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Sesame production under the influence of mineral nitrogen and nano urea nitrogen: A review

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Abstract

Sesame is one of the most important oilseed crops cultivated across the world. It is known as 'poor man's ghee' because of its rich oil content. Besides having potential, it is unable to yield to the fullest. The reason could be many but most prominent one would be lack of supply of adequate nutrients. Especially lack of nitrogenous fertilizers affects its overall production. As nitrogen is required in early growth stage. It is necessary to produce proteins, chlorophyll and nucleic acids. In India farmers rely on mineral nitrogen especially urea to meet the nitrogen demand of crop. Conventionally urea has been a solution to nitrogen deficiency which is extremely persistent in Indian soils but now farmers and scientists are thinking towards sustainable agriculture. It focuses much on providing more with less input. Here nano-fertilizers come into action. These nan-particles have the capacity to provide adequate nutrient supply with efficient nutrient use capacity, minimum wastage, and maximum uptake of nutrients by crops. 500 ml application of Nano-urea is equivalent to one bag of urea supplied. Both mineral nitrogen and nano based urea can be effectively used as nitrogen supplementary to crop, but the effect and efficiency vary in each.

Keywords: Sesame, mineral nitrogen, urea, nano-urea, nutrient use efficiency

Introduction

Sesame (*Sesamum indicum* L.) which is commonly called as 'til' is one of the most ancient edible oilseeds cultivated in India. India is the largest producer of this crop in the world and occupies 38% of acreage and 26% of total production (Singh *et al.*, 2018). In India it is widely cultivated in Uttar Pradesh and this state maximum area and production of sesame, while West Bengal have maximum productivity. Other states in which it is widely cultivated are as follows - Rajasthan, Andhra Pradesh, Orissa, Tamil Nadu, Madhya Pradesh, Gujarat and Karnataka. The origin of this crop dates to 2500-1400 B.C. and it is first found to be originated in South-western Africa, according to De Candolle (1886).

This crop is known for its high oil content which varies from 43-50% beside this its seeds are also rich in protein 22-25%, carbohydrate 11%. Sesame has most stable oil because of natural antioxidants present in the oil- sesame and sesame oil, this property makes it the ideal oil for cooking purposes (Berhe *et al.*, 2016) ^[3].

The major fatty acids present in the sesame are as follows.

Common Name	Content (%)
Myristic acid	<0.5
Palmitic acid	7-12
Palmitoleic acid	<0.5
Stearic acid	3.5-5.5
Oleic acid	32-54
Linoleic acid	35-59
Linolenic acid	<1.0
Arachidic acid	0.4-1.0
Eicosenoic acid	<0.5
Behenic acid	<0.5
Total FFA	1.5-2

Source (Berhe *et al.*, 2016) ^[3].

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Sesame is annual herbaceous crop, which grows well in tropical and subtropical region. Temperature ranging between 25-27 °C is most optimum for its germination, subsequent growth and flower initiation. Sesame is best suited to grow in well-drained sandy loam soil with adequate moisture. In northern India it is sown from last week of June to first week of July and 3-4 kg seeds required for one hectare land.

Besides having abundant qualities (high oil content, proteins, fatty acids), its production is limited in the country this could be due to following reasons

- The crop is usually grown by small and marginal farmers, because in India large farmers mainly focuses on rice, wheat cropping systems.
- These may be grown on poor soils without any adequate supply of manures and nutrients or on poor soils. As for getting good yield one should apply 20-25 tonnes compost/ FYM, 30kg nitrogen, 60 kg phosphorous and 30 kg potassium.
- Heavy infestation of weeds during the initial slow growth period.
- Sesamum is affected by several diseases like Phyllody, Blight, stem and root rot, etc. which again become a reason for its low production.

Amongst these the major problem associated with low production is poor supply of fertilizers which is extremely important for better seed and oil quality. As application of Nitrogen and Phosphorous increases number of capsules and seeds in the capsules. Nitrogen required for protein synthesis, chlorophyll formation and nucleic acids. Overall vegetative growth is governed by the application of nitrogen. Therefore, nitrogen plays a vital role in obtaining higher yield in sesame (Shilpi *et al.*, 2012) [8]. Also, it was stated that Nitrogen plays an important role of being the major constituent of proteins, chlorophyll, and nucleic acids. Therefore, adequate supply of nitrogen is very essential for sesame production.

