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Nutrient Dynamics in Soybean (*Glycine max* L.) as Influenced by Nano Urea and Conventional Nutrients

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Abstract

The present investigation was conducted at College of Agriculture, Bheemarayanagudi, Karnataka during *Kharif* season 2022-23 with a view to study the "Nutrient dynamics in soybean (*Glycine max* L.) as influenced by nano urea and conventional nutrients". The soil was clayey (Vertisols) in texture and experiment was laid out in randomized block design with 3 replications and comprised of nine treatments. The treatments comprise of rate of soil application of conventional (urea) and foliar application of nano urea fertilizers. Regional recommended P and K fertilizer rate is common for all the treatments. Results revealed that application of 100 % RDN as basal had produced significantly higher nitrogen uptake by seed, stover and whole plant. Results confirmed that reduced rate of conventional fertilizer can be substituted by foliar application of nano urea fertilizer spray to enhance N use efficiency and yield.

Key words : *Foliar spray, nano urea, seed yield, conventional fertilizer.*

Introduction

Over the time, farmers have engaged in conventional agricultural practice using chemical fertilizers for better crop yields and productivity. These practices adversely affect crop yield, physical and chemical properties of soil, water as a result of surface runoff and microbial ecological imbalance. The consistent use of chemical fertilizers to the crop plants over years has been affecting the food chain system causing several diseases to human beings (1).

Nitrogen is often the most limiting factor in crop production. Hence, application of N fertilizer results in higher biomass yield and protein yield and concentration in plant tissue. Nitrogen often affects amino acid composition of protein and in turn its nutritional quality. In cereals, abundant supply of N decreases the relative proportion of lysine and threonine. Thus, it needs reducing the biological value of the protein. Increased N supply generally improves kernel integrity and strength, results in better milling properties of the grain. In oilseed crops, protein levels are increased upon N fertilization, whereas oil concentration is decreased. Effect of N fertilization on oil composition and quality are inconsistent (2).

Indian soils are being exhausted heavily as 30 M t of nutrients removed, while 20 M t added by crops leaving a shortage of 10 M t consistently. Over the years fertilizer response ratio of crops has declined drastically (3). Nitrogen (N) is a key nutrient source for food, biomass and fibre production in agriculture. It is considered most important element in terms of the energy required for its synthesis, tonnage used and monetary value. However, compared with amounts of N applied to soil, the nitrogen use efficiency (NUE) by crops was very low in conventional fertilizers (50-70%). Plant nutrient formulations with dimensions greater than 100 nm is lost owing to leaching in the form of water-soluble nitrates, emission of gaseous ammonia and nitrogen oxides and long-term incorporation of mineral N into soil organic matter by soil microorganisms (4). Numerous attempts to increase the NUE have so far met with little success and the time may have come to apply nanotechnology to solve some of these problems.

It suggests that new nutrient delivery systems that exploit the nano scale porous domains on plant surfaces can be developed. Use of nanotechnology in fertilizer development remains relatively low (about 100 patents and patent applications between 1998 and 2008) compared with pharmaceuticals (> 6,000 patents and patent applications over the same period).

Nanotechnology is gradually moving from the experimental stage to the operational and practical stage. It will lead to a more tangible presence of the technology in the agricultural sector (5). In this regard, use of nano fertilizer to control release of nutrients can be an effective step towards achieving sustainable agriculture and sustainable environment (6).

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To address all the difficulties ahead, we should think of an alternate technology such as nanotechnology to precisely detect and deliver correct quantity of nutrients and other inputs required by crops in suitable proportion that promote productivity while ensuring environmental safety. Fertilizers contribute to the tune of 35-40 per cent of the productivity across crops. Zeolite based nano fertilizers are capable of releasing nutrients especially NO_3-N for more than 50 days while nutrient release from conventional fertilizer (urea) ceases to exist beyond 10-12 days (7). The study of nanotechnology holds great promise for providing modern intensive agriculture with long-lasting solutions to its pressing problems. Nanotechnology uses small-sized materials called nanoparticles (1-100 nm), which offer special properties and advantages. Large surface area to volume ratio provides chance for better and more efficient interaction of nanoparticles to target areas in addition to many other advantages. In addition to providing crop production systems with sustainability, nano fertilizers have the potential to meet plant nutritional needs without reducing crop yield. These nano fertilizers take advantage of the dynamics of surface area, size, shape and bio-assimilation. Their effectiveness was assessed based on studies conducted in several places with multiple crops over various crop seasons, both by research institutes and on the fields of progressive farmers spread out over 11,000 locations and 94 different crops in India. Separate tests for bio-efficacy, biosafety, toxicity and environmental compatibility have been conducted on nano-nitrogen, nano-zinc and nano-copper (8).

