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Effect of Foliar Application of Nano-Urea Under Different Nitrogen Levels on Growth and Nutrient Content of Pearl millet (*Pennisetum glaucum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment entitled "Effect of Foliar Application of Nano-Urea under Different Nitrogen Levels on Productivity and Quality of Pearl millet (*Pennisetum glaucum* L.)" was conducted at Research Farm, Vivekananda Global University, Jaipur (India) during *Kharif* season of 2021. The experiment was laid out with 9 treatment combinations comprising in a factorial randomized block design with three replications. Results showed that highest plant height, dry matter accumulation, chlorophyll content, nitrogen content, phosphorus content and potassium content in grain and straw of pearl millet was obtained with the application of 100% RDN which was significantly superior to 50% RDN. Results further showed that foliar spray of Nano-Urea (4 ml/l water) at 30 and 45 DAS significantly increased the plant height, dry matter accumulation, chlorophyll content, nitrogen content, phosphorus content and potassium content in grain and straw of pearl millet over control and foliar spray of Nano-Urea (4 ml/l water) at 30 DAS.

Keywords: Growth; nitrogen; nano-urea; nutrient content; pearl millet.

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1. INTRODUCTION

Pearlmillet [*Penisetum glaucum* (L.)] R. Br. Emend Stuntz] is one of the important cereal crops of arid and semi-arid regions. It has been estimated that pearl millet embodies a good productivity potential particularly in areas encountering extreme environmental stress situations on account of drought. It grows well on poor sandy soils as well as its drought escaping character has made it a popular crop of drought prone areas. It is extensively cultivated as dual-purpose crop. India is the largest producer of pearl millet with an annual production of 10.28 million tonnes from an area of 7.52 million ha with a productivity of 1368 kg ha^{-1} [1]. Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, and Haryana, are the major pearl millet growing states. All together they contribute more than 90 per cent of total area and production of the country. In the state of Rajasthan, pearl millet cultivation is mainly confined to the arid and semi-arid regions. Rajasthan stand first in the country that produced 4.69 million tons of grains from 4.29 million ha area. The average productivity of state is 1093 kg ha^{-1} [1] which is much below than its production potential; vary greatly with rainfall intensity and its distribution. Hence, our research effort should be diverted to remove the constraints that are responsible for its poor yield. Among the various constraints of its lower productivity in semi-arid region are erratic nature of climate, poor soil physical conditions, less availability and poor quality of irrigation water and imbalances fertilization with deficiencies of some macro and micro nutrients. Besides these, soils are course texture and have poor organic matter content, low water receptivity, excessive permeability and sharp increase in soil strength upon drying are also important factors associated with low production.

Nitrogen (N) occupies a conspicuous place in plant metabolic system. Nitrogen being a major food for plants is an essential constituent of protein and chlorophyll present in many major portions of the plant body. Nitrogen plays a most important role in various physiological processes [2]. Fertilizers have an axial role in enhancing the food production in developing countries especially after the introduction of high yielding and fertilizer responsive crop varieties. The applied nitrogen through fertilizers undergoes transformation processes such as biological nitrogen fixation, humus mineralization, immobilization, and nitrification at acidic and alkaline pH, respectively, denitrification and volatilization [3]. These transformation processes make nitrogen management very complex and quite difficult to improve the nitrogen use efficiency. In order to improve the nitrogen-use efficiency by crops, several strategies have been suggested in the past few decades. Among these, nanotechnology has the potential to revolutionize the agricultural system. Nano fertilizer technology is designed to deliver nutrients in a regulated pattern in correspondence with the crop demand thereby nutrient use efficiency can be improved without associated ill-effects [4]. Nano fertilizers are the important tools in agriculture to improve crop growth, yield and quality parameters, reduce wastage of fertilizers and cost of cultivation. Nanotechnology can reduce the rate of fertilizer nutrients loss through leaching and increase their availability to plants which ultimately leads to reduced water and soil pollution. Present day's nano fertilizers are emerging as an alternative to conventional fertilizers [5]. In order to solve higher fertilizer requirement during crop growth, environmental issues and also taking economic aspects, the use of nitrogen nano fertilizer is essential. Therefore, keeping above facts in view an experiment entitled "Effect of Foliar Application of Nano-Urea under Different Nitrogen Levels on Productivity and Quality of Pearl millet (*Penisetum glaucum* L.)" was conducted during *Kharif* season of 2021 at research farm, Vivekananda Global University, Jaipur.

