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*RESEARCH PAPER*

# Influence of nano nitrogen on growth, quality and nutrient uptake of *Kharif* sweet corn (*Zea mays* Saccharata)

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**Abstract :** A field experiment was conducted for boosting the productivity of *kharif* sweet corn (*Zea mays* Saccharata) at Agronomy Farm,RCSM College of Agriculture, Kolhapur (M.S.), India during *kharif*, 2020 in black Vertisolsoil using split plot design with four replications and two factors, where main plot factors consist of time of application *viz* $T_1$:15 days after sowing (DAS), $T_2$: 30 DAS and $T_3$: 45 DAS and sub plot factors consist of levels of nano nitrogen (N) fertilizers *viz*$N_1$: 1.00 L ha$^{-1}$, $N_2$: 1.25 L ha$^{-1}$ and $N_3$:1.50 L ha$^{-1}$. The results showed that at harvest, maximum plant height (183.41 cm), number of leaves (8.86 plant$^{-1}$), leaf area (58.40 dm$^2$plant$^{-1}$), dry matter accumulation (117.18 gplant$^{-1}$), length of cob (18.55 cm), diameter of cob (16.83 cm), weight of cob per plant (208.65 g), number of grains (371.25 cob$^{-1}$), green cob yield (125.96 q ha$^{-1}$), green fodder yield (344.39 q ha$^{-1}$), total uptake plant in total ((264, 98 and 230 kg ha$^{-1}$),yield of protein by grain (92.89 g kg$^{-1}$) and stover (50.96 g kg$^{-1}$) were obtained from treatment $N_3$ (1.5 L ha$^{-1}$) which was on par with treatment $N_2$ (1.25 L ha$^{-1}$) and significantly superior over $N_1$ (1 L ha$^{-1}$). While main plot showed that at harvest plant height (191.90 cm), number of leaves(10.09plant$^{-1}$), leaf area (62.63 dm$^2$plant$^{-1}$), dry matter accumulation (123.51 gplant$^{-1}$), length of cob (20.56 cm), diameter of cob (19.71 cm), weight of cob (222.29 g plant$^{-1}$), number of grains (402.07 cob$^{-1}$), green cob yield (138.32q ha$^{-1}$),stover yield (359.75q ha$^{-1}$), total uptake(287, 113 and 262 kg ha$^{-1}$), yield of protein by grain (97.36 g kg$^{-1}$) and stover (51.77 g kg$^{-1}$)were significantly maximum when foliar spray of NN was done at 15 (DAS). The foliar application at 15 DAS had taken minimum number of days to reach 50 per cent of tasselling (51.62 days) and silking (55.97 days).

**Key Words :** Sweet corn, Nano-nitrogen (NN), Growth attributes, Yield attributes, Nutrients uptake, Protein yield

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## INTRODUCTION

Maize or corn (*Zea mays* L.) is a major annual cereal crop of the world belonging to family *Poaceae*. In Greek the word, *Zea* which means "sustaining life" and mays is a word from Tainolanguage meaning "life giver"(Kumar and Jhariya, 2013). Maize being the most remunerative economical crop which make it the first choice for poor and under privileged population. Nutritional and clinical benefits of the maize if exploited

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well with the strategic interventions through value added maize product development, utilization and commercialization will support in ensuring better health of the Indian population. Availability of values added food products of maize on industrial level will ensure better nutritional and livelihood security. Commercialization, promotion and adoption of maize based values added food products will not only ensure higher return to farmers but also generate employment for women and youth with improved dietary diversity in food choices to the consumers (Muradia*et. al.* 2016).Among various types of maize, sweet corn (*Zea mays* convar. *saccharata* var. rugosa; also called sugar corn and pole corn) is distinguished from other maize varieties by its delicious taste and high sugar content (14 – 20%), when cob is in milk or immature stage. Sweet corn is a good source of energy and about 20 per cent of the dry matter is sugar, compared with only 3 per cent in dent maize at ear stage (Kipps, 1959). Sweet corn is different from other types due to presence of gene or genes that affect starch synthesis in endosperm, for increasing sugar content in the maize grain. The eight genes affect endosperms carbohydrates synthesis, which are being used either singly or in combination in sweet corn variety (Singh, 1998). Assured rainfall and favourable climatic condition help farmer cultivate sweet corn. The sweet corn is eaten raw especially during rainy season and for culinary purpose fetch good price to farmer.

