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Growth and Energy evaluation of Fodder Maize (*Zea Mays* L.) Under Late Sown Rainfed Conditions as Effected by Varying Seed Rate and Levels of Nitrogen

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Abstract

A field experiment entitled “Growth and Energy evaluation of Fodder Maize (*Zea Mays* L.) Under Late Sown Rainfed Conditions as effected by Varying Seed Rate and Levels of Nitrogen” was conducted at Crop Research Farm of Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore during *Kharif* 2023. The soil of the experimental field was silty clay loam with neutral pH, normal EC, medium in available N, P, K, and organic carbon. The experiment comprised of three seed rates viz; 40 kg ha⁻¹ (S₁), 60 kg ha⁻¹ (S₂) and 80 kg ha⁻¹ (S₃) as Factor-A and four nitrogen levels including control (N₀), 90 kg ha⁻¹ (N₁), 120 kg ha⁻¹ (N₂) and 150 kg ha⁻¹ (N₃) as Factor-B, randomised in blocks and replicated thrice. The variety tested was Shalimar Fodder Maize-1 and the experiment was laid out in RCBD factorial design. The results of the experiment revealed the higher values of growth characteristics viz., plant height, leaf area index, no. of leaves per plant, leaf stem ratio, dry matter accumulation, crop growth rate, relative growth rate and net assimilation rate were recorded with the application of seed rate of 80 kg ha⁻¹ and Nitrogen level of N₃ (150 kg ha⁻¹). The highest output energy (1186800 MJ ha⁻¹), net energy (1168508.28 MJ ha⁻¹) and energy intensity (19.85 MJ ha⁻¹) with the application of 80 kg ha⁻¹ (S₃) seed rate and Nitrogen level N₃ (150 kg ha⁻¹) followed by 80 kg ha⁻¹ (S₃) seed rate with N₂ (120 kg N ha⁻¹). The lowest output energy, net energy and energy intensity was observed in 40 kg ha⁻¹ (S₁) seed rate with Control (N₀).

Keywords: Gene effects, combining ability, GCA, SCA, yield attributing traits

Introduction

Maize (*Zea Mays* L.) is the third major cereal crop of the world and in India ranks third after wheat and rice. It is an important cereal crop owing to its highest production potential and having wider adaptability under varied agro-climatic conditions and hence called as “Queen of Cereals” (Choudhari and Channappagouda, 2015) [4]. Globally maize is grown on an area of about 193.7 million hectares with a production and productivity of about 1147 million MT and 5.75 t ha⁻¹ respectively (FAOSTAT, 2020). In India, it is grown on an area of 9.18 million hectares with annual production of 27.23 million tones and productivity of 2.96 t ha⁻¹ (DES, 2019). In the union territory of Jammu and Kashmir maize is the second most important cereal crop after rice and is grown on an area of 0.31 million hectare with production of 0.51 million tonnes with an average productivity of 1650 kg ha⁻¹ (DES, 2019). The area under fodder production in India is around 9085 million hectares and accounts only 4% of cultivated area and production of about 462 million tonnes for green fodder and 394 million tons for dry fodder respectively (DES, 2015). Maize (*Zea Mays* L.) is having many desirable fodder qualities due to which it is preferred as compared to other cultivated non fodder crops viz; high productivity, high production potential, broader adoptability, rapid growing nature, succulence, palatability, free from toxicants, rich in protein and minerals and having high digestibility than non-legume fodder (Sattar *et al.*, 1994) [23]. Hence, it is widely known as ready-made fodder crop. Maize forage supplies large amounts of energy rich forage for dairy animal diets; free from anti nutritional factors so can be fed to cattle at any growth stage (Dahmardeh *et al.*, 2009) [5]. Maize is very convenient crop for forage production and due to the high production green mass per unit