Soybean (*Glycine max* L.) is the world's most important seed legume, which contributes to 25 per cent of the global edible oil, about two-thirds of the world's protein concentrate for livestock feeding. Soybean meal is a valuable ingredient in formulated feeds for poultry and fish. It constitutes about 40 per cent protein and 20 per cent oil content hence it is known as "wonder crop". The oil and by-products have also increased demand and it necessitate intensifying efforts to expand soybean area. In recent past, farmers have engaged in conventional agricultural practice using chemical fertilizers for better crop yields and productivity. These practices adversely affect crop yield, physical and chemical properties of soil and water as a result of surface runoff and microbial ecological imbalance. The consistent use of chemical fertilizers in crop production over years has been affecting the food chain system causing several diseases to human beings (1).

Nano-urea fertilizer is an alternative to conventional fertilizers with slow and control release of N and it increases the crop yield by 10-15 %. Soybean being N responsive crop needs minimum quantity compared to other cereal crops. In this view, this experiment was conducted to study the effect of nano urea on nutrient dynamics in soybean (*Glycine max* L.) crop.

Materials and Methods

A field experiment was conducted during Kharif 2022-23 at College of Agriculture, Bheemarayanagudi, UAS, Raichur, Karnataka (16º15´N, 77º21´ E, altitude 389 m). The soil of the experimental site belongs to *Vertisols* (medium black soil). The soil was low in organic carbon (0.47%), available nitrogen (219.9 kg ha^{-1}), phosphorus (21.0 kg ha^{-1}) and high potassium (369.7 kg ha^{-1}) with pH of 8.34. The experiment was laid out in randomized complete block design (RCBD) with three replications. The treatments consisted of different rate of soil application of conventional (urea) and foliar application of IFFCO, India nano urea fertilizers. Application of 100 % recommended dose of nitrogen through chemical fertilizers, 75 % RDN as basal followed by nano urea spray @ 2 and 4 ml l^{-1} at 20 DAS, 50 % RDN as basal followed by nano-urea spray @ 2 and 4 ml l^{-1} at 20 DAS, 75 % RDN as basal followed by urea spray @ 2 % at 20 DAS, 50 % RDN as basal followed by urea spray @ 2 % at 20 DAS, Nano urea spray @ 2 and 4 ml l^{-1} at 20 and 40 DAS (see table 1 for further details). Regional recommended rate of P and K fertilizers were 80 and 25 kg ha^{-1} respectively was applied to all the treatments. The soybean variety DSB-21 was selected the study. Seeds were hand dibbled at 30 cm × 10 cm spacing in ridges and furrows on July 20, 2022 and harvested on October 27, 2022. The samples were collected harvest and dried at 65 ^{0}C in a hot air oven, powdered using a grinder, fitted with stainless steel bladders and preserved in polythene bags for further analysis of uptake of N as suggested by (9). Data analysis and interpretation was done using Fischer's method of variance technique as described by (10). The level of significance used in 'F' test was P=0.05.

Results and Discussion

Nitrogen content in leaves (%) : Application of different levels of nano urea had significant effect on the nitrogen content in soybean leaves (Table-1). Significantly higher nitrogen content in soybean leaves was found on 5th day after spray application of 75% RDN as basal followed by urea spray @ 2% at 20 DAS (2.53%) which was on par with application of 75% RDN as basal followed by nano urea spray @ 4 ml l^{-1} (2.50%) and application of 75% RDN as basal followed by nano urea spray @ 2 ml l^{-1} (2.48%). Nitrogen content in soybean leaves was recorded significantly lower in treatment with application of nano urea alone @ 2 ml l^{-1} at 20 and 40 DAS (1.20%) and 4 ml l^{-1} (1.35%).

