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Research Communication

Effect of nano-urea and herbicides on yield and yield attributes of wheat (*Triticum aestivum*)

AYAN SARKAR[1], TEEKAM SINGH[2], ABHIJEET MONDAL[3], SARVENDRA KUMAR[4], TAPAS KUMAR DAS[5], RAMANJIT KAUR[6], RISHI RAJ[7], PRAVEEN KUMAR UPADHYAY[8] AND SUSHEEL SARKAR[9]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2021–22 at Indian Agricultural Research Institute, New Delhi, to investigate the effect of nano-urea and herbicides on yield and yield-attributing characters of wheat (*Triticum aestivum* L.). The experiment was tested in a split-plot design with 4-nano-urea based treatments, viz. control (no nitrogen), recommended dose of nitrogen (RDN) 120 kg N/ha, 50% RDN + 2 sprays of nano-urea, at 40 and 60 days after sowing (DAS) and 75% RDN + 1 spray of nano-urea (at 60 DAS) in main plots and 4 herbicides based weed management options, viz. sulfosulfuron 75% + metsulfuron methyl 5% WG (ready mix) @ 40 g a.i./ ha at 30 DAS; tank-mix of clodinafop propargyl and carfentrazone-ethyl (60 and 20 g a.i./ha) at 30 DAS; weed-free check and unweeded check, in subplots and replicated thrice. Results revealed that, yield attributes were significantly higher with 100% RDN. This treatment also resulted in 40 and 18% more grain yield with 100% RDN (5.21 t/ha) over 50% RDN + 2 sprays of nano-urea (3.7 t/ha) and 75% RDN + 1 spray of nano-urea (4.4 t/ha) respectively. Among the weed-management options, weed-free check was superior in yield and yield attributes followed by tank mixed carfentrazone ethyl + clodinafop propargyl (60 and 20g a.i./ha) at 30 DAS. However, tank mixed carfentrazone ethyl + clodinafop propargyl was significant superior to the ready-mixed metsulfuron methyl + sulfosulfuron in terms of number of ear-bearing tillers/m^2 and number of grains/spike which resulted in significantly higher grain yield. Thus, 100% RDN (120 kg N/ha) along with tank-mixed carfentrazone ethyl + clodinafop propargyl (60 and 20 g a.i./ha) at 30 DAS are the more productive options for wheat-growing farmers keeping view of the uprising labour cost in manual weeding.

***Key words*:** Herbicide mixture, Nano-urea, Wheat, Yield attributes

Wheat (*Triticum aestivum* L.) is the most important cereal crop of the world and the second most important crop in India. To keep pace with the annual population growth rate of India, i.e. 0.97%, and to meet the future wheat demand of India by 2050, i.e. 140 million tonnes, the productivity from present level of 3.3 t/ha to 4.7 t/ha and production of wheat by 46% have to be increased (Ramadas *et al.,* 2019). Nitrogen and weed management are the 2 most important factors responsible for low productivity of wheat. The conventional urea is less efficient and more harmful to the environment; however, recently developed nano-fertilizers like nano-urea enhanced the nutrient-use efficiency with very low rate of application, reduced input cost, environmentally safe and most importantly enhanced productivity and quality (Kiran and Samal, 2021; Kumar *et al*., 2021). Foliar application of nano-fertilizers significantly increased yield of the crop (Tarafdar *et al.,* 2012). Weeds not only affect crops directly via allelopathy but also indirectly via competition for various resources due to their inbuild competitive advantage over crops, which ultimately results in poor nutrient use efficiency and yield reduction. Weed management in wheat through herbicides are most economical and productive (Pal *et al.,* 2016). Herbicide mixture was identified as better option for managing weeds in wheat (Singh, 2013). Tank-mix application of metsulfuron-methyl with clodinafop and sulfosulfuron significantly reduced the weed density and resulted in higher productivity of wheat (Singh, 2013). So, keeping these facts in views this study is aimed to know the effect of nano-urea and herbicide mixtures on yield and yield attributes of wheat.