area 12-25 t, total dry matter ha^{-1} , high energy content of dry matter and quality of biomass for silage (Mandic *et al.*, 2013)^[16]. Yet its growth and productivity are limited by varied climatic conditions, uneven topography, delay in harvesting of some rabi crops such as oats for seed production, that leads to delay in sowing of fodder maize and decrease in growth, yield and energy accumulation, but among the agronomic practices, seed rate and nitrogen application under late sown conditions of maize stabilizes the growth, yield and energy content of fodder maize. Apart from good nutrient management, establishment of an optimum plant stand (which influences crop growth, yield and hence energy output through its influence on light interception, rooting pattern and moisture extraction pattern) is equally important to get maximum yield of quality fodder (Verma and Joshi, 1998; Reddy and Reddi, 2006)^[26, 22]. Therefore, for maximum growth and energy output, the crop stand should be optimum. Similarly, nitrogen plays a great role in photosynthesis, protein synthesis and finally fodder quality and crop productivity (Ahmad, 2000)^[11]. Using different nitrogen rates in an experiment allows researchers to assess how varying levels of nitrogen influence plant growth and energy output. This helps identify the optimal nitrogen application rate for maximizing productivity while minimizing environmental impact. Additionally, it provides insights into the plant's nitrogen requirements under different conditions particularly under late sown conditions. Besides this, assessment of seed rate and nitrogen interactions under late sown rainfed conditions remain limited. Keeping the above cited facts into consideration, a field study entitled "Growth and Energy evaluation of Fodder Maize (*Zea Mays* L.) Under Late Sown Rainfed Conditions as effected by Varying Seed Rates and Levels of Nitrogen" was taken during the *Kharif* 2023 at Research Farm, Division of Agronomy of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, J&K, India, with the main objective of;

To study the effect of varying seed rates and levels of nitrogen on growth and energy evaluation of fodder maize under late sown *rainfed* conditions.

Materials and Methods

The Experiment was conducted at the Agronomy Research Farm, Faculty of Agriculture (FoA) Wadura, Sopore, SKUAST-K which is located between $34^{\circ} 21' \text{ N}$ latitude and $74^{\circ} 23' \text{ E}$ longitude and has an altitude of 1590 m above sea level. The experimental site was well-drained and with uniform topography. The experiment was conducted on silty clay loam with neutral pH, normal EC, medium in available N, P, K, and organic carbon. The experiment comprised of three seed rates viz; 40 kg ha^{-1} (S_1), 60 kg ha^{-1} (S_2) and 80 kg ha^{-1} (S_3) as Factor-A and four nitrogen levels including control (N_0), 90 kg ha^{-1} (N_1), 120 kg ha^{-1} (N_2) and 150 kg ha^{-1} (N_3) as Factor-B, randomised in blocks and replicated thrice. The variety tested was Shalimar Fodder Maize-1 and the experiment was laid out in RCBD factorial design. During the first week of July sowing was done in lines with row to row spacing of 30cm. The crop was fertilized according to the treatments. The full dose of phosphorous and potassium @ 60 $\text{kg P}_2\text{O}_5 \text{ ha}^{-1}$ and 40 $\text{kg K}_2\text{O ha}^{-1}$, respectively were applied uniformly to each plot as a basal dose using diammonium phosphate and muriate of potash as the source. In place of DAP, single superphosphate was applied in control plots (N_0). Nitrogen was applied as per treatments, half dose of nitrogen was applied as urea uniformly to each plot as a basal dose at the time of sowing and the remaining half dose of nitrogen was top dressed into two equal splits, one at 30 days after sowing at knee high stage and the second at 10-12 days before tassel initiation. The total rainfall received during the experimentation period was 145.50 mm. The crop was harvested

at 75% silking with the help of sickles (leaving two crop rows from each plot). The growth parameters which include plant height, leaf area index, leaf: stem ratio, number of leaves plant^{-1} , dry matter accumulation, CGR, RGR and NAR were recorded at 30 DAS, 60 DAS and at harvest. Observations were taken from a set of five randomly selected plants for each treatment of every replication. The data recorded from the five plants were then averaged to get the mean data per treatment, which was done for each treatment on all three replications.

