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ORIGINAL ARTICLE

NANO-FERTILIZER AND SPRAYING TIME EFFECTS ON SUDAN GRASS GROWTH AND FORAGE YIELD IN SOUTHERN IRAQ

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Abstract: A field experiment was conducted in Agriculture College farm, Basrah University, Iraq during autumn season 2020 to study the effect of foliar application levels of Nano-fertilizer concentrates (6, 9, 12 and 15 $g.L^{-1}$) and spray times (one time, two times and three times) on growth and forage yield of Sudan grass hybrid. A Randomized complete block design (RCBD) with a split- plots was used with three replications. The main-plots included spray times, while the sub- plots included levels of nano-fertilizer. The results showed that the concentrations of foliar nano fertilizer and the number of sprays and their interaction caused a significant effect on growth and forage yield. The values of the plant height, tillers number, leaves number, leaf area, stem diameter, green and dry forage yield of plant were 260 cm, 13.00 tiller $Plant^{-1}$, 23 leaf $tiller^{-1}$, 9750.16cm^2, 16.00mm, 56.97 $t.ha^{-1}$ and 22.96 $t.ha^{-1}$, respectively obtained from the interaction of three sprays and 15 $g.L^{-1}$. On the other hand, values of one spray and 3$g.L^{-1}$ of nano-fertilizer gave the lowest. The use of nano-fertilizers has a greater effect on growth and crop production. This would decrease the cost of fertilizer for crop production as well as reducing pollution risks.

Key Words: Nano-fertilizer, Sudan grass, Hybrid, Plant growth, Forage yield

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1. Introduction

The Sudan grass (Sorghum vulgare var. sudanense) is one of the sorghum groups that follow the Poaceae family and it is a forage crop that is native to tropical and subtropical regions in eastern Africa. It is regarded as a promising green forage, silage and hay source [Ali *et al.* (2014)]. and it is similar in many of vegetative and chemical characteristics to sorghum bicolor, which enabled the production of some hybrids between them. Sudan grass hybrids are a product of crossed sorghum with Sudanese, these hybrids grow up fast after being cut, produced the multiple cuts, re-growth capacity and resistance to drought and salinity [Jung *et al.* (2015)]. Micronutrients are important in plant growth and required in small amounts by plants. Micronutrients stimulate the photosynthesis cycle and thus influence the yield and quality of the plant. The addition of traditional chemical fertilizers and their excessive use lead to environmental pollution in addition to the high costs of these fertilizers [Walpola and Yoon (2012)], as a result of the negative effects of improper use of chemical fertilizers, including the problem of soil pollution as well as increasing the salinity of the soils of the region. It is necessary to think about using modern fertilizers as an alternative to traditional fertilizers and using them to provide the nutrients necessary for plant growth and increase productivity, while preserving soil from pollution [Miransari (2011)]. One of these is the environmentally friendly and very effective fertilizer called nano-fertilizer. Nano-fertilizers have distinct properties due to their small size and large surface area, which leads to an increase in the surface of absorption, which is reflected in the increase of photosynthesis, thus increased plant productivity. As a result, nanotechnology is used to produce these agriculturally useful nanoparticles and it can be used in increasing the value of agricultural production [Noaema *et al.* (2020)] Therefore, the present study aimed to investigate the effect of foliar spraying with nano-fertilizer and spray times on growth and forage yield of

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Sudan grass hybrid in southern of Iraq.

