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RESEARCH PAPER

# Effect of foliar and band application of urea in different formulation on growth and yield of maize

**Anupam, Narender Singh · Satpal · Mayank Kumar · Ujjwal Kamboj**

**Abstract** The field investigation entitled '"Effect of foliar application of nano-urea on yield and quality of maize" was carried out at Regional Research Station, Karnal of CCS Haryana Agricultural University, during *kharif* 2022. Nine treatments including control (No RDN) (0:60:60 – N:P:K kg/ha),100% RDN through urea (150:60:60 – N:P:K kg/ha), 100% RDN (three foliar spray of nano-urea at 15, 30 and 45 DAS), 100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS), 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS), 75% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS), 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS), 50% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) and 50% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) were laid out in randomized block design in three replicates. Application of nitrogen through different sources influenced the growth parameters and yield of maize crop. The plant height was significantly higher with 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) (43.6 cm) at 20 DAS, while with 100% RDN through urea (91.3 cm, 191.5 cm and 219.0 cm, respectively) at 40 DAS, 60 DAS and at maturity which was statistically at par with treatments 100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS), 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) and 100% RDN through urea at 20 DAS & 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) and 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) at 40 DAS & 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS), 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS), 100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) and 75% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) at 60 DAS and at maturity. Maximum dry matter accumulation per plant (71.1 g/m$^2$ ) was recorded with 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) at 20 DAS, while with 100% RDN through urea (203.9 g/m$^2$ , 1000.3 g/m$^2$ and 1256.3 g/m$^2$ , respectively) at 40 DAS, 60 DAS and at maturity which was significantly higher than all others treatments except 100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS), 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) and 75% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) at 20 DAS & 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) and 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) at 40 DAS & 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) and 100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) at 60 DAS & 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) at maturity. Grain yield (76.6 q/ha), stover yield (122.0 q/ha) and biological yield (198.5 q/ha) were recorded highest with 100% RDN through urea which was statistically at par with 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS).

**Keywords:** Maize · Conventional urea · Nano urea · Maize growth

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## Introduction

Maize (*Zea mays* L.) stands out as a highly versatile emerging crop with extensive adaptability across diverse agro-climatic conditions. It goes by the name of "queen of cereals" due to its highest yield potential among the cereal crops (Kannan *et al*., 2013). Plenty of industrial products which includes the starch, oil, protein, alcoholic drinks, food sweetener, pharmaceutical, cosmetic, film, textile, gum, packaging, and paper sectors etc. which use maize as a primary and foremost raw material (Kumar *et al*., 2012). It is an exceptional source of fat, protein, carbohydrates, several indispensable vitamins and minerals, but it lacks two key amino acids; lysine and tryptophan, which diminish its biological value. By including the opaqe-2 gene in quality protein maize (QPM), these lacking amino acids are now present in considerable quantities. Since maize is a staple crop and potential source of protein in many developing nations in Latin America, Africa, and Asia, the cultivation of QPM offers farmers the chance to grow nutritionally superior maize grains. Worldwide, maize is cultivated on an area of nearly 205.9 million hectares with production of 1210 million tonnes in about 170 countries having wide-ranging diversity of soil, climate, biodiversity and management practices that contributes 36% in the global grain production (FAO, 2022). The United States of America (USA) is the largest producer of maize contributing nearly 31.7% of the total production in the world and has the highest productivity (>11.1 t/ha) which is double than the global average (5.9 t/ha). In India, maize holds the position of the third most crucial food crop, following rice and wheat. According to FAO estimates, maize is grown in India in about 9.9 million hectares area with 31.7 million tonnes of production and average yield of 3.2 t/ha. Throughout the year, maize cultivation takes place in all states of the country for diverse purposes such as grain production, fodder, green cobs, sweet corn, baby corn, and popcorn, particularly in urban and suburban areas. Andhra Pradesh, Karnataka, and Rajasthan are the primary maize-growing states, collectively contributing over 80% of the total maize production. About 50 to 60% of maize production in India is consumed as food for humans and feed for cattle, 30 to 35% goes to poultry, piggery and fish meal, 10 to 12% in wet milling in starch and oil and about 3% in dry milling for conventional food requirements like Dalia, Sattu and other food products such as corn bread, corn chips. It is one of the principal fodder crops in north-west India during summer season (Singh *et al*., 2017). In Haryana, area under kharif maize is about 9300 ha with production of about 28000 tonnes and with average productivity 30.1 q/ha (Anonymous, 2022).

