A Study on the Standardization of Nanonitrogen and Nanozinc for Sustainable Paddy Production

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Abstract:

Investigation on Standardization of nano nitrogen and nano zinc for sustainable paddy production was undertaken. The growth, yield, quality and economics were considerably greater withapplication of 75% N and two foliar sprays of nano nitrogen and nano zinc at 25 to 30 and 45 to 50 DAT. The same treatment was statistically better in boosting the grain and straw production (6167 and 7288 kg ha^{-1}), net returns (Rs. 60,899 ha^{-1}) and B:C ratio (1.96). It was followed by treatment of 75% N and two foliar sprays of nano nitrogen at 25 to 30 and 45 to 50 DAT. The results revealed that application of 75% N and two foliar sprays of nano nitrogen and nano zinc at 25 to 30 and 45 to 50 DAT under SRI method was significantly higher in grain and straw yield, quality and economics whereas, SRI with recommended practice recorded significantly higher microbial population and soil enzymatic activity at 30 DAT and at 50% flowering.

Keywords: Nanonitrogen, Nanozinc, Standardization, Paddy production, Sustainable.

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Introduction:

In recent years, there has been an increased amount of focus placed on agricultural uses of nanotechnology, such as the utilisation of nanonitrogen and nanozinc. These nanoparticles have the potential to raise agricultural yield, improve the availability of nutrients, and stimulate plant development. Although research has been done on the effects of nanonutrients on a variety of crops, including paddy, the standardization of their use in the production of rice that is sustainable may still be an area of study that is currently being researched [1].

In order to meet the need for food from a growing population, farmers are increasingly turning to the use of fertilizer. Fertilizers, in particular nitrogen (N) and phosphate (P), are being used in several fold excess owing to their poor usage efficiency and availability in the desired chemical form, absorption by plants [1,2]. However, this is becoming a problem for the environment. In most agricultural situations, the use efficiency of nitrogen fertiliser (urea) is around 30–40%, while the use efficiency of phosphate is approximately 15–20% [3]. The intake of unused fertiliser is released into the environment, where it contributes to the pollution of the soil, air, and water. For example, urea has the ability to oxidise into nitrous oxide, which is a greenhouse gas, and release ammonia, both of which contribute to the warming of the planet's atmosphere and the pollution of its air [4]. Urea was leached through the soil in the form of nitrate, which impacted the quality of the drinking water. In addition, the usage of urea has an effect on the pH of the soil, which in turn has an effect on the plants' ability to effectively absorb important macro- and micronutrients [5]. In a similar vein, unused phosphate may run off and seep into water bodies, where it can contribute to the process of eutrophication and create dead zones [6, 7].

Alternative smart agri-inputs that are based on the principles of advanced chemical engineering, biotechnology, microbiology, and polymer science are now being developed for the control and delayed release of nutrients in the soil [8–11]. This is being done in an effort to increase the efficiency with which nutrients are used. However, because to the various agroclimatic conditions, plant and food demand variety, and soil nutrient profiles, the amount of success that may be achieved is restricted. The population of the world is forecast to reach over 10 billion by the year 2100, and Asia will continue to lead the pack in terms of population growth; thus, the need for food will increase. Because of this, it is essential to devise and implement sustainable agricultural practices that allow for the production of sufficient food while reducing the negative effects on the environment caused by fertilisers that are less effective. Current efforts, such as coated fertilisers for slow release [12], mixtures of macro and micro nutrients [13], crop diversification [14], green manure [15], gradual reduction of fertilisers [16], and organic farming practises, which include the use of organism-based fertiliser, decomposer, and extract of organisms [17], are currently being tested.

Exploration of nanotechnology has been going on over the last two decades with the goal of improving the efficiency with which plants utilise nutrients and delivering nutrients to specific areas of plants. Fertilisers manufactured at the nanoscale (1–100 nm), with a greater surface area to volume size ratio, the property of surface functionalization, and either gradual release or release dependent on the plant's reaction [18,19]. For example, zinc oxide nanofertilizers were utilised to mobilise natural phosphorus ion soil in addition to fertilising the zinc itself. This was done by adding the nanofertilizers to the soil. In a similar manner, urea that had been coated with hydroxyapatite was applied to a rice crop in an effort to reduce the amount of bulk alternative nitrogen fertiliser that was used, while apatite nanoparticles were used as a phosphorus fertiliser. The fascinating discovery proven by laboratory or small scale field trials with nanotechnology-based fertiliser inputs was the decrease in the requirement for traditional bulk alternatives while preserving or improving crop production [19]. This was evidenced by the fact that the crop productivity was either maintained or increased. This motivates the current research to explore the influence of nanofertilizers of nitrogen and zinc in conjunction with organic farming practises, which include the use of a limited or zero quantity of chemical fertiliser. Nanofertilizer of nitrogen and zinc was employed for crop fertilisation under the large scale agronomic experiments to evaluate chemical fertiliser to organic farming practises with nanofertilizer. This is the first report of its type, according to the literature, and the authors believe that it is also the first report of its kind that they have written. In order to decrease the excessive usage of bulk fertiliser such as urea, te nanofertilizers were used, in conjunction with organic agricultural practises. The overarching goal was to present an alternative agricultural practise that is both sustainable and precise.

