INFLUENCE OF LIQUID NANO UREA FERTILIZER ON GROWTH AND YIELD OF SUMMER RICE (*Oryza sativa* L.) UNDER SOUTH GUJARAT CONDITIONS

ABSTRACT

A field experiment was conducted during summer season for two consecutive years (2022-2023) at Navsari, Gujarat to study the effect of liquid Nano urea fertilizer on summer rice (*Oryza sativa* L.) under South Gujarat conditions. The experiment was laid out in randomized block design with three replications and twelve treatments comprising T_1: 100 % RDN (Recommended dose of nitrogen) through urea (120 kg N ha^{-1}), T_2: 75 % RDN + Seedling root dip in Nano urea at transplanting (TP) (4 ml L^{-1}), T_3: 50 % RDN + Seedling root dip in Nano urea at TP (4 ml L^{-1}), T_4: 25 % RDN + Seedling root dip in Nano urea at TP (4 ml L^{-1}), T_5: 75 % RDN + Spray of Nano urea at tillering stage (4 ml L^{-1}), T_6: 50 % RDN + Spray of Nano urea at tillering stag (4 ml L^{-1}), T_7: 25 % RDN + Spray of Nano urea at tillering stage (4 ml L^{-1}), T_8: 75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}), T_9: 50 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}), T_{10}: 25 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}), T_{11}: Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}) and T_{12}: Seedling root dip in Nano urea at TP + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}). Application of 75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}) obtain significantly higher growth attributes *viz*., periodical plant height, number of tillers plant^{-1}, dry matter accumulation plant^{-1}, chlorophyll content and growth indices including leaf area index (LAI) at 60 and 90 DAS, crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) during 30-60 DAS, 60-90 DAS, and 90 DAS-Harvest. Similarly, significantly higher grain yield was produced under treatment T_8 (4435 kg ha^{-1}) which was 3.24% higher than 100% RDN through conventional urea.

Keywords: Rice, Nano urea, Growth, Chlorophyll, LAI, CGR, RGR, NAR

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important staple food crop of the India, next to wheat feeding more than half of the world's population. Rice is a heat and water loving plant grown best under submerged condition. Rice, wheat and maize provide 20, 19 and 5 per cent of the world's dietary energy supply, respectively (Anon., 2004**).** Rice is most important food crop for more than two billion people in Asia, provides 27% of dietary energy and 20% of overall dietary protein (Bashir *et al*., 2007). Generally protein and fat content of rice is 6-7% and 2-2.5%, respectively and it provides 447 Kcal energy per 100 g rice (Anon., 2010). Global rough rice demand is estimated to rise from 723 million tons in 2015 and is further expected to increase to 852 million tonnes by 2035 (Brar and Khush, 2018). It is a predominant crop in the lowland ecosystem. Asia is considered the "rice bowl" of the world, producing and consuming more than 90 per cent of the world's rice, but India and China contribute more than half of the world's rice. Rice occupies an area of about 163 million hectares globally with production and productivity of 769 million tonnes and 4717 kg ha^{-1}, respectively. India ranks first in acreage (45.77 million hectares) and second in production (186.50 million metric tonnes) after China (Anon., 2022).

Nitrogen fertilizer plays an important role in crop production and has the most effect on increasing agricultural production and income. Nitrogen is a major nutrient for plants, which is very important for the improvement of photosynthesis, growth, development, yield, quality and biomass of rice. It is a component of amino acid in protein and an important component of chlorophyll in photosynthesis and it exists in various plant parts. The application of nitrogen in rice has prominent problems such as a large amount of nitrogenous fertilizers use, efficiency and high wastage. Excess application of nitrogenous fertilizers aggravates soil degradation and environmental pollution. Therefore, it is necessary to use alternative source of nitrogen, which can not only reduce the loss of nitrogen fertilizer, but also mitigate the pollution. Only 30-50% of nitrogen from urea is utilized by plants at the farm level and remain are wasted due to rapid chemical transformations such as leaching, which contaminates soil and water bodies and volatilization which leads to emissions of nitrous oxide into the atmosphere[19,20,21].

