-peat moss mixture of (1:1). Then on January 17, 2019, the cut pods soaked in the solutions of nano silver (30, 60 and 90 mg/L), GA_3 (50, 100 and 200 mg/L) in addition to distilled water as control for 24 hrs. On the next day, 3 seeds were planted in each poly bags, (figure 1). The experiment was completed on July 4, 2019.

2.3 Meteorological Data and Soil Properties

Table (1) illustrates the maximum and minimum temperatures, the relative humidity and the amount of rainfall in the field during the planting season which were registered by the Agro-Meteorological station in Taqtaq city, Koysinjaq, Erbil.

Figure 1. Seed planting procedure (1) preparing seeds bags (2) ripe seeds (3) cut seeds (4) soaking in treatments solutions (5) raising from solutions (6) planting (7) covering (8) emerging (9) two leaves seedling (10) plant stalk

Table 1. Meteorological data during the growing season (2019)

Months	Temperature (ºC)		Relative humidity (%)		Rain fall (mm)
	maximum	minimum	maximum	minimum	
January	16.4	6.6	74.5	51.4	74.5
February	18.3	7.9	86.1	48.1	86.1
March	22.5	12.5	208.4	52.7	208.4
April	35.4	22.1	129.0	47.4	129.0
May	48.4	29.7	25.4	12.0	25.4
June	56.9	36.5	0	13.0	0
July	49.5	29.5	0	5.5	0

The experiment soil taken from the Srusht Nursery in Taqtaq. Then the physical and chemical properties of the soil (as shown in table (2)) were determined by Agricultural Research Center/ Ainkawa/ Erbil, Department of Soil and Water Science at University of Sulaimanya and Department of Physics at Koya University.

Table 2. Some characteristics of the study soil

Property	Value
EC (Ds/m)	0.3
pH	7.68
Organic Matter (%)	1.12
HCO_3 (%)	1.093
CO_3 (%)	0
$CaCO_3$ (%)	34.95
Sand (%)	51.5
Silt (%)	24.1
Clay (%)	24.4
Soil texture	Sandy clay
Ca	38.60
K	4.26
Mg	3.80
S	0.83
Cu	0.02
Fe	8.96
Ni	0.02
Si	31.10
Zn	0.06
Al	8.78
Br	0.004
Cl	0.14
Mn	0.28
Rb	0.0184
Sr	0.10
Ti	1.12

2.4 Germination and Vegetative Growth Characteristic Studies

The germination rate was measured as indicated in Ahmadloo *et al.* (2012), the velocity of emergence was measured as showed in Ranal and Santana (2006), the plant height, number of branches per plant, length of the primary root, number of leaves per plant was measured as demonstrated by Khudhur and Omer (2015), dry and fresh weight (shoot and root) and dry matter (root and shoot) were measured as specified by Al-Sahaf, (1989), leaf area was calculated using the method described by Watson and Watson (1953).

2.5 Chemical Analysis

Total carotenoids pigments of chlorophylls a and b calculated as mentioned by Lichtenthaler and Wellburn (1983), total carbohydrate determined using the method outlined by Joslyn (1970), *Peroxidase* enzyme activity in leaf observed as it is stated by Nezih (1985) and chemical elements of root and shoots discovered using X-ray fluorescence (XRF) spectroscopy as explained by Haschke (2014) and Rodrigues *et al.* (2018).

2.6 Experimental Design and Statistical Analysis

Randomized Complete Block Design (RCBD) consisted of 7 treatments which are control (distillate water), NS30, NS60, NS90, GA50, GA100 and GA200, each treatment with 3 replications and 10 bags for each experimental unit.
The Duncan`s multiple comparison test used to assess the main treatment effects that varied when the F-value was significant at ≤0.05 using the statistical analysis system (SAS Program, 2005).