2. Materials and Methods

A field experiment was conducted in Agriculture College farm, Basrah University, Iraq during autumn season 2020 to study the effect of foliar application levels of Nano-fertilizer concentrates (6, 9, 12 and 15 g.L^{-1}) its symbol (N0, N1, N2, N3) and spray times (one time, two times and three times) its symbol (T1, T2, T3) on growth and forage yield of Sudan grass hybrid. A randomized complete block design (RCBD) with a split- plots was used with three replications. The main-plots included spray times while, the sub-plots included levels of Nano-fertilizer which contains 11 nutrients (5% nitrogen, 3% phosphorus, 3% potassium, 6% calcium, 6% magnesium, 8% zinc, 4.5% iron, 0.7% manganese, 0.1% boron, 0.65% copper, 65% molybdenum). Table 1 shows the physical and chemical properties of the soil which analyzed according to methods presented by Page *et al.* (1982). The plot was 3m×3m, with six rows of 50cm spacing, the distance between hills was 20 cm, seeds Sudan grass hybrid (6FSG 214 BMR) were sown on15th July. However, nitrogen fertilizer in form of urea (46.5 %N) at rate of 180 kg.N.ha^{-1}. was added in three doses. The first dose (60 kg.N.ha^{-1}) was added at sowing time, the second dose (60 kg.N.ha^{-1}) was added 21 days after sowing and the third dose (60 kg.N.ha^{-1}) was added 21 days after the second dose. Triple superphosphate fertilizer (46% P_2O_5) at a rate of 120 kg P_2O_5 h^{-1} was also added as a source of phosphorus at planting. Nano- fertilizer sprayed early in the morning during the various times: The first time (After 2 weeks from thinning), the second time (After 2 weeks from thinning + tillering) and the third time (after 2 weeks from thinning + tillering + stem elongation). Weed control was done manually whenever possible and cultural treatments were done according to the crop's needs. Before harvest, ten plants were randomly selected from each plot for collection of different data on growth characters such as plant height, number of tillers, number of leaves per tiller, leaf area and stem diameter. One square meter of each plot was selected from the middle rows to calculate the yield of green forage, then dried at 70^{o}C in an aerated oven in order to measure dry forage yield. The data were analyzed statistically by using Genstat edition 12.1. using the least significant difference (L.S.D) at 0.05% [Noaema *et al.* (2020)].

3. Results and Discussion

Plant height (cm)

Table 2 shows that the influence of nano fertilizer on plant height has a significant effect. N4 and N3 (15 and 18 g.L^{-1}) concentrations are superior by giving the average height reached 236.10 cm and 215.37 cm respectively, while the control treatment gave the lowest height (182.43cm). The role of nano-fertilizers in increasing cell division has resulted in an increase in plant height, as a result plant growth and development. This finding is in agreement with Dhoke *et al.* (2013), Bhatia (2014) and Sharifi *et al.* (2016) on the effects of nano-fertilizer on plant height on different plants. The data in Table 2 show that plant height was not significantly affected by spray times. The interaction between nano-fertilizer concentrations and the number of spraying times was significant ($P < 0.05$) . The highest plant height was at the concentration N4 and T3 (260.00cm) and the lowest value was associated with the addition of N1 with T1 (178.00cm). The spraying of three times in the stages when the plant is in need of nutrients may increase the ability of the plant to grow and develop.

Tillers number Plant^{-1}

The number of tillers of plant play an important role in its growth and development and directly influence on forage crop yield. The data (Table 2) regarding that number of tillers per plant was significantly influenced by nano-fertilizer concentrations, maximum tillers were observed in N4 (12.11 tiller Plant^{-1}) which was statistically at par with N3, where minimum tillers was in N1 (7.89 tiller Plant^{-1}). This may be due to an increase in photosynthetic pigments and mineral nutrient absorption, so nitrogen affects the growth and development of the plant as it regulates the action of plant hormones (auxins and cytokinins). Potassium also has a positive effect in the process of cell expansion, which is necessary for the processes of growth and division [Mengel and Arneke (1982)], in addition to its

Table 1: Some Physical and chemical properties of soil.

Properties	pH	EC (ds.m^{-1})	Organic matter (g.kg^{-1})	Available N	Available P	Available K	Sand	Silt	Clay
				(mg.kg^{-1})			%		
	7.5	22	1.50	30.50	19.33	111.40	3.80	5.30	0.9

Table 2: Effect of Nano fertilizer concentrations and spray times on Sudan grass growth and forage yield.