Source of Mineral Nitrogen- Conventional Use of Urea

Urea has been widely used by Indian farmers since the time green revolution. It has become an inevitable part of cropping practice and is one of the main sources of nitrogenous fertilizers. It has 46% 'N' content in it. High subsidies (ref TABLE: 2) are paid by government for its purchase and application (Kiran and Samal, 2021) [9]. Urea accounts for more than 82% 'N' applied to major crops in India.

Table 1: Urea Production, Import And Consumption During Last 5 Years (In '000 Mt)

Year	Production	Import	Urea consumption		Total
			Kharif	Rabi	
2016-17	24201	4971	14356	15258	29614
2017-18	24023	6011	14832	15062	29894
2018-19	23899	7555	15448	16571	32019
2019-20	24455	9124	15369	18326	33695
2020- 2021	24603	9828	17782	17260	35043

Source: Kumar *et al.*, 2021 [1]

Table 2: subsidies paid by government of india for urea during last 3 years (rs. Crore)

Year	Indigenous Urea	Imported Urea	Total
2016-17	40000	11257	51257
2017-18	36974	9980	46954
2019-20	32190	17155	49345

Source: Kumar *et al.*, 2021 [10]

It has been observed that on an average Indian farmers use 2 bags of Urea per acre of cropping land. This may vary according to crop (Kiran and Samal, 2021) [9]. Once urea is applied to soil it undergoes several physiochemical and biological reactions under the influence of enzyme Urease. Its hydrolysis the urea to readily available 'N' source. Apart from soil application, foliar application is also successful in urea. This could be attributed due to non-ionic composition and high 'N' content. Also, urea foliar application reduces the risk of leaf scorch, due to salt damage as urea form relatively low osmotic nutrient compared to other Nitrogenous sources.

1. Influence of Mineral Nitrogen on Growth

Effect of Nitrogen Fertilization on the Growth and Seed Yield of Sesame (*Sesamum indicum* L.), it was stated that, maximum number of branches per plant in sesame was obtained with the application of 75 kg N/ha in India, while in Nigeria tall plants (116cm), higher LAI (0.78), higher branches per plant (8.7), and TDM (total dry matter) (32.7g) per plant were obtained with the application of 100 kg N/ha. The application of N increased the overall growth and yield of sesame. (Zenawi and Mizan 2019) [15]. Study the effect of nipping, crop geometry and different levels of nitrogen on the growth and yield of sesame. Plant height increased with each successive increase in nitrogen (N) levels from 0 kg N/ha to 60 kg N/ha. Also, dry matter accumulation was found to increase with increasing level of N from 0 to 60 kg/ha. 60 kg/ha. (Kithan and Singh., 2017) [13]. Spacing of 45cm × 10cm + 75% RDN + 25% N through bokashi produced maximum plant height (92.65cm). This could be due to nitrogen application might have increased the meristematic activity of plant. This same treatment obtained maximum dry weight (17.92g) of plant which was statistically at par with spacing of 45cm × 10cm + 50% RDN + 50% N through bokashi. Maximum no. of leaves (39.87) per plant was observed under spacing 45 cm × 10cm + 75% RDN + 25% N through bokashi. (Reddy *et al.*, 2021) [14].

2. Influence of Mineral Nitrogen on Yield

Experimental data reveals that, highest no. of seeds/capsule (42.00) were observed with spacing of 45 cm × 10 cm + 75% RDN + 25% N through bokashi, and treatment with Spacing of 30cm × 10 cm + 50% RDN + 50% N was found statistically at par. While spacing of 30 cm × 10 cm + 100% RDN recorded the lowest no. of seeds/capsule (33.20). This same treatment recorded lowest test weight (2.54). The highest test weight was obtained with spacing of 60 cm × 10 cm + 100% RDN (3.22g). Maximum harvest index (37.30%), grain yield (1256.67kg/ha) and stover yield (2112.67kg/ha) was recorded under spacing of 45 cm × 10 cm + 75% RDN + 25% N through bokashi and minimum harvest index (31.30%) was obtained with spacing of 45 cm × 10 cm + 100% RDN. (Reddy *et al.*, 2021) [14]. Plots treated with 120 kg Nitrogen recorded highest capsules/sq.m. and this also recorded highest no. of capsules/ plant. This treatment also resulted in highest shelling percentage while the lowest was recorded in the control plot. Highest test weight, grain and stover yield and harvest index was recorded with application of 120 kg N/ha while the lowest of all recorded in control plot. (Ali and Jan., 2014) [11].