3. RESULTS AND DISCUSSION

3.1 Germination Rate and Velocity

Results in table (3) show that treated seeds of *Dalbergia Sissoo* with 100 mg/L GA_3 increased the percent of seeds germination to 80% which is significant compared to other GA_3 treatments and the highest concentration of nano silver 90 mg/L, which may due to toxic effects of NPs that may have substantial negative effects, such as reduction in seed (Yang *et al.*, 2017). Generally, there were non-significant differences between various concentrations of nano silver treatments, and the result was in line with the findings of Krishnaraj *et al.* (2012). The seed germination and other physiological activities could increase by applying of plant growth regulator at high concentration this is mainly because tolerance to toxic effects of GA_3 which was found to be consistent with the findings of Hoque and Haque (2002). Increased effectiveness of low concentrations of GA_3 may lead to the restoration of water content retardation; this may be due to water stress intolerance, which is parallel with the findings of Roychowdhury *et al.* (2012).

Table 3. Effect of nano silver and gibberellic acid on *Dalbergia sissoo* germination rate and velocity.

Treatments	Germination rate (%)	Velocity of emergence (days)
Control	70.00 a b	45.33 a
NS30	63.33 a b	41.96 a b
NS60	53.33 a b	44.22 a b
NS90	40.00 b	44.75 a b
GA50	56.67a b	47.00 a
GA100	80.00 a	47.13 a
GA200	50.00a b	39.27 b

** According to the Duncan test all above (means) in the same column which have similar letter are not considerably different at $p \leq 0.05$.*

According to the results, velocity of emergence of seeds was accelerated significantly when GA_3 at 200 mg/L was used compared to control, 50 and 100 mg/L of GA_3.

This result agrees with that of Awatif and Alaaeldin (2017) whom confirmed that seed pre-treatment with GAs promote seed germination not only through stimulation of hydrolyzing enzymes but also by antagonizing the inhibitory effect of ABA on germination process. From the table, it is also seen that all tested concentrations of nano silver, germination period was decreased in comparison with control treatment, it is also seen in the result of Kumar *et al.* (2020) whom stated that seed of wheatgrass (*Agropyron elongatum* L.) germination time decreased significantly from 4.01 to 1.68 days by using silver nanoparticles, and it refers to the activation of respiration and rapid ATP production (Azimi *et al.*, 2014).

3.2 Vegetative Growth

The impact of nano silver and gibberellic acid on vegetative growth of *Dalbergia Sissoo* seedling aged 5 months, described in table (4). The nano silver had more effect on the leaf area, dry and wet weight of root and shoot, while the low concentrations of gibberellic acid was highly effective on length of primary root, number of branch, plant height and number of leaf. Nano silver of 60 mg/L concentration and 50 mg/L of gibberellic acid were more effective than the other treatments. The lowest effect in all parameters (except number of leaf) acquire by NS90. Moreover, GA200 had lowest value in root dry weight, number of branch and length of primary root, while it had non-significant effect on leaf area, number of leaf, root fresh weight and shoot weight (dry and fresh). The results agreed with those of Al-Imam (2007), Delvadia *et al.* (2009), Yaseen *et al.* (2016) and Jasim *et al.* (2017).
The increases of growth parameters were mediated via gibberellic acid were due to the cell division and cell elongation (El-Batal *et al.*, 2016). In that respect, at high concentration nano silver reduce all growth parameters compared to other treatments. This reduction at higher doses may be attributed to toxic level of nanoparticles. Sahandi *et al.* (2011) and Salama (2012) also observed these results. In addition, the result indicates that nano silver and gibberellic acid treatments are significantly effective on the percentage of shoot dry matter, whereas NS60 had the highest value and GA200 had the lowest value. Besides nano silver treatments and GA100 had no effect on root dry matter percent, while 50 mg/L gibberellic acid was significantly affected.

3.3 Chemical Compositions

Table (5.) illustrates that nano silver and gibberellic acid had significant effect on chlorophyll b and total carotenoids.

