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# POTASSIUM FERRITE NANO COATED DAP FERTILIZER IMPROVES WHEAT (TRITICUM AESTIVUM L.) GROWTH AND YIELD UNDER ALKALINE CALCAREOUS SOIL CONDITIONS

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Currently 50% of the Pakistani soils are reported deficient in potassium (K) along with iron (Fe) due to alkaline calcareous nature. Intensive cropping of exhaustive crops has resulted in negative K and Fe balance and subsequent population also suffering from iron deficiency. Application of nanotechnology with the idea of enhanced bio-availability, reactivity, surface area and adhesive effect of nano materials has made it a revolutionary tool for enhanced crop growth and nutrient enrichment in agriculture. A field study was conducted to assess the effect of potassium ferrite ($KFeO_2$) nano coated diammonium phosphate (DAP) fertilizer on the growth attributes, yield parameters and uptake of nutrients by wheat crop. Results showed that plant height, shoot fresh and dry weight, chlorophyll contents, N, P, K and Fe uptake in shoot (at tillering and booting stage) and in grains and straw were significantly higher in treatment where recommended NP +10% $KFeO_2$ nano-coated DAP was applied. Similarly, grain and straw yield was significantly improved in NP10 treatment than all other coated and uncoated treatments. The treatment NP (RD NP from DAP, urea + no potassium (farmer common practice) showed the least effect on growth parameters, yield attributes and harvest index. The treatment with 75% RD of coated DAP + 25% of K showed statistically similar grain yield compared to NPK that indicated a positive and promising effect of K and Fe nanoparticles. It was concluded from the study that nano coated DAP was a practical approach that may be adopted for enhanced plant growth and yield attributes of wheat crop. It also improves the potassium and iron contents of wheat grain, which is beneficial for human health.
**Keywords**: slow release DAP, Harvest Index, iron uptake, nitrogen use efficiency.

## INTRODUCTION

Commercial fertilizers are being used for 40 to 60% of the world's food production. Nitrogenous and phosphatic fertilizers are applied in large amounts due to their primary role in the growth and development of plants. However, phosphorus use efficiency (PUE) ranges between 5-25% while the nitrogen use efficiency (NUE) generally ranges only between 30-40% depending upon agricultural system (Sanders *et al.,* 2012). Nitrogen (N) is a critical nutrient that primarily fuels the growth of crop, canopy expansion and solar radiation intervention (Morris *et al*., 2018).

Potassium, as a macronutrient, has several significant roles in crop growth and functions against stress conditions (Bukshs *et al*., 2012). Its role as osmolyte in osmoregulation to maintain cell turgidity and stomatal regulation is imperative for plant growth. It plays crucial role in activation of >70 enzymes (Hasanuzzaman *et al*., 2018). The movement of assimilate to the storage part takes place in presence of potassium and contributes towards the yield increase (Mengel, 2007). It regulates the nitrogen utilization and has interaction with many other essential nutrients as well (Bukshs, 2010). The fate of added K fertilizer depends upon the soil type and its adsorption capacity. Almost 57% of K applied may be adsorbed on soil colloids, depending upon the amount and soil mineralogy (Weil and Nyle, 2017).

Similarly, the optimum supply of micronutrients not only promotes the development and growth of the cereals but also improves the quality of the produce, which resultantly plays a key role in overcoming the micronutrient malnutrition in humans (Nadeem and Farooq, 2019). Iron present in ferrous ($Fe^{+2}$) or ferric ($Fe^{+3}$) forms are involved in redox reactions and necessary for the synthesis of chloroplast-protein complexes (Hassani *et al*., 2014). Nonetheless, availability of micronutrients like iron (Fe) is major issue particularly in alkaline calcareous soils (Shaver *et al*., 2017).

The foremost challenge to the nutrient uptake efficiency of applied nitrogen, phosphorous, potassium and iron are their rapid conversion into compounds that are unavailable to plants. They undergo run off, volatilization, leaching and fixation losses (Wang *et al*., 2013a). Phosphorus conversions and mobility in soil–plant system is also influenced by different physical, chemical and biological processes. The challenges of low nutrient use efficiency and environmental loss affect the ground water quality, environmental safety and crop production (Puntel *et al.,* 2016). Therefore, the low phosphorus and nitrogen use efficiency, potassium mining and site specific role of iron from the synthetic fertilizers is of great concern, particularly in alkaline calcareous soils of Pakistan (Sanders *et al.,* 2012).