Treatments		PH	TN	LN	LA	SD	GFY	DFY
Nano fertilizer ($g.l^{-1}$)	N1	182.43	7.89	17.78	6320.80	12.00	43.93	15.91
	N2	188.67	8.89	19.11	6507.81	12.66	48.41	17.56
	N3	215.37	10.11	20.00	7873.28	13.34	50.48	18.63
	N4	236.10	12.11	21.22	9726.60	14.67	54.62	20.87
LSD ($P \leq 0.05$)		20.28	1.25	1.058	824.10	0.477	1.503	0.705
Sprays time	T1	199.08	8.33	16.67	7542.15	11.59	45.33	16.37
	T2	201.03	10.33	20.58	7620.78	13.17	50.57	17.87
	T3	216.83	10.58	21.33	7658.45	14.75	52.18	20.51
LSD ($P \leq 0.05$)		N.S	1.09	0.916	N.S	0.413	1.302	0.610
T1	N1	178.00	7.33	15.00	6215.40	9.67	43.20	15.21
	N2	181.00	7.33	16.00	6461.27	11.33	42.87	15.26
	N3	207.0	8.00	17.00	7795.8	11.67	43.53	16.63
	N4	230.30	10.67	18.67	9696.11	13.67	51.60	18.37
T2	N1	182.00	8.00	19.00	6285.61	12.33	45.27	15.34
	N2	195.70	9.67	20.33	6522.94	12.33	48.95	17.04
	N3	208.40	11.00	21.00	7941.02	13.67	52.75	17.51
	N4	218.00	12.67	22.00	9733.53	14.33	55.30	21.57
T3	N1	187.30	8.33	19.33	6461.39	14.00	43.33	17.19
	N2	189.30	9.67	21.00	6539.21	14.33	53.40	20.40
	N3	230.70	11.33	22.00	7883.03	14.67	55.15	21.74
	N4	260.00	13.00	23.00	9750.16	16.00	56.97	22.96
LSD ($P \leq 0.05$)		35.12	2.17	1.833	1427.6	0.826	2.604	1.221

PH–Plant height (cm), TN-Tillers number ($plant^{-1}$), LN–Leaf number ($plant^{-1}$), LA–Leaf area (cm^2), SD- Stem diameter (mm), GFY–Grain forage yield ($t.ha^{-1}$). DFY-Dry forage yield ($t.ha^{-1}$).

role in activating enzymes, this will lead to an increase and accumulation of dry matter and growth rates and this was clearly reflected in the increase in the number of tillers, as well as the positive role of the micronutrients in the various biological processes that provided more favorable conditions for plant growth and This led to an increase in the number of tillers per plant. Data also revealed that tillers number was significantly affected by the spray times, the treatment T3 increased number of tillers per plant by 27.01 % compared to the control. The data also indicated that the interaction was significant, the maximum number of tillers (13.00 tiller $Plant^{-1}$) were noted when nano- fertilizer applied three times with a concentration of 15 $g.L^{-1}$ (N4T3) and minimum number of tillers (7.33 tiller $Plant^{-1}$) were observed in those treatments where nano- fertilizer applied at the concentrations of N1 and N2 when spraying at one time (T1).

Leaves number $tiller^{-1}$

Spraying of nano fertilizer also increased the number of leaves per tiller significantly (Table 1). Treatment N4 produced statistically the maximum number of leaves (21.22 leaf $tiller^{-1}$) as compared with N1 treatment of 17.78 leaves $tiller^{-1}$. Nano-fertilizers increase the rate of photosynthesis by creating more capacity for various metabolic processes in the plant that increase photosynthesis rates, resulting in increased dry matter and carbohydrate output and thus increased plant vegetative growth in general [Qureshi *et al.* (2018)]. The leaves number was 21.33 leaf $tiller^{-1}$ obtained at three sprays time (T3) at par with T2 (20.58 leaves $tiller^{-1}$), on the other hand the lowest Sudan grass leaves number per tiller were 16.67 at T1 treatment. The interaction effect of nano fertilizer with spray times was significant, the combination of N4T3 was superior with leaves number per tiller (23.00 leaves $tiller^{-1}$), while the combination N1T1 gave the lowest rate of number of leaves per tiller (15.00 leaves $tiller^{-1}$).