Table 4. The Effect of nano silver and gibberellic acid on some vegetative growth of *Dalbergia sissoo* plant

Treatments	Shoot fresh Weight (g)	Root Fresh Weight (g)	Shoot Dry Weight (g)	Root Dry Weight (g)	Leaf Area (cm^2)	Number of Branches /Plant	Length of Primary Root (cm)	Number of Leaf/ Plant	Plant Height (cm)	Shoot Dry Matter (%)	Root Dry Matter (%)
Control	3.20 d	1.15 d	0.80 d	0.45e	314.9 d	20.00 d	13.13 e	57.0 e	15.00 d	24.93 d	39.66 abc
NS30	8.73 b	3.60 a b	2.50 bc	1.20 b	801.0 c	29.00 cb	15.73 d	99.0 d	43.50 b	28.66 bcd	33.33 c
NS60	10.56 a	4.05 a	3.85 a	1.50 a	1666.9 a	27.66 c	22.76 b	164 .3 b	55.50 a	35.50 a	37.03 bc
NS90	7.13 c	2.55 c	2.15 c	0.95 c	662.1 c	26.33 c	15.66 d	139.3 bc	26.73 c	30.10 bc	37.26 bc
GA50	8.10 b c	3.10 b	2.70 b	1.40 a	907.1 cb	38.00 a	29.73 a	126.0 cd	50.50 ab	33.13 ab	46.33 a
GA100	8.90 b	3.10 b	2.69 b	1.10 b	1078.0 b	33.33 a b	22.26 b	204.3 a	47.00 ab	30.30 bc	35.46 bc
GA200	3.40 d	1.40 d	0.87 d	0.58 d	396.2 d	27.33 c	19.83 c	66.6 e	48.50 ab	26.23 cd	42.40 ab

** According to the Duncan test all above (means) in the same column which have similar letter are not considerably different at $p \leq 0.05$.*

The highest values were observed by NS30 and GA100 for chlorophyll b and total carotenoids but the lowest values for total carotenoids and chlorophyll b were by NS30 and GA100 respectively. All treatments had no significant effect on chlorophyll a content of leaf. Because of nanoparticles were passing through shoots after that assembled on leaves that cause disadvantage impact on tested plant chlorophyll content. The plant chlorophyll content may increases by low concentration, while may be decreased by high nanoparticle concentrations. Even though, the same results discovered by Mazumdar (2014) and Singh & Kashyap (2015). The results of chlorophyll content treated by gibberellic acid agreed with Tsai & Arteca (1985) and Stirk *et al.* (2019). The lower concentrations of NS and GA_3 treatments had significant effect on increasing shoot total carbohydrate compared to other treatments. The carbohydrate in leaves was increased significantly with successive increase in the concentrations of nano silver particles. The impact factors of increasing carbohydrate of leaves may possibly be consistent with photosynthetic pigments for the correlating AgNPs treatments. As well as low concentrations of nano silver caused increasing soluble sugar (Yaseen *et al.*, 2016). At the same time, nano silver treatment caused reduction in root carbohydrate. Reduction of the carbohydrate content may be attributed to the toxic level of nanoparticles resulting in a subsequent decrease in growth. Salama (2012) also obtained the same results. Although the results indicate that the effect of nano silver and gibberellic acid were non-significant on *Peroxidase* enzyme activity on leaves. Low activities of *Peroxidase* occurred in *Dalbergia Sissoo* treated with GA_3 which is with accordance with finding of Khader *et al.* (1988) on mango fruit. On the other hand, the non-effective of nano silver may be due to the inactivation of the *Peroxidase* by the non-specific degradation of the enzyme proteins or the production of excessive free radicals (Zare *et al.*, 2020).