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[2]Corresponding author's Email: teekam.singh@icar.gov.in

[1,3]M.Sc. Student, [2,5,6]Principal Scientist, [7,8]Scientist, Division of Agronomy, [4]Senior Scientist, Division of Soil Science and Agricultural Chemistry, ICAR-Indian Agricultural Research Institute. New Delhi 110 012; [9]Senior Scientist, ICAR-Indian Agricultural Statistics Research Institute, New Delhi 110 012

A field experiment was conducted during winter (*rabi*) season of 2021–22, to investigate the effect of nano-urea and herbicide mixtures on yield and yield attributes of wheat at the Indian Agricultural Research Institute, New Delhi. The soil of the experimental site was sandy loam (sand 58.6%, silt 22.8% and clay 18.6%) with electrical conductivity of 0.47 dS/m and soil *p*H of 7.8. The bulk density of 0–15 cm surface soil was 1.52 g/cm^3 with 0.41% oxidizable organic carbon, available N 221.38 kg/ha, available P 12.61 kg/ha and available K 241.11 kg/ha. The treatments were tested in a split-plot design with 4 main plot treatments, viz. control (no nitrogen), 100% recommended dose of nitrogen (RDN–120 kg N/ha), 50% RDN + 2 sprays of nano-urea at 40 and 60 days after sowing (DAS) and 75% RDN + 1 spray of nano-urea at 60 DAS and 4 subplot treatments, viz. sulfosulfuron 75% + metsulfuron methyl 5% WG (ready-mix) @ 40 g/ha (product basis) at 30 DAS; tank mix of clodinafop propargyl @ 60 g a.i./ha + carfentrazone-ethyl @ 20 g a.i./ha at 30 DAS; weed-free check; and unweeded check. Wheat variety 'HD 2967' was sown on 7 November 2021 with a seed rate of 100 kg/ha, maintaining a row-to-row spacing of 22.5 cm along with basal dose of recommended dose of P and K, i.e. 60 kg P_2O_5 and 60 kg K_2O/ha, applied uniformly across all treatments. Nitrogen was applied as per the treatments. In 100% RDN, nitrogen was applied basal at 60 kg/ha and 2 equal splits of 30 kg/ha top-dressed at 25 DAS and at the maximum tillering, i.e. 60 DAS. In 50% RDN + 2 sprays of nano-urea (at 40 and 60 DAS) treatment, nitrogen was applied basal as 30 kg/ha, and rest 30 kg/ha as top-dressed at 25 DAS as well as 2 sprays of nano-urea was done at 40 and 60 DAS. In 75% RDN + 1 spray of nano-urea (at 60 DAS) treatment nitrogen @ 45 kg/ha was applied basal, and rest 45 kg/ha top-dressed at 25 DAS as well as 1 spray of nano-urea was done at 60 DAS. Nano-urea was applied by spraying @ 4 ml nano-urea/litre of water. Urea, single superphosphate and muriate of potash were used as a source of soil-applied N, P and K fertilizer respectively. Herbicide was applied at 30 DAS. In weed-free check, total 6 hand-weedings were done at 15 days interval, starting from 25 DAS. At maturity, yield attributes and grain and straw yield of each plot recorded separately. Grain yield reported at 14% moisture content. The measured data were tested by analysis of variance (ANOVA) using SAS software package (Version 9.3). Standard error of mean and least significant difference (LSD) at 5% level of significance were calculated for each treatment and treatment means were compared.