Leaf area (cm^2)

Leaf area has a major impact on the crop's total biomass and fodder efficiency. The results (Table 2) showed that the nano fertilization had a significant increase in leaf area. Spraying of N4 nano-fertilizer produced maximum value of leaf area character (9726.60cm^2) as compared with other treatments. These results may be due to the fact that nano-fertilizers make it easier for plants to use nutrients, which improves pigment formation, photosynthesis rate, dry material production and increased plant development [Hediat (2012)]. On the other hand no significant differences were recorded among the spray times regarding to leaf area of plants. Optimums nano-fertilizer concentrations interaction with spray times played significant role in affecting leaf area, where superior interaction (N4 T3) on other interactions which was 9750.16cm^2, while the minimum leaf area was found with N1 T1 (6215.40 cm^2).

Stem diameter (mm)

The data presented in Table 2 found that stem diameter increased significantly from 12.00 mm of control plants to 14.67mm of plants treated by N4 of nano-fertilizer. Nano-fertilizers increase the rate of photosynthesis by allowing more space for various biochemical activities in the plant resulting in an increase in dry matter and carbohydrates production and thus reflected to increase the diameter of the stem [Abu Dahi (1997)]. Spray times lead to a significant increase in Stem diameter. The maximum stem diameter was recorded in T3 treatment (14.75 mm), while spray times T1 recorded 11.59 mm. The interaction effect of nano fertilizer and spray times was significant and led to the highest stem diameter of 16.00mm at N4T3, while the combination of N1T1 gave the minimum stem diameter (9.67mm).

Green fodder yield (t.ha^{-1})

The effect of nano fertilizer and sprays time on green forage yield (GFY) was significant (Table 2). The crop treated with N4 produced significantly higher GFY (54.62 t.ha^{-1}) than the other treatments, the minimum GFY was produced by N1 treatment (43.93 t.ha^{-1}). This may be due to the absorption and rapid assimilation of nano nutrients leading to an increase in some growth characteristics as height Plant and leaf area and then this was positively reflected an increase in the forage yield. The different spray times also produced significant effect on GFY of Sudan grass crop. The treatment T3 gave the highest values of GFY (52.18 t.ha^{-1}), whereas the spray time T1 gave the lowest values of GFY (45.33 t.ha^{-1}). The interaction regarding green forage yield GFY was also significant. Interaction N4T3 where superior on other interactions which gave 56.97 t.ha^{-1}, while the minimum GFY was noticed with N2T1 (42.87 t.ha^{-1}).

Dry forage yield (t.ha^{-1})

Data of Table 2, also revealed that that DFY was significantly increased with an increased in nano-fertilizer concentration. Spraying of N4 treatment producing maximum DFY (20.87 t.ha^{-1}), N1 treatment gave the lowest DFY (15.91 t.ha^{-1}). On the other side, spraying of nano fertilizers at T3 led to the highest values of DFY (.20.51 t.ha^{-1}), the minimum values were recorded with T1 treatment (16.37 t.ha^{-1}). Nano-fertilizer concentration and spraying time interaction also significantly affected DFY. The highest DFY was produced by N4T3 (56.97 t.ha^{-1}), while N1 with T1 gave lower DFY (15.21 t.ha^{-1}).

4. Conclusion

The use of nano fertilizers has a greater effect on growth and crop production. This would decrease the cost of fertilizer for crop production as well reducing pollution risks. Crop growth and forage yield are improved by nano fertilizers, it could be concluded that spraying of nano fertilizer at 15 g.l^{-1} and splitting foliar application of nano-fertilizer more than once (three sprays) gave the maximum values of growth, green and dry forage yield at Basrah governorate conditions, Iraq.

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