Material and Methods:

Soil characteristics of the experimental site

With the use of a soil auger, soil samples were obtained at random before to the experiment at a depth ranging from 0 to 15 centimetres to create a composite sample with a weight of 250 grammes. This was done in order to get an estimate of the initial fertility status and to learn about the physical and chemical features of the experimental plot. The sample was delivered to the laboratory, where it was air dried and pounded to the point where it could pass through a sieve with a mesh size of 2.0 mm.

Climatic conditions

The data relating to different weather parameters such as temperature (maximum and lowest), monthly total rainfall, relative humidity (maximum and minimum), brilliant sunlight hours, wind speed, and evaporation were gathered from the meteorological observatory. These characteristics were recorded throughout the years 2018, 2019, and 2020.

Crop husbandry

The Zonal Agricultural Research Station at V. C. Farm in Mandya is responsible for the development and release of the rice variety known as Thanu (KMP-101) IET 17164.

Characterization of nano particles

The Indian Farmers Fertiliser Co-operative Limited (IFFCO) was contacted in order to get the standard nano nitrogen and nano zinc particles. The necessary amount of standard nitrogen nanoparticles were dissolved in distilled water and then subjected to sonication at a temperature of sixty degrees Celsius for half an hour.

Observations recorded

The five plants in the net plot area that were randomly chosen and marked were used to collect data for biometric observations on growth parameters at four unique phases of crop development, namely at 30, 60, and 90 days after transplanting (DAT), as well as at harvest. However, a destructive sample approach was used in order to determine the distribution of dry matter and the leaf area index from five hills that were arbitrarily chosen inside the border plot area at certain time intervals. At the time of harvesting, data were collected on yield and yield characteristics.

Soil Studies

After the crop had been harvested, samples of the soil were collected from each of the treatments. We took samples from the first 0 to 15 centimetres of the surface. The samples that were obtained were then dried in the shade, pulverised into a fine consistency, and sieved using a 2 mm sieve. The sample that had been sieved to a size of 2 millimetres was used for the analysis of the following parameters.

Chemical analysis of plant

At the time of harvest, representative plant samples were picked from each treatment, washed, and then dried in the shade. After that, the samples were oven dried at 60 5o C for 24 to 48 hours, and then they were coarsely pulverised using a mixer grinder. The samples had previously been shade dried. In order to conduct the analysis, the plant samples were coarsely pulverised.

Biochemical analysis

The total carbohydrate content was estimated by the method of Hedge and Hofreiter, 1962. Carbohydrate is first hydrolysed into simple sugars using dilute hydrochloric acid. In hot acidic medium glucose is dehydrated to hydroxmethyl furfural. This compound forms with anthrone a green coloured product with absorption maximum at 630 πm.

Biological analysis

The technique described by Tabatabai and Bremner (1969) was used to determine the amount of phosphtase enzyme present in the sample. The Casida et al. (1964) approach was used to determine the amount of dehydrogenase enzyme that was present in the sample. The approach proposed by Watts and Crisp (1954) was used throughout the process of determining the level of urease activity present in the sample.

Statistical Analysis

In order to find out the outcome of the experiment and come to a conclusion about what it taught us, a statistical analysis was performed on the observations that were collected during the various phenological stages of the rice crop. Both the ANOVA and the F-test were carried out.

