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Effect of different levels of nitrogen and potassium on fodder maize (*Zea mays* L.) productivity under irrigated condition in coastal Karnataka during late *rabi* season

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Abstract
A field experiment entitled "Effect of different levels of Nitrogen and Potassium on Fodder maize (*Zea mays* L.) productivity under Irrigated Condition in Coastal Karnataka during late *rabi* Season" was conducted during late *rabi* 2023 at Zonal Agricultural and Horticultural Research Station (ZAHRS) Brahmavara, Udupi. The results of the experiment showed that, among different nitrogen levels, application of 150 per cent recorded significant higher plant height (316.07 cm), number of leaves (15.94 plant^{-1}), leaf area (4636.98 cm^2), dry matter accumulation (131.29 g plant^{-1}), stem girth (8.53 cm), green fodder yield (438.03 q ha^{-1}) net returns (45,457 ₹ ha^{-1}) and B: C ratio (2.07). However, it was on par with 125 per cent of nitrogen application. Among different potassium levels, the application of 150 per cent of potassium has recorded the higher plant height (295.26 cm), number of leaves (15.30 plant^{-1}), leaf area (4645.87 cm^2), dry matter accumulation (123.12 g plant^{-1}), stem girth (8.28 cm), green fodder yield (420.74 q ha^{-1}), net returns (42,103) and B: C ratio (2.00) over 125 per cent and 100 per cent potassium application.

Keywords: Fodder maize, nitrogen, potassium, green fodder yield

1. Introduction

Maize supplies large amounts of energy rich forage for dairy animal diets, free from anti-nutritional factors, and therefore can be fed to cattle at any growth stage (Dahmardeh *et al.*, 2009) [6]. Maize is a very convenient crop for forage production due to the high production of green fodder per unit area (12-25 total dry matter t ha^{-1}), high energy content of dry matter and the quality of biomass for silage (Mandic *et al.*, 2013) [13]. Compared to other cereal forages, maize is characterized by a high amount of non-structural carbohydrates which makes it the most popular in making silage. Since sugars and water-soluble carbohydrates are more important for silage preservation makes any external carbohydrate sources such as molasses and jaggery for silage making need is less (Daiz., 2018) [7]. Maize is highly nutritive, excellent and sustainable fodder for livestock (Iqbal *et al.*, 2006) [9]. The green fodder of maize possesses lactogenic properties and therefore, is suits for milch cattle (Valk., 2000) [20].

Fodder maize (*Zea mays* L.) is a miracle crop grown for food as well as fodder having greater utility in agriculture and allied sectors. The crop has an edge over other fodder crops due to its higher production potential of green herbage, which is succulent, sweet, palatable, nutritious with a lactogenic effect, and highly relished by the milch cattle at any stage of the crop growth.

Fertilizer application is one of the principal factors that directly influence fodder yield and quality. An adequate supply of nutrients at each growth stage is highly essential for improved yield and quality of fodder maize. Nitrogen is the most important essential element for plants and is required in a large amount. It is the basic constituent of chlorophyll, protoplasm, amino acids, and nucleic acids. It enhances the growth and development of all living tissues and helps in improving the quality of fodder and the protein content of grains. It is the most important yield-limiting factor in agricultural systems (Subedi and Ma, 2009) [19]. It is mainly supplied through mineral fertilizers, farm manure, symbiotic N_2 fixation and atmospheric wet and dry deposition. It is very essential for plant growth and makes up 1 to 4 per cent of the dry matter of the plants. It also mediates the utilization of phosphorus, potassium and other nutrients in plants.

Potassium plays an important role in improving the quality of crops. The potassium requirement of maize is high as it absorbs potassium in larger quantities than any other elements, except nitrogen. Potassium promotes the translocation of photosynthetic assimilates from leaves to grain through the phloem and the rate at which grain fills and the period for which it fills can be increased by K fertilization. The application of potash increases vigor and disease resistance in plants, helps in protein production of plants, induces plum development of grain, improves the quality of plants and helps in root development. Continuous application of potassium improves soil properties and the use of high rates of nitrogen along with the application of potassium has become very necessary due to intensive agriculture. Efficient utilization of applied nitrogen can be achieved only when it is applied with a balanced proportion of phosphorus and potassium (Braun and Roy, 1985) [4].