Growth Parameters Measurement

- 1. Plant Height (cm):** Measured from the base of the plant to the tip of the main shoot at intervals, e.g., 30, 60, 90 DAS.
- 2. Leaf Area Index (LAI):** Leaf area was measured using a leaf area meter. LAI was calculated as:

$$\text{LAI} = \text{Leaf area per plant (cm}^2\text{)} / \text{Ground area occupied per plant (cm}^2\text{)}$$

- 3. Leaf: Stem Ratio:** At harvest, leaves and stems were separated, oven-dried at 70°C until constant weight, and weighed. The ratio was computed as:

$$\text{Leaf: Stem Ratio} = \text{Dry weight of leaves} / \text{Dry weight of stems}$$

- 4. Number of Leaves per plant:** Counted manually at each observation stage.
- 5. Dry Matter Accumulation (g plant^{-1}):** Plants were sampled at 30 DAS, 60 DAS and at harvest, oven-dried at 70°C , and weighed to record total dry matter accumulation.
- 6. Crop Growth Rate (CGR):** Calculated between two sampling intervals as:

$$\text{CGR} = (W_2 - W_1) / (t_2 - t_1) \cdot 1/A$$

Where W_1 and W_2 = dry matter at times t_1 and t_2 , and A = ground area.

- 7. Relative Growth Rate (RGR):** Computed as:

$$\text{RGR} = \ln W_2 - \ln W_1 / (t_2 - t_1)$$

- 8. Net Assimilation Rate (NAR):** Derived using:

$$\text{NAR} = (W_2 - W_1) (\ln L_2 - \ln L_1) / (t_2 - t_1) (L_2 - L_1)$$

where L_1 and L_2 = leaf area at times t_1 and t_2 .

Energy evaluation

All the operations carried out from sowing to harvesting were converted into Mega Joules using conversion table (Mokhtarpur *et al.*, 2005)^[18]. The energy input ha^{-1} was calculated by converting the amount of different field operations done during cultivation of maize into mega joules using conversion table. The energy output ha^{-1} was calculated from average green fodder yield in each treatment combination by multiplying it with 18 Mega joules kg^{-1} of green fodder. The energy ratio, energy intensity and net energy were calculated using the following formula;

$$\text{Energy ratio} = \text{Energy output (MJ ha}^{-1}\text{)} / \text{Energy input (MJ ha}^{-1}\text{)}$$

$$\text{Net energy (MJ ha}^{-1}\text{)} = \text{Energy output} - \text{Energy input.}$$

$$\text{Energy intensity (MJ ₹}^{-1}\text{)} = \text{Energy Output (MJ ha}^{-1}\text{)} / \text{Cost of cultivation (₹ha}^{-1}\text{)}$$

The statistical analysis of the data was performed using

Microsoft Excel and “Indostat” software’s. Statistical significance between mean differences among treatments for various parameters was analysed using critical differences (CD) at 0.05 probability level.

Results and Discussion

Growth parameters

The analysis of data revealed that plant height, leaf area index, Leaf stem ratio, Number of leaves plant⁻¹, Dry matter accumulation, Crop growth rate (g m⁻² day⁻¹), Relative growth rate (g g⁻¹ day⁻¹) and Net assimilation rate (g m⁻² day⁻¹) were significantly influenced by seed rates and nitrogen levels throughout the crop growth period (Fig. 1). Seed rate of 80 kg ha⁻¹ (S₃) recorded significantly higher plant height, leaf stem ratio, Leaf area index, dry matter accumulation, Crop growth rate, RGR of 0.190 g g⁻¹ day⁻¹ (0-30 DAS), highest NAR of 37.43 g m⁻² day⁻¹ at 0-30 DAS at different growth stages. While leaf stem ratio consistently decreased right from 30 DAS (1.25) up to harvest (0.45) of the crop. Seed rate of 40 kg ha⁻¹ (S₁) showed the greater number of leaves plant⁻¹ (13.99) at harvest and a smaller number of leaves plant⁻¹ were seen in 80 kg ha⁻¹ (S₃) seed rate. Highest output energy (1186800 MJ ha⁻¹), net energy (1168508.28 MJ ha⁻¹) and energy intensity (19.85 MJ ha⁻¹) was recorded by fodder maize with 80 kg ha⁻¹ (S₃) seed rate and Nitrogen level N₃ (150 kg ha⁻¹) followed by 80 kg ha⁻¹ (S₃) seed rate with N₂ (120 kg N ha⁻¹). The lowest output energy, net energy and energy intensity was observed in 40 kg ha⁻¹ (S₁) seed rate with Control (N₀).