Study that application of 90 kg/ha of Nitrogen resulted in 22% higher pod over control treatment. 90 kg/ha nitrogen observed maximum biological yield this could be associated with increase in plant height, maximum number of pods/plants, number of leaves/plants, and number of branches/ plants which increase total biomass of the plant and resulted in more biological yield.

Number of seeds/pods increased from 0-90 kg N application. Grain yield, test weight and harvest index also showed similar trend as of number of seeds/pods. (Ibrahim *et al.*, 2014) ^[7].

3. Influence of Mineral Nitrogen on Quality

An experimental trial carried by De *et al.*, 2003, three nutrient level was fixed in split plot treatment i.e., 50% RDF (12.5:12.5:0 kg NPK ha⁻¹), 100% RDF (25:25:0 kg NPK ha⁻¹) and 150% RDF (37.5:37.5:0 kg NPK ha⁻¹). Among all the treatments maximum oil percentage (49.82%) was obtained with 150% RDF followed by 100% (49.30%) and 50% (48.63%) RDF. 150% RDF recorded highest oil yield (279.85 kg ha⁻¹) and was significantly at par with 100% and 50% of RDF. Bellaloui *et al.*, 2018 ^[2], in which 'N' fertilizer applied at four rates (44.7, 67.2, 89.6, and 112.0 kg/ha). It was observed that fertilizer application resulted in higher protein and oleic acid content in various varieties of sesame this is desirable as they provide high quality meal and oil stability this increase resulted in decrease in oil and linolenic acid. Nitrogen application leads to higher seed nutritional quality. Effect of urea, compost, manure and bio-fertilizers on yield, percentage, and composition of fatty acids of sesame seed oil. The experiment revealed that oleic acid content increased with nitrogen content. High oleic acid content indicates best for frying purpose while linolenic acid indicates oil suitable for salad purpose. While oleic acid content increased by the application Nitrogen, but it reduced linolenic acid. Increasing nitrogen content also increased stearic acid and palmitic acid as well. (Ganjineh *et al.*, 2019) ^[6]. 'N' Application had Effect on Sesame Seed Quality. Urea application enhances the uptake of nutrients N, P, K, Ca, Mg, Na, Fe, Cu, Mn, and Zn. Since 'N' is the building block of all plant. Seed quality in sesame could be determined by seed colour, seed size, aroma, oil, and protein contents, and oil and protein are mostly made up of 'N' and the seed size is also influenced by oil and protein contents to some extents. Application of 'N' fertilizer has great impacts on the quality of sesame seeds. (Zenawi and Mizan., 2019) ^[15].

4. Influence of Nitrogen on Economics of Production

Sarkar *et al.*, 2009, while the experimental conduct, observed that net returns and B: C ratio increased gradually with increasing levels of nitrogen and irrigation. Application of 80kg/ha of 'N' is highly productive and profitable for farmers. It was also found out that increasing nitrogen content from 0-80kg/ha increased B: C ratio in both the years of experimental conduct. An experiment conducted by Kithan and Singh., 2017 ^[13], it was revealed that the treatment consisting of nipping + 45 cm x 10 cm + 60 kg N ha⁻¹ recorded highest net monetary return (44284.51), and B:C ratio (2.00) among all the sixteen treatments. This was statistical at par with treatment consisting of nipping + 30 cm x 15 cm x 40 kg N/ha (1.95). Study on response of sesame (*Sesamum indicum* L.) to nitrogen and potassium fertilization and the economic aspect of study reveals that, among different levels of nitrogen application viz N (0, 20, 40 and 60 kg N/ha), 'N' application up to 40 kg/ha brought about significantly higher net returns (58350 ha⁻¹) and B: C ratio (3.9) over the lower levels. (Kale *et al.*, 2019) ^[12].

Nano Urea- A Boon for Indian Farmers

Since green revolution times Indian farmers have heavily depended on chemical source of fertilizers especially urea. Indian soils are particularly deficient of nitrogen mineral as its losses are more in the form of denitrification, volatilization, leaching etc. which has led to increased consumption of nitrogenous fertilizers. Due to volatilization nitrous oxides are

released into the atmosphere which is a greenhouse gas and cause for global warming (Kumar. Y *et al.*, 2021) ^[10]. Leaching of these chemicals leads to environmental pollution due to eutrophication. Thus, there should be an alternate and efficient source for nitrogen which could provide balanced nutrient needs without many losses because nitrogen is one of the most important macronutrients required by the crop especially during its vegetative growth.