Table 5. The Effect of nano silver and gibberellic acid on chlorophyll a, b and total carotenoids of leaf content in *Dalbergia sissoo*

Treatments	Chlorophyll a	Chlorophyll b	Total carotenoids	Total carbohydrate (%)		*Peroxidase* (absorbing units per gram of fresh leaves)
	mg/g fresh weight			Shoot	Root	
Control	1.28 a	0.97 b	0.16 c	11.83 c	22.20 c	943.30 a
NS30	1.27 a	1.36 a	0.01 e	25.10 a	18.90 c d e	1066.70 a
NS60	1.27 a	0.84 c	0.17 c	26.80 a	15.73 d e	1128.40 a
NS90	1.26 a	0.79 c d	0.19 b	16.83 b	21.13 c d	919.30 a
GA50	1.25 a	0.76 d e	0.20 b	19.96 b	35.00 a	1003.70 a
GA100	1.25 a	0.69 e	0.22 a	8.06 c	13.43 e	979.30 a
GA200	1.26 a	0.98 b	0.12 d	10.00 c	28.80 b	1157.70 a

** According to the Duncan test all above (means) in the same column which have similar letter are not considerably different at $p \leq 0.05$.*

3.4 Constituents of Macro and Micro Essential Elements

According to the results in table (6), nano silver and gibberellic acid were significantly affected on macro and micro essential elements of shoot except Fe element. NS60 had the highest effect on Mg, Cu and Zn, it may due to the highest shoot and root fresh and dry weight (Table 4). In addition, the highest value of K was due to N90 treatment and for Mn was by GA50, these may be because this treatment had the highest root dry weight, number of branches per plant, and length of primary root, while the highest value of Cl was recorded by GA200 treatment. Oppositely, the lowest value was recorded by NS60 for K and Mn, NS90 for Mg, GA50 for Cl, NS30, GA50 and GA100 for Cu compared to control.

For root, the results in table (7) indicate that NS90 had highest effect on Cu and Mn, while the highest value for Cl was due to GA100 treatment. Conversely, the lowest value was observed by NS90, GA50 and GA100, for Cl, Cu and Mn elements respectively. Besides, nano silver and gibberellic acid had no significant effect on Fe, Zn and macro elements.

Table (8) shows that (GA100 and GA200) impact on Br and NS60 on Rb were the highest and the lowest effect were noticed by control on Br and NS90 on Rb. In contrast, nano silver and gibberellic acid non-significantly affected on Al, Sr and Ti elements in shoot.

Table 6. The Effect of nano silver and gibberellic acid on some macro and micro elements of shoot dry matter of *Dalbergia Sissoo*

Treatments	Macro elements (%)		Micro elements (%)				
	K	Mg	Cl	Cu	Fe	Mn	Zn
Control	30.20 b	3.66 b c	0.45 b	0.05 a b	0.88 a	0.71 a b	0.06 b
NS30	31.30 b	4.46 a b	0.44 b	0.04 b	0.90 a	0.58 b	0.08 a b
NS60	29.75 b	4.97 a	0.56 b	0.07 a	2.27 a	0.49 b	0.14 a
NS90	37.10 a	3.05 c	0.64 a b	0.06 a b	0.81 a	0.60 a b	0.10 a b
GA50	33.60 a b	4.03 a b c	0.37 b	0.04 b	0.57 a	0.85 a	0.07 b
GA100	32.90 a b	4.73 a b	0.58 b	0.04 b	1.23 a	0.63 a b	0.08 a b
GA200	31.00 b	3.98 a b c	0.89 a	0.05 a b	1.21 a	0.65 a b	0.11 a b

** According to the Duncan test all above (means) in the same column which have similar letter are not considerably different at $p \leq 0.05$.*

The antagonistic effects between K and Rb content in shoot is clear where NS90 treatment gave the highest content of K (Table 6), whereas it gave lowest value of Rb (Table 7), also Mg and K antagonistic is appear in shoots (Table 3.4) (Pik, *et al.*, 2005 and Brataševec, 2013).

Furthermore, NS (except NS90) and GA_3 treatments had no significant effects on V. Referring to the root chemical elements the results indicate that NS30, GA50 and GA200 had the highest significant effect on Sr, Al and Ti respectively. In contrast, the lowest value in Al, Ti and Sr were noted by NS30 and GA200 compared to the control respectively. Moreover, nano silver and gibberellic acid had no significant effect on V, Br and Rb in root. The decreasing of (Br and Rb) in shoots and (Al and Ti) in root by using NS treatments which agrees with Yan and Chen (2019), stated that nano-silver may decrease root hair and inhibit root elongation (Table 4) which leads to inhibiting some minerals uptake.

