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# Nano-Urea for enhancing yield and farmers profit with potato in Uttar Pradesh

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## ABSTRACT

*Conventional fertilizer application techniques are resulting in seriously overdosing of chemical fertilizers which has become evident through the phenomenon of eutrophication, volatilization, leaching, release of nitrous oxides and thus being the greenhouse gases, contribute to the global warming. Nanotechnology is a promising field of research which has the potential to offer sustainable remedies to pressing challenge scon fronted to modern intensive agriculture. Nanofertilizers hold potential to fulfill plant nutrition requirements along with imparting sustainability to crop production systems and that too without compromising the crops yield. The results of 187 trials conducted on farmers' fields with potato have proved that the quantity of urea being applied by the farmers to supply nitrogen to the crop can be successfully reduced to half. The yields obtained with 50% less nitrogen as compared to FFP and applying 2 sprays of nano-nitrogen in standing crops gave yields higher than FFP in most of these trials. This paper describes the results of 187 on-farm trials conducted on potato during winter season of 2019-20 in Uttar Pradesh.*

**Keywords:** Nano urea, yield, farmers profit, potato, Uttar Pradesh.

## INTRODUCTION

Food production and distribution are under an increased and continuous stress at a global scale due to climate change, an increased human population, and decreased fertile lands and fresh water resources (Yogendra Kumar *et al.* 2020 a, b). Sustainable agriculture with a high productivity is crucial to alleviate the perils of hunger and increase food productivity. Since green revolution, chemical fertilizers have become an indispensable input of modern crop production systems, but these have environmental and ecological consequences. Loss of nutrients from agricultural fields in the form of leaching and gaseous emissions has been the leading source of environmental pollution and climate change. Ensuring the sustainability of crop production necessitates exploring other sources of nutrients modifying the prevalent nutrient sources. It is really unfortunate that modern profit-oriented farming systems encompass nitrogenous fertilizers use efficiency of only 25–45%.

Potato (*Solanum tuberosum* L.) is considered an important food crop which ranks fourth in the world among food crops, and the importance of this crop stand out as the stable food for many of the world population. Uttar Pradesh is the leading potato growing state in the country followed by West Bengal and Bihar. In India, as per estimates of 2019-20, the total area under potato is 21.5 lakh ha with total production of 51.95 million tonnes (Mt) and productivity of 24.17$t^{-ha}$ while the estimated total area and production of potato during the same period the area and production is projected as 6.04 million ha (Mha) and 14.43 mt respectively with the productivity of 23.9 t $ha^{-1}$. The contribution of Uttar Pradesh in total potato production of the country is 27 percent. Apparently, the productivity of potato in Uttar Pradesh as well as India is still very low compared with other countries mainly due to injudicious and imbalance use of fertilizers. Nitrogen (N) is the most critical nutrient element limiting agricultural production at a global scale. Despite many efforts, the N use efficiency (NUE) in agriculture remains in a range of less than 50%. Reaching targeted crop yields has resulted in overuse of N, which is an economic and environmental concern worldwide. Nanofertilizers are one of the most promising engineered materials that are being tested, either for soil or foliar applications (Mejias 2021). Encouraging results have been obtained using nanofertilizers in different crops; however, limited information has been reported about their use in

potato. This paper aims at studying the potential use of Nano Urea in potato as an innovative approach to improve NUE, high quality yield and farmers profit.

## MATERIALS AND METHODS

Total 187 trials were conducted on farmers' fields with potato in different districts of Uttar Pradesh during *rabi* 2019-20 with five treatments but in this paper as we are evaluating the effect of non-nano urea with nano-urea so the impacts of only two selected treatments viz. Farmer's Fertiliser Practice (FFP) (T1) and FFP - 50% N + 2 Spray of Nano Urea (T2) on potato based on 187 trials are being presented. The crop was sown in the month of November to first week of December 2019. The Nano urea used in these trials had 25000 ppm N. Four ml. of this liquid fertiliser was added in one litre of water and for one acre 500 ml of nano urea was added to 125 litres of water and sprayed twice during the crop season. The first spray was done 3 week after full germination and the second spray was made 10-15 days after first spray. The field was kept weed-free as far as practical. Plant protection measures were adopted as per the need of the crop. The crop was harvested at full maturity and the yield data were recorded from the net plot area harvested and economic returns were worked out.

## RESULTS AND DISCUSSION

The data of 187 trialsrelated to economic yield, the range and mean of responses, additional yield and economic returns recorded over recorded over FFP are given in Table 1.