Here the introduction of nanotechnology to prepare various fertilizers has a game changer in the field of chemical fertilizers. 'Nano' means very small, which ranges between 1-100nm. It is an achievement in the field of science to develop concentrated nutrients with higher surface area, efficiency, and utilization with minimal losses (Kumar. Y *et al.*, 2021) ^[10]. Nano fertilizers play an important role in the field of sustainable agriculture as they are environment friendly to use. Various studies indicates that use of nano-fertilizers increased plant nutrient use efficiency, reduced toxicity on soil microorganisms and reduced the amount of application of fertilizers applied and thus reducing the cost of cultivation (Kantwa S and Yadav L.R, 2022) ^[11].

Plant nutrients encapsulated in nanomaterial is what basically called as nano- fertilizers. These encapsulated nutrients can easily pass through the stomatal openings and thus directly deliver the said amount of nutrients effectively and this leads to reduced loss of nutrients and higher nutrient use efficiency (Kumar. Y *et al.*, 2021) ^[10].

Nano urea is one such encapsulated version of nutrient nitrogen. In India IFFCO is the pioneer institution responsible for establishment of Nano Biotechnology Research Centre (NBRC) at Kalol, Gandhinagar, Gujarat for the preparation of liquid nano-urea and after vigorous trials it got listed in FCO. One nanoparticle of urea is 55000 times smaller in size than urea granules. Nano-urea is sprayed @2-4ml/litre of water and this provide instant nitrogen supply to the plants (Bera. A *et al.*,) ^[4]. It has been found out that 500 ml bottle of nano-urea can replace one bag of conventional urea. IFFCO has revealed that nano urea is more than 80% efficient in providing nitrogen to plants. 500 ml nano-urea is sufficient to apply twice over an acre of land. It is 10,000 times more surface area to volume than granular urea (Kiran, K., & Samal, K. C. 2021) ^[9].

1. Influence of Nano Urea on Yield

Karamity *et al.*, 2020 conducted an agronomic experiment on effect of inter cropping of three oil summer crops with maize under levels of mineral 'N' and nano 'N' fertilizers. The experiment results revealed that, intercropping of maize with groundnut recorded highest growth and yield parameter than intercropping of maize with soybean and sesame. Also, highest growth and yield parameter observed with application of 75% nano fertilizer N + 25% N mineral fertilizer recorded for maize, for soybean and for sesame. In maize 75% nano fertilizer N + 25% N mineral fertilizer. In soybean and groundnut 50% nano fertilizer 'N' + 50% 'N' mineral fertilization. In sesame 50% 'N' mineral and 50% nano 'N' recorded highest seed yield (2.70&3.39 ardab/fad) while 100% mineral nitrogen resulted in lowest yield (1.98&2.21 ardab/fad). In the experimental conduct by Mahmoodi *et al.*, 2018 on effects of nano and chemical fertilizers on oil yield of *borago officinalis*. The experiment results revealed that, soil and foliar application of nano-urea and soil application of nano micro-complete gave highest number of branches (13.29 & 13.14) in the plant. The highest fresh weight of aerial parts is observed in foliar, soil application of urea. It was observed that, fresh weight increased by 51.1% as compared to control plot. Highest leaf area (1706 cm²) was also with soil +

foliar application of nano-urea and foliar application of urea. This experiment also showed that highest oil yield was with nano-urea fertilizers (10.96 mg/ha). Also, interaction between fertilizer type and application method had a significant impact, as combined application of nano iron fb foliar application of nano-urea resulted in highest essential oil yield. Effect of Mineral, Nano and Bio Nitrogen Fertilization on Nitrogen Content and Productivity of *Salvia officinalis* and it was revealed that application of nano urea provided better nutrient content to plant. This result was due to nano formulation of urea which helped in easy absorption of nano urea to soil colloids. With the application nano urea, the quantity of actual application of fertilizers were reduced and thus benefiting farmer on economical aspect. Therefore, nano urea can be exploited to rise food production, reduce costs, and guard the environment. Also, it was found that, 'N' produced through nano fertilizer stays longer in soil. Overall application of nano urea was helpful in increasing yield components like, plant height (64.4cm), fresh weight (11249 kg/fed) and dry matter (4395kg/fed) in sage. Nutrient use efficiency was highest with the application of nano urea fertilizers. Nano based fertilizers reduces the wastage by excessive use of commercial mineral fertilizers and thereby reducing pollution hazards.

