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Evaluation of Fodder Maize (*Zea mays* L.) Cv. African Tall and its Response to Different Rates of FYM and Biofertilizers under Cold arid Conditions of Kargil

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Fodder availability in cold arid regions is from 40 to 50 percent of real need, but in some areas it exceeds 50 percent [1]. Alfalfa, which is the sole fodder accessible to farmers and is dried and given to animals throughout the winter, is insufficient to meet the winter fodder shortfall. The region has a 73 percent fodder deficiency, according to reports [1]. The region's large fodder shortfall explains why the fodder development initiative is so important. Ladakh's freezing desert terrain has a lengthy, harsh winter that lasts 7-8 months and is devoid of any vegetation. During the winter, the entire animal rearing depends on the stored feed. Keeping these facts in view a field experiment entitled "Evaluation of fodder maize (*Zea mays L.)* Cv. *African tall* and its response to different rates of farmyard manure (FYM) and Biofertilizers under cold arid conditions of Kargil" was carried out at

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the research farm of Mountain Agriculture Research and Extension Station Kargil for the years 2015-16 and 2016-17 on silty clay loam soil low in available nitrogen and medium in available phosphorus and potassium with neutral pH. The experiment comprised of two factors *viz.,* Bio fertilizers (B1: Azotobacter, B2: Phosphorus solubilising bacteria (PSB), B3: Azospirillium, B4: Azotobacter + PSB, B5: Azospirillium + PSB) and three FYM rates (R_1= 10 t ha^{-1}, R_2 =20 t ha^{-1} and R_3 = 30 t ha^{-1}) was laid out in a Randomized block design replicated thrice, given nitrogen, phosphorus and potassium as per recommended package. The results revealed that highest plant height, number of leaves, stem girth and fodder yield were realized from the treatment comprising of FYM @30 t ha^{-1} + Azotobacter + PSB treatment among all the treatments. Also crude protein and crude fibre were recorded to be higher with the treatment of FYM @30 t ha^{-1} + Azotobacter + PSB.

Keywords: Fodder maize; forage yield; biofertilizers; FYM; crude protein; crude fibre.

1. INTRODUCTION

Maize (*Zea mays* L.) is the third major cereal crop of the world and in India ranks third after wheat and rice. Maize is considered as extensive cereal crop primarily due to highest productivity among cereals and acquires wider adaptability in varied agroclimatic conditions hence, known as "Queen of Cereals" [2]. Globally around 190 million hectares of area with production of about 1438 million tonnes is under maize cultivation [3]. In India about 9.50 million hectares with annual production of 27.23 million tonnes and productivity of 2.870 tonne $hectare^{-1}$ is under maize cultivation (DES. 2019). The area under fodder production in India is around 9.85 million hectares and accounts only 4 % of cultivated area and production of about 462 million tonnes for green fodder and 394 million tonnes for dry fodder respectively [4].

Despite its declining contribution to India's GDP, agriculture maintains a critical role in providing bread and butter to more than half of the country's population [5]. Among different enterprises under the giant umbrella of the agricultural production system; livestock is the most prominent one. According to the 19th livestock census, India has the world's highest livestock population at 512.06 million [6]. This sizeable livestock population plays a multitude of roles of ensuring food security, poverty alleviation, evading climate change and engaging women in agriculture in a large number [7]. Despite India's large livestock population and its global position with highest milk production (176.35 million tonnes in 2018-19); the productivity of Indian cattle is low compared to the global average and even lower than the European countries [8]. The reason can be different; from inappropriate and inadequate nutrition to breeding and lack of adaptability problem [9]. Lack of quantity and quality in green fodder is one of the prime factors which is holding back the higher production of dairy animals throughout India [10]. The problem can only be solved by high yielding quality fodder production, such as maize with suitable agronomic practices. Maize is one of the most important forage crops not only in India but all over the world owing to its higher growth rate and yield, wider adaptability, higher digestibility, more palatability and lack of any potential anti-nutritional factor [11].

