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Article

Effects of phosphorus fertilizer and nano-magnesium spray on the vegetative and reproductive of *Datura stramonium* L.

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ABSTRACT

In 2021, a field experiment was conducted at the College of Agriculture, University of Kerbala, Kerbala, Iraq, to study the effect of phosphate fertilization1 and nano-magnesium spraying on Datura plants' vegetative and reproductive traits. The experiment was conducted with three replications according to randomized complete block design (RCBD) with two factors. The first factor included four levels of Phosphorus fertilizer: 0, 25, 50, and 75 kg P h-1. The second factor included spraying of nano-magnesium in four concentrations: 0 (distilled water only) and 60, 120, and 180 mg Mg L^{-1}. The results showed that phosphorous caused a significant increase in the studied traits, as the treatment 50 kg P ha^{-1} gave the highest mean plant height, number of branches, number of leaves, leaf area, leaf yield, seed yield, alkaloids percentage in leaves and seeds, number of fruits and number of seeds, which amounted to 4953 cm and 27.62 $plant^{-1}$, 124.49 leaves Plant^{-1}, 1989.12 cm^2, 501.36 kg ha^{-1}, 501.49 kg ha^{-1}, 13.16%, 13.18%, 26.02 fruit $plant^{-1}$ and 228.14 seed $plant^{-1}$, respectively. The treatment 180 kg Mg h^{-1} gave the highest average plant height, number of branches, number of leaves, leaf area, yield of leaves, yield of seeds, percentage of alkaloids in leaves and seeds, number of fruits and number of seeds reaching 58.27 cm And 21.90 branches Plant^{-1}, 122.94 leaves Plant^{-1}, 1996.62 cm^2, 886.59 kg h^{-1}, 486.17 kg h^{-1}, 14.86%, 15.10%, 26.56 fruits $plant^{-1}$, 24.63 seeds $plant^{-1}$. Adding phosphorous and spraying nano-magnesium improves the vegetative and reproductive traits of the Datura plant.

Keywords. Fertilization; Nano–Nutrients; Medicinal Plant; Yield; alkaloids.

INTRODUCTION

Datura has many pharmaceutical properties because it contains organic esters known as alkaloids[1]. These alkaloids have antiasthmatic and anticholinergic properties, which treat various conditions, including digestive and respiratory disorders[2]. Several studies indicated the therapeutic importance of the Datura plant, as the extract of Datura leaves is used to relieve headaches, rheumatic pain, and gout and an ointment for burns, as well as the inclusion of some active substances in it in the treatment of Parkinson's disease, epilepsy and depression[3]. Previous studies have shown the role of nutrients, including phosphorous and magnesium, in improving Datura's vegetative and reproductive traits. Phosphorus is an essential element in the plant to enter the synthesis of some nucleic acids, and the synthesis of ADP and ATP is critical in energy transfer. Important in plant respiration and photosynthesis oxidation and reduction reactions[4]. It also works to change the environment of the roots. It thus improves the supply of water, nutrients, and compounds necessary for the

growth and formation of plant organs[5] concluded, after applying a field experiment on tobacco plants, that fertilizing with phosphorous at levels of 75 and 225 kg P_2O_5 h^{-1} caused a significant increase in The height of the plant and the number of leaves reached (96.4 and 97.9) cm and (28.2 and 28.5) leaves $Plant^{-1}$, superior to the non-fertilization treatment[5]. They were recorded when applying a field experiment on the tobacco plant using two levels of phosphate fertilizer, 75 and 225 kg h^{-1}, which caused a significant increase in seed yield, which reached 1635 and 1692 kg h^{-1} compared with the non-fertilization treatment.