Table-1 : Nitrogen content (%) in soybean leaves at before, 5th, 10th, 15th day after and at harvest after spray of chemical and nano urea fertilizers.

Treatment	Before spray	5th day after spray	10th day after spray	15th day after spray	Harvest
T_1 : 100% RDN through chemical fertilizers	2.09	2.28	2.41	2.38	1.76
T_2 : 75% RDN through chemical fertilizer & foliar spray of nano urea @ 2 ml l^{-1} @ 20 DAS	1.91	2.48	2.32	2.4	1.81
T_3 : 50% RDN through chemical fertilizer & foliar spray of nano urea @ 2 ml l^{-1} @ 20 DAS	1.84	2.26	2.36	2.39	1.59
T_4 : 75% RDN through chemical fertilizer & foliar spray of nano urea @ 4 ml l^{-1} @ 20 DAS	1.95	2.5	2.34	2.41	1.86
T_5 : 50% RDN through chemical fertilizer & foliar spray of nano urea @ 4 ml l^{-1} @ 20 DAS	1.85	2.27	2.38	2.38	1.64
T_6 : 75% RDN through chemical fertilizer & foliar spray of urea @ 2% @ 20 DAS	1.98	2.53	2.36	2.43	1.97
T_7 : 50% RDN through chemical fertilizer & foliar spray of urea @ 2% @ 20 DAS	1.87	2.3	2.4	2.45	1.71
T_8 : Nano urea spray at 2 ml l^{-1} @ 20 and 40 DAS	1.62	1.2	2.2	2.24	1.6
T_9 : Nano urea spray at 4 ml l^{-1} @ 20 and 40 DAS	1.78	1.35	2.28	2.33	1.75
S.Em. ±	0.06	0.07	0.05	0.02	0.06
CD @ 5%	0.17	0.2	0.15	0.07	0.17

Table-2 : Nitrogen uptake by seed, stover and whole soybean plant as influenced by application of chemical and nano urea fertilizers.

Treatment	N uptake by seed (kg ha^{-1})	N uptake by stover (kg ha^{-1})	Total N uptake (kg ha^{-1})
T_1 : 100% RDN through chemical fertilizers	119.2	35.6	154.8
T_2 : 75% RDN through chemical fertilizer & foliar spray of nano urea @ 2 ml l^{-1} @ 20 DAS	109.9	34.9	144.8
T_3 : 50% RDN through chemical fertilizer & foliar spray of nano urea @ 2 ml l^{-1} @ 20 DAS	102.2	26.0	128.2
T_4 : 75% RDN through chemical fertilizer & foliar spray of nano urea @ 4 ml l^{-1} @ 20 DAS	112.5	35.2	147.6
T_5 : 50% RDN through chemical fertilizer & foliar spray of nano urea @ 4 ml l^{-1} @ 20 DAS	103.9	28.3	132.2
T_6 : 75% RDN through chemical fertilizer & foliar spray of urea @ 2% @ 20 DAS	115.0	35.4	150.3
T_7 : 50% RDN through chemical fertilizer & foliar spray of urea @ 2% @ 20 DAS	105.4	31.9	137.3
T_8: Nano urea spray at 2 ml l^{-1} @ 20 and 40 DAS	41.6	7.3	48.9
T_9: Nano urea spray at 4 ml l^{-1} @ 20 and 40 DAS	52.4	10.8	63.2
S.Em. ±	3.6	0.4	4.6
CD @ 5%	10.8	1.2	13.9

Higher nitrogen content (2.41%) in soybean leaves was noticed with basal application of 100 per cent RDN at 10th day after spray. It was found on par with application of 50% RDN as basal followed by urea spray @ 2% at 20 DAS (2.40%) and application of 50% RDN as basal followed by nano urea spray @ 4 ml l^{-1} at 20 DAS (2.38%) and 2 ml l^{-1} (2.36%) and application of 75% RDN as basal followed by urea spray @ 2 % at 20 DAS (2.36%) and application of 75% RDN as basal followed by nano urea spray @ 4 ml l^{-1} (2.34%) and 2 ml l^{-1} (2.32%) and application of nano urea alone @ 4 ml l^{-1} at 20 and 40 DAS (2.28%). Significantly lower nitrogen content in soybean leaves was recorded in application of nano urea alone @ 2 ml l^{-1} at 20 and 40 DAS (2.20%).