Nitrogen, which is a key nutrient source for food, biomass and fibre production in agriculture, is most important element in fertilizers when judged in terms of energy required for its synthesis, tonnage used and monetary value. However, compared with the amounts of nitrogen applied to the soil, the nitrogen use efficiency (NUE) by crops is very low. It is well documented only 30-50 per cent of theapplied nitrogen using conventional fertilizers-plant nutrient formulations with dimensions greater than 100nmis utilizable by plant, while rest of nitrogen is subjected to leaching in the form of water-soluble nitrates, emission of gaseous ammonia and nitrogen oxides and long-term incorporation of mineral nitrogen into soil organic matter by soil microorganisms. Numerous attempts to increase the NUE have so far met with little success, and the time have come to apply nanotechnology to solve some of these problems (Maria, 2010). Being, fertilizer responsive and demanding crop require more amount of fertilizer, thereby applying nitrogenous fertilizer in nano-form will reduce the demand and cost.

The nano fertilizers have unique advantages due to their small size and larger surface area leading to increase the absorption, the high process of photosynthesis and increased production of active substances in the plant (Al-Sharay and Al-Rubaee, 2019). The basis of work of the nano fertilizer is the rapid supply of the nutrients and increased the duration of the fertilizer effect. Nanotechnology has a significant impact on improving the solubility of other soil elements, displacing and replacing insoluble elements, reducing nutrient mineralization, increasing bioavailability and easily absorbed by the plants, (Naderi and Danesh-Shahraki, 2013). Nano fertilizers are so effective that they reduce the fertilizer application rate or annual demand or when the traditional negative environmental impact fertilizers need to be resolved by regulations. There are some signs of economic possibilities of nano fertilizers proposed by nanotechnology experts dedicated to improving fertilizers (Anonymous, 2017).

Keeping these aspects as maize or sweet corn being an important crop, demerits of mineral fertilizer and efficiency of nano fertilizer, a field experiment entitled "Nano nitrogen for boosting the productivity of *Kharif* sweet corn (*Zea mays* Saccharata)" was conducted at Agronomy Farm, RCSM College of Agriculture, Kolhapur-416004, MH, India.

## Material and Methods

The Kolhapur falls under the Sub-montane zone of NARP and is situated at an elevation of 548 meters above the mean sea level on $16^0$42'.548 North latitude and $74^0$ 14'.329 East longitudinal. The experimental plot was medium black clay (Vertisol) with 90 cm depth, low in available Nitrogen (197.16 kg $ha^{-1}$), medium in available phosphorus(40.19kg $ha^{-1}$) and very high available potassium (297.04 kg $ha^{-1}$). The status of organic carbon content (0.59%) was high. The electrical conductivity and pH values were 0.28 dSm-$^1$and 7.90, respectively. The experiment was carried out under split plot design with four replications and two factors, where main plot factors consist of time of application *viz.,* $T_1$:15 days after sowing (DAS), $T_2$: 30 DAS and $T_3$: 45 DAS and sub plot factors consist of levels of nano nitrogen (NN) fertilizers *viz* $N_1$: 1.00 L per ha, $N_2$: 1.25 L per ha and $N_3$:1.50 L per ha making total nine treatment combinations.The variety sugar 75 was used for the experiment @ 15 kg $ha^{-1}$. The recommended dose of inorganic mineral fertilizers @ 120:60:40 NPK kg $ha^{-1}$ was also given.The inorganic mineral fertilizers were applied as per the recommended dose, where in half dose of nitrogenous fertilizer and full dose of phosphatic and potassic fertilizers were applied at the time of sowing as basal dose.The gross and net plot size were 6.00 m × 4.00 m and 4.5 m × 3.2m, respectively. The periodical observations of crop growth attributes and yield were recorded after seed emergence w. e. f. 30 DAS on 15 days interval up to harvest and at harvest *viz*., plant population, plant height (cm), number of functional leaves $plant^{-1}$, leaf area $plant^{-1}$ ($dm^2$), dry matter accumulation $plant^{-1}$(g), grain yield (q $ha^{-1}$) and stover yield (q $ha^{-1}$). The protein contentin grain and stover were also calculated. The experimental data was statistically analyzed by using a standard method of "analysis of variance" as reported by Panse and Sukhatme (1967).

## Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

**Growth:**

The results in Table 1 clearly indicated that the different growth factors were also significantly influenced by doses of nano nitrogen fertilizer. The growth parameter at harvest of sub plot *viz.* plant height (183.41 cm), number of leaves (8.86 $plant^{-1}$), leaf area (58.40 $dm^2$ $plant^{-1}$), dry matter accumulation (117.18 g $plant^{-1}$) and chlorophyll content at 50 DAS (1.76 gm $g^{-1}$) were maximum with treatment $N_3$ (1.5 L $ha^{-1}$) which was on par with treatment $N_2$ (1.25 L $ha^{-1}$). The significantly minimum number of days were required to reach 50 per cent tassel (55.18 days) and silk emergence (58.33 days) with treatment $N_3$ (1.5 litre $ha^{-1}$) which was on par with treatment $N_2$ (1.25 litre $ha^{-1}$). The foliar application of NN at 15 DAS ($T_1$) produced significantly higher growth parameters at harvest *viz.* mean plant height (191.90 cm), number of leaves (10.09 $plant^{-1}$), leaf area (62.63 $dm^2$ $plant^{-1}$), dry matter accumulation (123.51 g $plant^{-1}$) and chlorophyll content at 50 DAS (1.92 gm $g^{-1}$) were significantly maximum when spraying was done at 15 DAS ($T_1$) over later spraying *viz.*at 30 DAS ($T_2$) and 45 DAS ($T_3$). The days to 50 per cent tassel (51.62 days) and silk emergence (55.97 days) were significantly minimum when nano nitrogen fertilizer was applied at

**Table 1: Effect of time of application and levels of nano nitrogen fertilizer on growth attributing characters of sweet corn (Sugar-75)**

| Treatments | Growth attributing characters (At harvest) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Height (cm) | No. of leaves per plant | Leaf area per plant ($dm^2$) | Dry matter accumulation per plant (g) | Days to 50 % Tassel emergence | Days to 50 % silk emergence | Chlorophyll Content of fresh leaf (mg $g^{-1}$) |
| Time of Application (T) | | | | | | | |
| 15 DAS ($T_1$) | 191.90 | 10.09 | 62.63 | 123.51 | 51.62 | 55.97 | 1.92 |
| 30 DAS ($T_2$) | 171.51 | 7.91 | 54.44 | 107.79 | 58.03 | 61.28 | 1.34 |
| 45 DAS ($T_3$) | 160.83 | 6.37 | 49.39 | 103.70 | 60.52 | 65.55 | 1.27 |
| S.Em± | 4.66 | 0.45 | 2.26 | 3.63 | 1.72 | 1.35 | 0.23 |
| CD at 5% | 16.14 | 1.56 | 7.84 | 12.53 | 5.94 | 4.67 | 0.54 |
| Levels of Nano nitrogen fertilizer (N) | | | | | | | |
| NN @ 1.00 l $ha^{-1}$ ($N_1$) | 165.67 | 7.21 | 51.83 | 104.04 | 59.20 | 64.20 | 1.17 |
| NN @ 1.25 l $ha^{-1}$ ($N_2$) | 175.16 | 8.31 | 56.24 | 113.77 | 55.78 | 60.27 | 1.58 |
| NN @ 1.5 l $ha^{-1}$ ($N_3$) | 183.41 | 8.86 | 58.40 | 117.18 | 55.18 | 58.33 | 1.76 |
| S.Em± | 3.16 | 0.22 | 1.25 | 2.21 | 0.93 | 1.15 | 0.19 |
| CD at 5% | 9.39 | 0.64 | 3.72 | 6.56 | 2.76 | 3.43 | 0.38 |
| Interactions (T × N) | | | | | | | |
| S.Em± | 5.76 | 0.38 | 2.17 | 3.83 | 1.61 | 2.00 | 0.21 |
| CD at 5% | 17.10 | 1.12 | 6.45 | 11.37 | 4.78 | 5.93 | NS |