The Himalayas cover only 7% of India's land area, yet the twelve Himalayan states have a large livestock population. This massive cattle population is rapidly proliferating, and as a result of rising grazing pressure on grazing grounds, pastures, and scrub lands, they are rapidly degrading, resulting in a severe feed scarcity. Agriculture and animal husbandry, on the other hand, are culturally, religiously, and economically intertwined with the intricate fabric of society in the cold desert region, since mixed farming and livestock keeping constitute an intrinsic element of India's rural cold arid zone. Rangelands and their crops receive little consideration in agricultural strategies in much of the Hindu Kush Himalayan region, despite their importance. The value of animals in the local subsistence and market economies is crucial. The majority of Ladakh's terrain are more suited for livestock husbandry rather than crop production, which reflects this. These rangelands have produced the best pashmina wool in the world for decades [12]. Sheep wool has also been traded outside of the country for usage in clothes, pillows, and bedding. These rangelands supply additional important animal goods and services, including as meat, dairy, labour, and organic fertiliser, in addition to goat and sheep wool. Thus, animal production is without a doubt the most important production system in the Indian Trans Himalayan area of Ladakh. As a result, fodder production, supply, and conservation for lean periods is a critical issue for livestock production systems, and Alfa alfa is the only fodder crop in the region that cannot meet the fodder shortage in the cold arid region; thus, to address the fodder shortage, another fodder crop must be introduced to the region. Continuous cropping, soil erosion, nutrient loss, salt and other toxic element accumulation, water logging, and improper nutrient compensation are all contributing to a steady decline in soil fertility [13]. Biofertilizers are an alternative source for meeting crop nutrient requirements and to bridge the gaps [14] and are 100% natural organic fertilizers that enhance the nutrient quality of soil. Biofertilizers are organisms that aid to provide and keep in the soil all the nutrients and microorganisms required for the benefit of the plants [15]. Biofertilization can be useful to enhance the output and improve the quality of soil, responsible for agriculture environment [16] and Bio-fertilizers are essential to support developing organic agriculture, sustainable agriculture, green agriculture and non-pollution agriculture [17]. Biofertilizers are of great significance to get a yield of high quantity / quality and to reduce the environmental pollution as well. Application of nutrients in organic forms is gaining popularity due to rapid growing organic farming globally and manures that included essentially required macro- and micronutrients are now being marketed. Reports reveal significant effect of manures and other organic forms of nutrients including farmyard manure. The farmyard manure is another organic nutrient that has proved to be one of the most effective organic sources of nutrients for crop production [18]. In households where crop and livestock production are integrated, FYM can become a chief nutrient source for crops and reduce the need for fertilizers [19]. Keeping in view the above facts an experiment entitled "Evaluation of Fodder maize (*Zea mays L*.) Cv. African Tall and its response to different rates of FYM and Biofertilizers under cold arid conditions of Kargil" was carried out at the research farm of Mountain Agriculture research and Extension Station, SKUAST-K, Kargil during the years of 2016-17 and 2017-18.

2. MATERIALS AND METHODS

The field experiment entitled "Evaluation of fodder maize (*Zea mays L.)* Cv. African tall and its response to different rates of FYM and Biofertilizers under cold arid conditions of Kargil" was carried out at the research farm of Mountain Agriculture Research and Extension Station Kargil for the kharif season of 2016 and 2017 on silty clay loam soil low in available nitrogen and medium in available phosphorus and potassium with neutral pH. The experiment comprising of two factors *viz.,* Bio fertilizers (B_1: Azotobactor, B_2: PSB, B_3: Azospirillium, B_4:

Azotobactor + PSB, B_5: Azospirillium + PSB) and three FYM rates (F_1: 10 t ha^{-1}, F_2: 20^t ha^{-1} and F_3: 30t ha^{-1}).

The experiment was laid out in a Randomized block design and was replicated thrice, given nitrogen, phosphorus and potassium as per recommended package. The crop was kept weed free during the whole crop period and irrigation was applied at an interval of 5-8 days during the crop season. The recommended dose of FYM followed by farmers is 10-15 t ha^{-1}. The growth parameters observations were recorded from the ring line of the each treatment plot. Five random plants from each plot from the ring line excluding the border rows were selected for taking the observations on plant height, green and dry weight per plant. The fresh forage yield from the net plot leaving border rows and penultimate rows was recorded immediately after harvesting the maize crop which was then sun- dried in the same plot till the constant weight was recorded for dry fodder yield. Quality parameters crude protein, crude fibre, were analyzed at the harvest stage of the crop by using the methods as described by Tilley and Terry [20].

3. RESULTS AND DISCUSSION

3.1 Growth Prameters

The experiment included 3 FYM rates *viz.,* 10 (F_1), 20 (F_2) and 30 (F_3) t ha^{-1} and 5 levels of Biofertilizer viz. Azotobacter, Azospirillium, PSB, Azotobacter + PSB and Azospirillium + PSB. Plant height, an important growth character, monitors on architecture of plant there by governs the photosynthetic efficiency to utilize the natural resources. From the present investigation it was found that increase in FYM rates from 10 to 30 t ha^{-1} significantly and consistently improved the plant height of African tall (Table 1). The beneficial effects of FYM could be attributed to the fact that FYM supplied higher amount of both macro and micronutrient particularly nitrogen that helped in rapid cell division and cell elongation. Earlier Sujata et al. [21] have also reported significant improvement in the plant height. Freitas and Stamford [22] also reported significant increase in the plant height with FYM application up to 30 t ha^{-1}.