The cultivation of improved high-yielding varieties and the provision of well-balanced nutrient levels are two essential management strategies that can be implemented to improve the production scenario of any crop. The excessive use of nitrogenous fertilizer has led to various issues, making the judicious use of balanced fertilizers a significant concern in the present agricultural environment. Conversely, excessive fertilizer use raises production costs and on the other, it degrades the physical and chemical characteristics of the soil and renders the nutrients inaccessible to the plants. This makes the soil inopportunate for further crop production. Excessive application of urea creates the NPK imbalance in the soil, which boost the attack of insect-pests, causes crop lodging and deteriorates the soil health.

Nanotechnology has the potential to address all of these issues and nano fertilizers can substantially enhance agricultural productivity and promoting soil health in the long run. Hence, there is a requirement for innovative strategies to elevate agricultural productivity while mitigating adverse effects on the environment.

## Materials and methods

The investigation entitled "Effect of foliar application of nano-urea on yield and quality of maize" was carried out at the Regional Research Station, Karnal of CCS Haryana Agricultural University during the kharif 2022. The site is located at latitude of 297 31' 42.19½ N longitude of 760 58' 49.88½ E and at an altitude of 253 meters above mean sea level. It is roughly equidistant almost midway from New Delhi and Chandigarh and almost in centre heart of Haryana and lies on the main G.T. road (NH 1). The experiment was conducted in Randomized Block Design having three replications with the nine treatments viz., ($T_1$) Control, ($T_2$) 100% RDN through urea (150:60:60 - N:P:K kg/ha), ($T_3$) 100% RDN (three foliar spray of nano-urea at 15, 30 and 45 DAS), ($T_4$) 100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS), ($T_5$) 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS), ($T_6$) 75% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS),

($T_7$) 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS), ($T_8$) 50% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS), ($T_9$) 50% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS). The treatments were allocated to different plots at random in all the three replications using the random table.

## Results and discussion

At 20 DAS, plant height was significantly higher in treatment with 100% RDN (50% as basal by urea + 2 foliar sprays of nano-urea at 30 and 45 DAS). At 40 DAS, at 60 DAS and at maturity (100% RDN through urea) gave significantly higher plant height. At 40 DAS, it was found statistically at par with treatment $T_5$ and $T_7$ whereas at 60 DAS and at maturity, plant height was found statistically at par with treatment $T_5$, $T_7$, $T_4$ and $T_6$. Minimum plant height was recorded in treatment control (No RDN). Similar findings were reported by Samui *et al*. (2022).

At 20 DAS significantly higher LAI was observed under 100% RDN (50% as basal by urea + 2 foliar sprays of nano-urea at 30 and 45 DAS) and at 40 DAS, at 60 DAS and at maturity (100% RDN through urea) recorded higher LAI which was found statistically at par with 100% RDN (50% as basal by urea + 2 foliar sprays of nano-urea at 30 and 45 DAS) and 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS. Minimum LAI was recorded under control (No RDN). As plant height and number of leaves increased, it led to

**Table 1.** Effect of nitrogen management practices on plant height (cm) of maize at different intervals

| Treatments | | 20 DAS | 40 DAS | 60 DAS | At maturity |
|---|---|---|---|---|---|
| $T_1$ | Control (No RDN) (0:60:60 – N:P:K kg/ha) | 22.2 | 51.2 | 140.2 | 152.2 |
| $T_2$ | 100% RDN through urea (150:60:60 – N:P:K kg/ha) | 37.5 | 91.3 | 191.5 | 219.0 |
| $T_3$ | 100% RDN (three foliar spray of nano-urea at 15, 30 and 45 DAS) | 26.8 | 57.4 | 156.4 | 176.2 |
| $T_4$ | 100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 42.5 | 79.1 | 178.2 | 191.2 |
| $T_5$ | 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 43.6 | 85.2 | 187.0 | 202.3 |
| $T_6$ | 75% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 40.8 | 76.7 | 174.2 | 188 .6 |
| $T_7$ | 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 41.6 | 80.5 | 182.3 | 198.6 |
| $T_8$ | 50% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 30.4 | 72.3 | 162.2 | 180.0 |
| $T_9$ | 50% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 31.2 | 77.3 | 167.0 | 184.0 |
| | SE(m)± | 2.1 | 3.8 | 8.0 | 10.0 |
| | CD (P=0.05) | 6.3 | 11.6 | 24.4 | 30.4 |