15 DAS ($T_1$) over later spray *viz.* at 30 DAS ($T_2$) and 45 DAS ($T_3$). It could be attributed that prolonged exposure under nano nitrogen fertilizer at early stage feeds the crop gradually in a controlled manner in contradiction over rapid and spontaneous release of nutrients from the chemical fertilizers also other growth paraments *viz*. plant height, number of leaves per plant and leaf area have also been augmented findings are supported by (Iqbal, 2019). Further, higher dose of nano nitrogen may have increased the permeability of nutrients through cellular membrane of cell than lower doses of nano nitrogen thereby promoting plant growth attributing characters *vis-à-vis* the leaf area the results are supported by (Al-Saray and Al-Rubaee, 2019).This may also be due to role of high dose of nano nitrogen fertilizer in stimulating the production of auxins that encourages cell division and elongation of the total vegetative plant also has a direct impact on the plant height and other growth attributing characters the results are in conformity with (Al-Gym and Al-Asady, 2020). Similar results were also reported by Singh and Kumar (2017), Ghasemi*et. al.* (2017), Melika *et. al.* (2015), Amuamuha *et al.* (2012), Heba *et al.* (2016) and Armin *et al.* (2014).

## Yield:

The data in Table 2 showed that treatment $N_3$ (1.5 L $ha^{-1}$) produced maximum yield contributing characters *viz.*, length of cob (18.55 cm), diameter of cob (16.83 cm), weight of cob (208.65 g $plant^{-1}$) and number of grains (371.25 $cob^{-1}$), thus green cob yield (125.96 q $ha^{-1}$) and green stover yield (344.39 q $ha^{-1}$)which was on par with treatment $N_2$ (1.25 L $ha^{-1}$) and significantly superior over $N_1$ (1.00L $ha^{-1}$).The foliar application of NN in main plot at 15 DAS ($T_1$) provided significantly higher outputs of length of cob (20.56 cm), diameter of cob(19.71 cm), weight of cob (222.29 g $plant^{-1}$), number of grains (402.07 $cob^{-1}$), green cob yield (138.32 q $ha^{-1}$) and green stover yield (359.75 q $ha^{-1}$) over later spraying at 30 DAS ($T_2$) and 45 DAS ($T_3$).

The reason may be high dose of nano nitrogen fertilizer gave more area for various metabolic process in the plant thereby increasing the rate of photosynthesis and its role in stimulating the enzyme involved in influencing these traits by increasing the activity of chemical reactions and reducing the impact of free radicles that negatively affect the efficiency of work of some organelles in the plant thus increasing the overall yield of crop was observed by (Sorooshzadah *et al.,* 2012). It might also be due to high dose of nano nitrogen and mineral fertilizer has provided the most nutrients, especially the major ones, which increase the accumulation of dry matter and increase the leaf area that contribute to plant growth. Further it reduces the proportion of ovarian absorption and thus increased pollination and fertilization which leads to increased length of the cobs and number of rows in ears results are in