It was found from the present investigation that application of Azotobacter, Azospirillium and PSB increased the plant height, during both the years of investigation. However, highest plant height was recorded from the treatment applied with Azotobacter in combination with PSB, which was found at par with the treatment applied with Azospirillium in combination with PSB. This could be attributed to the fact that Azotobacter, Azospirillum and Phosphobacter can provide significant amount of nitrogen and phosphorus to increase the plant height. Also addition of Azotobacter, Azospirillum and PSB promotes the physiology and improves the root morphology. Luikham et al. [23] reported that in baby corn, maximum plant height was recorded with 100% dose of N + 10 t FYM ha^{-1}, which was at par with 75 % dose of N + 10 t FYM ha^{-1} and both these treatments were significantly superior over control.

Number of leaves per plant showed significant increase with increase in FYM levels, however highest number of leaves was found in the treatment applied with 30 t ha^{-1} of FYM, followed by the treatment applied with 20 t $ha^{-1}$of FYM. Both macro and micronutrients released from FYM might have stimulated more leaves per plant.

These results also corroborate the findings of Vadivel et al. [24] and Sankhyan et al. [25]. Application of biofertilizers in addition to recommended package also increased the number of functional leaves, however highest number of leaves was found in the treatment applied with Azotobacter and PSB. This might be due to addition of nitrogen and other nutrients and their availability to the crop. These results are in close conformity with the findings of Mangrio et al. [26] who reported increased number of leaves per plant with the application of Azotobacter + 100% NPK following application of Azospirillum + 100% NPK.

Stem girth also showed improvement with increase in FYM levels and highest stem girth was found when the crop was applied with 30 t ha^{-1} of FYM, which was followed by 20 t ha^{-1} of FYM. This might be due to the fact that application of FYM increased the amount of nutrients available to the crop. Mahmooda et al. [27] also reported increased stem girth of maize with the application of farmyard manure.

It was found from the investigation that there was significant increase in stem girth with the application of biofertilizers and highest stem girth was found from the treatment applied with Azotobacter and PSB, followed by the treatment applied with Azospirillium and PSB. This might be due to the fixation of atmospheric nitrogen and increase in availability of phosphorus, which improved the overall architecture of the crop. Chougale [28] also reported increased growth parameters with the application of recommended RDF + Azatobacter + PSB.

3.2 Forage Yield

Forage yield increased significantly with increase in FYM rate during both the years of experimentation (Table 1, Fig. 1), however highest forage yield of 360.26 q ha^{-1} and 361.83 q ha^{-1} during 1st and 2nd year of investigation respectively was found from the treatment applied with 30 t/ha of FYM followed by 20t/ha of FYM with 353.48 q ha^{-1} and 353.88 q ha^{-1} during 1st and 2nd year of study respectively. Research findings of Kumar and Puri [29] reported increased stover yield of maize with the application of FYM. Bhat et al. [30] also reported significant increase in stover yield of maize with the application of FYM up to 30 t ha^{-1}.

It was also found from the present investigation that application of biofertilizers increased the forage yield significantly and highest forage yield of 355.61 q ha^{-1} and 356.94 q ha^{-1} during 1st and 2nd year of study respectively was realised when the crop was given Azotobacter and PSB, which was followed by the treatment applied with Azospirillium and PSB. This might be due to the application of biofertilizers along with recommended dose of fertilizers. Jadav et al. [31] also reported the similar results (Table 1, Fig. 1).

3.3 Quality Parameters

3.3.1 Crude protein

Effect of different rates of FYM on crude protein content was found to be significant in both years of study (Table 2). Among the different FYM treatments, FYM 30 t ha^{-1} recorded significantly higher protein content during both the years whereas lowest proteincontent was recorded with the treatment FYM 10 t ha^{-1} during both the years. This might be due to the increased availability of nitrogen to the plant which resulted in increased protein content of the plant. The findings are well supported by the findings of Singh and Nepalia [32]. Data presented in Table 2 indicated that application of different biofertilizers had a significant effect on protein content of the crop. Among the various treatments significantly highest protein content was recorded with the treatment B4 (combination of Azotobacter + PSB) whereas the lowest protein content was recorded with the application of treatment B3 (PSB). Higher protein content with B4 treatment might be due to increased availability of nitrogen and its uptake. Increased N content could also be attributed to fixation of nitrogen through biological nitrogen fixation by Azotobacter culture. The finding are supported by the findings of Kalibhavi et al. [33].