Table 1: Effect of nano urea on economic yield and net return on potato crop

| S.No. | Name of Division | Mean Yield ($kgha^{-1}$) | | Response to T2 over FFP ($kgha^{-1}$) | Percent Increase with T2 over FFP | Net Return over FFP ($Rs.ha^{-1}$) |
|---|---|---|---|---|---|---|
| | | Farmer's Fertilizer Practice (FFP-T1) | FFP-50% N + 2 Sprays of Nano -N (T2) | | | |
| 1 | Meerut (17) | 49792 | 52877 | 3085 | 6 | 15425 |
| 2 | Agra (32) | 37010 | 43045 | 6035 | 16 | 30175 |
| 3 | Aligarh (36) | 29917 | 31862 | 1945 | 7 | 9725 |
| 4 | Bareilly (29) | 33934 | 36661 | 2727 | 8 | 13635 |
| 5 | Moradabad (17) | 23938 | 26453 | 2515 | 11 | 12575 |
| 6 | Kanpur (12) | 29150 | 32652 | 3502 | 12 | 17510 |
| 7 | Prayagraj (14) | 26660 | 28561 | 1901 | 7 | 9505 |
| 8 | Gorakhpur, Basti, Devipatan (6) | 24138 | 26799 | 2661 | 11 | 13305 |
| 9 | Faizabad (24) | 28042 | 30574 | 2532 | 9 | 12660 |
| Mean | Uttar Pradesh (187) | 32298 | 35414 | 3116 | 10 | 15580 |

*Data in parenthesis are number of trials*

The tuber yields of potato in different divisions under Farmer's Fertilizer Practice (FFP -$T_1$) varied between 23938 and 49792 $kgha^{-1}$ being lowest in Moradabad Division and the highest in Meerut Division with a mean value of 32,298 $kgha^{-1}$while the tuber yield with 50% reduction of N from FFP + 2 Sprays of Nano-N ($T_2$) gave considerably higher yield compared with FFP ($T_1$) and ranged between 26453 and 52877 $kgha^{-1}$in Moradabad and Meerut respectively. The corresponding increase over FFP being 2515 $kgha^{-1}$in Moradabad and 3085 $kgha^{-1}$in Meerut with mean increase of 3116 $kgha^{-1}$in the state. The percent increase recorded with 50% reduction of N from FFP + 2 Sprays of Nano-N ($T_2$) varied widely in different Divisions (6-16%) with a mean value of 10. The economic return with 50% reduction of N from FFP + 2 Sprays of Nano-N ($T_2$)over FFP ($T_1$) was lowest (Rs. 9505 $ha^{-1}$) in Prayagraj Division and the highest (Rs. 30175$ha^{-1}$) in Agra Division, the average economic return being Rs.15580 $ha^{-1}$. Mean effect of nanofertilizers on tuber yield, additional yield and economic return recorded with FFP + 2 Sprays of Nano-N ($T_2$)over FFP in different Zones of the state have been summarised in Fig. 1-4 which clearly demonstrated that with 50% reduction in N and 2 foliar sprays of Nano N would be more effective compared with FFP. These results prove the effectiveness of one bottle of 500 ml of Nano N with 25000 ppm N will be equivalent to one bag of urea. Since the N content of Nano Urea has now been increased to 40,000 ppm, only one bottle of 500 ml will be sufficient for 2 sprays for one acre area.

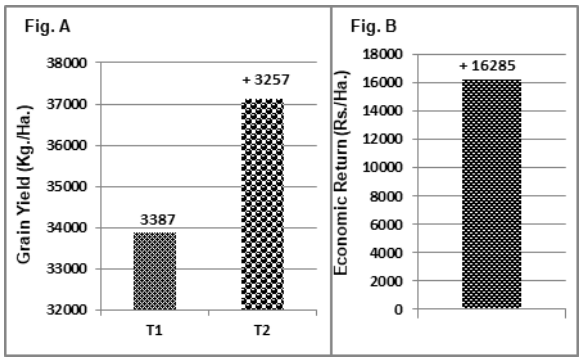


Fig. 1: Effect of IFFCO Nano Urea on Potato Crop Yield & Net Return in Western UP (No. of trials 151)

