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ENHANCING GROWTH AND YIELD OF *RABI* MAIZE (*ZEA MAYS* L.) WITH NANO UREA AND IRRIGATION SCHEDULING TECHNIQUES

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ABSTRACT

A field experiment was conducted during the winter months (October-February) of 2022-23 at the Instructional-cum Research Farm of Assam Agricultural University, Jorhat to assess the effect of different irrigation scheduling practices along with nano urea on growth and productivity of *rabi* maize. The experiment was laid out in split-plot design with four distinct irrigation schedules and three varied nitrogen management practices under main plot and sub plot treatments. Results revealed that relatively all growth parameters, yield attributing characters, cob, kernel and stover yield were higher under irrigation at grand growth period, tasseling and grain filling stages being statistically at par with irrigation at 0.8 IW/CPE ratio. Contrarily, 50% recommended doses of nitrogen (RDN) through urea as basal + 6 ml/litre nano urea at knee high and tasseling stage being at par with 50% RDN through urea as basal + 4 ml/litre nano urea at knee high and tasseling stage recorded significantly highest cob, kernel and stover yield over recommended doses of fertilizers (RDF) + water spray at knee high and tasseling stage. Interaction effect was observed for kernel weight/cob, kernel and stover yield. However, lowest growth, yield parameters and yield were observed under rainfed and 0.6 IW/CPE of irrigation scheduling.

Key words : IW/CPE ratio, Nano urea, *Rabi* maize, RDF, RDN, Water spray.

Introduction

Maize (*Zea mays* L.) is now recognized as one of the most adaptable and promising crops worldwide, thriving in diverse agro-climatic conditions and displaying remarkable insensitivity to variations in photoperiod and temperature. Among all cereals, maize boasts the highest genetic yield potential and holds the title of the "Queen of Cereals" on a global scale. The maize variety DKC 9081 stands out as a high-yielding hybrid, with a genetic potential of 90.98 q/ha, featuring impressive cob size, a greater number of kernel rows per cob, and a strong response to input conditions. In 2021, global maize production reached a staggering 1.2 billion tonnes, with the United States alone contributing 384 million metric tonnes. In India, maize ranks as the third most important crop, following rice and wheat, and in the year 2021-22, it contributed around 31.51 million tonnes to the overall production, cultivated on approximately 9.9 million hectares of land (FAOSTAT). In peri-urban areas, maize cultivation primarily focuses on obtaining kernels, green cobs, sweet corn, baby corn, animal fodder, and popcorn. Maize is a valuable crop, constituting about 72% of the starch source, 10% protein and 4% fat, providing approximately 365 Kilo calorie per 100 grams of energy density (Ranum *et al*., 2014). Despite its high nutrient demands, maize requires a relatively substantial amount of fertilizers. It responds favorably to nutrient applications, whether they come from organic or inorganic sources. One critical nutrient that often limits maize growth is nitrogen, making its effective management essential for improving nutrient use efficiency (NUE) and overall system productivity.

The introduction of nano urea as a nitrogen source during crop establishment has demonstrated remarkable efficiency and impact on crop yield and productivity. Nano fertilizers release plant nutrients in a controlled and balanced manner, enhancing NUE. When nano urea is applied by spraying it onto leaves, it easily penetrates through stomata and other openings, becoming assimilated into plant cells through apoplastic and symplastic movement. Unutilized nitrogen is stored in plant vacuoles and gradually released to support proper plant growth and development.

Conversely, the adoption of assured irrigation practices in *rabi* maize cultivation leads to increased production levels and output, ultimately benefiting farmers by maintaining economic stability within the input-output cycle. Effective irrigation scheduling plays a crucial role in preserving soil moisture potential, thus establishing a harmonious soil-plant relationship and subsequently enhancing crop growth, yield, as well as nutrient and water absorption. Nevertheless, the timing, frequency, and duration of irrigation during the crop's active growth stage, in conjunction with the soil's capacity to absorb, store, and release water for the plants, all influence production outcomes. Furthermore, apart from achieving optimal irrigation, the application of irrigation at critical growth stages of the crop significantly contributes to enhancing maize productivity per unit area. To achieve a comprehensive assessment of the impact of nano urea foliar spray and irrigation scheduling based on the IW/CPE (Irrigation Water to Crop Pan Evaporation) ratio, the experiment was initiated to study the effects of nano urea on *rabi* maize growth and yield, as well as the impact of various irrigation management practices in *rabi* maize cultivation.