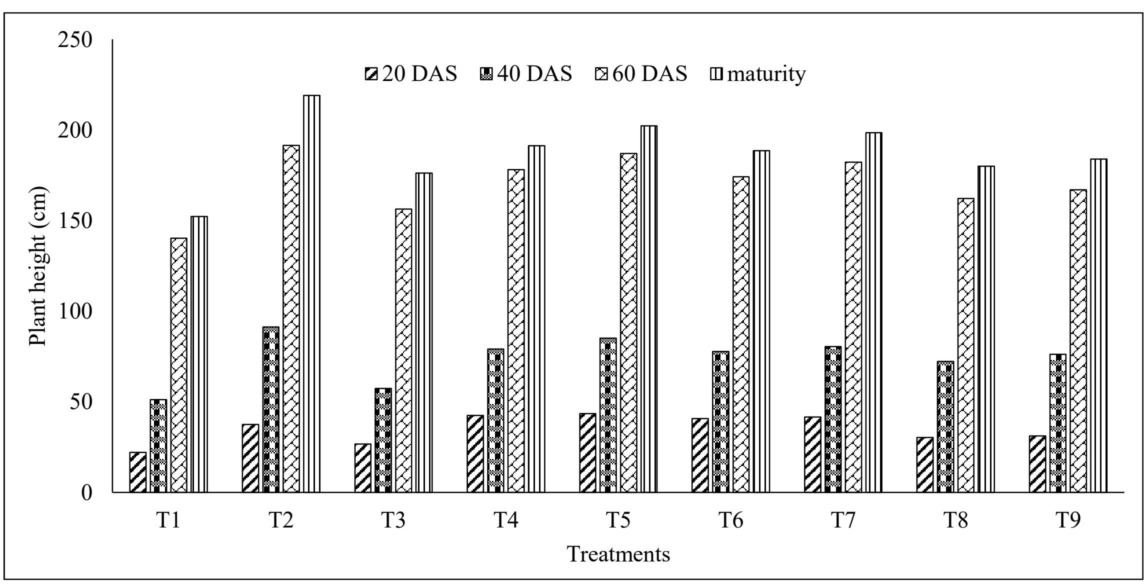


**Figure 1.** Effect of nitrogen management practices on plant height (cm) of maize at different intervals

**Table 2.** Effect of nitrogen management practices on Leaf area index (LAI) of maize at different intervals

| Treatments | | 20 DAS | 40 DAS | 60 DAS | At maturity |
|---|---|---|---|---|---|
| $T_1$ | Control (No RDN) (0:60:60 – N:P:K kg/ha) | 0.44 | 1.83 | 4.06 | 2.41 |
| $T_2$ | 100% RDN through urea (150:60:60 – N:P:K kg/ha) | 0.83 | 2.94 | 5.38 | 3.20 |
| $T_3$ | 100% RDN (three foliar spray of nano-urea at 15, 30 and 45 DAS) | 0.52 | 1.95 | 4.12 | 2.89 |
| $T_4$ | 100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 0.90 | 2.54 | 4.98 | 3.02 |
| $T_5$ | 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 0.91 | 2.84 | 5.04 | 3.06 |
| $T_6$ | 75% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 0.87 | 2.50 | 4.86 | 2.97 |
| $T_7$ | 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 0.84 | 2.63 | 4.93 | 2.99 |
| $T_8$ | 50% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 0.75 | 2.26 | 4.21 | 2.57 |
| $T_9$ | 50% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 0.77 | 2.32 | 4.26 | 2.62 |
| | SE(m)± | 0.04 | 0.13 | 0.25 | 0.12 |
| | CD (P=0.05) | 0.11 | 0.38 | 0.77 | 0.30 |

