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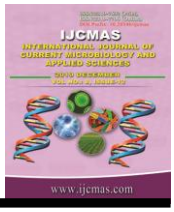

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Effect of Integrated Use of Nano and Non-Nano Fertilizers on Yield and Yield Attributes of Wheat (*Triticum aestivum* L.)

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A B S T R A C T

An experiment entitled, "Effect of integrated use of nano and non-nano fertilizers on yield and yield attributes of wheat (*Triticum aestivum* L.)" was conducted at the research farm of Farming System Research Centre of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha during the *rabi* season of 2015-2016. The experimental results revealed that among the treatments, treatment T_7 (100 % NPK + Nano NPK (L) sprays at 20, 30 & 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water) though statistically at par with the treatment T_3 (100 % N + 100 % P_2O_5 + 50 % K + 50 % Nano-K (G) @ 31.25 kg/ha + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water) and T_2 (100 % N + 100 % P_2O_5 + 100 % Nano-K (G) @ 62.5 kg/ha) recorded significantly higher grain yield (44.45 q/ha), straw yield (55.99 q/ha) and harvest index(44.25 %). However, the yield attributes *viz*. effective tillers per metre row length, length of ear (cm), number of grains per ear and 1000-grain weight (g) were also recorded significantly higher in T_7 which was statistically at par with the treatment T_3 and T_2. Henceforth, based on one year study, it is concluded that treatment T_7 (100 % NPK + Nano NPK (L) sprays at 20, 30 and 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage @ 4 ml/litre of water 115 and 125 DAS) was the best treatment in increasing the grain yield of wheat crop.

Introduction

Wheat is a cereal grain, originally from the Levant region (Feldman *et al.*, 2007) but now cultivated worldwide. Wheat is an important source of carbohydrates (Shewry and Hey, 2015). Globally, it is the leading source of vegetal protein in human food, having a protein content of about 13 %, which is relatively high compared to other major cereals, but relatively low in protein quality for supplying essential amino acids. The wheat crop is grown in India in an area of about 30 million hectare with a production and productivity of 90.78 million tonnes and 2.99 tonnes per hectare respectively (Anonymous, 2016a). It is the major *rabi* crop of Jammu and Kashmir state and is grown on acreage of 292

thousand hectares with an annual production of 602 thousand metric tonnes with an average productivity of 2.06 tonnes per ha (Anonymous, 2016b) which is quite low as compared to national average productivity. The green revolution of 1970's triggering high growth in agriculture which paved the way for food security in India mainly relied on short statured high yielding varieties which were responsive to inorganic fertilizers namely, Urea, DAP and MOP, thereby ensuring food security to the 1.2 billion up to early 21st century. India is mainly dependant on inputs of fertilizers which are imported from other countries and the input costs are rising on day to day basis with subsequent reduction in subsidies on imported fertilizers by Govt. of India to save foreign exchange besides increasing the GDP of the country. Presently 35-40 % of the crop productivity depends upon fertilizer, but some of the fertilizer affects the plant growth directly. Ironically, indiscriminate and imbalanced use of these inorganic fertilizers has adversely affected the soil health, human well-being besides reducing factor productivity. The application of urea, DAP and MOP have been found to have lower fertilizer efficiency which ranges from 20 to 50 % for nitrogen and 10-25 % for phosphorus and 70-80 % potassium (Shaviv, 2000; Chinnamuthu and Boopathi, 2009) owing to leaching losses besides volatilization and denitrification losses which not only contribute to the green house gases emission but also certain health hazards such as blue baby syndrome as a result of eutrophication and leaching losses of urea. Because of the shortage of arable land, limited water and nutrient resources, the development of agriculture sector is only possible by increasing resource use efficiency with the minimum damage to production bed through effective use of modern technologies (Naderi and Shahraki, 2013). To overcome all these drawbacks, nanotechnology holds promise and nano-fertilizers can go a long way in ensuring sustainable soil health and crop production (Lal, 2008). The chelated & revolutionary nutritional nano-fertilizers formulated with organic and chelated micro nutrients, trace elements, vitamins, probiotics, seaweed extract and humic acid served as complete nutritional fertilizer for all the crops. These high performance and efficient fertilizers enhanced the crop production while protecting ecology. Also, the deficiency of potassium had been reported in large area of Jammu region, therefore the nano-potassium was also included in the experiment. Thus, the present study was undertaken to evaluate the response of wheat crop to eco-friendly granular as well as foliar Nano-NPK and Nano-K fertilizers under Jammu conditions so that a viable and economically feasible option can be given to the farmers of the region for maintaining sustainable crop production with improved quality of the wheat crop. It is pertinent to mention here that no work on this aspect had been initiated in Jammu region so far.