Materials and Methods

A field experiment was conducted during the *rabi* season of 2022-23 at AAU, Jorhat (26°44' N latitude and 94°10' E longitude and at an altitude of 91.0 m above mean sea level) to investigate the effect of various irrigation scheduling techniques along with effective nitrogen management practices in maize. The cumulative pan evaporation (CPE) was 185.4 mm and the rainfall received during the crop growth period was 82.4 mm. against the total evaporation of 194.9 mm. Fig. 1 resulting in a net deficit of 112.6 mm of evapo-transpirational requirement of the crop. Bright sunshine hours ranged from 0.1 to 9.7 hours/day. The rainfall received during the early stages *i.e.* during sowing was 40.9 mm and therefore the crop received optimum moisture during the initial growth period. On the other hand, during the grain

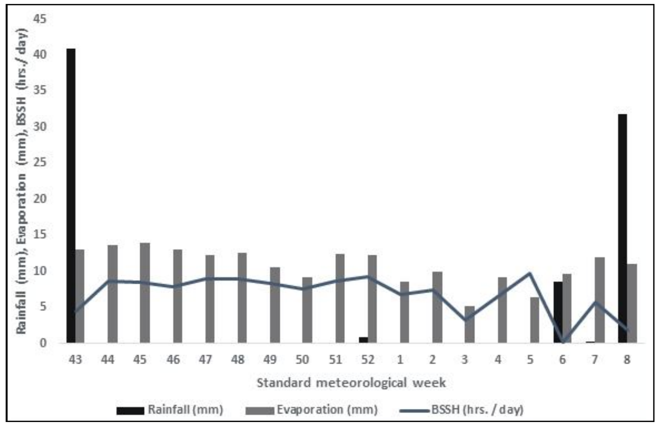

Fig. 1 : Weekly average rainfall (mm), evaporation (mm) and bright sunshine hours (hours/day) throughout the crop growing period.

filling stage, there was an abundance of rainfall received which led to better grain filling capability to the crop. Soil was acidic in pH with medium organic C (0.67%), low in available nitrogen (247.43 kg/ha), available phosphorus (18.53 kg/ha) and medium in available potassium (185.76 kg/ha). The experiment was laid out in a split-plot design (three replications) with four irrigation schedules *viz.*, rainfed (I_1), irrigation at IW/CPE 0.6 (I_2), 0.8 (I_3) and irrigation at grand growth period + tasseling + grain filling stage (I_4) allotted to main plots, and three nitrogen management practices *viz.*, RDF (Recommended doses of fertilizer) + water spray at knee high and tasseling stage (N_1), 50% RDN (Recommended doses of nitrogen) through urea as basal + 4 ml/litre nano urea at knee high and tasseling stage (N_2) and 50% RDN through urea as basal + 6 ml/litre nano urea at knee high and tasseling stage (N_3) allotted to sub-plots. DKC 9081 variety of maize was sown @ 22.5 kg/ haat 60 cm × 25 cm geometry. The depth of irrigation was 6 cm for each single irrigation advocated. The dates of irrigation for treatment I_4 were 22.11.22, 6.01.23 and 30.02.23, for I_3: 3.12.22 and 1.02.23, for I_2: 23.12.22, respectively. Alternatively, the dates of nano urea foliar spray for treatment N2 and N3 were 24.11.12 and 5.01.23. The height was measured using a meter scale from the ground surface to the tip of the folded leaf, however following the tasseling stage, it was measured from the base to the ligule of the uppermost fully opened leaf. Leaf are index (LAI) was calculated by dividing the plant's total leaf area by the ground area as given by Sestak *et al*. (1971). The plants were chopped and sun dried for 48 hours which were further dried in hot air oven at 60 ± 5ºC for obtaining a constant dry weight. Days to 50% tasseling, 50% silking and days to maturity required in each plot were observed and recorded. Number of cobs/plant were calculated by selecting five random plants from each plot. The length and weight of five cobs with and without husk were measured with the help of meter scale and digital weighing balance and average was carried out. Number of kernel rows/cob was counted using the cobs chosen for individual cob weight. By multiplying the average number of kernel rows/cob by the average number of kernels/row, the number of kernels/cob was calculated. Cob yield was recorded from the crop harvested from each net plot area. Five randomly chosen cobs from each plot were selected to measure the total weight of kernels in each cob which were then computed for estimation of total kernel yield. Test weight was calculated by bulking thousand numbers of kernels and weighing them after drying under the sun to reduce the moisture content up to 14%. The total stover yield was calculated by cutting the plant close to the ground after a week of harvesting and weighing until a constant weight obtained. Furthermore, harvest index was calculated by dividing economic yield and biological yield and shelling percentage by kernel yield and cob yield. According to the split-plot design (SPD) method described by Panse and Sukhatme (1954), the data generated from the experiment at various growth stages for each parameter were statistically analyzed and analysis of variance were carried out. Critical difference (CD) was worked out at 5 per cent level of probability wherever the treatment differences were found significant.