Magnesium is one of the components of chlorophyll in plants, as no other element can play this role in place of magnesium, as it activates and mediates some biochemical reactions[6]. Magnesium is an essential element in the metabolic processes of ATP during the synthesis of respiration, which is necessary for activating many enzymes that are organic catalysts in phosphorous metabolism. Magnesium activates more plant enzymes than any other nutrient[7]. Magnesium has essential properties that help the plant in various growth processes, such as root and vegetative growth and increasing the size of fruits, in addition to its active role in the formation of cells, as well as its ability to build strong roots and solid stems[8]. Nine recorded, after applying a field experiment on a tomato plant using three levels of magnesium, 0.04%, 0.08% and 0.12%, that treatment with 0.12% magnesium caused a significant increase in plant height, several branches and number of fruits with averages of 72.98 cm and 7.94 branch $Plant^{-1}$ and 31.01 fruit $plant^{-1}$ fruit, respectively, compared to the no-addition treatment, which gave 66.82 cm and 6.30 branch $plant^{-1}$ and 22.99 fruit $plant^{-1}$, respectively. Therefore, this study was conducted to understand the role of phosphorous and nano-magnesium in improving the vegetative and reproductive of Datura plants.

MATERIALS AND METHODS

A field experiment was carried out during the 2021 agricultural season in one of the experimental fields of the College of Agriculture, University of Karbala - Karbala - Iraq, to study the effect of phosphate fertilization and spraying with nano-magnesium on the vegetative and reproductive of Datura. The experiment was carried out with three replications according to a randomized complete blocks design with two factors; the first factor included four levels of Phosphorus fertilizer: 0, 25, 50 and 75 kg P h^{-1}, while the second factor included the spraying of nano-magnesium in four concentrations: 0 (distilled water only) and 60 And 120 and 180 mg Mg L^{-1}, then the following field measurements were taken:

Plant height (cm) was measured from the soil surface level to the top of the plant's main stem.

- Number of branches (branches $plant^{-1}$): The total number of primary and secondary branches of five plants for each experimental unit was calculated.

-Number of leaves (leave $plant^{-1}$): The number of leaves per plant was calculated, and then the average was extracted.

-Leaf area (cm^2): The disks method was used to estimate the leaf area.[9]

- leaf yield (kg h^{-1}): The leaves of the plants were weighed.

- Number of fruits (fruit $plant^{-1}$): Five plants were taken randomly from the median lines, then their average was extracted.

-Number of seeds (seed $fruit^{-1}$):The measurement was made using the number of fruits taken from the five measured plants, and the average was extracted.accordingly

- Weight of 1000 seeds (g): 1000 seeds were weighed using the sensitive scale.

-Total seed yield (kg h^{-1}): The yield was measured for each experimental unit and then converted to kg. H-1

Percentage of alkaloids in leaves and seeds-: Leaves and seeds samples were taken from all experimental units, and the alkaloids were calculated as a percentage of the weight of the analyzed sample as 10 gm of dried leaves and seeds were extracted by Soxhlet extractor with 50 ml of methanol at a temperature of 50 °C until the weight was stable[10,11].

Statistical data analysis

All traits were statistically analyzed. The statistics software GenStat12 employed the least significant difference (LSD) test at a 0.05 probability value.

RESULTS

The results of Table 1 showed that phosphorous caused a significant increase in plant height, number of branches, number of leaves and leaf area, as the treatments 50 kg P h^{-1} gave the highest averages for plant height, which reached 62.49 cm, and for the number of branches came 27.62 branches $Plant^{-1}$ and the number of leaves reached 124.49 leaves $Plant^{-1}$ and the leaf area reached 1989.12 cm^2 respectively. In contrast, the non-fertilization treatment gave the lowest averages 50.54cm and 12.64 branches $plant^{-1}$ and 83.30 leaves $plant^{-1}$ and 1897.39 cm^2), respectively.

Table shows that there was no significant effect of spraying treatments with Nano-magnesium on plant height and number of branches, that treatment 180 mg Mg L^{-1} gave the highest number of leaves (122.94 leaf $plant^{-1}$) and leaf area (1996.62 cm^2) respectively, superior to the control treatment, which gave (98.85 leaf $plant^{-1}$) and (1931.59 cm^2). Also, the table results showed no significant interaction between phosphorous and Nano-magnesium spray treatments on plant height and number of branches. At the same time, there was significant interaction in the number of leaves and leaf area, that the treatment 180 mg L^{-1} interacting with 50 kg P ha^{-1} gave the highest leaf area and number of leaves of Datura plant reached 2056.60 cm2 and 150.59 $leaf^{-1,}$ respectively, while the four levels of Nano-magnesium interacting with the treatment of no phosphorous addition gave the lowest averages.

