Integrated use of nano and non-nano fertilizers and their effect on quality and relative economics of wheat (*Triticum aestivum* L.)

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ABSTRACT

An experiment entitled, **"Effect of integrated use of nano and non-nano fertilizers on quality and relative economics 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 carbohydrate content (65.38 %) over all the other treatments in comparison. The highest net returns (Rs. 64580.58 per hectare) were recorded in 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) over control and other treatments and was followed by treatment T_2 (100 % N + 100 % P_2O_5 + 100 % Nano-K (G) @ 62.5 kg/ha) which gave net returns of Rs. 64390.83 per hectare. However, highest B:C ratio (2.87) was recorded in treatment T_2 (100 % N + 100 % P_2O_5 + 100 % Nano-K (G) @ 62.5 kg/ha) followed by treatment T_1 (RDF) which recorded B:C ratio of 2.83.

Key words: Nano-fertilizers, WH-1105, Nano-K, Nano NPK, B:C ratio and Quality.

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. When eaten as the whole grain is a source of multiple nutrients and fibre. In a small part of the general population, gluten - the major part of wheat protein can trigger coeliac disease, non-coeliac gluten sensitivity, gluten ataxia and dermatitis herpetiformis (Ludvigsson *et al*., 2013). 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, 2016). 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, 2016a) 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). Fertilizers, nutrients encapsulated inside nano porous materials, coated with thin polymer film, or delivered as particle or emulsions of nano scales dimensions (Rai *et al.*, 2012) are known as Nano-fertilizers. Nano-particles below 100 nm size can be used as fertilizer for efficient nutrient management besides an added advantage of stress tolerating ability. Nano-fertilizers provide the major nutrients to the crop as per the requirement in a phased manner as it contains nutrients and growth promoters encapsulated in nano scale polymers. These nano scale polymers ensure low and a target efficient release for providing the nutrients to the crop in a sustained manner during its life cycle thus ensuring increased nutrient use efficiency. These could also release their active ingredients in response to environmental triggers and biological demands more precisely and play a beneficial role in soil health by building up carbon uptake, improving soil aggregation and water holding capacity. Nano-fertilizers being encapsulated in nano-particles increase the uptake of nutrients (Tarafdar *et al.*, 2014). These fertilizers made through biological process, are eco-friendly and have been designed to match inorganic fertilizers in terms of nutrient composition and application rates. Nano-fertilizers are synthesized in order to regulate the release of nutrients depending on the requirements of the crops and are more efficient than ordinary fertilizers (Liu and Lal, 2015). The chelated & revolutionary nutritional nano-fertilizers formulated with organic & 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. The relevant quality parameters were recorded in wheat crop and 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. The economics was worked out based on the prevailing prices in the market during the period both for inputs and the outputs.

RESULTS AND DISCUSSION

Quality

Quality of wheat in terms of protein content and carbohydrate content reported in Table 1 revealed that in case of quality parameters, protein content failed to show significant results with the integrated use of nano and non-nano fertilizers. However, carbohydrate content of wheat increased significantly with the integrated use of nano and non-nano fertilizers on the wheat. Highest carbohydrate content was recorded in the 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 @ 4 ml/litre of water) which was although found to be 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). This might be due to more surface area and more availability of nutrients to the crop plant which help to increase these quality parameters of the plant (such as protein, sugar content) by enhancing the rate of reaction or synthesis process in the plant system Mir *et al*. (2015), Rajaie and Ziaeyan (2009), Ghafari and Razmjoo (2013).

Table 1: Effect of integrated use of nano and non-nano fertilizers on quality of wheat

	Treatments	Protein content (%)	Carbohydrate content (%)
T_1	RDF (control) (N:P:K @ 100:50:25 kg/ha)	11.17	63.21
T_2	100 % N + 100 % P_2O_5 + 100% Nano-K (G) @62.5 kg/ha	11.14	64.10
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	11.14	64.21
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	11.16	63.14
T_5	75 % N+ 50% P_2O_5 + 50 % Nano-K (G) @ 31.25 kg/ha + Nano NPK (G) @62.5 kg/ha	11.17	62.05
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	11.15	63.01
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	11.14	65.38
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	11.17	61.54
SEm±		0.01	0.48
CD (5%)		NS	1.45

***Granular – (G)**
***Liquid – (L)**

Relative economics

The treatment wise economic returns were worked out with the help of operating cost of individual treatment and the cost of production. The variations in economics of wheat further led to marked variations in its relative economics. The data so obtained have been given in the Table 2. Variation on gross returns and net returns has been founded by application of integrated use of nano and non-nano fertilizers. The economic feasibility and usefulness of a treatment can be effectively adjusted in terms of B: C ratio and net returns. 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) fetched more net returns (64580.58 Rs./ha) and 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) fetched more gross returns (95778.00 Rs. /ha). However, the 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) fetched less net returns (33070.88 Rs./ha) and gross returns (62517.17 Rs./ha) both. 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 @ 4 ml/litre of water) recorded numerically higher value for net returns followed by treatment T_2 (100 % N + 100 % P_2O_5 + 100 % Nano-K (G) @ 62.5 kg/ha) which was ultimately due to the significant difference in grain & straw yield of wheat crop and cost of fertilizers incurred at different treatments. However, highest B:C ratio was recorded in treatment T_2 (100 % N + 100 % P_2O_5 + 100 % Nano-K (G) @ 62.5 kg/ha) followed by treatment T_1 (RDF), whereas the lowest B:C ratio was observed in treatment 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 @ 4 ml/litre of water at grain development stage) which might be due to variation in cost of cultivation and net returns.

Table 2: Effect of integrated use of nano and non-nano fertilizers on relative economics of wheat

	Treatments	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
T_1	RDF (control) (N:P:K @ 100:50:25 kg/ha)	20900	80068.83	59168.83	2.83
T_2	100 % N + 100 % P_2O_5 + 100% Nano-K (G) @62.5 kg/ha	22425	86815.83	64390.83	2.87
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	26882	91462.58	64580.58	2.40
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	26501.13	76496.67	49995.54	1.89
T_5	75 % N+ 50% P_2O_5 + 50 % Nano-K (G) @ 31.25 kg/ha + Nano NPK (G) @62.5 kg/ha	22719.67	68956.58	46236.91	2.04
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	31569.67	75708.00	44138.33	1.40
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	31515	95778.00	64263.00	2.04
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	29446.29	62517.17	33070.88	1.12

***Granular – (G)**
***Liquid – (L)**

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 carbohydrate content of wheat crop. However, treatment T_2 (100 % N + 100 % P_2O_5 + 100 % Nano-K (G) @ 62.5 kg/ha) was found to be the most economical treatment as it gave highest benefit: cost ratio of wheat.

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