Result:

IFFCO nano particles Characterization

The UV-Visible spectrophotometer, Zeta sizer, Scanning Electron Microscope, and Energy Dispersive Spectrometer (EDS) data are reviewed in relation to the characterization of IFFCO nano zinc particles. The zeta sizer was used to characterise the average particle diameter of the nano zinc particles based on the results of the intensity distribution analysis. The scanning electron microscope was used in order to characterise the morphological characteristics of nano zinc particles. The nano zinc particles that were created were in the shape of triangles. The creation of nano zinc particles seemed to have a hexagonal form when viewed under a scanning electron microscope (SEM). Either energy dispersive X-ray spectroscopy (EDS) or energy dispersive X-ray spectroscopy (EDX) refers to a method of elemental analysis that, when combined with a scanning electron microscope, may be used to detect the chemical composition of a material. The nano zinc particles that were produced had a zinc concentration of 67.15 percent on a weight basis in the sample.

Different methods effect of nano nitrogen and nano zincapplication of transplanted paddy on growth, yield and quality

The plant's capability for photosynthesis is directly related to the amount of dry matter it produces. The application of nano nitrogen and nano zinc fertilisers to the rice crop made the fertilisers easily accessible to the crop, which in turn increased the physiological activity of the crop. Higher plant height, more number of tillers per hill, leaf area, and significantly higher dry matter production in leaves and stem were observed as a result of improved nutrient uptake and efficient utilisation. These factors, in turn, contributed to increased mobilisation and accumulation of photosynthates in the reproductive parts of rice.

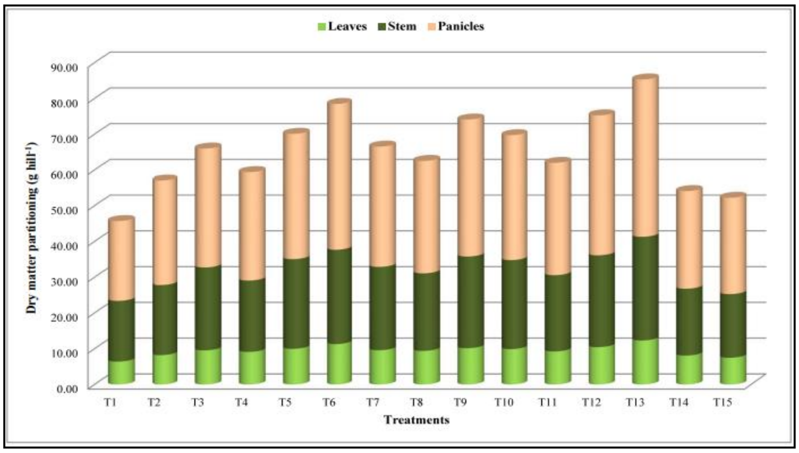

Figure 1: Different methods of nano nitrogen and nano zine application Influence in transplanted paddy during kharif season on dry matter partitioning

Harvest index and Dry matter efficiency

Both the harvest index and the dry matter efficiency did not substantially change as a result of the treatment effects.

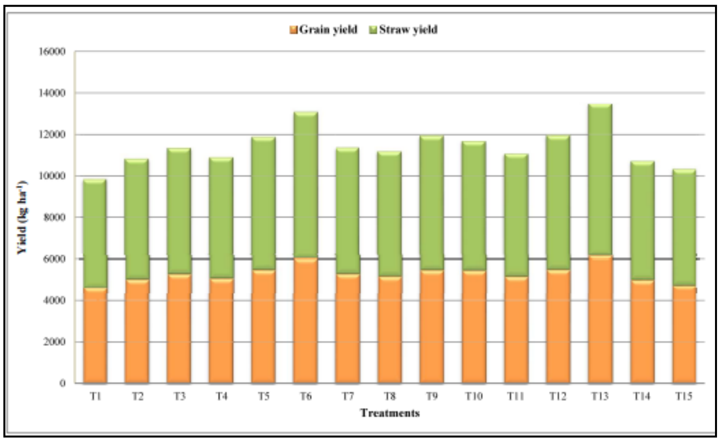

Figure 2: Different methods of nano nitrogen and nano zine application Influence of transplanted paddy during kharif season on grain yield and straw yield

Tryptophan and lysine (%)

There was a substantial difference between treatments in the levels of amino acids like tryptophan and lysine. Tryptophan levels were found to be significantly higher in the treatments that included the application of 75% nitrogen and two foliar sprays of nano nitrogen and nano zinc at 25 to 30 and 45 to 50 DAT (T13: 0.91%), followed by the application of 100% nitrogen and one foliar spray of nano zinc at 25 to 30 DAT (T9: 0.88%), and application of 75% nitrogen and one foliar spray of nano nitrogen and nano zinc at 25 to 30 DAT.