Table 7. The Effect of nano silver and gibberellic acid on some macro and micro elements of root dry matter of *Dalbergia Sissoo*

Treatments	Macro elements (%)		Micro elements (%)				
	K	Mg	Cl	Cu	Fe	Mn	Zn
Control	31.50 a	3.79 a	2.18 b	0.09 a b	9.90 a	0.33 a b	0.15 a
NS30	44.90 a	5.03 a	1.78 b c	0.08 a b	3.40 a	0.29 a b c	0.18 a
NS60	29.72 a	4.26 a	1.85 b c	0.07 a b	7.65 a	0.29 a b c	0.14 a
NS90	35.10 a	4.52 a	1.62 c	0.10 a	3.60 a	0.35 a	0.15 a
GA50	31.05 a	4.45 a	2.20 b	0.05 b	6.20 a	0.24 b c	0.13 a
GA100	35.10 a	4.57 a	4.12 a	0.08 a b	5.49 a	0.22 c	0.15 a
GA200	30.50 a	4.51 a	1.94 b c	0.06 a b	7.01 a	0.26 a b c	0.16 a

* *According to the Duncan test all above (means) in the same column which have similar letter are not considerably different at $p \leq 0.05$.*

Table 8. Effect of nano silver and gibberellic acid on some beneficial and toxic elements of shoot and root dry matter of *Dalbergia Sissoo*

Treatments	Some Beneficial and Toxic Elements in Shoot						Some Beneficial and Toxic Elements in Root					
	V	Al	Br	Rb	Sr	Ti	V	Al	Br	Rb	Sr	Ti
Control	0.01 b	0.39 a	0.006 c	0.013 d	1.28 a	0.07 a	0.02 a	4.06 a b	0.02 a	0.027 a	0.63 b c	0.55 a b
NS30	0.01 b	0.48 a	0.007 bc	0.026 b	1.73 a	0.08 a	0.02 a	1.93 c	0.01 a	0.024 a	1.12 a	0.23 b
NS60	0.01 b	1.19 a	0.007 c	0.035 a	1.46 a	0.12 a	0.03 a	4.25 a b	0.01 a	0.021 a b	0.49 b c	0.43 a b
NS90	0.02 a	0.38 a	0.007 c	0.011 d	1.06 a	0.05 a	0.02 a	2.40 b c	0.02 a	0.023 a b	0.73 a b	0.35 a b
GA50	0.007 c	0.36 a	0.009 b	0.022 bc	2.48 a	0.04 a	0.02 a	4.72 a	0.02 a	0.024 a	0.67 a b c	0.53 a b
GA100	0.002 d	0.77 a	0.019 a	0.031 a	2.95 a	0.08 a	0.03 a	3.49 a b c	0.03 a	0.014 b c	0.42 b c	0.43 a b
GA200	0.007 c	0.61 a	0.019 a	0.018 c	1.51 a	0.09 a	0.03 a	4.46 a	0.01 a	0.011 c	0.23 b c	0.60 a

* *According to the Duncan test all above (means) in the same column which have similar letter are not considerably different at $p \leq 0.05$.*

4. CONCLUSIONS AND RECOMMENDATIONS

The study concludes that application of nano silver on *Dalbergia Sissoo* seeds especially at 60 mg/L significantly increases certain vegetative growth parameters, shoot carbohydrate and certain of chemical nutrients. GA_3 mainly 50 and 100 mg/L significantly increases germination rate, a number of vegetative growth parameters, total carotenoids, shoot and root carbohydrate compared to other gibberellic acid concentrations. In addition to investigating the effects of nano-silver and gibberellic acid on the anatomical changes in plants, it is recommended to conduct the experiments used in this study in different soil texture.

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