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment was carried out during *Kharif* season of 2021 at Research Farm, Vivekananda Global University, Jaipur. Geographically, the study area is located at 075°88'99" E longitude and 26°81'17" N latitude and this region falls under agro-climatic zone III A of Rajasthan (Semi-arid Eastern Plain Zone). The region's climate is classified as semi-arid with characterized by aridity of the atmosphere and extremity of temperature both in summer (45.5ºC) and winter (4ºC) with annual rainfall of 500-700 mm. The soil of experimental field was loamy sand in texture, slightly alkaline in reaction.

2.2 Experimentation and Crop Husbandry

The experiment was laid out in factorial randomized block design with three replications and consisting three nitrogen levels (50% RDN, 75% RDN and 100% RDN) and three treatment of Nano-Urea (control, one spray of nano urea at 4 ml/l water at 30 DAS and two spray of nano urea at 4 ml/l water at 30 and 45 DAS). The gross plot size was 5.0 m x 3.6 m (18.0 m^2) and total experimental area was 486 m^2. The pearl millet variety 'HHB-229' was sown on 14^{th} July 2021. On the basis of gross plot size, the required quantity of fertilizer and Nano-Urea as per treatments was calculated and weighted for different plots. Full recommended dose of 40 kg P_2O_5 ha^{-1} was applied uniformly as basal at the time of sowing. Recommended dose of nitrogen at 90 kg ha^{-1} and was applied half as basal and half as top dressing. Liquid nano-urea was sprayed as per treatments. Standard crop production practice and methods were followed for fertilizer application and crop protection management to grow the crop.

2.3 Data Collection

Five plants were selected randomly from net plot and tagged for measurement of plant height and dry matter accumulation of pearl millet at different growth stages. Grain sample of pearl millet from individual plot was taken at the time of threshing for estimation of N, P and K content. The samples were dried in oven and grind separately using grinder and nitrogen content was determined by colorimetric method using Nessler's reagent [6], phosphorus content was determined by Vanadomolybdophosphoric acid method [7] and potassium content was determined by tri - acid digested material using Flame photometer [7].

2.4 Statistical Analysis

Comprehensive statistical analysis (treatment mean, standard error mean, critical difference and range of variation) and test of significance test (F-test) were carried out for each quantitative and qualitative trait. For this, entire biometric data recorded during the course of investigation were compiled in proper tables and statistically analyzed by using the standard procedures of statistical analysis for factorial randomized block design suggest by Panse and Sukhatme [8].