Phosphorous levels	Plant height (cm)	No.of branches (branche $plant^{-1}$)	No. of leaves (leave $plant^{-1}$)	Leaf area (cm^2)
Control (0)	50.54 c	12.64 c	83.30 c	1989.02 c
25 kg P h^{-1}	57.53 b	19.84 b	98.72 b	1942.18 b
50 kg P h^{-1}	62.49 a	27.62 a	124.49 a	1989.12 a
75 kg P h^{-1}	62.53 a	27.59 a	125.35 a	1989.21 a
LSD 0.05	2.067*	1.702*	6.064*	17.654*
Magnesium concentrations				
CONTROL (0)	58.32 a	21.89 a	98.85 d	1931.59 d
60 mg Mg L^{-1}	58.06 a	21.83a	101.76 c	1938.98 c
120 mg Mg L^{-1}	58.45 a	22.06 a	108.30 b	1955.70 b
180 mg Mg L^{-1}	58.27 a	21.90 a	122.94 a	1996.62 a

LSD 0.05		N.S	N.S	6.064*	17.654*
CONTROL (0)	CONTROL (0)	50.54 a	12.40 a	81.61 de	1894.22 de
	60 mg Mg L^{-1}	50.22 a	12.68 a	81.52 de	1896.82 de
	120 mg Mg L^{-1}	50.77 a	12.83 a	83.50 de	1905.58 de
	180 mg Mg L^{-1}	50.70 a	12.66 a	86.58 de	1912.94 de
25 kg P h^{-1}	CONTROL (0)	57.62 a	19.95 a	92.72 d	1927.40 d
	60 mg Mg L^{-1}	57.03 a	19.59 a	94.45 d	1934.37 d
	120 mg Mg L^{-1}	57.91 a	19.89 a	100.27 d	1946.59 d
	180 mg Mg L^{-1}	57.55 a	19.92 a	107.45 bcd	1960.37 bcd
50 kg P h^{-1}	CONTROL (0)	62.53 a	27.69 a	110.70 c	1952.37 c
	60 mg Mg L^{-1}	62.41 a	27.37 a	115.49 bc	1962.22 bc
	120 mg Mg L^{-1}	62.60 a	27.77 a	124.61 b	1985.28 b
	180 mg Mg L^{-1}	62.41 a	27.64 a	147.14 a	2056.60 a
75 kg P h^{-1}	CONTROL (0)	62.60 a	27.52 a	110.38 c	1952.38 c
	60 mg Mg L^{-1}	62.60 a	27.69 a	115.58 bc	1962.52 bc
	120 mg Mg L^{-1}	62.53 a	27.77 a	124.83 b	1985.34 b
	180 mg Mg L^{-1}	62.41 a	27.37 a	150.59 a	2056.59 a
LSD 0.05		N.S	N.S	12.129*	35.307*

*: It means that there are significant differences at the level of probability 0.05.

N.S: It means that there are no significant differences at the level of probability 0.05.

a, b, c, d,e: Similar letters mean there are no significant differences; different letters mean there are substantial differences

Table 1. Effect of phosphorous and nano-magnesium spray on some traits of vegetative growth of Datura.