**Table 2: Effect of time of application and levels of nano nitrogen fertilizer on yield attributing characters of sweet corn (Sugar-75)**

| Treatments | Length of cob | Diameter of cob | Weight of cob | Number of grains | Green cob yield | Stover yield |
|---|---|---|---|---|---|---|
| | (cm) | | (g) | ($cob^{-1}$) | ($q\ ha^{-1}$) | |
| **Time of Application (T)** | | | | | | |
| 15 DAS ($T_1$) | 20.56 | 19.71 | 222.29 | 402.07 | 138.32 | 359.75 |
| 30 DAS ($T_2$) | 17.28 | 15.55 | 192.64 | 343.54 | 112.63 | 319.99 |
| 45 DAS ($T_3$) | 14.37 | 11.93 | 177.29 | 329.33 | 107.43 | 305.68 |
| S.Em ± | 0.80 | 0.68 | 7.51 | 9.02 | 3.74 | 10.37 |
| CD at 5% | 2.76 | 2.34 | 25.99 | 31.22 | 12.96 | 35.88 |
| **Levels of Nano nitrogen fertilizer (N)** | | | | | | |
| NN @ 1.00 l $ha^{-1}$ ($N_1$) | 15.82 | 14.21 | 183.94 | 339.37 | 112.59 | 312.14 |
| NN @ 1.25 l $ha^{-1}$ ($N_2$) | 17.84 | 16.16 | 199.63 | 364.33 | 119.83 | 328.88 |
| NN @ 1.5 l $ha^{-1}$ ($N_3$) | 18.55 | 16.83 | 208.65 | 371.25 | 125.96 | 344.39 |
| S.Em ± | 0.50 | 0.38 | 3.98 | 6.43 | 2.17 | 6.70 |
| CD at 5% | 1.49 | 1.12 | 11.81 | 19.12 | 6.46 | 19.92 |
| **Interactions (T × N)** | | | | | | |
| S.Em ± | 0.87 | 0.65 | 6.89 | 11.14 | 3.76 | 11.61 |
| CD at 5% | 2.58 | 1.95 | 20.46 | 33.11 | 11.18 | 34.50 |

line with those reported by (Al-Saray and Al-Rubaee, 2019). There may be some another reason that higher dose of nano nitrogen fertilizer helped in increasing the size and efficacy of the source, which caused an increasing in the representation of nutrients that helped to form a good downstream and then a heaver grain weight (Sharifi and Namvar, 2016). Jian *et al.* (2008), Fan *et al.* (2012), Prasad *et al.* (2012), Morteza *et al.* (2013), Kole *et al.* (2013), Manikandan and Subramanian (2016), Hagab *et al.* (2018), Anupama *et al.* (2020) and Al-Juthery *et al.* (2019) reported similar findings.

**Nutrient uptake and protein yield:**

The data presented in Table 3 and 4. Indicated that

**Table 3: Effect of time of application and levels of nano nitrogen fertilizer on nutrients uptake by sweet corn (Sugar-75)**

| Treatments | Mean nutrients uptake by crop | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Nitrogen | | | Phosphorus | | | Potassium | | |
| | (kg ha$^{-1}$) | | | | | | | | |
| | Grain | Stover | Total | Grain | Stover | Total | Grain | Stover | Total |
| Time of Application (T) (Main Plot Treatment) | | | | | | | | | |
| 15 DAS ($T_1$) | 219 | 68 | 287 | 82 | 31 | 113 | 128 | 132 | 262 |
| 30 DAS ($T_2$) | 180 | 50 | 230 | 60 | 22 | 82 | 96 | 98 | 194 |
| 45 DAS ($T_3$) | 169 | 45 | 215 | 56 | 20 | 75 | 90 | 85 | 178 |
| S.Em± | 8.18 | 1.58 | 6.89 | 2.33 | 1.03 | 2.84 | 2.78 | 3.76 | 5.57 |
| CD at 5% | 28.29 | 5.48 | 23.84 | 8.08 | 3.57 | 9.81 | 9.62 | 13.03 | 19.29 |
| Dose of Nano nitrogen fertilizer (N) (Sub Plot Treatment) | | | | | | | | | |
| NN @ 1.00 l ha$^{-1}$ ($N_1$) | 174 | 46 | 220 | 59 | 20 | 78 | 95 | 88 | 184 |
| NN @ 1.25 l ha$^{-1}$ ($N_2$) | 191 | 56 | 249 | 68 | 26 | 95 | 106 | 109 | 220 |
| NN @ 1.5 l ha$^{-1}$ ($N_3$) | 204 | 61 | 264 | 71 | 27 | 98 | 113 | 117 | 230 |
| S.Em ± | 4.69 | 1.52 | 5.51 | 1.74 | 0.95 | 2.04 | 2.40 | 2.60 | 3.39 |
| CD at 5% | 13.93 | 4.51 | 16.36 | 5.16 | 2.81 | 6.07 | 7.13 | 7.71 | 10.06 |
| Interactions (T × N) | | | | | | | | | |
| S.Em ± | 8.12 | 2.63 | 9.54 | 3.01 | 1.64 | 3.54 | 4.16 | 4.50 | 5.86 |
| CD at 5% | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 4: Effect of time of application and levels of nano nitrogen fertilizer on total protein yield by sweet corn (Sugar-75)**