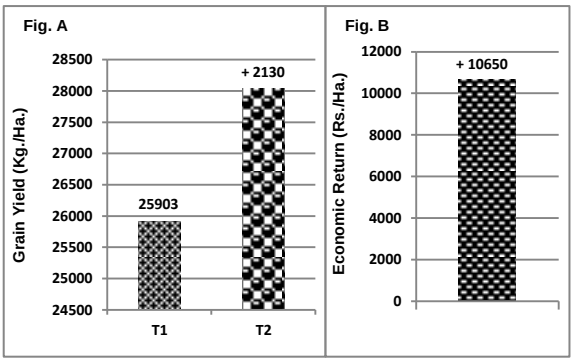


Fig. 2: Effect of IFFCO Nano Urea on Potato Crop Yield & Net Return in Western UP (No. of trials 131) & Net Return in Eastern UP (No. of trials 20)

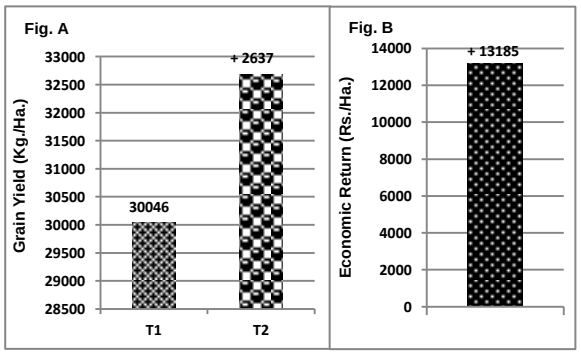


Fig. 3: Effect of IFFCO Nano Urea on Potato Crop Yield & Net Return in Central UP (No. of Trials 36)

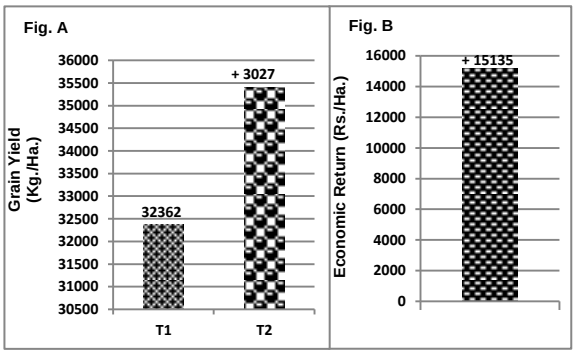


Fig. 1: Effect of IFFCO Nano Urea on Potato Crop Yield & Net Return in UP State (No. of Trials 187)

Several researchers have reported that N management through nano N fertilizers is one of the important approaches in achieving high productivity of potato (Moinuddin *et al.,* (2017).Recently, a group from the Sri Lankan Institute of Nanotechnology developed an advanced N nanofertilizer using urea-coated hydroxyapatite nanoparticles (rod-shaped structures, with an average aspect ratio of 10) for targeted delivery, and slow release of N (Kottegoda*et al.* 2017). Urea-hydroxyapatite nanoparticles were selected as a result of their chemical compatibility and rich N and phosphorus sources, respectively. The Nanohybrid of urea-modified hydroxyapatite, synthesized with N weight of 40%, releases N 12 times slower than conventional urea. Moreover, field trials with rice showed that slow release properties of the nano hybrid resulted in better yield data 50% lower concentration of urea. A subsequent goal would, therefore, betooptimize the nanoscale N fertilizerto maximize its potential in a range of arable soil types by following quantitative-structural area relationship models (Chhowalla (2017) and Kottegoda *et al.* (2017) nanohybrids for slow release of nitrogen and observed that nanohybrids strongly binds the urea, which released over longer period of time (up to one week) and the release rate was reduced by~2 times compared to that of pure urea. Urea-encapsulated HA nanoparticles even on the day 60 the nanofertilizer was releasing nitrogen > 10 mg, clearly showing the efficacy of the slow release process. In case of commercial fertilizer, the release of nitrogen was within four days (Kottegoda *et al.,* 2011). Pereira *et al.* (2015) found that urea loaded polycaprolactone nanocomposites released the nitrogen for a long period of time (> 90 hr) over to conventional urea (<25 hr). (Selva Preetha and Balakrishnan (2017) reviewed that releasing pattern of phosphorous fertilizer extended by the surface modification of fertilizer using various nanoclays and zeolite. Nano-formulations have been shown to release phosphate for an extended period of 40-50 days and the conventional fertilizer let out nutrients only upto 10-12 days. The review of literature suggests that surface modified zeolite could be potential strategy to promote phosphorus use efficiency which hardly exceeds 18-20 per cent in conventional system (Sharmila Rahale, 2011).