The results of Table 2 showed that phosphorus caused a significant increase in the yield of leaves and the number of fruits of Datura, that treatment 50 kg P ha^{-1} gave the highest averages of the yield of leaves and number of fruits reached 945.76 kg ha^{-1}, 26.02 fruit $Plant^{-1}$, respectively. In contrast, the non-fertilization treatment gave the lowest averages (671.09 kg ha^{-1} and 16.83 fruit $plant^{-1}$). In comparison, the table results showed no significant effect of phosphorus treatments on the weight of 1000 grains. As shown in Table that,

spraying Nano-magnesium caused a significant increase in the yield of leaves and the number of fruits of Datura, and the treatment 180 mg Mg L^{-1} gave the highest yield of leaves (886.59 kg ha^{-1}) and the number of fruits (26.56 fruits $plant^{-1}$), while the control treatment gave the lowest averages (815.21 kg ha^{-1} and 19.21 fruits $plant^{-1}$) respectively. The results of Table showed a significant interaction between phosphorus and nano-magnesium spray in the yield of Datura leaves; the interaction of 180 mg Mg L^{-1} with 50 and 75 kg h^{-1} gave the highest yield of leaves (1015.24 and 1088.66 kg h^{-1}) respectively and for the number of fruits (33.44 and 33.43 fruits $plant^{-1}$) respectively, while the four treatments of phosphorus and magnesium interacting with the non-fertilization treatment gave the lowest averages of leaf yield and the number of Datura fruits.

Phosphorous levels		**Leaf yield (kg h^{-1})**	**Number of fruits (fruit $plant^{-1}$)**	**Number of seeds (seed $fruit^{-1}$)**	**Weight of 1000 seeds (g)**
Control (0)		671.09 c	16.83 c	179.64 c	4.26 a
25 kg P h^{-1}		798.30 b	20.35 b	193.22 b	4.89 a
50 kg P h^{-1}		945.76 a	26.02 a	228.14 a	5.03 a
75 kg P h^{-1}		947.00 a	25.98 a	227.86 a	5.11 a
LSD 0.05		18.827 *	1.749 *	13.462*	N.S
Magnesium concentrations					
CONTROL (0)		815.21 c	19.21 c	189.36 c	4.49 a
60 mg Mg L^{-1}		822.01 bc	20.93 bc	195.09 bc	4.96 a
120 mg Mg L^{-1}		838.33 b	22.49 b	203.78 b	4.96 a
180 mg Mg L^{-1}		886.59 a	26.56 a	240.63 a	4.88 a
LSD 0.05		18.827 *	1.749 *	13.462 *	N.S
CONTROL (0)	CONTROL (0)	650.66 f	16.56 f	176.32 f	162.85 a
	60 mg Mg L^{-1}	657.48 ef	16.66 ef	177.48 of	4.71 a
	120 mg Mg L^{-1}	682.58 ef	16.94 ef	182.05 of	4.73 a
	180 mg Mg L^{-1}	693.63 e	17.15 e	182.70 e	4.74 a
25 kg P h^{-1}	CONTROL (0)	789.12 c	18.65 c	185.22 c	4.89 a
	60 mg Mg L^{-1}	791.64 c	19.56 c	189.46 c	4.90 a
	120 mg Mg L^{-1}	800.58 c	20.94 c	195.61 c	4.90 a
	180 mg Mg L^{-1}	811.85 c	22.23 c	202.60 c	4.89 a
50 kg P h^{-1}	CONTROL (0)	910.57 b	20.86 b	198.41 b	5.12 a

	60 mg Mg L^{-1}	919.63 b	23.75 b	206.75 b	5.12 a
	120 mg Mg L^{-1}	934.61 b	26.05 b	218.75 b	5.11 a
	180 mg Mg L^{-1}	1018.24 a	33.44 a	288.63 a	4.79 a
75 kg P h^{-1}	CONTROL (0)	910.48 b	20.76 b	197.47 b	5.10 a
	60 mg Mg L^{-1}	919.29 b	23.73 b	206.66 b	5.12 a
	120 mg Mg L^{-1}	935.55 b	26.01 b	218.70 b	5.12 a
	180 mg Mg L^{-1}	1022.66 a	33.43 a	288.61 a	5.12 a
LSD 0.05		37.654 *	3.499 *	26.924 *	N.S

*: It means that there are significant differences at the level of probability 0.05.

N.S: It means that there are no significant differences at the level of probability 0.05.

a, b, c, d,e, f: Similar letters mean no significant differences, but different letters mean significant differences.