Materials and Methods

The field experiment was conducted during *rabi* season of 2015-2016 at the Research Farm, FSR Centre, SKUAST-J, Main campus Chatha, Jammu. Geographically, the experimental site was located at 32^0 - 40´ N latitude and 74^0 - 58´ E longitude with an altitude of 332 meters above mean sea level in the Shiwalik foothills of North-Western Himalayas. The climate of the experimental site was mainly sub- tropical in nature endowed with hot and dry early summers followed by hot and humid monsoon seasons and cold and dry winters. The mean annual rainfall of the location varies from 1050 - 1115 mm of which 70 % rainfall is received from June to September, whereas the remaining 30 % of rainfall is received in few scanty showers of cyclonic winter rains from December to March due to western disturbances. However, the total rainfall and

its distribution are subjected to large variations. The soil of experimental site was clay loam in texture, slightly alkaline in reaction, low in organic carbon, available nitrogen and potassium but medium in available phosphorus. The experiment was laid out in randomized-block design with eight treatments and three replications at the research farm of Farming System Research Centre of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha. Urea, DAP and MOP were used as chemical sources of fertilizer and for nano-fertilizer treatments, Nano NPK and Nano-K in granular (G) and liquid forms (L) were used in the experiment.

The experiment consisted of 8 treatments *viz*. T_1: RDF (Control), T_2: 100 % N + 100 % P_2O_5 + 100 % Nano-K (G) @ 62.5 kg/ha, T_3: 100 % N + 100 % P_2O_5 + 50 % K + 50 % Nano-K (G) @ 31.25 kg/ha + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water, T_4: 75 % N + 100 % P_2O_5 + 50 % K + 50 % Nano –K (G) @ 31.25 kg/ha + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water, T_5: 75 % N + 50 % P_2O_5 + 50 % Nano-K (G) @ 31.25 kg/ha + Nano NPK (G) @ 62.5 kg/ha, T_6: 75 % N + 50 % P_2O_5 + 100 % Nano-K (G) @ 62.5 kg/ha + Nano NPK (G) @ 37.5kg/ha + 2 Nano NPK (L) sprays at 25 and 45 DAS @ 3ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water, T_7: 100 % NPK + Nano NPK (L) sprays at 20, 30 & 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water and T_8: 50 % NPK + Nano NPK (L) sprays at 20, 30 & 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water which was arranged in Randomized Block design with three replications. The crop variety WH-1105 was sown on 30th November, 2015. Full dose of P and K along with one third of N was applied as basal dose at the time of sowing through inorganic sources of nutrients *viz*. Urea, DAP and MOP, respectively and remaining two third was applied in two equal splits at CRI stage and pre booting stage. Granular as well as foliar forms of Nano-NPK and Nano-K were applied as per the treatments. Data was collected regarding yield and yield attributes of wheat grains. Data recorded on various parameters of the experiment was subjected to analysis by using Fisher's method of analysis of variance (ANOVA) and interpreted as outlined by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was p = 0.05. Critical difference values were calculated where F test was found significant.

Results and Discussion

Yield attributes

The data on various yield attributes *viz*. effective tillers per metre row length, length of ear (cm), number of grains per ear and 1000-grain weight (g) as influenced by the integrated use of nano and non-nano fertilizers were recorded and presented in Table 1. Data indicated that among the applied treatments, T_7 (100 % NPK + Nano NPK (L) sprays at 20, 30 & 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water) though at par with the treatment T_3 (100 % N + 100 % P_2O_5 + 50 % K + 50 % Nano-K (G) @ 31.25 kg/ha + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water), T_2 (100 % N + 100 % P_2O_5 + 100 % Nano-K (G) @ 62.5 kg/ha) and T_1 (RDF) recorded significantly higher number of effective tillers (75.19), maximum length of the ear (14.38 cm), maximum number of grains per ear (39.06) and highest 1000-grain weight (42.50 g), than the control and other treatments in comparison. The increase in

yield attributes *viz*. number of effective tillers/metre row length, length of ear (cm), number of grains per ear, 1000-grain weight may be due to the reason that nano-NPK promotes the plant to absorb the water of soil and nutrients, then the photosynthesis is improved (Wu, 2013). Further, nano-NPK is considered the biological pump for the plants to absorb nutrients and water (Ma *et al.,* 2009). Liu and Liao (2008) reported increased water uptake due to application of nano-materials which increased the N, P & K uptake and resulted in increased biomass production. However, treatment T_8 (50 % NPK + Nano NPK (L) sprays at 20, 30 & 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water) recorded significantly lowest number of effective tillers (63.17), minimum length of the ear (9.54 cm), minimum number of grains per ear (31.72) and lowest 1000-grain weight (35.79 g).