Basal application of 50% RDN followed by urea spray @ 2% at 20 DAS was recorded significantly higher nitrogen content (2.45%) in soybean leaves at 15th day after spray. It was found on par with application of 75% RDN as basal followed by urea spray @ 2% at 20 DAS (2.43%) and application of 75% RDN as basal followed by nano urea spray @ 4 ml l^{-1} (2.41%) and 2 ml l^{-1} (2.40%) and application of 50% RDN as basal followed by nano urea spray @ 2 ml l^{-1} at 20 DAS (2.39 %) and 4 ml l^{-1} (2.38%) and basal application of 100 per cent RDN (2.38%). Application of nano urea alone @ 2 ml l^{-1} at 20 and 40 DAS (2.24%) and 4 ml l^{-1} (2.33%) was recorded significantly lower nitrogen content in soybean leaves.

Nitrogen content of leaves recorded at harvest after spray was found significantly higher by application of 75% RDN as basal followed by urea spray @ 2% at 20 DAS (1.97%) which was found on par with application of 75% RDN as basal followed by nano urea spray @ 4 ml l^{-1}

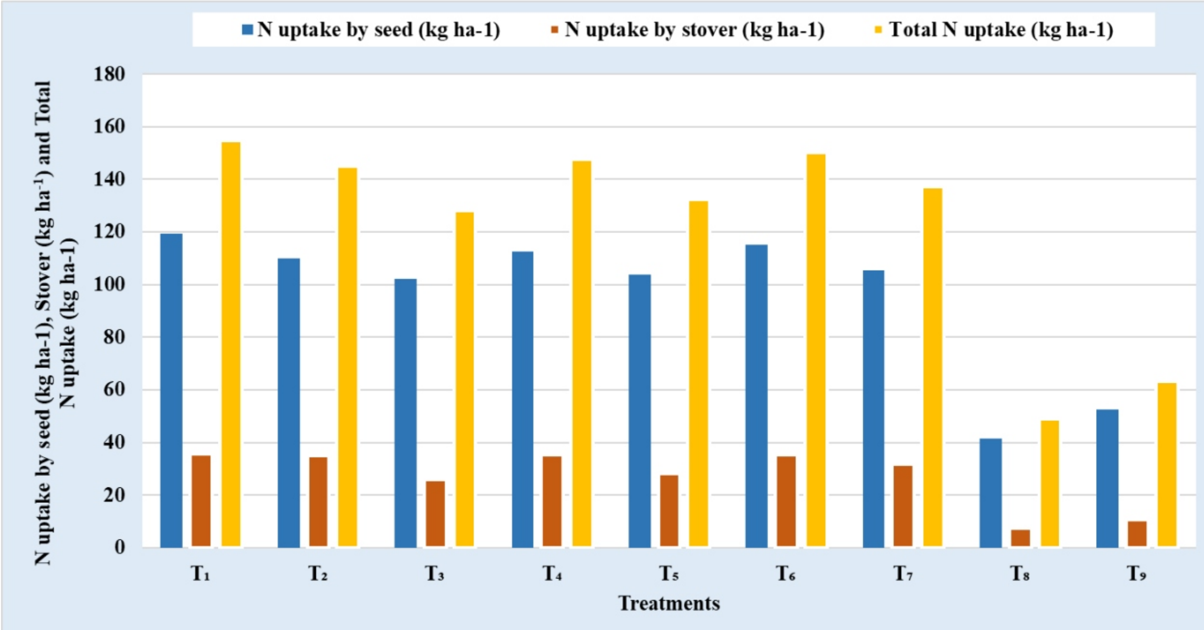

Fig.-1 : Nitrogen uptake by seed (kg ha^{-1}), stover (kg ha^{-1}) and total nitrogen uptake in soybean as influenced by nano urea and conventional nutrients.

(1.86%) and 2 ml l^{-1} (1.81%). Application of 50% RDN as basal followed by nano urea spray @ 2 ml l^{-1} at 20 DAS (1.59%) and application of nano urea alone @ 2 ml l^{-1} at 20 and 40 DAS (1.60%) was recorded significantly lower nitrogen content in soybean leaves. Similar results were also concluded by (11,12,13).