Table 2. Effect of phosphorous and nano-magnesium spray on some productive traits of Datura

The results of Table 3 showed that phosphorus caused a significant increase in the total seed yield and alkaloids in leaves and alkaloids in seeds, treatment 50 kg P ha^{-1} gave the highest seed yield (501.36 kg ha^{-1}) and for alkaloids in leaves (13.16%) and alkaloids in seeds (13.18%) respectively, while the non-fertilization treatment gave the lowest averages (320.29 kg h^{-1}, 4.36% and 5.37%). As shown, spraying Nano-magnesium caused a significant increase in the total seed yield and alkaloids in leaves and seeds; the treatment 180 mg Mg L^{-1} recorded the highest seed yield (486.17 kg h^{-1}) and alkaloids in leaves (14.86%) and in seeds (15.10 %). In contrast, the distilled water spray treatment recorded the lowest averages (395.49 kg h^{-1}, 5.43% and 5.83%). The results of Table 3 showed a significant interaction between phosphorus and Nano-magnesium spray in the total seed yield, recorded 180 mg Mg L^{-1} interacting with 50 and 75 kg P $h^{-1,}$ the highest total seed yield of Datura plant (599.81 and 600.88 kg h^{-1}) respectively, and for alkaloids in leaves (20.83% and 20.86%) respectively, and for alkaloids of roots (20.86% and 20.87%) respectively, While the control treatment for magnesium interacting with no phosphorous fertilization less than averages.

Phosphorous levels	**Seed yield (kg h^{-1})**	**Alkaloids in leaves (%)**	**Alkaloids in seeds (%)**
Control (0)	320.29 c	4.36 c	5.37 c
25 kg P h^{-1}	384.12 b	8.76 b	9.16 b
50 kg P h^{-1}	501.36 a	13.16 a	13.18 a
75 kg P h^{-1}	501.49 a	13.16 a	13.18 a
LSD 0.05	19.276 *	1.633 *	1.772 *
CONTROL (0)	395.49 c	5.43 d	5.83 d
60 mg Mg L^{-1}	405.54 bc	8.44 c	8.84 c
120 mg Mg L^{-1}	422.07 b	10.72 b	11.12 b

180 mg Mg L^{-1}		486.17 a	14.86 a	15.10 a
LSD 0.05		19.276 *	1.633 *	1.772 *
CONTROL (0)	CONTROL (0)	310.39 c	4.13 c	5.18 c
	60 mg Mg L^{-1}	311.69 c	4.13 c	5.20 c
	120 mg Mg L^{-1}	324.29 c	4.34 c	5.47 c
	180 mg Mg L^{-1}	334.81 c	4.83 c	5.64 c
25 kg P h^{-1}	CONTROL (0)	310.39 c	5.25 c	5.84 c
	60 mg Mg L^{-1}	311.69 c	7.26 c	7.84 c
	120 mg Mg L^{-1}	324.29 c	9.64 bc	9.91 bc
	180 mg Mg L^{-1}	334.81 c	12.90 b	13.05 b
50 kg P h^{-1}	CONTROL (0)	451.19 b	6.18 c	6.15 c
	60 mg Mg L^{-1}	467.06 b	11.19 b	11.16 b
	120 mg Mg L^{-1}	487.37 b	14.45 b	14.56 b
	180 mg Mg L^{-1}	599.81 a	20.83 a	20.86 a
75 kg P h^{-1}	CONTROL (0)	454.44 b	6.14 c	6.15 c
	60 mg Mg L^{-1}	469.78 b	11.18 b	11.18 b
	120 mg Mg L^{-1}	488.85 b	14.46 b	14.54 b
	180 mg Mg L^{-1}	600.88 a	20.86 a	20.87 a
LSD 0.05		38.553 *	3.266 *	3.544 *

*: It means that there are significant differences at the level of probability 0.05.

N.S: It means that there are no significant differences at the level of probability 0.05.

a, b, c, d: Similar letters mean no significant differences and different letters mean significant differences.

Table 3. Effect of phosphorous and nano-magnesium spray on seed yield and percentage of alkaloids in leaves and seeds of Datura.