Grain and straw yield

The integrated use of nano and non-nano fertilizers had significant effect on the grain yield. The data presented in Table 2 and Figure 1 depicts that treatment T_7 (100 % NPK + Nano NPK (L) sprays at 20, 30 & 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water) recorded significantly maximum grain yield (44.45 q/ha) and straw yield (55.99 q/ha) which was however, statistically at par with the treatment T_3 (100 % N + 100 % P_2O_5 + 50 % K + 50 % Nano-K (G) @ 31.25 kg/ha + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water) and T_2 (100 % N + 100 % P_2O_5 + 100 % Nano-K (G) @ 62.5 kg/ha). Benzon *et al.,* (2015) reported synergistic effect of the nano-fertilizers on the efficacy of conventional fertilizer for better nutrient absorption by plant cells resulting to optimal growth plant parts and metabolic process such as photosynthesis leads to higher photosynthates accumulation and translocation to the economic parts of the plant, thus resulting in high yield which may be attributed to increased source (leaves) and sink (economic part) strength (Taiz and Zeiger, 2006). Foliar application of Nano-fertilizers significantly increase the crop yield (Tarafdar *et al.,* 2012). As mentioned earlier, nano-fertilizers may have affected these processes through its nutrient transportation capability in terms of penetration and movement of a wide range of nutrients, from roots uptake to foliage penetration and movements within the plant.

A number of studies proved the significance of nano-fertilizers. For instance, Sirisena *et al.,* (2013) obtained higher grain yield in rice with the application of nano-K fertilizer. This is in agreement with the findings of Liu *et al.,* (2009), Harsini *et al.,* (2014), Azize*t al.,* (2016), Hafeez *et al.,* (2015), Jafarzadeh *et al.,* (2013), Kumar *et al.,* (2014), Sheikhbaglou *et al.,* (2010) and Sirisena *et al.,* (2013).The significantly minimum grain yield (28.23 q/ha) and straw yield (38.92 q/ha) was recorded in treatment T_8 (50 % NPK + Nano NPK (L) sprays at 20, 30 & 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water).

Harvest index (%)

The data pertinent to the harvest index in Table 2 reveals that the effect of integrated use of nano and non-nano fertilizers on the harvest index was found to be non-significant.

Table.1 Effect of integrated use of nano and non-nano fertilizers on yield attributes of wheat

Treatments		Effective tillers/m	Length of the ear (cm)	Grains per ear	1000-grain weight (g)
T_1	RDF (control) (N:P:K @ 100:50:25 kg/ha)	72.03	11.61	35.83	39.53
T_2	100 % N + 100 % P_2O_5 + 100% Nano-K (G) @62.5 kg/ha	73.78	12.10	36.72	40.91
T_3	100 % N + 100 % P_2O_5+ 50 % K + 50% Nano-K (G) @ 31.25 kg/ha + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water	74.25	13.36	37.72	41.31
T_4	75 % N + 100 % P_2O_5 + 50 % K + 50% Nano-K (G) @ 31.25 kg/ha + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water	71.91	11.47	35.81	38.28
T_5	75 % N+ 50% P_2O_5 + 50 % Nano-K (G) @ 31.25 kg/ha + Nano NPK (G) @62.5 kg/ha	69.78	10.41	32.61	36.47
T_6	75 % N + 50% P_2O_5 + 100 % Nano-K (G) @62.5 kg/ha + Nano NPK (G) @ 37.5kg/ha + 2 Nano NPK (L) sprays at 25 and 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water	71.97	11.34	34.50	38.66
T_7	RDF + 3 Nano NPK (L) sprays at 20, 35 and 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water	75.19	14.38	39.06	42.50
T_8	50 % RDF + 3 Nano NPK (L) sprays at 20, 35 and 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water	63.17	9.54	31.72	35.79
SEm±		1.70	0.42	1.04	1.16
CD (5%)		5.17	1.30	3.15	3.53