Results and Discussion

Growth attributes : Irrigation schedules significantly influenced the growth as well as phenological parameters of maize. Among the various treatments of irrigation schedules, a significantly higher plant height, leaf area index, dry matter accumulation was obtained under irrigation at grand growth period + tasseling + grain filling stage being statistically at par with irrigation at 0.8 IW/CPE as compared with the remaining treatments (Table 1). The observed phenomenon is likely attributed to the increased moisture availability in the soil during the active growth stages of the crop. In addition to irrigating during the crucial stages of plant development, such as the period encompassing grand growth, tasseling, and grain filling, the irrigation schedule coincided with a 0.8 ratio of IW/CPE during the knee-high stage and cob formation stage. Furthermore, there was abundant rainfall during the grain filling stage of the crop. Consequently, the adequate moisture levels in the soil during these pivotal growth stages, facilitated by the irrigation treatments, enabled the plants to enhance nutrient absorption from the soil. As a result, the crops grew taller and exhibited more robust development compared to those in soil with limited moisture. Increased irrigation patterns promote plant growth mechanisms such as cell division and elongation, leading to a substantial rise in overall plant biomass. This finding is consistent with the observations made by Jadhav (1988), who similarly noted that as the number of irrigation events increased, the accumulation of dry matter in plants significantly improved. Furthermore, an elevated leaf area index was observed as a result of the expanded photosynthetic surface and increased biomass accumulation in the crops. Similar trends of growth patterns with increasing irrigation intervals were observed by Srivastav *et al*. (2022). Conversely, when compared to irrigation scheduled at a 0.6 IW/CPE ratio and rainfed treatment, both sets of results exhibited a significant increase. This unmistakably highlights the fact that the crops subjected to these treatments endured heightened soil moisture stress due to the more extended intervals between irrigation and reliance on rainfall, resulting in diminished growth patterns. Rainfed treatment took longer days for 50% tasseling, 50% silking and days to harvesting compared to others. This might be because of increasing water stress during the crop active growth stage under these treatments.

In terms of nitrogen management practices, higher values of growth characteristics were noticed under the plots receiving nano urea in combination with conventional urea compared to application of conventional urea solely. Among the treatments,50% RDN through urea as basal + 6 ml/litre nano urea at knee high and tasseling stage resulted significantly highest plant height, leaf area index, dry matter accumulation being statistically at par with 50% RDN through urea as basal + 4 ml/litre nano urea at knee high and tasseling stage. This phenomenon could be attributed to the enhanced nutrient utilization efficiency of nano urea, which resulted in greater accessibility of nutrients in a readily available from directly to the plant’s foliage. This played a pivotal role in various aspects of plant physiology, including active photosynthesis, the transport of photosynthetic products, protein synthesis, regulation of stomatal function, water use efficiency, ionic balance, activation of various plant enzymes, and several other crucial mechanisms. Comparable outcomes were documented in studies conducted by Reddy *et al*. (2022) affirming the impact of enhanced nutrient use efficiency on plant performance.

Conversely, concerning nitrogen management practices, the application of RDF along with water spray during the knee-high and tasseling stages exhibited the shortest duration for achieving 50% tasseling, 50% silking, and harvesting. Conventional urea application might have led to lower nitrogen availability due to increased losses

Table 1 : Effect of irrigation schedules and nitrogen management practices on growth parameters of maize.