Nano urea is a novel form of urea fertilizer developed by IFFCO Co-operative Limited at Kalol, Gujarat. The size of one Nano urea particle is 30 nanometres, which is about 10,000 times smaller than conventional granular urea particles. This leads to a significantly larger surface area-to-volume ratio. Due to its ultra-small size and unique surface properties, liquid Nano urea is absorbed more effectively by plants when sprayed on their leaves. Once absorbed, these nanoparticles reach plant parts requiring nitrogen and release nutrients in a controlled manner. This reduction in usage minimizes wastage in the environment. Additionally, it offers protection to plants against various biotic and abiotic stresses. Beyond yield improvement, increased nutrient use efficiency, enhanced nutritional quality of crops and it also promotes soil health. It reduces undesirable toxicities in soil and mitigates potential negative effects associated with over-application, thus reducing the frequency of application. Therefore, Nanotechnology holds great potential for achieving sustainable agriculture, particularly in developing countries. Nano urea has also undergone biosafety and toxicity testing in accordance with Indian norms and international guidelines established by Organisation for Economic Co-operation and Development (OECD), which are globally adopted and accepted. The present study was therefore undertaken to investigate the influence of liquid Nano urea fertilizer on summer rice (*Oryza sativa* L.) under South Gujarat conditions.

MATERIALS AND METHODS

A field experiment was conducted at College Farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari during summer season of 2022 and 2023. The soil of the experimental site was clay in texture, having pH 7.5, medium in organic carbon (OC) and low, medium and high in available nitrogen, phosphorus and potassium, respectively. The experiment was laid out in randomized block design and twelve treatments comprising T_1: 100 % RDN through urea (120 kg N ha^{-1}), T_2: 75 % RDN + Seedling root dip in Nano urea at TP (4 ml L^{-1}), T_3: 50 % RDN + Seedling root dip in Nano urea at TP (4 ml L^{-1}), T_4: 25 % RDN + Seedling root dip in Nano urea at TP (4 ml L^{-1}), T_5: 75 % RDN + Spray of Nano urea at tillering stage (4 ml L^{-1}), T_6: 50 % RDN + Spray of Nano urea at tillering stag (4 ml L^{-1}), T_7: 25 % RDN + Spray of Nano urea at tillering stage (4 ml L^{-1}), T_8: 75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}), T_9: 50 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}), T_{10}: 25 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}), T_{11}: Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}) and T_{12}: Seedling root dip in Nano urea at TP + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}). Application of 75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}). Rice GNR 3, transplanted during the summer season with recommended practices. Nitrogen was applied in three equal splits at the time of transplanting, active tillering stage and panicle initiation stage as per treatments. Nano urea has been manufactured by Indian Farmers Fertiliser Co-operative Limited (IFFCO) contains 40000 mg kg^{-1} (4%) of nitrogen. Nano urea was sprayed as 4 ml of Nano urea $litre^{-1}$ of water. In this experiment Nano urea was applied through two methods *viz*., root dip and foliar spray. Root of rice seedlings dip in the Nano urea @ 4 ml L^{-1} for 15 minutes at the time of transplanting and sprayed at tillering and panicle initiation stages as per treatment with 4 ml L^{-1} of water by using 600 litre of water ha^{-1} through the flat-fan nozzle. Whereas, full dose of phosphorus (30 kg ha^{-1}) and Zinc as a $ZnSO_4$ (20 kg ha^{-1}) was applied as basal application uniformly to all the treatments. Summer rice 'GNR 3' was transplanted during summer season in February under irrigated condition at the same location and harvested in June during both the years. Irrigation was given to the crop as per recommendation, a thin film of irrigation water was maintained till the establishment of seedlings. Subsequently water level in the field was maintained at the depth of 5 ± 2 cm during the entire period of crop growth till early dough stage through irrigation. Drain water from the field one week before harvest of the crop. All the cultural operation was carried out as per recommendations.