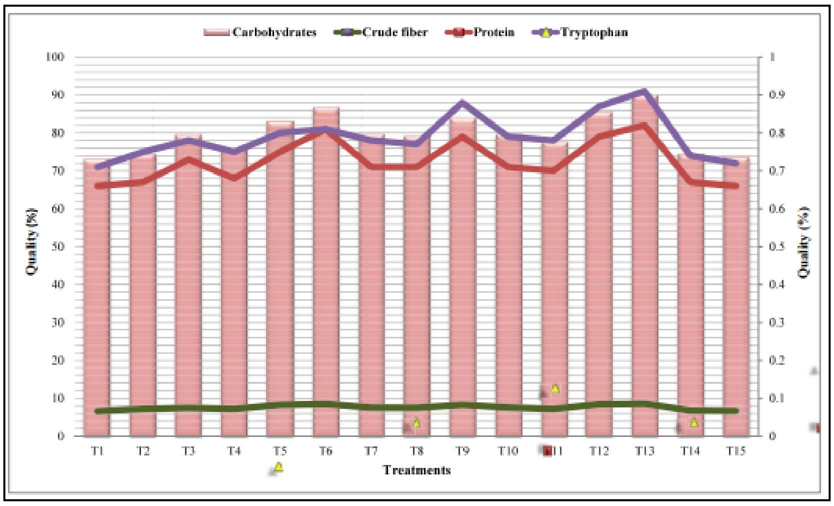

Figure 3: Nano nitrogen and nano zine application influence on quality parameters of different methods of paddy grains during kharif season

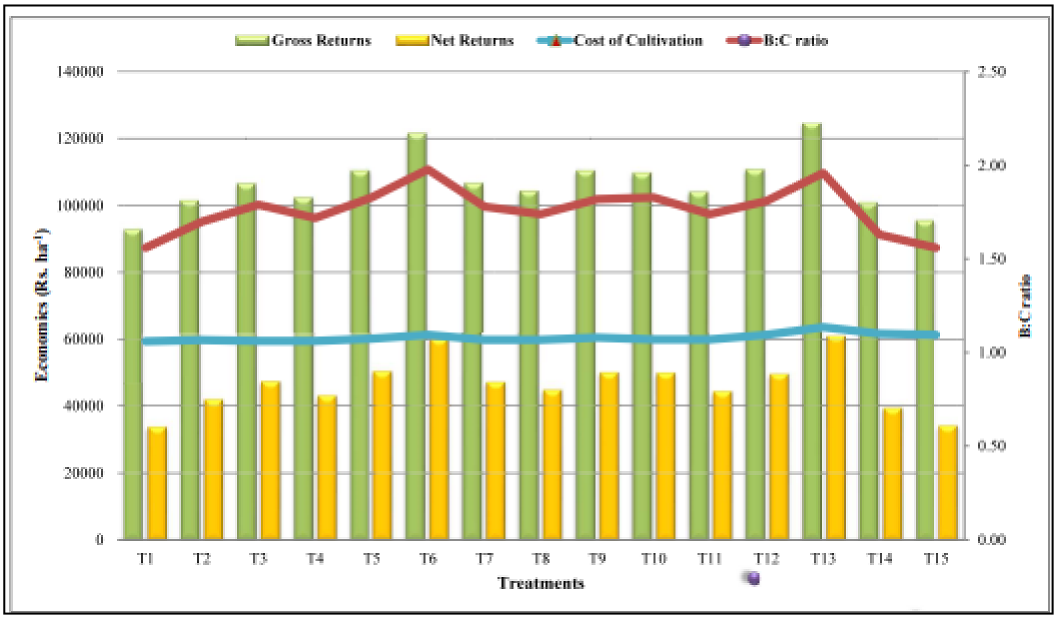

Figure 4: Different methods Influence of transplanted paddy during kharif season of nano nitrogen and nano zinc application on economics

Conclusion:

Application of 75% nitrogen along with two foliar sprays of nano nitrogen and nano zinc at 25 to 30 and 45 to 50 days after transplanting under the SRI method resulted in significantly higher grain and straw yield (7886 and 9397 kg ha^{-1}), quality as measured by protein (8.45%) and tryptophan (0.86%), as well as economics as measured by net returns (Rs. 1,03,276 ha^{-1}) and B:C ratio (2.85). On the other hand, SRI with suggested practise reported a considerably greater microbial population and soil enzymatic activity at 30 days after transplanting and at 50 percent blooming.

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