Enhancing Growth and Nutrient Use Efficiency in Potato through Nano Urea and Zinc Sulfate Application in Haryana

Abstract

The present study investigates the impact of nano urea and zinc sulfate on the growth and nutrient use efficiency of potato in Haryana. Given potato's responsiveness to nitrogen, this research explores alternative nutrient management approaches to mitigate the environmental issues linked to conventional nitrogen fertilizers. Nano urea, a recent innovation in agricultural nanotechnology, is designed for gradual nutrient release, potentially improving nitrogen use efficiency. Zinc, a critical micronutrient, enhances potato growth by improving enzymatic antioxidant activity, starch, and total soluble sugar content. Conducted during the 2022-23 and 2023-24 *Rabi* seasons at CCS Haryana Agricultural University, the experiment used a randomized block design with 11 treatments combinations, *viz*., T1: Control, T2: RDN (Recommended dose of nitrogen, i.e. 150 kg/ha), T3:75% RDN + 25% N through Nano-Urea foliar spray at 30 and 45 DAP, T4: 50% RDN + 50% N through Nano-Urea foliar spray at 30 and 45 DAP, T5:75% RDN + foliar spray 2% urea at 30 and 45 DAP, T6: 50% RDN + foliar spray 2% urea at 30 and 45 DAP, T7: RDN + ZnSO4 @10 kg/ha, T8: T3+ Foliar spray of ZnSO4@ 0.2% at 30 and 45 DAP, T9: T4 + Foliar spray of ZnSO4@ 0.2% at 30 and 45 DAP, T10: T5 + Foliar spray of ZnSO4@ 0.2% at 30 and 45 DAP, T11: T6 + Foliar spray of ZnSO4@ 0.2% at 30 and 45 DAP. Key findings indicate that nano urea combined with zinc sulfate significantly increased plant height, especially under treatment T8 (75% RDN + 25% nitrogen through nano urea + foliar spray of $ZnSO_4$ at 0.2% at 30 and 45 days after planting [DAP]). This treatment also yielded the highest nitrogen use efficiency, suggesting nano urea's effectiveness in enhancing nutrient uptake. The study underscores nano urea's potential in sustainable potato cultivation, providing a regulated nutrient supply while addressing environmental concerns such as nitrogen leaching and greenhouse gas emissions. These findings offer promising insights for optimizing nitrogen and zinc management in potato crops to boost yield and quality sustainably.

Introduction:

The potato is esteemed as the "King of Vegetables" and is a highly valued vegetable crop within Haryana as well. It ranks as the most significant crop following wheat and rice, being cultivated in over 150 nations globally (**Singh, 2008**). In India, potatoes are cultivated over an expanse of 2,326.8 thousand hectares, yielding a production of 56,761.8 thousand metric tonnes and a productivity rate of 24.40 metric tonnes per hectare, respectively (**Anonymous, 2022**). In the state of Haryana, potatoes occupy an area of

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31.91 thousand hectares, yielding a production of 750.00 thousand metric tonnes with a productivity rate of 23.50 metric tonnes per hectare (**Anonymous, 2022a**).

Potato, recognized as a crop of considerable nutritional value, necessitates the presence of essential plant nutrients in optimal concentrations for the successful cultivation of the crop. Among the various essential nutrients, nitrogen stands as the most critical and limiting factor for the growth and development of crops. It plays a crucial role in the structure and configuration of nucleic acids, proteins, free amino acids, and enzymes within the plant. According to **Tisdale and Nelson (1975)**, nitrogen is an indispensable component of the chlorophyll molecule in addition to its function in protein formation. Potato exhibits a significant responsiveness to nitrogen (**Lynch and Rowberry, 1997**). Nitrogen is crucial for plant growth, as well as the production of proteins, protoplasm, and chlorophyll, its deficiency results in chlorosis and a decrease in leaf size, stunted growth (characterized by thin stems), and ultimately a decline in yield (**Perrenoud, 1993**).