3. RESULTS AND DISCUSSION

3.1 Effect of Nitrogen Levels on Growth

A close perusal of data presented in Table 1 indicated that plant height, dry matter accumulation and chlorophyll content of pearl millet was affected significantly by different nitrogen levels. Application of 100% recommended dose of nitrogen being remained at par with application of 75% RDN, recorded significantly highest plant height and dry matter accumulation of pearl millet at 20, 40, 60 DAS as well as at harvest as compared to 50% RDN. The significantly highest chlorophyll content in pearl millet at 60 DAS was recorded with the application of 100% RDN which was closely followed by the application of 75% RDN but found superior to 50% RDN. It is well known fact that adequate fertilization to crops is known to improve various physiological and metabolic processes in the plant system. The increase in the growth character described above under higher dose of nitrogen may be ascribed to the fictional role of nitrogen in the plant body. This might be also due to the synergistic effect of nitrogen on chlorophyll content, cell division, photosynthetic rate and root activities of plants, resulting higher removal of nutrient and thereby increasing the growth attributes. Nitrogen played a key role in carbohydrates and protein metabolism; hence, it is essential in plant growth and development. The chief function of nitrogen is multiplication and cell elongation and tissue differentiation that ultimately enhanced vegetative growth through plant height and number and size of leaves (more leaf area). Large leaf area enhanced the capacity of the plants to intercept adequate sunlight, which might have resulted in the production of more assimilate thereby enhancing growth and development of the crop. Thus, with adequate supply of nitrogen the plants grow tall, produce more LAI and ultimately greater production of total dry matter accumulation. These results are in accordance with the findings of Bhanuchandar et al. [9], Choudhary et al. [10], Mandeewal et al. [11], Mandeewal et al. [12], Rana and Prasad [13], Kakarla et al. [14], Minz et al. [15] and Sharma et al. [16] in pearl millet and other field crops.

3.2 Effect of Nano-Urea on growth

It is evident from the data (Table 1) that the plant height, dry matter accumulation and chlorophyll content of pearl millet was significantly enhanced by the foliar application of Nano-Urea. Foliar spray of Nano-Urea (4 ml/l water) at 30 and 45 DAS recorded maximum plant height and dry matter accumulation of pearl millet at 40 DAS as compared to control but found statistically at par with foliar spray of Nano-Urea (4 ml/l water) at 30

DAS. The data further revealed that the same treatment also recorded significantly highest plant height and dry matter accumulation at 60 DAS as well as at harvest of pearl millet but it was found superior over control as well as foliar spray of Nano-Urea (4 ml/l water) at 30 DAS. Foliar spray of Nano-Urea (4 ml/l water) at 30 and 45 DAS recorded significantly highest chlorophyll content in pearl millet as compared to control and foliar spray of Nano-Urea (4 ml/l water) at 30 DAS. Nano-fertilizers have important role in physiological and biochemical processes of crops by increasing the availability of nutrients, which help in enhancing metabolic processes and promoting meristematic activities causing higher apical growth and photosynthetic area. It was observed that foliar spraying of nano N increased the growth attributes due to enhanced availability of nutrients through easy penetration of nano N through stomata of leaves via gas uptake [17]. This may be due to the role of nano fertilizers in improving the solubility and dispersion of insoluble nutrients to plants which affect the availability of nutrients, resulting from the increased effectiveness of plant biology leading to more efficient absorption of nutrients [18]. The other reason is, the ability of nano fertilizers to release nutrients for a longer period of time which helps in sustaining the nutrient supply of the plant, which has a positive effect on improving plant growth [19]. Foliar application of nano nitrogen caused increase in the nitrogen uptake through leaves and roots that might have led to increased mobilization of synthesized carbohydrates into amino acid and protein which stimulated the rapid cell division and cell elongation. Similar results have been reported by [20-22].

3.3 Effect of Nitrogen Levels on Nutrient Content

It is evident from the data in Table 2 that N, P and K content in grain and straw of pearl millet was significantly increased due to the nitrogen levels. The highest N, P and K content in grain and straw was recorded under the treatment of 100% RDN which was significantly higher over 50% RDN and 75% RDN.

The positive influence of nitrogen application on nutrient content in pearl millet appears to be due to improved nutritional level both in the root zone and plant system. The increased availability of nitrogen in root zone coupled with increased metabolic activity at cellular level might have increased nutrient uptake and their accumulation in vegetative plant parts. Increased accumulation of nutrients in vegetative plant parts with improved metabolism led to greater translocation of nutrients to reproductive organs of the crop and ultimately increased the contents in grain and straw. These results are in close conformity with the findings of [23-28].