Plant height, dry matter accumulation $plant^{-1}$ measured, number of tillers $plant^{-1}$ and chlorophyll content measured at 30, 60, 90 DAT and at harvest. Readings of leaf chlorophyll content were taken with hand held device Soil Plant Analysis Development (SPAD) chlorophyll meter. SPAD is a plant analysis technique developed by IRRI, Philippines for nitrogen management in rice crop. It measures the difference between the transmittance of a red (650 nm) and an infrared (940 nm) light through the leaf giving the SPAD value (Uddling *et al.*, 2007). Growth indices *viz*., leaf area index at 60 and 90 DAT, crop growth rate and relative growth rate during 30-60 DAT, 60-90 DAT and during 90 DAT-harvest and net assimilation rate during 60-90 DAT calculated as per following formula. Experimental crop was harvested after it attained physiological maturity of grain, crop from each net plots were harvested and allowed to sun dried. Threshing was done manually and the grain yield was recorded after winnowing and cleaning. Grain yield thus obtained from each plot were recorded as kg $plot^{-1}$ and after it converted to kg ha^{-1}.

The statistical analysis of the data of various observations recorded during investigation was carried out under Randomized Block Design through analysis of variance technique as described by Panse and Sukhatme (1978). The significant difference was tested by F-test at five per cent level of significance. The standard error of mean was calculated for all the parameters however, the critical difference were calculated when the difference among treatments were found significant. Further pooled analysis variance of two year workout to study the year effect on treatment and their interaction (Cochron and Cox, 1962).

Leaf area index

Leaf area index (LAI) is the ratio of leaf area to the area of ground cover. Then according to the formula given by Watson (1947).

$$\text{Larea index (LAI)} = \frac{\text{Area of total number of leaves surface}}{\text{Ground area covered by plant}}$$

Crop growth rate (CGR) (g m^{-2} day^{-1})

Crop growth rate represents dry matter production of crop per unit area per unit time (Watson, 1952) was calculated by following formula:

$$CGR = \frac{1}{P} \times \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W_1 and W_2 are dry matter production of plant at time t_1 and t_2, respectively and P = Ground area.

Relative growth rate (RGR) (g g^{-1} day^{-1})

Relative growth rate of crop at time instant (t) is defined as the increase of dry matter production of crop per unit weight per unit time was calculated by following formula:

$$RGR = \frac{InW_2 - InW_1}{t_2 - t_1}$$

Where, W_1 and W_2 are dry matter production of plant at time t_1 and t_2, respectively.

Net assimilation rate (NAR) (g day^{-1} m^{-1})

Net assimilation rate indirectly indicates the rate of net photosynthesis.

$$NAR = \frac{(W_2 - W_1) \times (InL_2 - InL_1)}{(t_2 - t_1) \times (L_2 - L_1)}$$

Where, W_1 and W_2 are dry matter production and L_1 and L_2 are leaf area of plant at time t_1 and t_2, respectively.

RESULTS AND DISCUSSION

Results revealed that growth attributes of summer rice *i.e*. periodical plant height, number of tillers $plant^{-1}$, dry matter accumulation $plant^{-1}$ and chlorophyll content in leaves and growth indices *viz*., leaf area index, crop growth rate, relative growth rate and net assimilation rate were significantly influenced by different treatments.

Growth attributes

100 % RDN through urea *i.e*. 120 kg N ha^{-1} treatment (T_1) recorded significantly taller plants and number of tillers $plant^{-1}$ at 30 DAT (Table 1), However, it remained at par with treatments T_2 (75 % RDN + Seedling root dip in Nano urea at transplanting (TP) (4 ml L^{-1})), T_5 (75 % RDN + Spray of Nano urea at tillering stage (4 ml L^{-1})) and T_8 (75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1})). Plant height at 60 DAT was recorded significantly higher under the treatment T_1, but it was statistically at par with treatments T_2, T_5, T_6, T_8 and T_9. Treatment T_8 (75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1})) noted significantly taller plants at 90 DAT and at harvest, but it remained statistically at par with treatments T_1 (100 % RDN through urea (120 kg N ha^{-1})) and T_5 (75 % RDN + Spray of Nano urea at tillering stage (4 ml L^{-1})). Number of tillers $plant^{-1}$ at 60 DAT was recorded higher with treatment T_1 (100 % RDN through urea (120 kg N ha^{-1})) which remained at par with treatments T_2, T_5 and T_8. Application of 75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}) treatment (T_8) produced significantly more number of tillers $plant^{-1}$ at 90 DAT, which was comparable with treatment T_1 (Table 1).