Conventional fertilizer application methodologies have resulted in the significant overdosing of chemical fertilizers, a phenomenon that has become evident through issues such as eutrophication, volatilization, leaching, and the release of nitrous oxides, which are greenhouse gases contributing to global warming. An avant-garde technology known as nanotechnology is being developed to address the limitations of existing agricultural practices. One of the most promising advancements arising from the application of agricultural nanotechnology is the design of next-generation or "smart" fertilizers that potentially enhance nutrient utilization efficiency (**Brunner *et al.*, 2006**). Nanofertilizers (NFs) are nano-structured formulations of fertilizers that provide macro- and micronutrients, ensuring that nutrient release occurs gradually and under controlled conditions (**De Rosa *et al.*, 2010**). The novel physico-chemical characteristics of these nano-structured fertilizers enable them to release nutrients more effectively than traditional fertilizers. Nanofertilizers or nano-encapsulated nutrients possess the capability to release nutrients efficiently and on demand, thereby regulating plant development and enhancing target activity (**Nair *et al.*, 2010**). A new agricultural input derived from nanotechnology, nano urea, provides nitrogen to plants. Among these innovations, nanourea—a nanoscale variant of urea—has attracted considerable attention for its potential to improve nitrogen use efficiency in crops. Nanourea has the potential to enhance nitrogen use efficiency, which subsequently translates into improved growth, yield, and quality of crops. By facilitating a more regulated release of nitrogen, nanourea mitigates the risk of nutrient runoff and leaching, thereby addressing some of the significant environmental challenges associated with conventional fertilization methodologies.

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Plants necessitate a variety of nutrients for their growth and development, among which zinc is a vital micronutrient and the second most prevalent transition metal in plants following iron. The micronutrient zinc is capable of augmenting the enzymatic antioxidants (catalase and peroxidase), nonenzymatic antioxidants (total phenolics and anthocyanins), as well as carbohydrates (starch and total soluble sugars) in potato plants. There are gaps in the current knowledge of understanding the impact of nano urea and micronutrient like Zn on the growth and metabolism of potato plants.

Materials and Methods-

The present experiment was conducted at the Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during the winter seasons of 2022-23 and 2023-24 to study the effect of nano urea and zinc sulphate on growth, and nitrogen use efficiency of potato crop. The experiment was laid out in randomized block design with three replications. The experiment involved eleven treatments *i.e.* T1= Control; T2= RDN (Recommended dose of nitrogen, *i.e.* 150 kg/ha); T3= 75% RDN + 25% N through Nano-Urea foliar spray at 30 and 45 DAP; T4=50% RDN + 50% N through Nano-Urea foliar spray at 30 and 45 DAP; T5= 75% RDN + foliar spray 2% urea at 30 and 45 DAP; T6= 50% RDN + foliar spray 2% urea at 30 and 45 DAP; T7= RDN + $ZnSO_4$ @10 kg/ha; T8= T3+ Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP; T9= T4 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP; T10= T5 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP; T11= T6 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP.

Result and Discussion

The data on plant emergence percentage at 30 DAP has been presented in Table 1. Different treatments did not influence the plant emergence percentage significantly in both the years.

The pooled data confirmed that different treatments did not influence the plant emergence percentage significantly in both the years. However, maximum plant emergence percentage (94.67 %) was observed with treatment T2 (RDN (Recommended dose of nitrogen, *i.e.* 150 kg/ha), whereas, minimum plant emergence percentage (90.54 %) was observed with the control treatment. This result might be due to the food material that was already present in the seed tubers, which gave the emerging shoots an initial boost, rather than the application of fertilization, as the seed tubers did not build a root system to absorb the applied nitrogen prior to the shoot and root emergence.

The data on plant height at 30 DAP has been presented in Table 2. Plant height was significantly influenced by different treatments in both the years of investigation.

The pooled data confirmed that the maximum plant height (34.73 cm) was observed with treatment T7 (RDN + $ZnSO_4$ @10 kg/ha) which was found at par with treatment T2 (RDN (Recommended dose of nitrogen, *i.e.* 150 kg/ha) *i.e.* 33.72 cm, whereas, minimum plant height (23.83 cm) was observed with the control treatment. The probable reason might be due to the favourable effect of zinc on the proliferation of roots and thereby increasing the uptake of other plant nutrients particularly nitrogen from the soil, supplying it to the aerial parts of the plant and ultimately enhancing the vegetative growth of plants

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(**Poornima *et al*. 2019**). The increased availability of nitrogen, which is a chief component of amino acids, proteins, vitamins, enzymes and plant growth regulators (auxins), promoted rapid cell division and cell elongation, both longitudinally and transversely, and increased meristematic activities leading to an increase in internodal length, and thus, increased plant height at later growth stages. The findings of current investigation are in confirmation with the findings of **Jatav *et a*l. (2017), Singh *et al.* (2018) and Kumar *et al.* (2022).**

The data on plant height at 60 DAP has been presented in Table 3. Plant height was significantly influenced by different treatments in both the years of investigation.

The pooled data confirmed that the maximum plant height (43.22 cm) at 60 DAP was observed with treatment T7 (RDN + $ZnSO_4$ @10 kg/ha) which was found at par with treatments T8 (42.44 cm), T2 (42.16 cm) and T3 (41.74 cm), whereas, minimum plant height (32.28 cm) was observed with the control treatment.