In order to enhance the nutrient use efficiency (NUE), advance and efficient fertilizer types and methods of application need to be researched and developed (Zeroual and Kossir, 2012). The technique of slow/controlled release fertilizers has been reported to improve NUE of exhaustive crops (Gordon and Tindall, 2006). It has been shown in studies that the use of slow release targeted fertilizers reduces nutrient loss to environment (Guertal, 2009; Giroto *et al*., 2017; Dimkpa *et al*., 2020; Zheng *et al.,* 2020). The use of nanomaterials for precise provision of nutrients to the plants is also reported (Raliya *et al.*, 2016). Nanotechnology is a potential route to achieve sustainable agriculture by precisely implementing the metal oxide nanomaterials as fertilizers for crop growth (Nair *et al*., 2010). However, the desired progression in nano fertilizer technology for targeted delivery of nutrients has yet to be widely established (Zhu *et al*., 2008; Wang *et al*., 2013b).

The major factor hampering sustainable increase in yield of staple crops, such as wheat, is the low soil fertility status of Pakistani soils especially in nitrogen and phosphorus (Atak *et al.,* 2006). Nutrient use efficiency may be enhanced by limiting the interaction of fertilizer material with the colloidal surfaces of the soil (Barrow, 2015). Fernandes *et al.* (2017) reported that coated fertilizers regulate the nutrient dissolution. Presently, intensive research is concentrating towards formulation of eco-friendly nano-coated slow release fertilizers and to evaluate its efficacy on growth attributes and yield parameters of crops (Mani and Sudeshna, 2016; Parveen and Mushtaq, 2019; Shang *et al.,* 2019). Hence, this study was undertaken to evaluate the effect of novel smart potassium ferrite ($KFeO_2$) nano coated diammonium phosphate (DAP) fertilizer on yield attributes of wheat crop at different growth stages.

## MATERIALS AND METHODS

To check the efficacy of potassium ferrite nano-coated DAP on wheat growth, a field study was conducted at the research farm of the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan.

The following seven different treatment combinations were tested.

1. NPK: RD NPK (from Urea, DAP and $K_2SO_4$)
2. NP: RD NP (from DAP, Urea) + No Potassium (Farmer common practice)
3. NP5: RD NP (5% $KFeO_2$ nano-coated DAP) + urea + No Potassium
4. NP10: RD NP (10% $KFeO_2$ nano-coated DAP) + urea + No Potassium
5. NP5K: 75% RD NP (from 5% nano-coated DAP) + urea + 25% RD of K from $K_2SO_4$
6. NP10K: 75% RD NP (from 10% nano-coated DAP) + urea + 25% RD of K from $K_2SO_4$
7. NPKn: RD of NP (DAP, Urea) + K nanoparticles @ 15% of RD

Recommended dose (RD) of NPK used for wheat was 120-90-60 kg ha$^{-1}$ respectively. Commercial DAP, nano coated DAP, urea and SOP were used in the experiment.

***Experimentation*****:** The experiment was conducted under Randomized Complete Block Design (RCBD) with three replicates in winter (Rabi) season of 2017-2018. The tested wheat variety was Galaxy-2013. The composite soil samples were collected from the field before sowing from two depths viz. 0-15cm and 15-30cm and analyzed for all the physiochemical parameters following the standard laboratory protocols. The suitable crop cultural practices were adopted throughout the growing period. The data of shoot length and dry weight was observed at tillering, booting and harvesting stage. The chlorophyll content was recorded at booting stage using Minolta SPAD-502 (Welbum, 1994). At the time of harvest, the grain and biomass yield was recorded. Grain and straw samples were collected at maturity for N, P, K and Fe contents.