Treatment	Plant height (cm)	Leaf area index	Dry weight (g/plant)	Days to 50% tasseling	Days to 50% silking	Days to maturity
Irrigation schedules						
Rainfed	176.72	4.83	146.23	72.22	81.22	118.11
Irrigation at 0.6 IW/CPE ratio	185.88	5.10	148.87	73.35	83.56	119.89
Irrigation at 0.8 IW/CPE ratio	196.84	5.34	169.74	75.78	86.11	122.22
Irrigation at grand growth period + tasseling + grain filling stage	205.14	5.47	175.07	76.56	87.78	124.67
SEm ±	2.94	0.04	1.59	0.54	0.64	0.59
CD (P = 0.05)	10.19	0.12	5.53	1.87	2.23	2.03
Nitrogen management practices						
RDF + water spray at knee high and tasseling stage	186.53	4.94	145.81	73.83	83.17	118.75
50% RDN through urea as basal + 4 ml/litre nano urea at knee high and tasseling stage	191.87	5.24	166.13	74.67	85.33	121.83
50% RDN through urea as basal + 6 ml/litre nano urea at knee high and tasseling stage	195.04	5.36	167.99	74.92	85.50	123.08
SEm±	1.75	0.09	1.58	0.23	0.65	0.71
CD (P = 0.05)	5.27	0.27	4.73	0.71	1.95	2.14
Interaction (I × N)	NS	NS	NS	NS	NS	NS

from the soil and reduced nutrient utilization efficiency compared to nano urea. Consequently, this earlier onset of various phenological parameters was observed. However, in the nano urea treatments, the higher nitrogen availability promoted greater vegetative growth in the crop, leading to a significant delay in maturity. Ashraf *et al.* (2016) also recorded similar observation.

Yield attributes and yield : The data presented in Table 2 clearly demonstrates the significant impact of both irrigation schedules and nitrogen management practices on the yield-related characteristics of maize. Among the various irrigation schedules, the one involving three applications, specifically during the grand growth period, tasseling and grain-filling stages, resulted in the highest values for attributes such as the number of kernel rows/cob, number of kernels/cob, kernel weight/cob, as well as cob, kernel and stover yield. Notably, this performance was statistically at par with irrigation scheduled at a 0.8 IW/CPE ratio. This superior performance can likely be attributed to the maintenance of favorable soil moisture conditions throughout the crop's growth, which facilitated better growth and development. Additionally, it enabled the efficient allocation of photosynthates and dry matter to the kernels. Adequate moisture availability likely contributed to increased photosynthates production and facilitated quick translocation within the plant. These findings align closely with previous studies by Srivastav *et al.* (2022).

Conversely, the lowest values for yield-related characteristics were observed under rainfed conditions, followed by irrigation scheduled at a 0.6 IW/CPE ratio. The decline in yield patterns can be attributed to insufficient soil moisture, which subsequently reduced processes driven by turgor pressure. These processes include photosynthesis, stomatal conductance, leaf expansion, the absorption of photosynthetically active radiation (PAR) and the duration of leaf area. Ultimately, this reduction in these vital processes led to reduced yield attributes and decrease in both kernel and biological yield. These observations are consistent with earlier findings by Muchow *et al*. (1989). It's worth noting that previous research has also indicated that reduced yields under moisture-stress conditions can be attributed to lower kernel numbers per cob and decreased kernel weight/cob.

The combined application of nano urea sprays alongside 50% normal urea fertilization yielded significantly better results when compared to the sole

Table 2 : Effect of irrigation schedules and nitrogen management practices on yield attributing characters and yield of maize.

Treatment	Number of kernel rows/cob	Number of kernels/ cob	Kernel weight/cob (g)	Cob yield with husk (q/ha)	Kernel yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
Irrigation schedules							
Rainfed	12.83	340.35	97.09	80.44	57.50	107.03	34.84
Irrigation at 0.6 IW/CPE ratio	12.94	350.99	100.77	81.85	59.68	108.34	35.45
Irrigation at 0.8 IW/CPE ratio	13.72	385.81	112.51	86.97	66.61	113.47	36.98
Irrigation at grand growth period + tasseling + grain filling stage	13.89	392.93	115.92	89.80	68.69	115.53	37.28
SEm±	0.21	3.36	1.20	1.29	1.41	0.82	0.44
CD (P=0.05)	0.72	11.63	4.16	4.47	4.88	2.84	1.52
Nitrogen management practices							
RDF + water spray at knee high and tasseling stage	12.92	339.42	97.41	81.92	57.50	107.28	34.78
50% RDN through urea as basal + 4 ml/litre nano urea at knee high and tasseling stage	13.50	379.15	110.73	85.55	65.36	112.38	36.74
50% RDN through urea as basal + 6 ml/litre nano urea at knee high and tasseling stage	13.63	383.97	111.58	86.82	66.50	113.62	36.90
SEm±	0.18	2.83	0.68	0.99	0.42	0.45	0.31
CD (P = 0.05)	0.55	8.50	2.05	2.97	1.26	1.34	0.94
Interaction (I × N)	NS	NS	4.10	NS	2.51	2.68	NS