Among nitrogen levels, N₃ (150 kg ha⁻¹) recorded higher plant height, leaf stem ratio (1.23), Leaf area index, number of leaves plant⁻¹, dry matter accumulation, Crop growth rate, 0.304 g g⁻¹ day⁻¹ (0-30 DAS), highest net assimilation rate of 57.68 g m⁻² day⁻¹ (0-30 DAS) at different growth stages and was at par with N₂ (120 kg ha⁻¹). Whereas N₀ (control) recorded significantly lower value.

Energy evaluation

The data pertaining to the input energy, output energy, net energy, energy ratio and energy intensity is presented in Table 2. The analysis of data revealed that the seed rates and nitrogen levels had a significant impact on energy Indicators. Energy evaluation in terms of output energy, net energy and energy intensity was worked out for various treatment combinations. It was evident from the data that the highest output energy (1186800 MJ ha⁻¹), net energy (1168508.28 MJ ha⁻¹) and energy intensity (19.85 MJ ha⁻¹) was recorded in fodder maize with 80 kg ha⁻¹ (S₃) seed rate and Nitrogen level N₃ (150 kg ha⁻¹) followed by 80 kg ha⁻¹ (S₃) seed rate with N₂ (120 kg N ha⁻¹). The lowest output energy, net energy and energy intensity was observed in 40 kg ha⁻¹ (S₁) seed rate with Control (N₀).

Discussion

The plant height is controlled by genetic makeup of the species and the environment to which plants are subjected during the growth and development. Further, shading effect causes the auxins to move from illuminated side to shade side and thus imbalance of auxin causes more elongation of plants in shade with curvature compared to being in light. Since auxin is sensitive to light, shading prevents its destruction and thus higher accumulation of auxin in shady plants triggers its growth. Earlier Ayub *et al.* (2007) have also reported significant increase in plant height of pearl millet with increase in seed rate from 10 to 20 kg ha⁻¹ and Joshi and Kumar (2007) also found that 60 kg ha⁻¹ seed rate significantly increased the plant height of maize over 50 kg ha⁻¹. The improvement in plant height with each successive increment of nitrogen may be attributed to the fact that nitrogen is an essential component of protein, the building

blocks of plants, and it helps in maintaining higher auxin levels, which may have resulted in better plant height as reported by Singh *et al.* (2000) [24]. The increase in plant height in response to increasing nitrogen levels was in conformity with the earlier findings of Ali *et al.* (2012) [2] and Kashinath *et al.* (2014) [12]. Higher leaf area index was attributed to the effect of high plant population on vegetative and reproductive development. Similar findings have also been made by Valadabadi and Farhani (2010) [24]. The increase in leaf area index with nitrogen fertilization might be attributed to the fact that more protein synthesis at higher levels of nitrogen induced vegetative growth, which resulted in an increase of photosynthetic surface, which in turn stimulated more leaf length, leaf width and leaf blade size. Similar findings were also reported by Osman *et al.* (2010) [20]. Highest leaf stem ratio may be due to the reason higher seed rates result in more plants per unit area, leading to increased competition for light. Maize plants, in response, may grow taller to compete for sunlight, resulting in a higher allocation of resources to stem growth rather than leaf growth. Kumar *et al.* (2016) reported that with higher seed rates leaf stem ratio decreases. mainly due to the rapid expansion of green foliage, which could intercept and utilize the incident solar radiation in the production of photosynthates, resulting in higher meristematic activity and leaf stem ratio of fodder maize. Similarly, an increase in leaf stem ratio with an increase in nitrogen levels was reported by Manjanagouda *et al.* (2017) and Somashkhar (2018). Number of functional leaves plant⁻¹ remained unaffected by seed rates. Ayub *et al.* (2007) also found that number of leaves plant⁻¹ of pearl millet remained unaffected with different seed rates. An increase in the number of green leaves may be due to the availability of sufficient nitrogen at all stages of growth. Plant height increased the number of nodes plant⁻¹, which resulted in the greater number of leaves plant⁻¹. Again nitrogen helped in the rapid growth and development of plants by helping in photosynthesis and various biochemical processes which respond to growth (Iqbal *et al.* 2016). Increase in dry matter yield with increased seed rate was mainly due to more plant densities viz; more plant height, more leaf area and more functional leaves per unit area. Dry matter production is related to the amount of solar radiation intercepted by the canopy. As plant densities increase, the canopy expands more rapidly, more radiation is intercepted and more dry matter produced. Increase in dry matter yield with increased seed rate has also been reported by Ayub *et al.* (2007) and Valadabadi and Farhani (2010) [24]. The increase in dry matter production at higher nitrogen levels might be due to enhanced metabolic activities as well as more cell growth and elongation. An increased dose of nitrogen enhanced the photosynthetic surface area (LAI), resulting in higher dry matter accumulation. The results are in accordance with the findings reported by Puri and Tiwana (2008) [21], Ali *et al.* (2012) [2] and Mahdi *et al.* (2012) [15]. Highest crop growth rate, relative growth rate and net assimilation rate may be attributed to increased dry matter production which occurred due to higher leaf area development, which is the potential site of photosynthesis while sowing crops with less seed rate obtain low crop growth, relative growth rate and net assimilation rate. This is mainly due to fact that higher seed rates lead to a denser canopy, which can intercept more sunlight. This increased light interception enhances the overall photosynthetic efficiency of the crop stand, contributing to higher CGR, RGR, and NAR. The results were in accordance with the findings reported by Nag *et al.* (2005). Among the Nitrogen levels, N₃ (150 kg ha⁻¹) recorded significantly higher crop growth rate, relative growth rate and net assimilation rate. However, N₃ was at par with N₂ (120 kg ha⁻¹). The lowest CGR, NGR and NAR was recorded with N₀ (Control). These results are in agreement with the findings of Jassal *et al.* (2017) [24] who