***Soil analysis*****:** The Mclean (1982) method was followed to determine the pH and electrical conductivity of the soil. The textural class was confirmed by performing particle size analysis (Bouyoucos, 1962). The soil was examined for total nitrogen (Jackson, 1962). Walkey (1947) method was adopted to determine the organic matter content. The available P content was measured using sodium bicarbonate as extractant (Olsen *et al*., 1954). The potassium content was determined on PEP-7 Janway Flame Photometer (Sheldrich and Wang, 1993). The DTPA extractable method (Lindsay and Norvell, 1978) was used to measure the Fe content on Atomic Absorption Spectrophotometer (AAS Thermo ICE 3300, German origin). The data regarding analysis of soil used in experiment is presented in Table 1.

**Table 1. The soil physio-chemical parameters of field before sowing.**

| Parameters | Symbol | Unit | Value |
|---|---|---|---|
| H-ion activity | pH | - | 8.76 |
| Electrical conductivity | ECe | dSm$^{-1}$ | 0.84 |
| Organic matter | OM | % | 0.84 |
| Texture | - | - | Sandy clay loam |
| Nitrogen | N | % | 0.04 |
| Phosphorus | P | mg kg$^{-1}$ | 9.34 |
| Potassium | K | mg kg$^{-1}$ | 188 |
| Iron | Fe | mg kg$^{-1}$ | 2.51 |

***Plant analysis*:** The plant samples (shoot at tillering and booting, grain and straw) were collected and dried in oven (EYELA, WFO-600 ND) at 65ºC. The wet digestion (Jones and Case, 1990) was done for the chemical analysis of the plant samples.

Uptake of nutrients = Yield (g) × concentration (%)

***Crop and Harvest index; Relative Growth Rate*:** The harvest and crop index were calculated using the following formulas.

Harvest index = Grain yield/Straw yield (Reddy, 2004)

Crop index = Grain yield/Grain yield + Straw yield (Beadle, 1993)

Relative Growth rate (RGR) = $D_2$-$D_1$/$t_2$-$t_1$ (Hoffmann and Poorter, 2002)

(Where $D_1$and $D_2$ was dry weight at 1st and 2nd harvest, $t_2$-$t_1$ was the difference of days between two harvests)

***Statistical analysis*:** The STATISTIX 8.1® (Hill and Lewicki, 2006) software was used for statistical analysis. The Analysis of Variance (ANOVA) was used and Turkey-HSD test was applied to compare the treatment means (Steel *et al*., 1997). The parameters were statistically analyzed at $\alpha$= 0.05.

## RESULTS

***Growth parameters*:** The plant height of the wheat plant showed significant ($p \leq 0.05$) increase towards the application of nano coated fertilizers. The plant height measured at two growth stages (tillering and booting) showed that NP10 gave maximum plant height of 60.3 and 80.7 cm, respectively (Table 2). The NP10 showed an increase of 25.3% in plant height over NPK at tillering stage. Similarly, it showed an increase of 7.9% over NPK at booting stage. The results exhibited that NP10 performed better than all other nano coated DAP treatments.

The shoot dry weight showed progressive increase at both harvesting stages (tillering and booting) in all the treatments. The maximum shoot dry weight (1.88 g) was recorded in NP10 at tillering stage with an increase of 24.4% over NPK (Table 2). Similarly, the NP10K showed a decrease of 11.5% in shoot dry weight as compared to the NP10 (7.8 g). It was clearly observed that response of nano coated treatment with 10% coating rate was most effective.

***Relative Growth rate*:** The result showed the relative growth rate (shoot dry matter) of NP10 was maximum (71mg dry matter per day) which was calculated after 30 and 50 days of sowing (Table 1). The NP showed least relative growth rate which directs the ineffective response of wheat crop to the unbalanced nutrient application. The application of 10% coated DAP with 25% additional K fertilizer (NP10K) also showed good response towards relative growth rate. The NP10 showed 22.4% increase in relative growth rate when compared with NPK (Table 2).

