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Evaluation of Fodder Production and Nutritional Composition of Fresh and Ensiled African Tall Maize (*Zea mays* L.) Grown under Various Types and Levels of Fertilization

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Abstract

The experiment was conducted during October-December, 2020 at Forage Production Unit, College of Veterinary Science, Korutla, Jagityala, Telangana State, India to evaluate the yield of fodder under different manure or fertilizer applications and along with nutritional composition in fresh and ensiled form. African tall maize (ATM) was sown under four treatments and five replications in randomise block design (RBD) (T₁=control or no fertiliser application, T₂: Recommended dose of fertilisers application @ 120:60:40 NPK kg ha⁻¹, T₃: Farm Yard Manure (FYM) applied @ 10 t ha⁻¹ and T₄: Sheep manure applied @ 3 t ha⁻¹. The results showed a green fodder yield of 36.5 t ha⁻¹ in T₂ followed by T₃ (23.8 t ha⁻¹), T₄ (22.1 t ha⁻¹) and T₁ (20.3 t ha⁻¹) respectively. There was significant difference for plant height and number of leaves at harvest, green fodder yield and forage dry matter yield among the treatments. Maize as a forage should be cultivated with recommended fertilisers to gain the highest fresh forage yields and CP yields. There were no significant differences in Ether extract (EE), crude fibre (CF) and phosphorous content of fresh forage and silage while significant difference was seen in crude protein (CP), total ash (TA), neutral detergent fibre (NDF), acid detergent fibre (ADF) and calcium content. The nutrient composition of silage was higher than the values of fresh forage. The study showed that the nutrient composition of silage was preferable than the fresh fodder maize harvested at 85 DAS with recommended fertilizers.

Keywords: African tall maize, fodder, proximate, silage, yield

1. Introduction

Maize is one of the most important food and fodder crop in India and has the highest production among all the cereals (Rajkumara et al., 2020, Shivakumar, 2018, Kumar and Ram, 2021). In southern part of India maize is commonly grown as *Kharif* crop and fodder maize under changing environmental conditions may be the sustainable solution (Abraha and Savage, 2006, Moradi et al., 2012, Xu et al., 2017). It is extensively being used in animal feeding (Chaudhary et al., 2016) safely unlike sorghum (Nkhata et al., 2018), which contains HCN which is toxic if fed too early. Maize is a most nutritious, succulent and palatable fodder crop amongst the cereals also during summer season (Anonymous, 2022, Rupal et al., 2019, Rupal et al., 2020, Rupal et al., 2021). It contains sufficient quantities of protein and minerals and possesses high digestibility as compared to other non-legume fodders (Chaudhary et al., 2014). It is an established fact that provision of green fodder for livestock is an important component of optimal, sustainable and economical production of milk and meat. Fodder maize is quick growing and produces high

biomass (t DM⁻¹ ha⁻¹ cut⁻¹) and most suitable for silage making (Kumar et al., 2019, Brar et al., 2017, Borreani et al., 2018, Bhattacharyya et al., 2008, Ndleleni et al., 2021, Ulger et al., 2020) when compared with other grasses, legumes and crops.

Farmyard manure is the major source of soil organic matter in the intensive cropping system. Organic matter usage increases water holding capacity of the soil (Liu et al., 2022) and increases water availability for plant. It also improves physical properties of soil. It is the source for phosphorus and sulphur. It occupies a prominent position among the bulky organic manures available in India with a potential supply of 13.39 mt of N, P₂O₅ and K₂O per annum, besides improving the soil properties (Manna and Ganguly, 2003). The conjoint use of organic manures and chemical fertilizers (Xianjin et al., 2021, Lukiwati et al., 2018, Kanengoni et al., 2016) can help in enhancing and maintaining stability in production with least degradation in chemical and physical properties of soil. Supplementing N through organic sources plays a vital role in increasing the yield of any crop. Organic farming is gaining importance in view of sustained agriculture and maintaining



ecological balance. It lies in a simple principle of utilizing cheap and local inputs with zero utilization of chemicals in any form like fertilizer, herbicide, pesticide, antibiotic, hormone etc.