3.3.2 Crude fiber

The effect of different levels of FYM on crude fibre content was non significant in both years of investigation, however FYM 30 t ha^{-1} recorded statistically higher values of crude fibre content whereas FYM 10 t ha^{-1} recoded statistically lowest values of crude fibre content. The findings are in close conformity with the findings of Sharma et al. (2016). From the present 2 years investigation it was found that crude protein content was significantly affected by biofertilizers application (Table 2). Among the various treatments, combination of

Table 1. Plant height, stem girth, number of leaves of fodder maize (*Zea mays* L.) Cv. African Tall as influenced by different levels biofertilizers and FYM

Treatments	Plant Height (cm)		Stem girth (cm)		No.of leaves (Nos.)		Forage yield (q/ha)	
	1st year	2nd year	1st year	2st year	1st year	2nd year	1st year	2nd year
F1= FYM@ 10t/ha	321.79	324.92	5.58	6.00	9.11	9.33	338.66	339.11
F2 = FYM @20t/ha	336.54	337.76	6.25	6.86	10.19	10.06	353.48	353.88
F3= FYM @30t/ha	350.56	351.88	7.19	7.65	11.36	11.41	360.26	361.83
Cd	**2.429**	**0.481**	**0.153**	**0.175**	**0.223**	**0.332**	**0.775**	**1.480**
B1= (Azotobacter)	336.56	337.47	5.76	6.06	10.21	9.61	351.11	351.50
B2=(Azospirillium)	334.73	334.78	6.41	7.17	9.80	10.36	348.31	349.27
B3=(PSB)	330.37	333.32	6.31	6.91	9.69	10.07	345.96	347.35
B4=(B1+PSB)	342.74	343.74	6.76	7.24	10.94	10.58	355.61	356.94
B5=(B2+PSB)	337.90	341.73	6.46	6.86	10.47	10.72	353.02	352.88
Cd	**2.209**	**0.782**	**0.322**	**0.230**	**0.227**	**0.219**	**0.663**	**1.176**

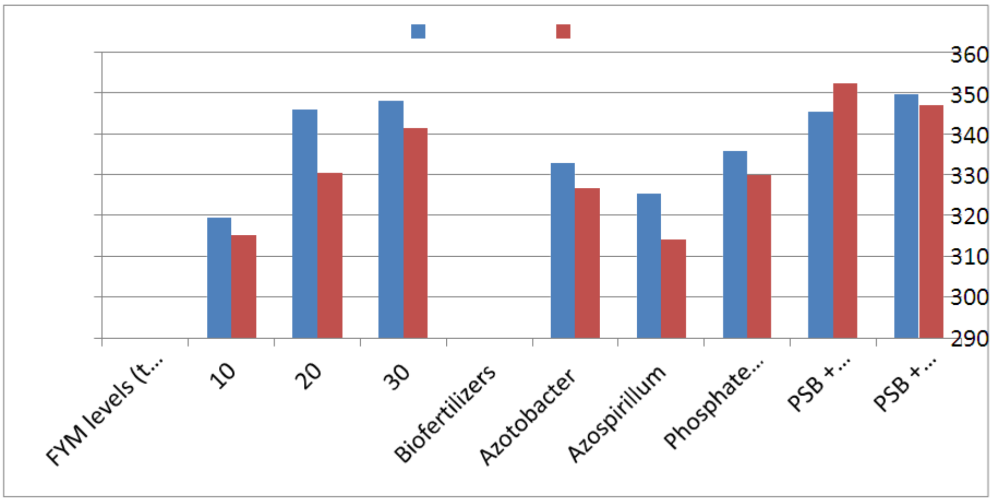

Fig. 1. Effect of biofertilizers and FYM on forage yield of fodder maize (*Zea mays* L.) Cv. African Tall

Table 2. Crude protein and crude fibre of fodder maize (*Zea mays* L.) Cv. African Tall as influenced by different levels Biofertilizers and FYM

Treatments	Crude protein		Crude fiber	
	1st year	2nd year	1st year	2nd year
F1= Fym @ 10t/ha	6.23	6.50	19.62	20.07
F2 = FYM @20t/ha	7.84	7.05	20.27	21.77
F3= FYM @30t/ha	8.60	8.96	22.82	22.95
CD	**0.09**	**0.20**	**N.S**	**N.S**
B1= (Azotobacter)	7.76	7.78	22.10	22.10
B2=(Azospirillium)	7.06	7.18	18.83	21.40
B3=(PSB)	7.04	6.85	20.17	21.03
B4=(B1+PSB)	8.34	8.07	22.64	22.46
B5=(B2+PSB)	7.57	7.66	20.77	21.88
CD	**0.14**	**0.13**	**2.65**	**1.14**

Azotobacter and PSB recorded significantly higher fibre content compared to other treatments. Fiber content is an important constituent for human food and animal feed. It is generally affected by environmental conditions, varietal characteristics and fertilizer treatments [34]. These findings are in close conformity of Fadlalla et al. [35].

4. CONCLUSION

Based on the results of the investigation, it can be concluded that to obtain maximum biomass of African tall with high quality traits under cold arid conditions, the crop needs to be supplied with 30 tonnes of FYM along with azotobactor, PSB in combination with recommended dose of NPK.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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