***Yield and yield parameters*:** Balanced nutrition applied at right time resulted in the better growth and yield comparing to unbalanced nutrition. The results showed that the application of nano coated fertilizer with 10% coating rate @ 100% application rate resulted in maximum number of grains per spike and highest 1000 grain weight. The least values

**Table 2. Effect of nano coated and uncoated fertilizers application on plant height, shoot dry weight and RGR, significant at *p*≤0.05.**

| Treatments | plant height (cm) | | Shoot dry weight (g) | | RGR (g day$^{-1}$) |
|---|---|---|---|---|---|
| | Tillering (30) | Booting (50) | Tillering (30) | Booting (50) | |
| NPK | 45.0±5.3$^{bc}$ | 74.3±4.2$^{bc}$ | 1.42±0.44$^{b}$ | 4.5±0.22$^{d}$ | 0.058 |
| NP | 36.7±4.7$^{c}$ | 50.2±4.0$^{d}$ | 1.08±0.17$^{ab}$ | 3.0±0.43$^{e}$ | 0.051 |
| NP5 | 52.0±5.6$^{ab}$ | 72.0±3.0$^{ab}$ | 1.51±0.27$^{ab}$ | 5.9±0.29$^{bc}$ | 0.068 |
| NP10 | 60.3±5.2$^{a}$ | 80.7±4.0$^{a}$ | 1.88±0.13$^{a}$ | 7.8±0.55$^{a}$ | 0.071 |
| NP5K | 43.7±2.5$^{bc}$ | 66.7±3.1$^{bc}$ | 1.51±0.22$^{ab}$ | 5.1±0.40$^{cd}$ | 0.065 |
| NP10K | 46.0±3.6$^{abc}$ | 73.7±4.0$^{bc}$ | 1.71±0.18$^{ab}$ | 6.9±0.30$^{ab}$ | 0.070 |
| NPKn | 46.7±2.1$^{abc}$ | 67.7±3.2$^{bc}$ | 1.40±0.24$^{ab}$ | 4.9±0.65$^{cd}$ | 0.063 |

**Table 3. Grains spike$^{-1}$, thousand grain weight, chlorophyll content, grain yield, straw yield, harvest and crop index means in comparison to the different combinations of nano coated and uncoated fertilizers, significant at *p*≤0.05.**

| Treatments | Grains spike$^{-1}$ (No.) | 1000 grain weight (g) | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Harvest Index (%) | Crop Index (%) | Chlorophyll content (SPAD value) |
|---|---|---|---|---|---|---|---|
| NPK | 38±2.6$^{c}$ | 41.8±4$^{bc}$ | 4.3±0.2$^{b}$ | 7.9±0.4$^{ab}$ | 49±0.06$^{ab}$ | 33±0.03$^{ab}$ | 48.8±4.5$^{bc}$ |
| NP | 28±3.0$^{d}$ | 37.4±2$^{c}$ | 2.9±0.21$^{d}$ | 6.6±0.6$^{b}$ | 45±0.06$^{b}$ | 31±0.03$^{b}$ | 39.1±2.5$^{bc}$ |
| NP5 | 48±3.6$^{ab}$ | 45.8±4$^{bc}$ | 4.0±0.2$^{bc}$ | 8.0±0.8$^{ab}$ | 51±0.03$^{ab}$ | 34±0.01$^{ab}$ | 54.6±4.6$^{b}$ |
| NP10 | 55±4.5$^{a}$ | 54.6±4$^{a}$ | 5.1±0.3$^{a}$ | 8.4±0.2$^{a}$ | 60±0.43$^{a}$ | 37±0.02$^{a}$ | 60.8±2.4$^{a}$ |
| NP5K | 45±2.5$^{bc}$ | 42.1±1$^{bc}$ | 3.5±0.3$^{cd}$ | 7.1±0.4$^{ab}$ | 49±0.04$^{ab}$ | 33±0.02$^{ab}$ | 49.5±2.2$^{bc}$ |
| NP10K | 53±3.8$^{ab}$ | 49.5±4$^{ab}$ | 4.1±0.2$^{bc}$ | 7.9±0.3$^{ab}$ | 52±0.01$^{ab}$ | 34±0.01$^{ab}$ | 55.8±2.6$^{bc}$ |
| NPKn | 36±2.5$^{cd}$ | 41.8±2$^{bc}$ | 3.4±0.3$^{cd}$ | 7.2±0.7$^{ab}$ | 48±0.01$^{b}$ | 32±0.01$^{b}$ | 49.8±2.9$^{bc}$ |

were noted in NP (farmer practice) which clearly indicated the positive effect of unbalanced nutrition on yield parameters. The NP10 showed an increase of 14.5% and 19.2% in No. of grains per spike and 1000 grain weight, respectively, over NP5. This increase in 1000 grain weight was 30.6% and 10.3%, respectively, over NPK and NP10K (Table 3).