Higher levels of nitrogen up to 75 % RDN with two sprays of liquid Nano urea at the active tillering and panicle initiation stages helped in increase the plant height and formation of more number of tillers $plant^{-1}$ could be attributed to the readily accessible nitrogen source delivered by Nano urea. Nano urea, a cornerstone of foliar Nano urea application, introduces Nano-sized nitrogen particles that offer a more substantial nutrient supply compared to traditional fertilizers resulting in improved nutrient absorption and transport mechanisms, leading to increased cell division and higher protein content in the cells, this heightened accessibility likely contributes to the augmented taller plant and more tiller count per plant. These findings are consistent with those reported by Rathnayaka *et al*. (2018), Rostaman *et al*. (2021), Midde *et al*. (2022) and Mallikarjuna and Kanavi (2023) who observed similar trends regarding plant height and tiller numbers in rice crop.

Dry matter accumulation plant^{-1} (Table 1) was not altered remarkably due to various treatments of nitrogen management at 30 DAT in rice. However, significantly higher dry matter accumulation plant^{-1} at 60 DAT was observed under the treatment T_1 (100 % RDN through urea (120 kg N ha^{-1})), but it remained at par with treatments T_5 (75 % RDN + Spray of Nano urea at tillering stage (4 ml L^{-1})) and T_8 (75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1})). Whereas treatment T_8 produced significantly higher dry matter plant^{-1}, but it was comparable with treatment T_1 at 90 DAT and at harvest. The application of increased levels of nitrogen with foliar application of Nano urea fertilizer containing Nano-urea significantly boosted the accumulation of dry matter. This enhancement can likely be attributed to the increased effectiveness of Nano-urea fertilizers, owing to their larger surface area. The larger leaf areas enabled greater utilization of solar radiation and available nutrients which is crucial for expanding the photosynthetic surface area. This, in turn, could have resulted in enhanced accumulation and translocation of photosynthates, ultimately boosting biomass production. These findings align with previous research conducted by Rostaman *et al.* (2021).

Chlorophyll content (SPAD meter readings) at 30 DAT in leaves of rice was noted significantly higher with treatment T_1 (100 % RDN through urea (120 kg N ha^{-1}), but it remained at par with treatments T_2, T_5 and T_8. While, treatment T_5 (75 % RDN + Spray of Nano urea at tillering stage (4 ml L^{-1})) recorded significantly higher chlorophyll content at 60 DAT, but it was statistically at par with treatments T_1, T_2, T_6, T_8 and T_9. At 90 DAT, significantly higher chlorophyll content under the treatment T_8 (75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1})), but it remained at par with treatments T_1, T_5 and T_9. At harvest, chlorophyll content in rice was found non-significant (Table 2).

Growth indices

Application of 100 % RDN through urea (120 kg N ha^{-1}) treatment (T_1) obtained significantly higher leaf area index at 60 DAT and it remained at par with treatments $T_{2,}$ T_5 and T_8. While at 90 DAT, significantly higher leaf area index was noticed under the treatment T_8 (75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1})), but it was comparable with treatment T_1 (100 % RDN through urea (120 kg N ha^{-1}) (Table 2). The application of Nano urea during the various stages of rice improved the leaf area because the application of nitrogen through conventional fertilizer along with two foliar sprays of Nano urea at tillering and panicle initiation stages ensures better nutrient absorption and penetration via leaves, promoting overall canopy development and leaf growth. Similar results were also recorded by Gewaily *et al*. (2019) and Navya *et al*. (2022).

Crop growth rate and relative growth rate during 30-60 DAT (Table 3) were recorded significantly higher with the application of 100 % RDN through urea (120 kg N ha^{-1}), but it was statistically at par with treatments T_5 and T_8. Whereas, treatment T_8 (75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1})) observed significantly higher crop growth rate during 60-90 DAT and 90 DAT-harvest, but it remained at par with treatment T_1. While, in the case of relative growth rate during 60-90 DAT and 90 DAT-harvest was recorded significantly higher under treatment T_8 which was statistically at par with treatments T_1, T_5 and T_9.