The data on plant height at harvest has been presented in Table 4. Plant height was significantly influenced by different treatments in both the years of investigation.

The pooled data confirmed that the maximum plant height (57.30 cm) at harvest was observed with treatment T8 (T3+ Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP), which was found at par with treatment T3 (56.89 cm) and T7 (55.47 cm), whereas, minimum plant height (41.34 cm) was observed with the control treatment.

The data on number of stems per hill at 50 DAP has been presented in Table 5. Number of stems per hill was not significantly influenced by different treatments in both the years of investigation.

The pooled data confirmed that the maximum number of stems per hill at 50 DAP (5.67) was observed with treatment T8 (T3+ Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP) whereas, minimum number of stems per hill at 50 DAP *i.e.* 4.04 was observed with the control treatment. The effect was might be likely because stem number is primarily determined by the number of sprouts that emerge from the tuber at planting. Nitrogen application may enhance overall plant growth, but it does not influence the initial number of sprouts, which is governed by factors such as tuber size, variety, and planting conditions.

The data on nitrogen use efficiency (%) in soil after experimentation has been presented in Table 6. Nitrogen uptake by foliage (%) was significantly influenced by different treatments in both the years of investigation.

The pooled data confirmed that the maximum nitrogen use efficiency *i.e.*14.81% was observed with treatment T8 (T3+ Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP) which was found at par with treatment T3 (75% RDN + 25% N through Nano-Urea foliar spray at 30 and 45 DAP) *i.e.* 13.20%, whereas, minimum nitrogen use efficiency *i.e.* 0.00% was observed with the control treatment. This might be attributed due to the fact that nano fertilizer have large surface area and particle size less than the

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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 (**Manikanta *et al*., 2024**). The results are supported by **Nemati and Sharifi (2012), Shemi (2017), Gheith *et al.* (2022) and Muñoz-Márquez *et al.* (2022).**

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Conclusion:

It is concluded that 75% recommended dose of nitrogen (RDN), with full doses of P2O5 and K2O + 25% N through Nano-Urea foliar spray at 30 and 45 DAP along with Foliar spray of ZnSO4@ 0.2% at 30 and 45 DAP recorded higher growth and resulted in higher nutrient use efficiency in potato production.

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Table 1: Effect of nano urea & zinc sulphate on plant emergence (%) at 30 DAP

Treatments		2022-23	2023-24	Pooled
T1	Control	89.44	91.63	90.54
T2	RDN (Recommended dose of nitrogen, *i.e.* 150 kg/ha)	95.00	94.33	94.67
T3	75% RDN + 25% N through Nano-Urea foliar spray at 30 and 45 DAP	94.13	93.62	93.88
T4	50% RDN + 50% N through Nano-Urea foliar spray at 30 and 45 DAP	92.15	92.11	92.13
T5	75% RDN + foliar spray 2% urea at 30 and 45 DAP	94.01	93.23	93.62
T6	50% RDN + foliar spray 2% urea at 30 and 45 DAP	92.10	92.19	92.15
T7	RDN + $ZnSO_4$ @10 kg/ha	94.68	94.29	94.49
T8	T3+ Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	94.12	93.12	93.62
T9	T4 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	91.11	92.61	91.86
T10	T5 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	94.42	93.01	93.72
T11	T6 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	91.06	92.06	91.56
C.D at 5%		NS	NS	NS

Table 2: Effect of nano urea & zinc sulphate on plant height (cm) at 30 DAP

Treatments		2022-23	2023-24	Pooled
T1	Control	25.79	21.86	23.83

T2	RDN (Recommended dose of nitrogen, *i.e.* 150 kg/ha)	35.21	32.22	33.72
T3	75% RDN + 25% N through Nano-Urea foliar spray at 30 and 45 DAP	34.45	30.15	32.30
T4	50% RDN + 50% N through Nano-Urea foliar spray at 30 and 45 DAP	29.48	27.40	28.44
T5	75% RDN + foliar spray 2% urea at 30 and 45 DAP	33.57	29.63	31.60
T6	50% RDN + foliar spray 2% urea at 30 and 45 DAP	30.56	26.34	28.45
T7	RDN + $ZnSO_4$ @10 kg/ha	36.12	33.33	34.73
T8	T3+ Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	33.15	30.48	31.82
T9	T4 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	30.53	27.18	28.86
T10	T5 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	33.54	31.36	32.45
T11	T6 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	29.78	27.38	28.58
C.D at 5%		1.50	1.84	1.05