observed greater values of CGR, NGR and NAR with higher nitrogen levels. The maximum values of output energy, net energy and energy intensity could be attributed to highest green fodder yield obtained with seed rate 80 kg ha⁻¹ (S₃) and 150 kg

ha⁻¹ nitrogen level (N₃). Liu *et al.* (2019) also discovered that increasing the seed rates and nitrogen dose increased the output energy, net energy and energy intensity of fodder maize.

Table 1: Growth parameters of fodder maize under varied seed rates and nitrogen levels

Treatments	Plant height (cm)			Leaf area index			Leaf stem ratio			Number of leaves plant ⁻¹			Dry matter accumulation (q ha ⁻¹)			Crop growth rate (g m ⁻² day ⁻¹)			Relative growth rate (g g ⁻¹ day ⁻¹)			Net assimilation rate (g m ⁻² day ⁻¹)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Seed rates (kg ha⁻¹)																								
40 (S ₁)	30.52	176.14	242.74	1.44	2.89	3.92	1.25	0.78	0.45	6.78	12.05	13.99	21.8	79.88	131.73	7.26	19.37	18.28	0.178	0.044	0.018	30.44	9.84	5.40
60 (S ₂)	36.82	178.64	255.04	1.61	3.31	4.25	1.19	0.75	0.41	6.01	11.19	12.86	28.54	87.57	144.42	9.52	19.67	18.34	0.188	0.038	0.017	36.27	8.99	4.73
80 (S ₃)	41.69	184.52	279.49	1.77	3.85	4.45	1.09	0.67	0.36	5.40	9.93	11.73	31.9	99.33	155.59	10.66	22.45	18.75	0.190	0.038	0.017	37.43	8.78	4.95
SEm±	1.37	2.78	3.43	0.03	0.12	0.90	0.04	0.03	0.02	0.20	0.27	0.41	1.11	2.58	3.23	0.33	0.45	0.10	0.002	0.001	0.000	1.51	0.09	0.08
CD (p≤0.05)	4.04	8.20	11.26	0.09	0.35	0.30	0.11	0.08	0.05	0.66	0.90	1.36	3.29	7.62	9.53	1.09	1.49	0.32	0.005	0.003	NS	4.46	0.27	0.24
Nitrogen levels (kg ha⁻¹)																								
Control (N ₀)	28.19	158.12	236.94	1.08	2.90	3.60	1.07	0.61	0.32	4.13	7.23	8.45	16.15	82.00	124.38	5.38	21.95	14.12	0.276	0.055	0.014	45.83	19.38	8.94
90 (N ₁)	35.06	172.03	256.90	1.48	3.96	5.59	1.13	0.73	0.38	6.49	11.72	13.04	27.65	96.47	142.13	9.21	22.93	15.22	0.294	0.042	0.013	52.17	22.63	12.96
120 (N ₂)	38.77	175.67	265.54	1.68	4.25	5.91	1.19	0.81	0.44	7.19	12.38	13.73	33.75	102.88	150.36	11.05	23.24	15.82	0.301	0.038	0.013	55.48	24.11	14.92
150 (N ₃)	41.35	186.25	273.98	1.79	4.43	6.20	1.23	0.86	0.48	7.76	12.90	14.33	36.87	107.57	157.21	12.29	23.56	16.54	0.304	0.036	0.013	57.68	25.85	16.48
SEm±	1.58	3.21	4.43	0.04	0.06	0.10	0.01	0.02	0.01	0.19	0.21	0.23	1.14	1.61	2.33	0.18	0.36	0.57	0.001	0.001	0.000	0.26	0.22	0.09
CD (p≤0.05)	4.67	9.47	13.0	0.12	0.20	0.30	0.05	0.07	0.05	0.58	0.65	0.68	3.35	4.74	6.86	0.54	1.06	1.69	0.002	0.002	NS	0.75	0.62	0.28