| Treatments | Protein yield of grain | Crude protein yield of stover |
|---|---|---|
| | (g kg$^{-1}$) | |
| Time of Application (T) | | |
| 15 DAS ($T_1$) | 97.36 | 51.77 |
| 30 DAS ($T_2$) | 88.57 | 49.21 |
| 45 DAS ($T_3$) | 85.16 | 48.20 |
| S.Em± | 1.35 | 0.65 |
| CD at 5% | 4.67 | 2.26 |
| Levels of Nano nitrogen fertilizer (N) | | |
| NN @ 1.00 l ha$^{-1}$ ($N_1$) | 87.41 | 48.34 |
| NN @ 1.25 l ha$^{-1}$ ($N_2$) | 90.80 | 49.88 |
| NN @ 1.5 l ha$^{-1}$ ($N_3$) | 92.89 | 50.96 |
| S.Em ± | 0.90 | 0.46 |
| CD at 5% | 2.69 | 1.38 |
| Interactions (T × N) | | |
| S.Em ± | 1.57 | 0.80 |
| CD at 5% | NS | NS |

levels of NN and application time of NN fertilizer greatly influenced the nutrient uptake (N, P and K) by grain, stover and plant in total and also the protein yield by grain and stover.The treatment $N_3$ (1.5 L $ha^{-1}$) recorded higher uptake of all the three nutrients, namely N, P and K, respectively by grain (204, 71 and 113 kg $ha^{-1}$), stover (61, 27 and 117 kg $ha^{-1}$) and plant in total (264, 98 and 230 kg $ha^{-1}$) and protein yield of grain (92.89 g $kg^{-1}$)and stover (50.96 g $kg^{-1}$) which is on par with treatment $N_2$ (1.25 L $ha^{-1}$) and superior of treatment $N_1$ (1.00 L $ha^{-1}$). The foliar application of NN in main plot at 15 DAS ($T_1$) provided significantly higher uptake of all the three nutrients, namely N, P and K, respectively by grain (219, 82 and 128kg $ha^{-1}$), stover (68, 31 and 132kg $ha^{-1}$) andplant in total (287, 113 and 262kg $ha^{-1}$) and protein yield of grain (97.36g $kg^{-1}$) and stover (51.77g $kg^{-1}$) over later spraying at 30 DAS ($T_2$) and 45 DAS ($T_3$). The reason may be high dose of nano nitrogen fertilizer provided more surface area and more availability of nutrients to the crop plant which help to increase the protein yield by enhancing the rate of reaction or synthesis process in the plant system (Singh and Kumar, 2017).The reason may also be significant concentration of N, P and K thus protein content is attributed with high dose of nano nitrogen and mineral fertilizers which may have provided most of the nutrients especially the major ones are reported by (Sharifi and Taghizaden, 2016). Similar results were reported by Prasad *et al.* (2012), Suriyaprabha *et al.* (2012), Anonymous (2016), El-Metwally *et al.* (2018), Kha *et al.* (2019), Al-Gym and Al-Asady (2020) and Melika *et al.* (2015).

### Conclusion:

Based on the experimental results, it is suggested to apply foliar spray of nano nitrogen fertilizer at 15 days after sowing with 1.25 L per ha or 1.5 L per ha for getting optimum yield and returns thereby maintaining the soil health.

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