2. Influence of Nano Urea on Quality

In the experimental conduct by Mahmoodi *et al.*, 2018, it was observed from the experiment that in *borago offinalis*, soil application of complete (CCI = 50.91) and nanozinc (CCI = 48.35) showed highest chlorophyll index while the lowest chlorophyll index was observed in control treatment. It was also observed that in guar application of urea and biological fertilizers increased chlorophyll contents. This could be since Nitrogen plays important role in chlorophyll synthesis and thereby producing effective photosynthates. It was further revealed that essence percentage was maximum in nano-urea fertilizer and lowest in control treatments. Responses of Soybean Genotypes to Different Nitrogen and Phosphorus Sources: Impacts on Yield Components, Seed Yield, and Seed Protein, the experimental results showed that 90 kg N/ha urea application showed the highest number of filled and total pods. For seed yield, harvest index, and seed protein, only urea and nano-N had effects, compared to Nitroplus and control treatments. Thus, it was concluded that, urea, nano-n, and inoculation of Nitroplus increased yield, as compared to non-application of 'N'.

3. Influence of Nano Urea on Growth and Growth attributes

Effect of nitrogen and zinc nano fertilizer with the organic farming practices on cereal and oil seed. It was revealed that application of nitrogen and zinc were having same results in terms of plant height and growth as with the conventional fertilization method. Nano fertilizers for sustainable crop production, higher nutrient use efficiency and enhanced profitability using different cropping systems like – maize-wheat and mustard – pearl millet cropping systems, it was evident from the study that application of nano fertilizers alone or in combination of fertilizer N doses substituted 50% N in mustard by two sprays of nano nitrogen. (Kumar *et al.*, (2021) ^[10]. In cotton, application of nano Urea – liquid, nano Zn, nano Cu along with 50% soil application of fertilizers provided a better growth and development. It helped in enhancing yield and effectively increased economy i.e., B: C ratio. Responses of Soybean Genotypes to Different Nitrogen and Phosphorus Sources: Impacts on Yield Components, Seed Yield, and Seed

Protein, in this the effect of shoot growth were analysed and they found out that 90 kg N/ ha urea application yielded the highest plant height at 28 days after growing. Urea fertilizer also showed the highest effect in stem biomass, followed by nano- N.

4. Influence of Nano Urea on Economics of Sesame

Nano fertilizers, the experimental data revealed that among five parameters viz. Farmer's fertilizer practice (FFP), FFP-50% N + 2 Sprays of Nano-N, FFP-50% N + 2 Sprays of nano- Zn, FFP-50% N + 2 Sprays of nano Cu, FFP- 50% + 1 spray of nano-N, + 1 spray of nano-Zn + 1 spray of nano- Cu, the highest mean yield was obtained in FFP 50% N + 2 spray of Nano-N in mustard crop and in other crops (wheat, lentil, amaranthus, tomato, to name a few) similar trend was observed. (Kumar *et al.*, 2020) ^[10]. Effect of inter cropping of three oil summer crops with maize under levels of mineral 'N' and nano 'N' fertilizers. It was concluded from the experiment that net profit was in maize-groundnut intercropping were obtained using using 75% Nano plus 25% mineral N (13.875 & 11.922 L.E. fad) and also the monetary advantage index (MAI) recorded highest with the same treatment (13.303 & 11.35 L.E. fad), while, the lowest net return (1.022 & 0.968 L.E. fad) was recorded for intercropping soybean with maize received rate of 100% mineral fertilizer.

Conclusion

It is concluded that both mineral nitrogen- urea and nano-urea are a good source of nitrogen supplementary to the crop. The actual variation lies in its efficiency, effectiveness, and ease of application. Conventional urea application is the method that farmers are using from time immemorial and undoubtedly it is one of the cheapest and easily available sources of nitrogen, but it is more prone to loss in the form of volatilization. Since the goal of farming is now not just producing crop but how sustainably to produce crop with less inputs. Nano –urea has definitely a solution to replace conventional nitrogen fertilizers as it has capacity to provide sufficient nitrogen with minimal wastage. Nano-urea is definitely a boon to Indian farmers and now goal is to reach this technology to more and more farmers and reduce dependence on exported nitrogenous fertilizers.

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