Table 2: Energy evaluation of fodder maize under varied seed rates and nitrogen levels

Treatments	Input energy (MJ ha ⁻¹)	Output energy (MJ ha ⁻¹)	Net energy (MJ ha ⁻¹)	Energy ratio	Energy intensity (MJ ha ⁻¹)
S ₁ N ₀	2973.65	396600	393626.35	133.37	15.04
S ₁ N ₁	10459.67	880200	869740.33	84.15	15.44
S ₁ N ₂	14396.85	914400	900003.15	63.51	15.93
S ₁ N ₃	18363.72	934800	916436.28	50.90	16.18
S ₂ N ₀	3287.65	425400	422112.35	129.39	15.54
S ₂ N ₁	10773.67	979800	969026.33	90.94	16.89
S ₂ N ₂	14710.85	1013400	998689.15	68.89	17.35
S ₂ N ₃	18677.72	1055400	1036722.28	56.51	17.95
S ₃ N ₀	3601.65	441000	437398.35	122.44	15.55
S ₃ N ₁	11087.67	1091400	1080312.33	98.43	18.50
S ₃ N ₂	15024.85	1124400	1109375.15	74.84	18.93
S ₃ N ₃	18991.72	1186800	1167808.28	62.49	19.85

Reference

- Ahmad N. Fertilizer scenario in Pakistan: policies and development. In: Ahmad N, editor. Proceedings of the Conference Agriculture and Fertilizer Use. Islamabad, Pakistan: Planning and Development Division, Government of Pakistan; 2000. p. 15-21.
- Ali S, Sahiba, Malik MA, Hassan FU, Ansar M. Growth of rainfed fodder maize under different levels of nitrogen and phosphorus. Pakistan Journal of Agriculture Research. 2012;25(3):35-37.
- Ayub M, Nadeem MA, Tanveer A, Tahir M, Khan RMA. Interactive effect of different nitrogen levels and seeding rates on fodder yield and quality of pearl millet. Pakistan Journal of Agricultural Sciences. 2007;40(4):39-43.
- Choudhari VV, Channappagouda BB. Effect of organics on morphophysiological traits and grain yield of maize (*Zea Mays* L.). The Bioscan. 2015;10(1):339-344.
- Dahmardeh M, Ghanbari A, Syasar B, Ramroudi M. Effect of intercropping maize with cowpea on green forage yield and quality evaluation. Asian Journal of Plant Science. 2009;8(3):235-239.
- Department of Economic and Statistical Research. Agricultural statistics in India. 2015. Available from: <https://desagri.gov.in/document-report/agricultural-statistics-at-a-glance-2019/>
- Department of Economic and Statistical Research. Agricultural statistics in India. 2019. Available from: <https://desagri.gov.in/document-report/agricultural-statistics-at-a-glance-2015/>
- FAOSTAT. Food and Agricultural Organization of the United Nations. 2020. Available from: <https://iimr.icar.gov.in/world-maze-scenario/>
- Iqbal J, Khan R, Wahid A, Sardar K, Khan N, Ali M, *et al.* Effect of nitrogen and zinc on maize (*Zea Mays* L.) yield components and plant concentration. Advances in Environmental Biology. 2016;10(10):203-209.
- Jassal RK, Kang JS, Singh H, Singh T. Growth, phenology and seed yield of fodder maize in relation to different planting methods and nitrogen levels. International Journal of Current Microbiology and Applied Sciences. 2017;6(4):1723-1735.
- Joshi YP, Kumar K. Effect of nitrogen levels and seed rates on growth, yield and quality of fodder maize variety 'African tall'. Forage Research. 2007;33(3):171-173.
- Kashinath BC. Performance of fodder maize under varied crop geometry and nitrogen levels [MSc thesis]. Tirupati: Sri Venkateswara Agricultural College, Acharya NG Ranga