A significantly higher net assimilation rate during 60-90 DAT was observed with the application of 75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}) treatment (T_8), but it remained at par with treatment T_1 and T_5 (Table 3) in combined results. The measured growth indices namely CGR, RGR and NAR were found to be higher in treatment T_8 (75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1})). These results suggest that Nano-urea can either provide nutrients for the plant or aid in the transport or absorption of available nutrients resulting in better crop growth. Nano-urea might have a synergistic impact on the conventional urea fertilizer for better nutrient absorption by plant cells, resulting in optimal growth and development of rice. These findings are in line with those found by Gewaily *et al*. (2019) and Dhamankar *et al*. (2023).

Grain yield

The grain yield is an important parameter that determines the commercial viability and acceptability of rice and is one of the most important traits attaining the highest consideration in research programs. So, the data regarding grain yield of summer rice was significantly affected by different levels of nitrogen along with the spray of liquid Nano urea fertilizer are furnished in Table 2. The data indicated that 75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}) treatment (T_8) produced significantly higher grain yield 4435 kg ha^{-1}, but it remained statistically at par with 100 % RDN through urea (120 kg N ha^{-1}) (T_1). However, spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1}) treatment (T_{11}) recorded significantly lower grain yield 2889 kg ha^{-1}, but it was statistically at par with treatments T_3, T_4, T_7, T_{10} and T_{12}. Treatment T_8 (75 % RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml L^{-1})) produced 3.24% higher grain yield than treatment T_1 (100 % RDN through urea (120 kg N ha^{-1})). The trend of treatments to produced grain yield were $T_8>T_1>T_5>T_2>T_9>T_6>T_3>T_{10}>T_7>T_4>T_{12}>T_{11}$. The higher yield of rice grains might be due to the provision of N through urea through conventional urea with sprays of Nano urea at active tillering and panicle initiation stage which provides nitrogen regularly to plant might have enhanced the photosynthetic activities, translocation of assimilates and accumulation of assimilates in the reproductive part of the panicle and hastened the cell division and cell elongation, all these factors are responsible for improvement in the grain yield of rice. Such type of results was also found by Gewaily *et al*. (2019), Velmurugan *et al*. (2021), Sahu *et al*. (2022) and Sarvajeet *et al*. (2024).

CONCLUSION

In light of the results obtained from two years investigation, it can be concluded that to obtain higher growth attributes and yield of summer rice *cv*. GNR 3, the crop should be fertilized with 75% RDN (90 kg N ha^{-1}) and two sprays of Nano urea 4 ml L^{-1} at the tillering and panicle initiation stage. Additionally, it also replaced 25% of the requirement of nitrogen from conventional fertilizers.

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Table 1: Periodical plant height, number of tillers and dry matter accumulation of rice at 30, 60, 90 DAT and at harvest as influenced by different treatments (pooled data of 2 years)

Treatments	Plant height (cm)				Number of tillers plant^{-1}				Dry matter accumulation plant^{-1} (g)			
	At 30 DAT	At 60 DAT	At 90 DAT	At Harvest	At 30 DAT	At 60 DAT	At 90 DAT	At Harvest	At 30 DAT	At 60 DAT	At 90 DAT	At Harvest
T_1	31.6	67.7	96.5	97.6	3.94	8.13	9.84	9.60	2.45	17.46	30.34	34.17
T_2	30.3	62.5	85.8	86.4	3.79	7.54	8.63	8.39	2.44	14.14	23.30	26.01
T_3	27.5	57.1	79.0	79.6	3.44	6.41	7.51	7.33	2.39	12.98	20.60	22.65
T_4	27.4	55.2	76.2	76.6	3.20	6.22	7.14	6.88	2.36	12.54	19.80	21.81
T_5	29.4	66.2	92.9	93.9	3.80	7.83	8.74	8.40	2.44	16.52	28.06	31.45
T_6	27.2	61.5	83.6	84.5	3.22	7.20	7.92	7.62	2.36	14.10	23.42	26.10
T_7	26.3	58.8	81.8	82.7	3.22	6.60	7.57	7.33	2.33	13.43	21.81	24.18
T_8	29.5	66.6	98.0	98.9	3.71	7.78	9.97	9.77	2.43	16.92	31.37	35.46
T_9	27.6	62.3	88.8	89.7	3.44	7.24	8.77	8.60	2.40	13.72	24.19	27.22
T_{10}	26.8	59.3	85.1	86.1	3.24	6.81	8.40	7.82	2.34	12.70	21.99	24.44
T_{11}	24.1	52.7	75.7	76.0	3.02	6.12	7.04	6.74	2.24	11.80	18.97	20.75
T_{12}	25.0	54.9	78.9	79.4	3.23	6.29	7.32	7.18	2.31	12.44	20.22	22.40
SEm±	0.9	1.99	2.84	2.84	0.11	0.23	0.24	0.26	0.07	0.46	0.76	0.81
CD (P=0.05)	2.6	5.66	8.11	8.10	0.32	0.64	0.67	0.73	NS	1.32	2.16	2.30
Y	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
YxT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Periodical chlorophyll content and leaf area index (LAI) of rice as influenced by different treatments (Pooled data of 2 years)