Table 3: Effect of nano urea & zinc sulphate on plant height (cm) at 60 DAP

Treatments		2022-23	2023-24	Pooled
T1	Control	34.03	30.52	32.28
T2	RDN (Recommended dose of nitrogen, *i.e.* 150 kg/ha)	44.15	40.17	42.16
T3	75% RDN + 25% N through Nano-Urea foliar spray at 30 and 45 DAP	43.85	39.62	41.74
T4	50% RDN + 50% N through Nano-Urea foliar spray at 30 and 45 DAP	39.18	35.16	37.17
T5	75% RDN + foliar spray 2% urea at 30 and 45 DAP	41.23	35.32	38.28
T6	50% RDN + foliar spray 2% urea at 30 and 45 DAP	38.14	33.14	35.64
T7	RDN + $ZnSO_4$ @10 kg/ha	45.32	41.12	43.22
T8	T3+ Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	44.03	40.85	42.44
T9	T4 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	43.59	36.24	39.92
T10	T5 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	43.56	39.74	41.65
T11	T6 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	39.12	34.14	36.63
C.D at 5%		1.62	1.52	1.54

Table 4: Effect of nano urea & zinc sulphate on plant height (cm) at harvest

Treatments		2022-23	2023-24	Pooled
T1	Control	42.78	39.89	41.34
T2	RDN (Recommended dose of nitrogen, *i.e.* 150 kg/ha)	56.23	53.64	54.94
T3	75% RDN + 25% N through Nano-Urea foliar spray at 30 and 45 DAP	58.47	55.31	56.89
T4	50% RDN + 50% N through Nano-Urea foliar spray at 30 and 45 DAP	51.62	47.63	49.63
T5	75% RDN + foliar spray 2% urea at 30 and 45 DAP	51.98	48.39	50.19
T6	50% RDN + foliar spray 2% urea at 30 and 45 DAP	50.36	47.11	48.74
T7	RDN + $ZnSO_4$ @10 kg/ha	57.32	53.62	55.47
T8	T3+ Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	58.69	55.91	57.30
T9	T4 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	49.36	46.91	48.14
T10	T5 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	54.36	51.13	52.75
T11	T6 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	50.76	46.78	48.77
C.D at 5%		2.68	2.22	1.96

Table 5: Effect of nano urea & zinc sulphate on Number of stems per hill at 50 DAP

Treatments		2022-23	2023-24	Pooled
T1	Control	4.05	4.02	4.04
T2	RDN (Recommended dose of nitrogen, *i.e.* 150 kg/ha)	5.37	5.40	5.39
T3	75% RDN + 25% N through Nano-Urea foliar spray at 30 and 45 DAP	5.57	5.61	5.59
T4	50% RDN + 50% N through Nano-Urea foliar spray at 30 and 45 DAP	4.38	4.34	4.36
T5	75% RDN + foliar spray 2% urea at 30 and 45 DAP	4.70	4.73	4.72
T6	50% RDN + foliar spray 2% urea at 30 and 45 DAP	4.04	4.10	4.07
T7	RDN + $ZnSO_4$ @10 kg/ha	5.39	5.30	5.35
T8	T3+ Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	5.68	5.65	5.67
T9	T4 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	4.52	4.45	4.49
T10	T5 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	4.90	4.94	4.92
T11	T6 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	4.29	4.30	4.30
C.D at 5%		NS	NS	NS

Table 6: Effect of nano urea & zinc sulphate on nitrogen use efficiency (%)

Treatments		2022-23	2023-24	Pooled
T1	Control	0.00	0.00	0.00
T2	RDN (Recommended dose of nitrogen, *i.e.* 150 kg/ha)	9.28	9.19	9.24
T3	75% RDN + 25% N through Nano-Urea foliar spray at 30 and 45 DAP	13.26	13.15	13.20
T4	50% RDN + 50% N through Nano-Urea foliar spray at 30 and 45 DAP	11.55	11.38	11.46
T5	75% RDN + foliar spray 2% urea at 30 and 45 DAP	9.37	9.72	9.54
T6	50% RDN + foliar spray 2% urea at 30 and 45 DAP	6.58	6.91	6.75
T7	RDN + $ZnSO_4$ @10 kg/ha	9.09	8.92	9.00
T8	T3+ Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	14.32	15.30	14.81
T9	T4 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	10.80	11.83	11.32
T10	T5 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	9.03	8.96	8.99
T11	T6 + Foliar spray of $ZnSO_4$@ 0.2% at 30 and 45 DAP	7.73	8.19	7.96
C.D at 5%		1.15	2.04	1.89