The highest value of SPAD (chlorophyll contents) was found in treatment NP10 (60.8). The SPAD value ranged from 39.1 to 60.8 in all seven treatments. The NP10 treatment showed an increase of 24% over the NPK treatment.

The maximum grain and straw yield (5.1 and 8.4 t ha$^{-1}$) was recorded in NP10 and this increase was 18.6 and 6.3% over the NPK (traditionally used fertilizers) in grain and straw yield, respectively, which clearly depicted the response of wheat crop to the nano coated DAP.

The highest harvest and crop index was calculated in NP10(60%) followed by NPK and NP10K. The highest harvest index in NP10 indicated its better performance compared to traditional DAP used and to the farmer practice i.e., NPK and NP treatments, respectively.

The crop index was calculated that showed highest value for the treatment NP10 (0.37). The lowest value was calculated in NP treatment. The NPK treatment (0.35) showed lower crop index compared to the NP10 treatment but statistically similar value for other coated treatments.

***Nutrient uptake at different stages*****:** The NP10 clearly depicted the highest uptake of N, P, K and Fe at two growth stages (tillering and booting), in grain and straw (Fig. 1 & 2). The NP10 showed an increase of 36.4 and 22.2% N over NPK in grain and straw, respectively. The results showed the increased N content that may be due to reduced N losses and increased availability due to slow release fertilizer (Figure 1). The applied fertilizer rates and types (coated and uncoated fertilizers) showed the variation of P contents in shoot at tillering and booting stage. The increased P uptake in coated treatments showed clearly the better P release from the coated DAP. The NP10 showed an increase of 21.8 and 18.8% P over NPK in grain and straw, respectively (Fig. 1).

The higher coating rate on DAP with $KFeO_2$ NPs increased the activity of K ions and added Fe ions in the soil medium as auxiliary nutrient and resultantly in plant. The treatments where coated DAP was applied or nanoparticles were added performed better than the traditional fertilizer. The better performance of nano coated DAP supported the hypothesis that $KFeO_2$ nanoparticles supplemented the K content and Fe in the soil and resultantly in the plant. The NP10 showed increased K uptake of 24 and 9.1% in grain and straw, respectively, over NPK (Figure 2). The addition of Fe was clearly calculated from the Fe uptake that showed an increase of 20.6, 25.3, 46.6 and 48.5% at tillering, booting in grain and straw, respectively, over NP5 when compared with NP10.

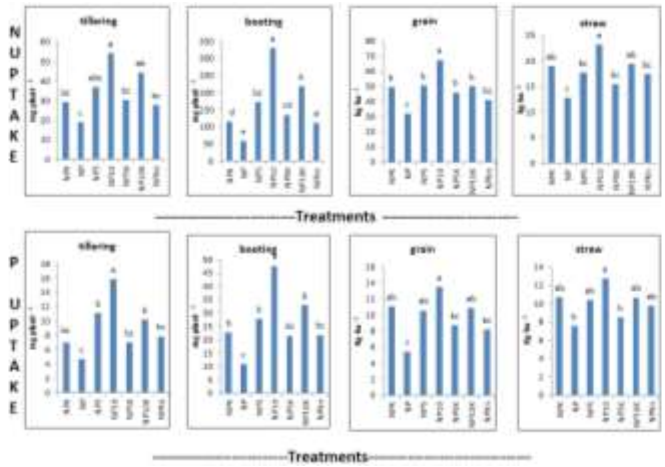


**Figure 1. Effect of different combinations of nano coated and uncoated fertilizers on N and P uptake in shoot (at tillering and booting stage) and in grain and straw (at harvesting), significant at *p*≤0.05.**