The highest total weed density and weed biomass at 40 DAS was observed with the control (Fig. 1). However, the successive increment in nitrogen level significantly suppressed the total weed population and weed dry-matter

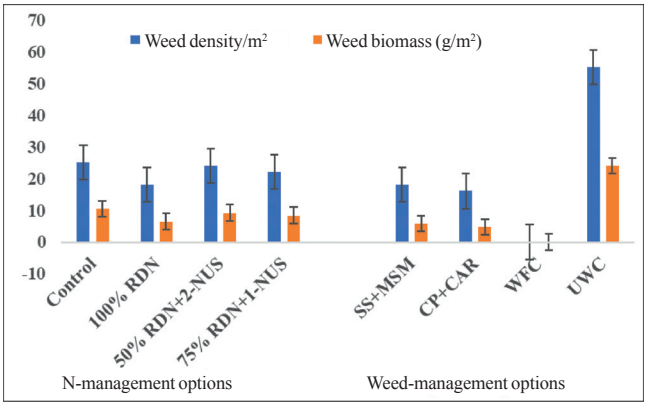

Fig. 1. Nano-urea and herbicides effect on weed density and biomass at 40 days after sowing in wheat

accumulation which is mainly owing to vigorous growth of wheat seedlings. After the weed-free check, tank-mixed clodinafop propargyl + carfentrazone ethyl (CP + CAR) registered the significantly lowest weed density and biomass, followed by ready-mixed sulfosulfuron + metsulfuron methyl (SS + MSM) which showed the effectiveness and compatibility of tank-mixed clodinafop propargyl + carfentrazone ethyl in wheat. However, the highest weed density and biomass were recorded with weedy check.

There was significant difference in the yield attributes, viz. effective tillers/m^2, spike length (cm), spikelets/spike, grains/spike and 1,000-grain weight (g), due to nano-urea-based nitrogen and weed-management practices (Table 1). Yield parameters except effective tillers/m^2 were significantly higher with 100% RDN, followed by 75% RDN + 1 spray of nano-urea at 60 DAS owing to higher amount of nitrogen supplied through 100% RDN as compared to nano-urea spray. Effective tillers/m^2 were statistically at par between 50% RDN + 2 sprays of nano-urea (at 40 and 60 DAS) and 75% RDN + 1 spray of nano-urea at 60 DAS. The lowest values for yield attributes were obtained with the control. Effective tillers/m^2 and grains/spike were significantly higher with weed free check (321 and 38.26 respectively), followed by tank-mixture of carfentrazone ethyl + clodinafop propargyl (311 and 36.37). The lowest values for yield attributes were found with unweeded control. Tank-mixed herbicides of carfentrazone ethyl + clodinafop propargyl was found better than ready-mixed metsulfuron methyl + sulfosulfuron in terms of yield attributes. These results confirm the findings of Singh (2013) and Ram and Kaur (2020).

Grain yield was significantly higher with 100% RDN, followed by 75% RDN + 1 nano-urea spray and 50% RDN + 2 nano-urea sprays (Fig. 2). Superior performance of 100% RDN was mainly owing to higher availability of nitrogen compared to nano-urea- based nitrogen-management options as nano-urea contained only 4% N (weight/

Table 1. Effect of nano-urea-based nitrogen management and herbicide mixtures on yield attributing characters of wheat

Treatment	Effective tillers (no./m^2)	Spike length (cm)	Spikelets/spike	Grains/spike	1,000-grain weight (g)
Nitrogen management					
Control	262	7.69	19.41	33.56	40.17
100% RDN	339	11.91	23.34	38.43	41.24
50% RDN + 2-NUS	285	8.92	20.93	34.93	40.75
75% RDN + 1-NUS	312	9.57	22.26	36.07	40.90
SEm±	3.2	0.35	0.47	0.53	0.10
CD (P=0.05)	11.1	1.22	1.66	1.84	0.36
Herbicide mixture					
SS + MSM	303	9.46	21.32	35.44	40.62
CP + CAR	311	9.46	21.76	36.37	40.88
WFC	321	9.76	22.25	38.26	41.25
UWC	264	9.35	20.62	32.92	40.31
SEm±	1.3	0.23	0.50	0.28	0.41
CD (P=0.05)	3.9	NS	NS	0.83	NS

RDN, Recommended doses of nitrogen; NUS, nano-urea spray; SS + MSM, sulfosulfuron + metsulfuron methyl; CP + CAR, clodinafop propargyl + carfentrazone ethyl; WFC, weed-free control; UWC, unweeded control; LSD, least significant difference

volume basis) and providing hardly 50 to 100 g nitrogen/ha which might not be able to substitute to 25 or 50% of RDN (30 or 60 kg N/ha) of wheat in spite of having higher efficiency of nano-fertilizers. Fernando *et al.* (2019) reported that, yield attributes and yield increased significantly with increasing nitrogen up to 140 kg/ha in wheat. However, Velmurugan *et al*. (2021) and Sahu *et al*. (2022) reported that, nano-urea performed better than commercial urea in various other type of crops.