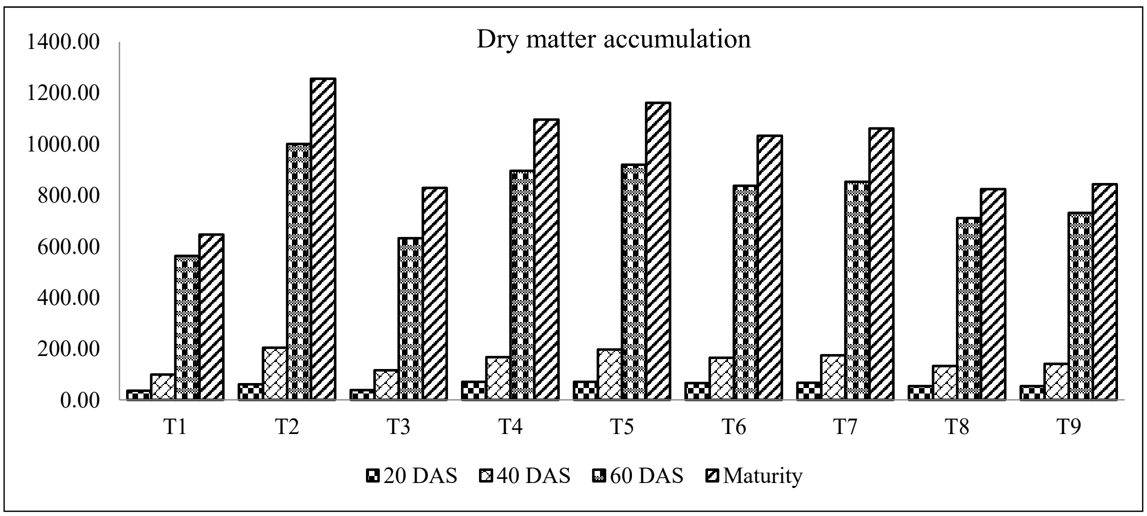


**Figure 2.** Effect of nitrogen management practices on Leaf area index (LAI) of maize at different intervals

higher canopy development under various nutrient management. This also increased the chlorophyll content of leaves which further increased the absorption and utilization of incoming solar radiation which enhanced the photosynthesis. This increase in photosynthesis was reflected as increase in LAI. It might also be due to increased uptake of nutrients. Similar findings were reported by Neogi and Das (2022); Samui *et al*. (2022).

Dry matter accumulation differed significantly at different nitrogen management practices at 20 DAS, 40 DAS, 60 DAS and at maturity. Maximum Dry matter accumulation was recorded under 100% RDN (50% as basal by urea + 2 foliar sprays of nano-urea at 30 and 45 DAS) at 20 DAS and at 40 DAS, 60 DAS and at maturity it is maximum in (100% RDN through urea). Enhanced dry matter production with adequate supply of nitrogen, as presented in this experiment also confirms the results reported by Kumar (2008) and Sutar (2012).

Among all the treatments, significantly higher grain yield was recorded in (100% RDN through urea) which was found at par with 100% RDN (50% as basal by urea + 2 foliar sprays of nano-urea at 30 and 45 DAS). The grain yield might be increased because of the positive effect of nitrogen in increasing the source size and to establish an appropriate source - sink relationship, respectively. Increase in grain yield with increasing nitrogen levels was also reported by Rathnayaka *et al.* (2018); Adhikari *et al.* (2021); Khalil *et al.* (2019) which confirms the findings of present experiment.

Stover yield was significantly increased in treatment (100% RDN through urea) which was statistically at par with 100% RDN (50% as basal by urea + 2 foliar sprays

**Table 3.** Effect of nitrogen management practices on dry matter accumulation (g/m$^2$) of maize at different intervals

| Treatments | | 20 DAS | 40 DAS DAS | 60 DAS | At maturity |
|---|---|---|---|---|---|
| $T_1$ | Control (No RDN) (0:60:60 – N:P:K kg/ha) | 35.5 | 99.8 | 563.3 | 646.0 |
| $T_2$ | 100% RDN through urea (150:60:60 – N:P:K kg/ha) | 60.6 | 203.8 | 1000.3 | 1256.3 |
| $T_3$ | 100% RDN (three foliar spray of nano-urea at 15, 30 and 45 DAS) | 38.1 | 115.5 | 632.3 | 828.3 |
| $T_4$ | 100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 70.5 | 167.7 | 896.0 | 1095.9 |
| $T_5$ | 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 71.1 | 197.2 | 919.0 | 1161.6 |
| $T_6$ | 75% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 66.3 | 165.1 | 836.7 | 1032.7 |
| $T_7$ | 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 66.5 | 174.5 | 853.3 | 1061.6 |
| $T_8$ | 50% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 53.7 | 132.8 | 711.1 | 824.3 |
| $T_9$ | 50% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 54.1 | 141.5 | 731.1 | 842.8 |
| | SE(m)± | 3.9 | 10.3 | 44.7 | 52.1 |
| | CD (P=0.05) | 11.8 | 31.1 | 135.3 | 157.7 |