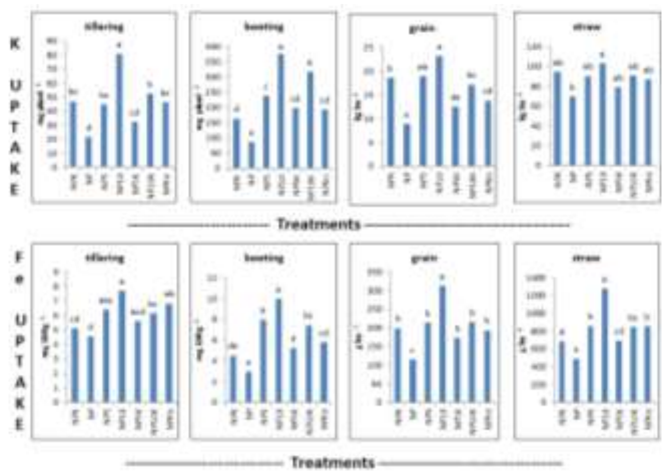


**Figure 2. Effect of different combinations of nano coated and uncoated fertilizers on K and Fe uptake in shoot (at tillering and booting stage) and in grain and straw (at harvesting), significant at *p*≤0.05**

## DISCUSSION

***Growth attributes of wheat crop*****:** The growth parameters of wheat crop showed significant response towards the applied potassium ferrite ($KFeO_2$) nano coated DAP fertilizer. The application of NP10 (RD NP (10 % $KFeO_2$ nano-coated DAP + urea + no exogenous potassium) showed maximum height of wheat plant at both growth stages (tillering and booting). The increase of plant height was clear indications towards nano coated DAP applied at recommended rate with 10% highest coating rate. Similar results were reported by Nazaran *et al.* (2009), who stated that application of iron in nano size improved the quality and yield of the crop. Maurya *et al.*

(2014) also stated that the addition of K enhanced the plant height compared to the plant with no potassium application.

The increase in dry weight also showed positive response of the crop to the applied $KFeO_2$ nano coated treatments. Peyvandi *et al.* (2011) described the research conclusions that application of nano iron improved the growth attributes of the crop. Al-Juthery *et al.* (2018) stated that nano fertilizers improved all the growth attributes of wheat crop when compared to different conventional fertilizers.

The wheat plant showed increased chlorophyll contents where nano potassium and iron coated DAP fertilizers was applied. Abdel-Aziz *et al*. (2016) reported that the chlorophyll contents increased with the application of nano fertilizers. The results of current study are in accordance with Pavendi *et al.* (2011) who strongly correlated that iron application increased the chlorophyll content. Hasanuzzaman *et al*. (2018) elucidated the physiological impacts like turgor maintenance, cell enlargement of potassium application that resultantly improved the growth of the plant. Guendouz *et al*. (2014) stated that the chlorophyll was the direct indicator of N content in the leaf as it increases with the timely release of nutrients from the slow release fertilizers (Kottegodda *et al*., 2011).

***Yield attributes*:** The application of K nano coated DAP fertilizers significantly increased the yield attributes. The wax coating of $KFeO_2$ nano particles slowed down the dissolution of DAP fertilizers and increased time of contact of the roots with K and Fe. Tabatabaii and Yarina (2011) elaborated that improved cell division and assimilates translocation to phloem with potassium utilization improved the number of grains spike$^{-1}$, which was the clear and direct indicator of the improved yield. The results of the presented study were consistent with the conclusions of Ma *et al.* (2000) who described that the use of K promoted the spikelet growth and number. The coatings slowed down the release of nutrients from DAP and made it available for longer time and added up the K in the soil that enhanced the crop growth. Vegra and Sveenjaak (2006) concluded that application of K with N increased the 1000 grain weight of wheat. The nano coating supplemented the K to the crop that increased the grain weight of wheat crop and resultantly yield. Hossain *et al.* (2015) also reported similar results that 1000 grain weight was increased with the application of K. Singh *et al.* (2017) reported that the use of nano fertilizers resulted in the improved plant growth, dry matter accumulation, photosynthetic rate, phloem translocation as compared to non-coated traditional fertilizers. The similar results were quoted by Ali and Al-Juthery, (2017).