Field experiments were conducted during 2016 and 2017in Egypt to estimate whether NPK nanofertilizers applied in equivalent or lower rates could replace recommended levels of NPK chemical fertilizers in potato farming systems without retrograde effects upon yield production or quality (El-Azeim*et al.,* 2019). Impacts of recommended rates of NPK chemical fertilizers (control treatments) compared to NPK nanofertilizers in equivalent or lower rates (100%, 50% and 25%), foliar or soil applied on potato productivity and quality were studied. Compared with control treatments, plots receiving foliar application of NPK nanofertilizers at 50% or 25% of recommended level showed higher values of economic yield (23.59-ton/ha), starch rates (79.62%), NPK nutrient use efficiency (67.74,278.92, 118.54 kg potato $kg^{-1}$nutrient), harvest index (59.24%) and only lower potato nitrate content (1.15 g $kg^{-1}$ ) as a harmful indicator. Among all treatments, foliar application of NPK nanofertilizers at 50% rate was found to be the most economical treatment as it gave highest potato yield and quality plus highest profit: cost ratio of potato production. This research recommends foliar application of nanofertilizers in potato production to increase production and quality compared to soil applications. As yet, using lower rates of nanofertilizers as foliar application in the present study proved to be an eco-friendly environmental and economic alternative to recommended rates of chemical fertilizers with significant increase in potato productivity and quality.The results of our study clearly demonstrate that Nano-N fertilizer would help improving the yield and farmers profit with much lesser quantity of nitrogen due to slow release of nutrients in a controlled way which is in consonance with findings of (Rameshaiah and Jpallavi (2015). These fertilizers exhibit novel physio-chemical properties so they satisfy plants nutrients demand more efficiently in compares on with conventional fertilizers. The controlled release of the nutrient could be through the process of dissolution and ion exchange reactions (Jyothi and Hebsur, 2017; Ali and Al-Juthery, 2017). Nanofertilizers improve NUE due to their high specific surface area (between 1 to 100 nm), which facilitates good absorption of the nutrients by plants (Singh *et al.,* 2017).Benzon*et al.,*(2015) is of the view that Nano-nitrogen fertilizer hold potential to be used in place of mineral urea and it can also reduce environmental pollution caused by leaching, de-nitrification and volatilization of fertilizers. Nanomaterials under less than 100 nm in size could beused as fertilizer for effective nutrient management as well as the advantages of slow release, stress tolerance (Bottero 2016 and Merghany*et al.,*2019),reduce soil toxicity, increase NUE, minimizethe potential negative effects associated with over dosage and reduce the frequency of fertilizer application (Liu and Lal 2015). Hence, nanofertilizers as a superior product of nanotechnology, can go faringuaranteeing fertilizers use efficiency and ensuring sustainable agriculture, soil health and crop production (Abdel-Aziz *et al.* 2016 and Yogendra Kumar *et al.* 2020 a,b). Therefore, the scope for application of nano fertilizers in agricultural system needs to be prioritized in 21st century to accelerate the productivity of crops and sustain soil health and environmental quality through promoting use of Nanoparticles in fertilizers and nano-sensorsins oil microbial activity (Belal and El-Ramady 2016 and Chhipa*et al.,* 2016).

Due to the small size of Nano Urea Liquid, its bottle can be kept in the pocket and will significantly bring down the cost of logistics and warehousing also. This nano-urea has been tested for biosafety and toxicity as per the guidelines of the Department of Biotechnology (DBT), Government of India and OECD international guidelines. Nano urea is safe for the user; safe for flora and fauna and is non-toxic, however, it is recommended to use a face mask and gloves while spraying on the crop. IFFCO Nano Urea Liquid is now included in Fertiliser Control Order (FCO, 1985). Nano nitrogen particles size varies from 20-50 nm. When sprayed on leaves, nano-urea easily enters through stomata and other openings and is assimilated by the plant cells. It is easily distributed through the phloem from source to sink inside the plant as per its need. Unutilized nitrogen is stored in the plant vacuole and is slowly released for proper growth and development of the plant. In India, nano-urea liquid is expected to potentially replace 13.7 Mt of conventional urea usage by 2023. Urea also forms 82 per cent of the total nitrogenous fertilisers consumed in India, with an annual consumption of 33.6 Mt in 2019-20.This nano-urea is first nanofertilizer approved by the

Government of India and included in the Fertilizer Control Order (FCO). It will give a huge positive impact on the quality of underground water, very significant reduction in the global warming with an impact on climate change and sustainable development. Undoubtedly, nano-urea would be a product of the 21st century to keep the environment, soil, air and water safe for future generations while securing food for all.

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