Organic manures act not only as a source of nutrients and organic matter, but also increase size, biodiversity and activity of the microbial population in soil (Khushpure and Bhojar, 2018), influence structure, nutrients turnover and many other related physical, chemical and biological parameters of the soil (Albiach et al., 2000). The conjoint use of organic manures like sheep manure and chemical fertilizers helps in enhancing and maintaining stability in maize production. The productivity of maize is largely dependent on its nutrient management but ways to increase its production are yet not well defined.

The present study was taken up to evaluate the output or yield of fodder maize variety African tall maize (ATM) (*Zea mays* L.) when fertilized with various types of manure sources. Out of the above the best yielder was evaluated for nutritional composition in as such green form and ensiled form which can be reported as an economical and potential fodder maize in Northern Telangana during normal or scarcity or disaster conditions.

2. Materials and Methods

2.1. Plant cultivation and fodder production

The experiment was conducted during I, October-December 2020 at Forage Production Unit, College of Veterinary Science, Korutla, Jagityala, Telangana State, India. The geographical location of the experimental site was 18°49'50.2" N Latitude, 78°56'55" E Longitude with an altitude of 243.2 m above mean sea level. This area is classified as North Telangana Agro Climatic Zone. The experiment was laid out using ATM in a randomized block design (RBD) with four treatments with five replications in sandy loam soil. The plot size used for planting was 6.5×5 m² (32.5 m²). The ATM was spaced at 30×10 cm² with population of about 3,33,333 plants ha⁻¹. The site of experiment was ploughed to 0.2–0.3 m depth after the removal of stubble, followed by harrowing prior to sowing the seed. Treatment imposition was done as per the treatments T₁ (control no fertiliser application), T₂ (recommended dose of fertilisers i.e. 120 kg of N ha⁻¹, 60 kg P₂O₅ ha⁻¹ and 40 kg of K₂O ha⁻¹) total P and K fertilisers was applied as basal and Nitrogen was applied in 3 split doses T₃ (FYM @ 10 t ha⁻¹ applied 15 days before sowing) T₄ (Sheep manure @ 3 t ha⁻¹ applied before 15 days of the sowing). ATM was sown to a depth of approximately 3–5 cm by hand on October 16, 2020. Seed rates of 40 kg ha⁻¹ was sown to allow for thinning. Pre emergency weedicid was sprayed to control weeds for initial 15 days and after weeding was carried out manually using locally made hoes and labourers. During the experimental period, the field was irrigated 6 times with 15 days interval.

2.2. Measurement of forage growth parameters

5 plant stands of the middle rows of each replicate were tagged and used for determining the following agronomic

parameters: plant height, number of leaves per plant leaf width and leaf length (cm). The height of the tagged plants was measured from ground level to the top of the last leaf (flag leaf) using a meter rule and the mean values were computed.

2.3. Harvesting of forage material and biomass measurement

ATM was harvested at 85 days after sowing (DAS) at dough grain stage. At harvest the plants were cut at a height of 10 cm above the ground. Tagged plant stands were cut from each replicate at harvest to determine the forage dry matter yield components and forage yield of the maize. Yield components determined include number of leaves per plant, number of green or dead leaves per plant and Leaf to stem ratio. After determination of these various components of yield, they were immediately weighed to obtain fresh weight and then oven dried for 48 h to obtain the dry weight which was used to determine the dry matter for various components and for a whole plant stand from where the fresh forage and forage DM yields per hectare were obtained.

2.4. Ensiling of maize materials

Out of the ATM harvested at 85 DAS, forage material from T₂ treatment was ensiled. As such form of green forage from T₂ and silage made from T₂ was used to evaluate various physical, chemical and nutritional compositions.

ATM from T₂ was allowed to wilt in the sun for 5–6 h before ensiling. Fodder maize was chopped into 2 cm pieces with the help of chaff cutter and was immediately placed in transparent silage polythene bags (0.8×0.4 m²) at harvesting time. These bags were sealed airtight and kept at room temperatures to allow for anaerobic fermentation for 40 days. Physical characteristics of the silage: temperature, colour, aroma, and pH of the silages were determined immediately after the silage polythene bags were opened. Sub-samples of the silage materials were also taken, oven-dried and milled for proximate and mineral analysis.