***Grain and Straw yield; harvest and crop index*:** The coating of DAP slowed down the dissolution which not only enhanced the availability of nutrients but also synchronized the supply with demand of the plants. Ashraf *et al.* (2011) revealed that K application was important for grain filling and its deficiency resulted in reduced grain size and weight. The balanced fertilization was a key factor to improve the yield as collective role of nutrients enhanced the yield of wheat crop (Yousaf *et al.,* 2017). Saha *et al.* (2010) verified the improved grain yield when correlated with the K application. Imran and Gurmani, 2011 quoted that researchers concluded the improved grain and straw yield of wheat crop when supplied with K fertilizers. Beigi *et al.* (2010) also described that the nano fertilizers controlled the release of nutrients and Fe played significant role for grain yield. The results of field study exhibited that nano coated DAP caused slow release of N which not only reduced the environmental losses of nutrients but also increased the yield. This was in accordance with the findings of Al-Taey *et al.* (2018). Hadis *et al.* (2018) and Allah *et al*. (2020) also supported the results of this study that the application of P in adequate amount and K as nanoparticles improved the dry weight, enhanced rate of photosynthesis and phloem transport that eventually resulted in enhanced grain yield. Zare*et al.* (2013) reported a similar positive response of wheat crop in terms of yield when supplied with K nutrition. Khan *et al.* (2015) reported that the K application was required equally with N and P to achieve the desired yield and to minimize the yield gaps. The nano fertilizers application improved the harvest and crop index of the wheat crop as depicted by Abdel-Aziz *et al*. (2016). Khan *et al.* (2014) stated that K application increase the harvest index when supplied along with other essential nutrients.

***Nutrient uptake at different stages of wheat growth*:** The nutrient status for N, P, K and Fe of wheat plants was enhanced with the use of nano coated DAP fertilizer as compared to the conventional non coated fertilizers and imbalanced fertilization. Hu *et al.* (2017) stated the increased uptake of Fe in the shoot when nanoparticles were the source of applied Fe. The lower level of nutrients in NP treatment was due to the imbalanced fertilization as it clearly indicated that the depletion of nutrients appeared where K was not supplied to the crop with P and K (Bereket *et al.,* 2011). The P uptake was related to several soil properties and plant inherent properties to transform the rhizosphere (Balemi and Negisho, 2012) but coated fertilizers maintained the P availability to the plants by slow release throughout the required period, as also reported by Joseph *et al.* (2019).

The use of nano coated fertilizer increased the uptake of all the nutrients increased and it was related to increased nutrient content and the yield. Ghahremani *et al.* (2014) elaborated the findings that nano fertilizers slowed down the release of nutrients and increased the uptake use efficiency of applied fertilizers. It was reported that lack of K fertilization for a longer time period (10 years) resulted in the decline of K concentration in plants (Gaj*et al.,* 2014). Rietra *et al*. (2017) explained that the imbalanced fertilization resulted in the reduced nutrient uptake that was correlated with reduced growth and yield attributes of the wheat crop. Subsequently, deficiency of K is further aggravated, when N is supplied in abundant and resulted in the reduced uptake of nutrients.

Nitrogen and P uptake may be enhanced due to increased availability as described by Abdel-Aziz *et al.* (2018).

***Conclusion*****:** The field trial established that the use of potassium ferrite ($KFeO_2$) nano coated DAP positively affected the growth and yield parameters of the wheat crop. Coating of 10%$KFeO_2$ nano materials on DAP in NP10 treatment exhibited significant results when compared with uncoated DAP treatment (NPK) and the farmer general practice of NP application alone without K. The NP10K treatment showed better results for most of the growth and yield attributes compared to the NP treatment and NPK which clearly indicated the improved impact of nanoparticles coatings on DAP for enhanced and steady release and resultantly increased uptake of nutrients by plants.

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