- Agricultural University; 2014.
13. Kumar R, Singh M, Tomar SK, Meena BS, Rathore DK. Productivity and nutritive parameters of fodder maize under varying plant density and fertility levels for improved animal productivity. *Indian Journal of Animal Research*. 2016;50(2):199-202.
 14. Liu J, Zhang H, Wang Y. Effect of nitrogen fertilization on biomass yield and fodder quality in maize. *Agronomy Journal*. 2019;111(4):1567-1576.
 15. Mahdi SS, Hasan B, Singh L. Influence of seed rate, nitrogen and zinc on fodder maize (*Zea Mays* L.) in temperate conditions of western Himalayas. *Indian Journal of Agronomy*. 2012;57(1):85-88.
 16. Mandic V, Simic A, Tomic Z, Krnjaja V, Bijelic Z, Marinkov G, *et al.* Effect of drought and foliar fertilization on maize production. In: *Proceedings of the 10th International Symposium*; 2013. p. 1332.
 17. Manjanagouda S, Sannagoudar, Lalitha BS, Prajwal Kumar GK, Prashant, Bhavya V. Effect of varieties, cutting, and nitrogen management on green fodder yield, nutrient uptake, available soil nutrient status, and economics of dual-purpose pearl millet (*Pennisetum glaucum* L.). *International Journal of Current Microbiology and Applied Sciences*. 2017;6(12):214-226.
 18. Mokhtarpur H, Mosavat SA, Bazi M, Saberi A. Effect of sowing date and planting density on early yield of sweet corn (*Zea Mays* L. var. *saccharata*). *Iranian Journal of Crop Sciences*. 2005;8:171-183.
 19. Nag BL, Rahman MA, Talukder MMR, Hossain MH, Alam MS. Growth analysis and dry matter partitioning of mungbean (*Vigna radiata* (L.) Wilczek) under variable seed rates. *Legume Research*. 2005;28(3):157-165.
 20. Osman S, Abdelsalam Y, Abdelsalam K. Effect of nitrogen and seed rate on growth and yield of forage sorghum. *Journal of Science and Technology*. 2010;11(2):123-136.
 21. Puri KP, Tiwana US. Effect of organic and inorganic sources of nitrogen in forage maize. *Forage Research*. 2008;34(1):62-63.
 22. Reddy TY, Reddi GHS. Principles and practices of agronomy: plant population. 3rd ed. Ludhiana: Kalyani Publishers; 2006. p. 193-203.
 23. Sattar MA, Haque MF, Rahman MM. Intercropping maize with broadcast rice at different row spacing. *Bangladesh Journal of Agricultural Research*. 1994;19:159-164.
 24. Singh DP, Rana NS, Singh RP. Dry-matter production and nitrogen uptake in winter maize (*Zea Mays* L.) based intercropping system under different levels of nitrogen. *Indian Journal of Agronomy*. 2000;45(4):676-680.
 25. Valadabadi SA, Farhani HA. Effects of planting density and pattern on physiological growth indices in maize (*Zea Mays* L.) under nitrogenous fertilizer application. *Journal of Agricultural Extension and Rural Development*. 2010;2(3):40-47.
 26. Verma SK, Joshi YP. Effect of nitrogen and seed rate on leaf area index, nitrogen content, nitrogen uptake and dry matter yield of teosinte at different growth stages. *Forage Research*. 1998;24(1):45-47.