2.5. Chemical analysis

The dried samples of the feeds (silage and fresh fodder materials) were ground with a Wiley mill to pass a 1 mm screen and analyzed for quality components. Proximate composition and cell wall constituents (Van Soest et al., 1991) were estimated in the dried and pooled samples. Ca and P content were determined by titration method (Talapatra et al, 1940).

2.6. Statistical analysis

The experimental data were statistically analysed for analysis of variance through the procedure appropriate to the experiment laid out as described by Panse and Sukhatme (1985). Interpretation of results was based on 'F' test. The comparison among means was made by calculating critical difference (CD) at 5% level of significance.

3. Results and Discussion

3.1. Yield components

Forage growth parameters and green fodder yield components are presented in Table 1. Plant height of ATM was significantly



Table 1: Forage yield and yield components of fodder maize in response to nutrient management treatments

Treatments	No. of leaves plant ⁻¹	plant height in cm	leaf length in cm	leaf width in cm	Green fodder yield (t ha ⁻¹)	Forage dry mat- ter yield (t ha ⁻¹)
T ₁ : Control (no fertilizer)	8.8	232.4	71.9	6.2	20.3	4.9
T ₂ : Recommended Dose of Fertilizer NPK (12:60:40)	12.4	263.0	93.1	8.0	36.5	7.5
T ₃ : FYM @ 10 t ha ⁻¹	9.4	249.4	83.6	7.4	23.8	6.4
T ₄ : Sheep manure @ 3 t ha ⁻¹	10.0	243.2	81.6	7.6	22.1	6.0
SEm±	0.2	4.0	1.3	0.1	0.6	0.2
CD (p=0.05)	0.4*	8.6*	2.7*	0.3*	1.2*	0.3*

influenced in T₂, T₃ and T₄ compared to control T₁. Among all the treatments ATM from T₂ has highest plant height followed by T₃, T₄ and T₁ (T₂>T₃>T₄>T₁) with the corresponding values of 263.0, 249.4, 243.2 and 232.4 cm, respectively. The number of leaves per plant was recorded highest in T₂ (12.4 cm), which was significantly higher than the T₄ (10.0), T₃ (9.4) and T₁ (8.8). Leaf length of ATM was significantly higher in T₂ than all other treatment groups. The mean values of leaf length (cm) in T₂, T₃, T₄ and T₁ were 93.1, 83.6, 81.6 and 71.9 cm, respectively. The leaf width of ATM was significantly high in T₂ (8.0) as compared to T₄ (7.6), T₃ (7.4) and T₁ (6.2). The leaf width was statistically at par in T₄ and T₃ groups and was statistically higher than the T₁.

The green fodder yield was recorded highest in T₂ followed by T₃, T₄ and T₁ group. The green fodder yield 36.5 t ha⁻¹ (t ha⁻¹) was recorded in T₂ followed by T₃ (23.8 t ha⁻¹), T₄ (22.1 t ha⁻¹) and T₁ (20.3 t ha⁻¹) respectively. The dry matter yield (DMY) was significantly higher in T₂ as compared to other treatment groups. DMY was 7.5 t ha⁻¹ in T₂ followed by T₃ (6.4 t ha⁻¹), T₄ (6.0 t ha⁻¹) and T₁ (4.9 t ha⁻¹). It was also reported that the green fodder yield was 25.17 t ha⁻¹ on application of 50 kg N ha⁻¹ which has increased to 29.33 t ha⁻¹ when 100 kg N ha⁻¹ was applied. Bhattacharyya et al. (2008), Kumar et al. (2019) while comparing organic and inorganic fertilizers and different combinations reported comparable green fodder yield of 19.50 t ha⁻¹ obtained on application of 100 kg N ha⁻¹. The green fodder yields of 39.20 t ha⁻¹ were recorded when a combination of inorganic and organic fertilizers (200 kg N+12 t FYM ha⁻¹) were applied. Similar results were reported by Kumar et al. (2016), The green fodder and dry matter yields of maize were significantly higher with the use of 100% RDF than the other treatment except treatment, with 75 per cent RDF+25 per cent N through FYM+Azotobacter. Maximum fodder yield (460 q ha⁻¹) was recorded with the application of 100 per cent Recommended Dose of Fertilizer (RDF) followed by 75 per cent RDF+25 per cent N through FYM+Azotobacter having yield (443 q ha⁻¹) and it was 93.2 and 86.1% higher over the control (238 q ha⁻¹). The corresponding values for dry matter were 80.9 and 74.0 per cent higher over the control. The beneficial response of 100% RDF to various yield studies could be ascribed due to favourable effect of growth