Treatments	Chlorophyll content (SPAD Value)				LAI		Grain Yield (kg ha^{-1})
	At 30 DAT	At 60 DAT	At 90 DAT	At Harvest	At 60 DAT	At 90 DAT	
T_1	40.68	44.79	39.98	18.72	3.34	3.04	4296
T_2	37.68	42.28	36.27	17.77	3.07	2.66	3840
T_3	36.54	39.19	35.57	17.50	2.62	2.32	3139
T_4	34.83	39.01	32.59	17.43	2.54	2.22	2957
T_5	39.63	45.81	38.43	19.19	3.19	2.69	3909
T_6	36.87	42.36	35.91	17.97	2.81	2.45	3488
T_7	34.50	39.62	35.97	17.40	2.58	2.34	3168
T_8	39.57	45.51	40.55	19.73	3.17	3.08	4435
T_9	36.53	43.43	38.28	17.89	2.90	2.70	3531
T_{10}	35.20	39.79	34.76	17.59	2.71	2.60	3170
T_{11}	33.12	38.72	33.00	18.14	2.50	2.18	2889
T_{12}	34.47	39.60	34.34	18.02	2.56	2.26	2955
SEm±	0.89	1.02	0.82	0.52	0.09	0.08	114
CD (P=0.05)	2.54	2.90	2.33	NS	0.27	0.22	325
Y	NS	NS	NS	NS	NS	NS	NS
YxT	NS	NS	NS	NS	NS	NS	NS

Table 3: Crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) as influenced by different treatments (Pooled data of 2 years)

Treatments	CGR ($g\ m^{-2}\ day^{-1}$)			RGR ($g\ g^{-1}\ day^{-1}$)			NAR ($g\ m^{-2}\ day^{-1}$)
	During 30-60 DAT	During 60-90 DAT	During 90 DAT-Harvest	During 30-60 DAT	During 60-90 DAT	During 90 DAT-Harvest	During 60-90 DAT
T_1	16.68	14.31	12.18	0.0655	0.0184	0.0040	0.000430
T_2	13.00	10.18	8.65	0.0584	0.0167	0.0037	0.000339
T_3	11.77	8.46	6.51	0.0565	0.0154	0.0032	0.000328
T_4	11.32	8.06	6.39	0.0557	0.0152	0.0032	0.000333
T_5	15.64	12.82	10.79	0.0637	0.0177	0.0038	0.000419
T_6	13.05	10.35	8.53	0.0596	0.0169	0.0036	0.000378
T_7	12.33	9.31	7.55	0.0582	0.0162	0.0035	0.000363
T_8	16.10	16.05	13.02	0.0646	0.0206	0.0041	0.000491
T_9	12.59	11.63	9.68	0.0581	0.0188	0.0039	0.000396
T_{10}	11.50	10.32	7.89	0.0563	0.0183	0.0035	0.000371
T_{11}	10.62	7.97	5.66	0.0552	0.0158	0.0030	0.000328
T_{12}	11.25	8.65	6.96	0.0561	0.0162	0.0034	0.000345
SEm±	0.52	0.49	0.53	0.0015	0.0006	0.0002	0.00002
CD (P=0.05)	1.50	1.41	1.52	0.0043	0.0017	0.0006	0.00006
Y	NS	NS	NS	NS	NS	NS	NS
YxT	NS	NS	NS	NS	NS	NS	NS