application of urea. The investigation revealed that both the yield and yield-related characteristics were notably higher in the treatment group receiving 50% RDN through urea as a basal application along with 6 ml/litre of nano urea at the knee-high and tasseling growth stages. Importantly, this performance was statistically at par with the treatment that received 50% RDN through urea as a basal application, coupled with 4 ml/litre of nano urea at the same critical growth stages. The observed increase in yield attributes and overall yield in the treatment recieving nano urea sprays can be attributed to the ability of nano urea to enhance crop growth and improve nutrient utilization efficiency. This enhancement, in turn, led to improved photosynthetic rates and biological efficiency. It's noteworthy that the supply of adequate nano urea sprays at critical growth stages promotes meristematic cell activity and stimulates cell elongation in crops, resulting in increased yield attributes. This observation is consistent with the findings of Jassim *et al*. (2019).

Interaction effect : Interaction effects between different irrigation schedules and nitrogen management practices were observed in combination, particularly concerning kernel weight/cob, kernel and stover yield (Figs. 2, 3 and 4, respectively). Notably, the highest values for kernel weight/cob, grain yield and stover yield these parameters were recorded in the treatment group, where irrigation was scheduled during the grand growth period, tasseling and grain-filling stages, coupled with 50% of the RDN through urea as a basal application and 6 ml/ litre of nano urea at the knee-high and tasseling stages. Importantly, these results were statistically equivalent to the treatment groups involving irrigation at the same critical growth stages, combined with 50% RDN through urea as a basal application and 4 ml/ litre of nano urea at knee-high and tasseling stages.

Similarly, they were at par with the combination of irrigation scheduled at 0.8 IW/CPE ratio, along with 50% RDN through urea as a basal application and 6 ml/litre of nano urea at knee-high and tasseling stages (Figs. 2, 3 and 4).

The success of these treatment combinations can be attributed to the practice of reliable irrigation, coupled with the application of nano urea foliar sprays in addition to conventional urea. This approach enhanced soil moisture availability and significantly improved nutrient

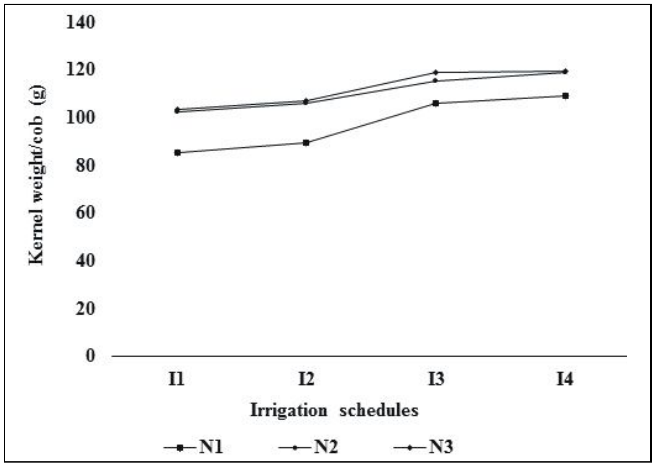

Fig. 2 : Interaction effect of irrigation schedules and nitrogen management practices on kernel weight/cob of maize.

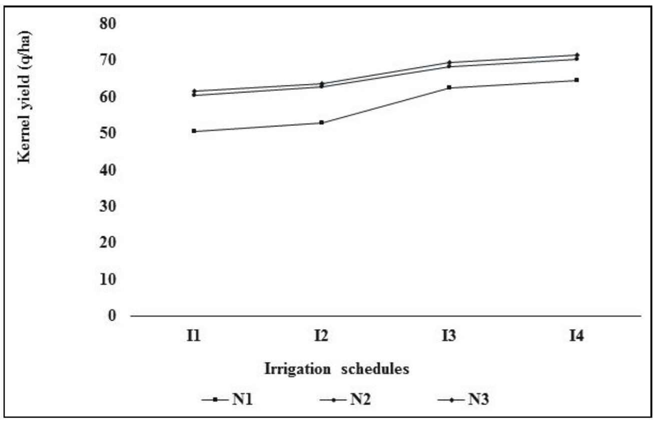

Fig. 3 : Interaction effect of irrigation schedules and nitrogen management practices on kernel yield of maize.