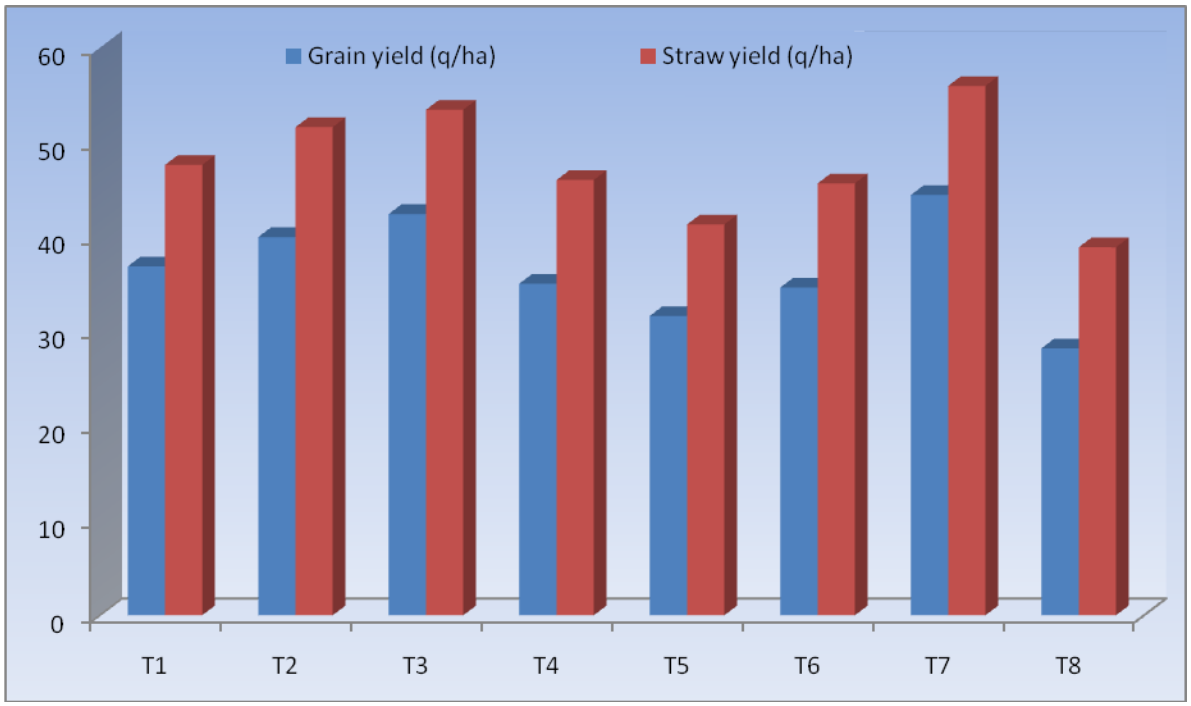
***Granular – (G)**
***Liquid – (L)**

Table.2 Effect of integrated use of nano and non-nano fertilizers on grain yield, straw yield, biological yield and harvest index of wheat

Treatments		Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
T_1	RDF (control) (N:P:K @ 100:50:25 kg/ha)	36.89	47.63	84.52	43.64
T_2	100 % N + 100 % P_2O_5 + 100% Nano-K (G) @62.5 kg/ha	40.00	51.63	91.63	43.65
T_3	100 % N + 100 % P_2O_5+ 50 % K + 50% Nano-K (G) @ 31.25 kg/ha + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water	42.44	53.47	95.92	44.25
T_4	75 % N + 100 % P_2O_5 + 50 % K + 50% Nano-K (G) @ 31.25 kg/ha + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water	35.07	46.04	81.11	43.24
T_5	75 % N+ 50% P_2O_5 + 50 % Nano-K (G) @ 31.25 kg/ha + Nano NPK (G) @62.5 kg/ha	31.66	41.34	73.00	43.37
T_6	75 % N + 50% P_2O_5 + 100 % Nano-K (G) @62.5 kg/ha + Nano NPK (G) @ 37.5kg/ha + 2 Nano NPK (L) sprays at 25 and 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water	34.67	45.68	80.35	43.14
T_7	RDF + 3 Nano NPK (L) sprays at 20, 35 and 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water	44.45	55.99	100.44	44.25
T_8	50 % RDF + 3 Nano NPK (L) sprays at 20, 35 and 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water	28.23	38.92	67.16	42.04
SEm±		1.13	1.90	3.03	0.95
CD (5%)		3.44	5.77	9.19	NS

***Granular – (G)**
***Liquid – (L)**

Fig.1 Effect of integrated use of nano and non-nano fertilizers on grain yield and straw yield of wheat



Treatment T_7 (100 % NPK + Nano NPK (L) sprays at 20, 30 and 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water) recorded the maximum harvest index (44.25 %) whereas the minimum harvest index i.e. 42.04 % was recorded in treatment T_8 (50 % NPK + Nano NPK (L) sprays at 20, 30 and 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at110 and 125 DAS @ 4ml/litre of water.

On the basis of one year study, it is concluded that among the different integrated nano and non-nano fertilizers, treatment T_7 (100 % NPK + Nano NPK (L) sprays at 20, 30 & 45 DAS @ 3 ml/litre of water + 2 Nano-K (L) sprays at grain development stage at 110 and 125 DAS @ 4 ml/litre of water) was found to be the best treatment in increasing the crop yield and yield attributes of wheat crop.

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