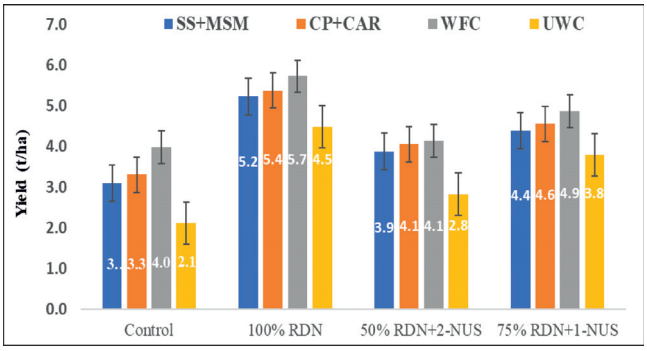

Fig. 2. Effect of nano-urea and herbicide mixtures on grain yield of wheat

The interaction effect was significant for grain yield and the maximum grain yield was recorded with the combination of 100% RDN and weeds free (5.7 t/ha), closely followed by 100% RDN and carfentrazone ethyl + clodinafop propargyl (5.4 t/ha), as crop plants were able to uptake more nutrients under weed-free environment and results in higher grain yield. The lowest grain yield was recorded with treatment combination of nitrogen control and unweeded control (2.1 t/ha).

The significantly higher total nitrogen uptake by wheat was recorded with 100% RDN over rest of the N levels, followed by 75% RDN + 1 spray of nano-urea (Fig. 3). However, total N uptake by 75% RDN + 1 spray of nano-urea and 50% RDN + 2 sprays of nano-urea were remained at par with each other. The progressive increase in nitrogen levels increased the N uptake of wheat (Pappu *et al*., 2021). Among the weed-management practices, total nitrogen uptake of wheat was the significantly higher with weed-free check over rest of the weed-management options, followed by tank-mixed clodinafop propargyl + carfentrazone ethyl. However, the lowest total nitrogen uptake by wheat was recorded with un-weeded check.

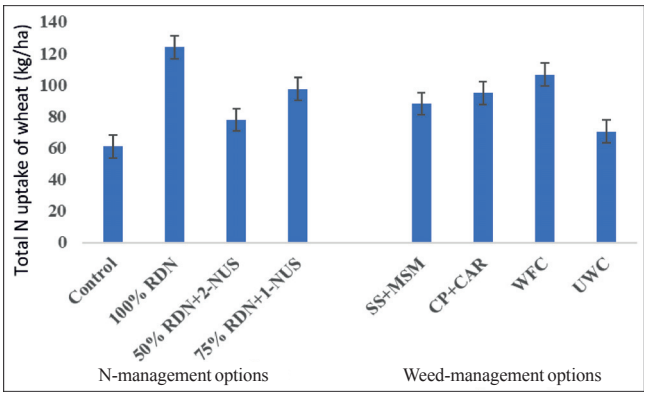

Fig. 3. Total nitrogen uptake of wheat as influenced by nano-urea and herbicide mixtures

Thus, 100% recommended doses of nitrogen (120 kg/ha) was more productive for wheat than nano-urea-based 50% RDN + 2 sprays of nano-urea and 75% RDN + 1 spray of nano-urea. Tank-mixture of carfentrazone ethyl +

clodinafop propargyl might be a better option for managing the weeds after weed-free manual weeding. Therefore, 100% RDN along with carfentrazone ethyl + clodinafop propargyl was more productive for wheat.

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