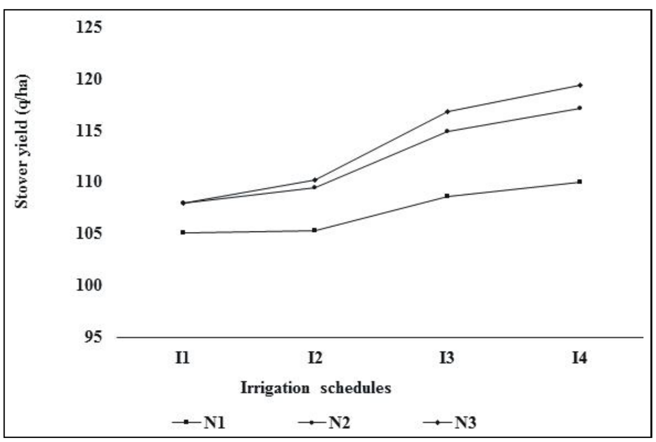

Fig. 4 : Interaction effect of irrigation schedules and nitrogen management practices on stover yield of maize.

use efficiency. As a result, stomatal conductance was maintained, photosynthetic rates increased and nutrient translocation from source to sink was facilitated. These factors collectively contributed to the improved yield-related characteristics and overall crop yield.

Conclusion

Thus, both irrigation schedules and nitrogen management practices brought significant differences in growth, yield attributing characters and yield. The results revealed that I_4 recorded the highest growth, yield attributing characters as well as kernel and stover yield of maize which was statistically at par with I_3. Among the nitrogen management practices, N_3 produced better plant growth, yield attributing characters and yield of maize being statistically at par with N_2. Moreover, interaction effect were also observed under the treatment combination of I_4N_3 being statistically at par with I_4N_2 and I_3N_3. It is therefore concluded that I_4N_3 would be the best management practices for generation of higher output to the farmers.

References

Ashraf, U., Salim M.N., Alam Sher, Aqil Kkhan, Shenggang P.A.N. and Xiangru Tang (2016). Maize growth, yield formation and water-nitrogen usage in response to varied irrigation and nitrogen supply under semi-arid climate. *Turk. J. Field Crops*, **21(1)**, 88-96.

Food and Agriculture Organization Corporate Statistical Database (2022). Food and Agriculture Organization, Rome.

Jadhav, S.N. (1988). Water use and productivity of mustard as influenced by sowing dates, insect pest control measures and irrigation. *Ph.D. Thesis*, Division of Agronomy, Indian Agricultural Research Institute, New Delhi.

Jassim, R.A., Kadhem H.N. and Nooni G.B. (2019). Impact of levels and time of foliar application of nano fertilizer (super micro plus) on some components of growth and yield of rice (*Oryza sativa*). *Plant Archives*, **19(1)**, 1279-1283.

Muchow, R.C. (1989). Comparative productivity of maize, sorghum and pearl millet in a semi- arid tropical environment. II: Effect of water deficits. *Field Crops Res.*, **20**, 207-219.

Panse, V.G. and Sukhatme P.V. (1954). Statistical methods for agricultural workers. *Statistical methods for agricultural workers*.

Ranum, P., Peña Rosas J.P. and Garcia Casal M.N. (2014). Global maize production, utilization and consumption. *Annals New York Acad. Sci.*, **1312(1)**, 105-112.

Reddy, B.M., Elankavi S., Kumar M.S., Sai M.V. and Vani B.D. (2022). Effects of conventional and nano fertilizers on growth and yield of maize (*Zea mays* L.). *Quarterly Res. J. Plant Anim. Sci./Bhartiya Krishi Anusandhan Patrika*, **37(4)**.

Sestak, Z., Catský J. and Jarvis P.G. (1971). Plant photosynthetic production. In: *Manual of methods.*

Srivastav, A.K., Patel V.K. and Nand V. (2022). Effect of land configuration and moisture regimes on productivity of hybrid maize (*Zea mays* L.) in summer season. *Int. J. Plant Soil Sci.*, **34(1)**, 63-70.