DISCUSSION

The function of phosphorus in stimulating cell division may be related to the function of phosphorus in increasing the height, number of branches, and number of leaves of the Datura plant when phosphorous levels increase[12, 13]. Phosphorus contributes to forming energy components (ATP, CTP, and GTP) and synthesizing nucleic acids, DNA, RNA, and enzymatic chaperones. Amine derivatives affect the synthesis of gibberellic acid and cause plants to become more robust and grow to a bigger height[14]. Amine derivatives boost cellular

activity and help to maintain normal hormone levels. Phosphorus does more than just fortify the plant's root structure; it also helps the plant create cytokinins, increasing the potential number of cells that may be produced[15]. Phosphorus is essential for healthy plant growth. Breaking the domination apical will result in the growth of cell membranes, the transport of sugar, and the expansion of leaves[16]. This will also result in the production of lateral buds and extra branches. Increasing the availability of magnesium pectate, which coexists with calcium pectate in sticking cellulose fibers when building cell walls, and thus increasing the process of cell division, which works to increase the number of leaves[17], is attributed to the role that nano-magnesium plays in increasing the availability of magnesium pectate. This is in addition to the entry of magnesium into the chlorophyll molecule, which increases the amount of magnesium in the chlorophyll molecule. It is possible to trace the rise in leaf yield to the increase in phosphorus absorbed during the early stages of plant growth. This led to the increase in the number of leaves and the number of leaves that the plant produced. Branches, leaf area, and chlorophyll concentration, which increased the amount of metabolism necessary in increasing flower buds and stimulating them to form fruits[18], in addition to the role of indirect phosphorus in the absorption of nitrogen and potassium through the development of the root system, which increases vegetative growth[4]. Branches, leaf area, and chlorophyll concentration all increased the metabolism necessary to increase flower buds and stimulate them to form fruits[3]. The availability of phosphorus led to an increase in the plant's overall growth, in addition to its contribution to the formation of nucleic acids and some energy compounds; this increased the number of branches and the number of fruits, which then increased the number of seeds. The significance of phosphorus in the plant's metabolic activities is demonstrated by the fact that its availability led to an increase in the plant's overall growth. It is possible to attribute the increase in leaf yield and the number of Datura fruits that occurred after spraying with Nanomagnesium to the role that magnesium played in increasing the number of leaves, branches, and leaf area. This role was positively reflected in the increase in the yield of leaves, and its role in improving the photosynthesis process was also a contributing factor. Extending the surface area of the leaves increases the quantity of photosynthetic products accumulated, which is necessary for the development of flower buds and leads to an increase in the total number of fruits produced. The increase in phosphorous levels caused a significant increase in the whole seed yield, and the percentage of alkaloids in seeds and leaves can be attributed to the role of phosphorus. Phosphorus also plays a role in creating amino acids by helping to make enzymes, which are required for some of the most critical steps in producing amino acids. That spraying Nano-magnesium caused a significant increase in the total seed yield as well as an increase in the number of alkaloids found in the leaves and seeds, and that this moral superiority is due to the rise in the content of chlorophyll leaves and then raising the efficiency of carbon representation, which caused an increase in primary and secondary metabolic products including alkaloids[19]. In addition, magnesium's effect in elevating the proportion of alkaloids present in the plant's leaves led to an increase in the compound's accumulation in the seeds[20].

CONCLUSIONS

The results of this study enable us to conclude that phosphorus and magnesium increase the yield of the leaves, which is an essential part of the plant since the Datura leaf contains the active compounds involved in the pharmaceutical industry. It is noted that phosphorus and magnesium increase the yield of leaves, seeds, and active substances. This is what makes us recommend spraying nano-magnesium and treating it with phosphorous fertilizer to workers in the field of medicinal plants to increase the production of alkaloids from the Datura plant. It was also discovered that excessive amounts of phosphorous and nano-magnesium may not be

advantageous to the plant; consequently, we advise adding these elements at moderate levels to prevent increasing their concentrations within the plant, which would ultimately cause the plant to suffer from damage.

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