Nitrogen Uptake

Nitrogen uptake by seed (kg ha^{-1}) : Application of different levels of nano urea to soybean had significant influence on nitrogen uptake by seed (Table-2).

Greater uptake of nitrogen in soybean seed was noticed with 100 per cent RDN as basal (119.2 kg ha^{-1}) when compared with other treatments except basal application of 75% RDN followed by urea spray @ 2% at 20 DAS (115.0 kg ha^{-1}) and application of 75% RDN as basal followed by nano urea spray @ 4 ml l^{-1} (112.5 kg ha^{-1}) and 2 ml l^{-1} (109.9 kg ha^{-1}). Comparatively lower nitrogen uptake in soybean seed was observed in treatment with application of nano urea alone @ 2 ml l^{-1} at 20 and 40 DAS (41.6 kg ha^{-1}) and 4 ml l^{-1} (52.4 kg ha^{-1}). These findings were in accordance with (2,13,14).

Nitrogen uptake by stover (kg ha^{-1}) : Nitrogen uptake by soybean stover was significantly influenced by application of different levels of nano urea (Table-2 and Fig.-1).

Application of 100 per cent RDN as basal was recorded significantly higher nitrogen uptake in soybean stover (35.6 kg ha^{-1}) when compared with other treatments. However, it was found on par with basal application of 75% RDN followed by urea spray @ 2% at 20 DAS (35.4 kg ha^{-1}) and application of 75% RDN as basal followed by nano urea spray @ 4 ml l^{-1} (35.2 kg ha^{-1}) and 2 ml l^{-1} (34.9 kg ha^{-1}). Application of nano urea alone @ 2 ml l^{-1} at 20 and 40 DAS (7.3 kg ha^{-1}) and 4 ml l^{-1} (10.8 kg ha^{-1}) were observed significantly lower nitrogen uptake in soybean stover. It is a product of nitrogen content of soybean stover and biomass yield. Greater N uptake in stem was due to differential response of soybean plants to nutrient application.

Total nitrogen uptake (kg ha^{-1}) : Application of different levels of nano urea fertilizer was significantly affected the total uptake of nitrogen in soybean (Table-2). It is a combination of uptake by seed and stover of soybean.

Total nitrogen uptake in soybean was found significantly higher by application of 100 per cent RDN as basal (154.8 kg ha^{-1}) when compared with other treatments. However, it was on par with basal application of 75% RDN followed by urea spray @ 2% at 20 DAS (150.3 kg ha^{-1}) and application of 75% RDN as basal followed by nano urea spray @ 4 ml l^{-1} (147.6 kg ha^{-1}) and 2 ml l^{-1} (144.8 kg ha^{-1}). Total nitrogen uptake in soybean was resulted significantly lower in treatment which received barely application of nano urea @ 2 ml l^{-1} at 20 and 40 DAS (48.9 kg ha^{-1}) and 4 ml l^{-1} (63.2 kg ha^{-1}). Application of 75% RDN as basal followed by urea spray @ 2% at 20 DAS to foliage of soybean was recorded higher total nitrogen in soybean (150.3 kg ha^{-1}) compared to combined application of treatments from T_2 to T_5.

Greater uptake of nitrogen by soybean plant was observed by basal application of 100 per cent recommended dose of nitrogen (40 kg ha^{-1}). Greater uptake of nitrogen by whole plant might be due to increased biomass production of plant which helps to absorb more nitrogen in liquid form and uptake from soil due to higher root development. Lower nitrogen uptake was noticed in nano urea spray @ 2 ml l^{-1} at 20 and 40 DAS and 4 ml l^{-1}, low availability of nitrogen in soil might responsible for lower uptake of N. These findings were in accordance with (15,16).

Conclusions

It was concluded that basal application of 100 per cent RDN (40 kg ha^{-1}), 80 kg P_2O_5 ha^{-1} and 25 kg K_2O ha^{-1} recorded significantly higher nitrogen uptake by seed, stover and total nitrogen uptake in soybean when compared with other treatments. However, it was found on par with basal application of 75 per cent RDN followed by urea spray @ 2 %, nano nitrogen spray @ 4 ml l^{-1} and 2 ml l^{-1} at 20 DAS. We can reduce the 25 per cent conventional chemical fertilizer with foliar spray of nano urea.

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