Table 1. Effect of nitrogen levels and Nano-Urea on growth attributes of pearl millet

Treatments	Plant height (cm)				Dry matter accumulation (g m^{-2})				Chlorophyll content (mg g^{-1}) at 60 DAS
	At 20 DAS	At 40 DAS	At 60 DAS	At harvest	At 20 DAS	At 40 DAS	At 60 DAS	At harvest	
Nitrogen levels									
50% RDN	16.1	41.8	116.4	126.6	20.1	138.5	523.4	671.3	2.29
75% RDN	19.0	50.9	141.3	152.1	22.6	161.6	614.3	782.6	2.57
100% RDN	20.6	54.2	150.1	161.5	23.1	171.9	652.0	835.0	2.64
SEm ±	0.7	1.7	4.0	4.5	0.7	5.1	17.6	21.9	0.04
CD (P=0.05)	2.0	5.2	12.1	13.4	2.0	15.1	52.8	65.6	0.11
Nano-urea									
Control	17.9	41.4	115.6	124.9	21.6	137.6	520.9	666.8	2.27
One spray of nano urea at 4 ml/l water at 30 DAS	18.6	51.2	137.8	148.6	22.0	162.4	604.1	768.1	2.54
Two spray of nano urea at 4 ml/l water at 30 and 45 DAS	19.2	54.4	154.4	166.6	22.3	172.0	664.7	854.0	2.69
SEm ±	0.7	1.7	4.0	4.5	0.7	5.1	17.6	21.9	0.04
CD (P=0.05)	NS	5.2	12.1	13.4	NS	15.1	52.8	65.6	0.11

Table 2. Effect of nitrogen levels and Nano-Urea on nutrient content of pearl millet

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	In grain	In straw	In grain	In straw	In grain	In straw
Nitrogen levels						
50% RDN	1.35	0.523	0.243	0.156	0.406	1.49
75% RDN	1.51	0.598	0.274	0.176	0.467	1.69
100% RDN	1.61	0.637	0.297	0.192	0.509	1.84
SEm ±	0.02	0.009	0.004	0.003	0.007	0.03
CD (P=0.05)	0.07	0.026	0.013	0.008	0.022	0.08
Nano-urea						
Control	1.33	0.520	0.240	0.154	0.404	1.47
One spray of nano urea at 4 ml/l water at 30 DAS	1.53	0.594	0.277	0.178	0.470	1.70
Two spray of nano urea at 4 ml/l water at 30 and 45 DAS	1.63	0.643	0.297	0.192	0.508	1.85
SEm ±	0.02	0.009	0.004	0.003	0.007	0.03
CD (P=0.05)	0.07	0.026	0.013	0.008	0.022	0.08

3.4 Effect of Nano-Urea on Nutrient Content

Further reference of data given in Table 2 revealed that N, P and K content in grain and straw significantly enhanced due to foliar spray of Nano-Urea in the comparison of control. The significantly highest N, P and K content in grain and straw of pearl millet was recorded with foliar spray of Nano-Urea (4 ml/l water) at 30 and 45 DAS over control and foliar spray of Nano-Urea (4 ml/l water) at 30 DAS. This might be due to the fact that nano-fertilizers have large surface area and particle size, less than the pore size of root and leaves of the plant which can increase penetration into the plant from applied surface and improve uptake and nutrient use efficiency of the nano-fertilizer. Reduction of particle size results in increased specific surface area and number of particles per unit area of a fertilizer that provide more opportunity to contact of nano-fertilizer which leads to more penetration and uptake of the nutrient and thus results in high nutrient content and their uptake [29]. Significant improvement in the present study is in close agreement with the findings of Burhan and AL-Hassan [30] and Mehta and Bharat [31].

4. CONCLUSION

Keeping in view the objectives to undertake the study and the results obtained after conducting the experiment for one year, it was concluded that application of different nitrogen levels and foliar spray of Nano-Urea significantly enhanced the growth and nutrient content of pearl millet. The application of 100% RDN and foliar spray of Nano-Urea (4 ml/l water) at 30 and 45 DAS gave significantly highest growth parameters and N, P and K content in grain and straw of pearl millet.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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