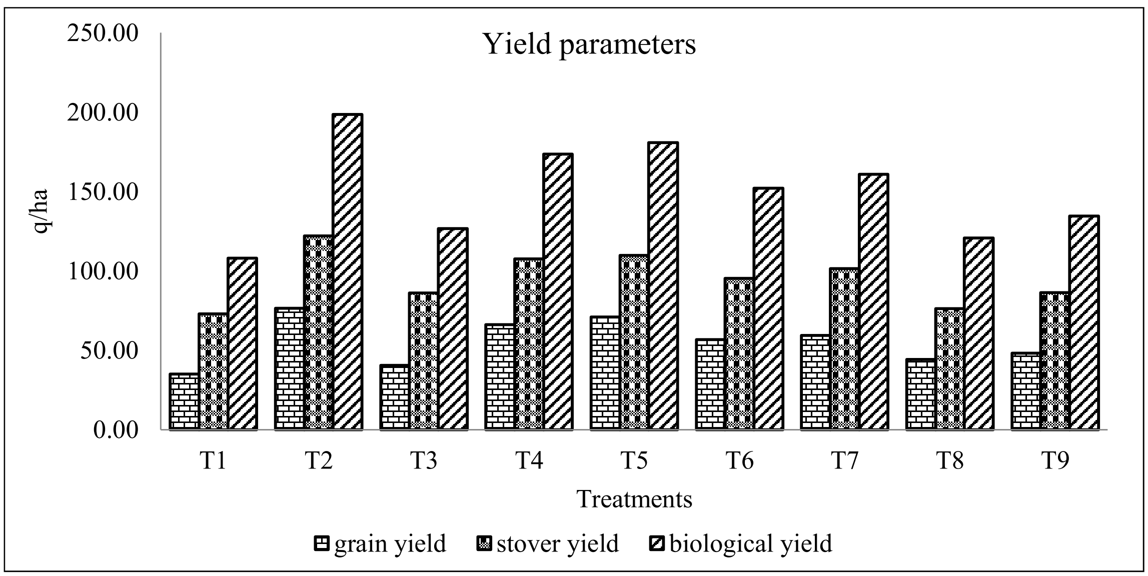


**Figure 3.** Effect of nitrogen management practices on dry matter accumulation (g/m$^2$) of maize at different intervals

of nano-urea at 30 and 45 DAS) 109.78 q/ha. This increase in stover yield was attributed to the increased morphological growth of the plant. These results are in close agreement with the studies reported by Samui *et al.* (2022); Rathnayaka *et al.* (2018) and Adhikari *et al.* (2021).

Biological yield was found significantly different among various nitrogen management practices and significantly higher biological yield was recorded from (100% RDN through urea) which was statistically at par with 100% RDN (50% as basal by urea + 2 foliar sprays of nano-urea at 30 and 45 DAS). These results are in close conformity with the findings reported by Jajoria *et al.* (2020).

Among all the treatments, significantly higher harvest index was observed in treatment 100% RDN (50% as basal by urea + 2 foliar sprays of nano-urea at 30 and 45 DAS) which was statistically at par with treatment (100% RDN through urea) 38.6%, (100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS)) 38.1%, and (75% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS)) 37.3%, (75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS)) 36.9% and (50% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS)) 36.8% whereas, minimum harvest index (32.0%) was observed in (100% RDN (three foliar spray of nano-urea at 15, 30 and 45 DAS)). Increased harvest index indicates the accumulation of photosynthates in grain and not in straw. Similar findings were reported by Jajoria *et al.* (2020); Rathnayaka *et al.* (2018) and Adhikari *et al.* (2021).

**Table 4.** Effect of nitrogen management practices on grain yield, stover yield, biological yield and harvest index (%) of maize

| Treatments | | Grain yield (q/ha) | Stover yield (q/ha) | Biological yield (q/ha) | Harvest index (%) |
|---|---|---|---|---|---|
| $T_1$ | Control (No RDN) (0:60:60 – N:P:K kg/ha) | 34.95 | 73.01 | 107.95 | 33.0 |
| $T_2$ | 100% RDN through urea (150:60:60 – N:P:K kg/ha) | 76.55 | 121.96 | 198.51 | 38.6 |
| $T_3$ | 100% RDN (three foliar spray of nano-urea at 15, 30 and 45 DAS) | 40.56 | 85.99 | 126.55 | 32.0 |
| $T_4$ | 100% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 66.14 | 107.48 | 173.62 | 38.1 |
| $T_5$ | 100% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 71.02 | 109.78 | 187.80 | 39.4 |
| $T_6$ | 75% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 56.72 | 95.29 | 152.01 | 37.3 |
| $T_7$ | 75% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 59.28 | 101.47 | 160.75 | 36.9 |
| $T_8$ | 50% RDN (50% as basal by urea + one foliar spray of nano-urea at 45 DAS) | 44.33 | 76.31 | 120.63 | 36.8 |
| $T_9$ | 50% RDN (50% as basal by urea + two foliar sprays of nano-urea at 30 and 45 DAS) | 48.27 | 86.20 | 134.47 | 35.8 |
| | SE(m)± | 2.28 | 4.51 | 5.87 | 1.1 |
| | CD (P=0.05) | 6.90 | 13.65 | 17.74 | 3.5 |

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