characters, namely, plant height and dry matter accumulation and physiological parameters. Compared with chemical fertilizers, lone organic fertilizers do not meet the nutritional needs of crops because they contain a comparatively less quantity of nutrients. (Ayoola and Makinde, 2008; Abou el Magd, and Hoda Mohammed, 2005). The results of this study showed that the DM yield from the inorganic fertilizers was higher than that from the lone application of organic fertilizer. Makinde et al., (2001) indicated that fodder maize performance resulting from chemical fertilizer applications alone and a mixture of organic and inorganic fertilizer applications was significantly higher than that resulting from organic fertilizer application alone.

The significant increase in fodder yield with increase in fertility levels could be attributed to conducive effect on root and shoot growth of plant which in turn accrued from increased morphological parameters. The potential forage yields of forage maize varieties should be between 16–40 t ha⁻¹ and many research works have shown forage DMY above this range which may be due to variations in the genotype and plant density of forage maize yield.

3.2. Nutritional composition of the Forage

Proximate and mineral composition of ATM from T₂ forage and silage are presented in Table 2. The result showed that there were no significant differences in Ether extract (EE), crude fibre (CF) and phosphorous content of fresh forage and silage. The results obtained from this trial showed that there was significant difference in crude protein (CP), total ash (TA), neutral detergent fibre (NDF), acid detergent fibre (ADF) and calcium content. The Ca and P contents obtained in this trial were higher than the values obtained by Ballard et al. (2001). Average CP content of ATM from T₂ of the present study is well within the range as reported in the previous studies of Wadhwa et al. (2018) where the CP content ranged between 6–9% in fodder maize.

The ash content was higher in silage (9.8%) the ash contents obtained in this trial to the result reported by Amole et al., 2011. There was no significant difference in EE and CF contents of silage and forage. The CP content was higher in silage than the forage. The NDF value (58.2%) was higher in silage than in



Table 2: Proximate, and mineral composition of forage and silage of fodder maize (% DM)

Parameter (%)	Fodder Maize		SEM±	LOS
	Fresh forage mean	Silage mean		
Crude protein (CP)	6.9	8.7	0.61	**
Ether extract (EE)	7.0	7.1	0.08	NS
Crude fibre (CF)	28.6	28.8	0.75	NS
Total Ash	4.5	9.8	0.85	**
Neutral detergent fibre (NDF)	58.2	51.3	0.76	**
Acid detergent fibre (ADF)	30.8	32.7	0.82	*
Phosphorus (P)	0.1	0.3	0.21	NS
Calcium (Ca)	0.5	1.2	0.05	**

Note: LOS Level of significance, S.E. standard error. *Significant ($p < 0.05$), **Significant ($p < 0.01$) NS, Not significant

forage. Ballard et al. (2001) reported increase in total ash, EE and CP in fermented maize with a decrease in NDF contents after fermentation. Kanengoni et al. (2016) also reported a decrease in NDF content was in line with their results. It was noted that the CP increment after fermentation may be attributed to microbial synthesis of protein and to loss in carbohydrates. Darby and Lauer (2002) reported a decrease in NDF content after ensiling, which is also similar to the report in this study. The increase in ADF content after fermentation is in contrast with the report of Kanengoni et al. (2016) who reported that ensiling had reduced ADF content. The values obtained in this study in CP, TA, ADF and NDF contents were similar to the values obtained by Ballard et al. (2001).

The proximate and mineral compositions of maize silage depend on the stage of harvest and silage material sample with a variation range of 6.0–9.5, 23.6–33.2 and 41.0–54.1% for CP, ADF and NDF contents, respectively. Different values have also been reported for mineral content in maize silages.

4. Conclusion

The application of RDF (NPK12:60:40) had a significant effect on the growth parameters and green fodder yield of fodder maize grown during the months of October-December when compared to organic manures (FYM, Sheep manure) and controlled treatments. Silage significantly improved crude protein (8.7%), total ash (9.8%), calcium (1.2%) and reduced NDF, ADF when compared to green fodder, as evidenced by higher values in silage.

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