2. Materials and Methods

The experiment was conducted at Zonal Agricultural and Horticultural Research Station (ZAHRS) Brahmavara, Udupi, Karnataka during late *rabi* 2023. The experimental site is situated at 12º 54′ N latitude and 74º 54′ E longitude at an altitude of 10 m above mean sea level. It falls under Karnataka's Agro - Climatic Zone-X (Coastal Zone) The investigation site had sandy loam in texture, pH (5.34) and non-saline (EC: 0.048 dSm^{-1}), organic carbon (1.18%), available nitrogen (315.03 kg ha^{-1}), available phosphorus (59.23 kg ha^{-1}) and available potassium (140.37 kg K_2O ha^{-1}). The experiment was laid out in Randomized complete block design (factorial concept) with nine treatment combinations consist of three different levels of nitrogen *viz*., N_1 (100% RDF *i.e*., 90 kg N ha^{-1}), N_2 (125% RDF *i.e*., 112.5 kg N ha^{-1}), N_3 (150% RDF *i.e*., 135 kg N ha^{-1}) with three different levels of potassium fertilizer *viz*., K_1 (100% RDF *i.e*., 30 kg K_2O ha^{-1}), K_2 (125% RDF *i.e*., 37.5 kg K_2O ha^{-1}), and K_3 (150% RDF *i.e*., 45 kg K_2O ha^{-1}) which is replicated three times. Necessary plant protection measures were taken as per the requirement. Periodical observations were recorded. The data so obtained were subjected to statistical analysis as per the standard procedures given by Gomez and Gomez (1984).

3. Results and Discussion
3.1 Growth parameters
Effect of Nitrogen
3.1.1 Plant height (cm)

Maximum plant height (316.07 cm) was obtained when highest N dose (135 kg ha^{-1}) was applied followed by 112.5 kg ha^{-1} (285.65 cm). However, plant height was minimum (256.45 cm) when (90 kg ha^{-1}) N dose was applied as presented in Table (1). As nitrogen levels increased and plants aged, their height grew at various growth stages. This observation underscores that higher nitrogen application enhances plant physiological processes, such as cell division and elongation, as well as supports timely metabolic activities and better photosynthate assimilation. These findings align with Kumar *et al.* (2008) [11]. The increase in plant height with higher nitrogen doses suggests that plants utilize nitrogen during active cell division to produce the building blocks (proteins) necessary for cell elongation, as noted by Iqbal *et al*. (2006) [9].

3.1.2 Number of Leaves Plant^{-1}

Number of leaves under the effect of nitrogen levels showed significant results. The maximum number of leaves were produced by 135 kg N ha^{-1} (15.94) followed by 112.5 kg N ha^{-1} (15.01). The minimum number of leaves is observed in plants receiving 90 kg N ha^{-1} (12.86) The rise in leaf number and leaf weight with adequate nitrogen can be explained by improved nutrient absorption due to better root development and enhanced carbohydrate movement from source to growing points in well-fertilized plants. Nitrogen fertilizer primarily enhances the number of green leaves and their expansion rate, which increases the canopy's ability to capture solar radiation, due to better root development and more efficient carbohydrate transport from source to sink (Singh and Agarwal, 2001). [18]

3.1.3 Leaf Area

The leaf area per plant resulted by the application of nitrogen were presented in (Table 1). It shows that the maximum leaf area was 4636.98 cm^{-2} which received maximum nitrogen rate (135 kg ha^{-1}) followed by 4509.79 cm^{-2} which received (112.5 kg ha^{-1}). The minimum leaf area was 4290.11 cm^{-2} which received (90 kg ha^{-1}) minimum nitrogen. The greater leaf area at higher nitrogen levels is likely due to enhanced leaf expansion rates, driven by more rapid cell division and expansion, as well as increased photosynthate production, which led to greater leaf length and width. This larger leaf area per plant of forage sorghum may also be attributed to providing the optimal amount of nitrogen to plants grown in soil with initially low nitrogen content. These findings align with the results of Mayub *et al*. (2002) [14], Nadeem *et al*. (2009) [15], and Khan *et al.* (2014) [10].

3.1.4 Dry matter accumulation

Mean data of different treatments indicated that maximum dry matter accumulation (131.29 g $plant^{-1}$) was noted in plants received 135 kg N ha^{-1} followed by 112.5 kg N ha^{-1} (121.18 g $plant^{-1}$). However, minimum dry matter (106.31 g $plant^{-1}$) was recorded in plants received 90 kg N ha^{-1} as illustrated in Table (1). The higher nitrogen application likely promoted more vigorous plant growth, leading to greater dry matter partitioning. Cerny *et al.* (2012) [5] noted a linear increase in dry matter yield for fodder maize with increased nitrogen.

3.1.5 Stem diameter

Maximum Stem diameter (8.53 cm) was obtained when highest N dose (135 kg ha^{-1}) was applied followed by 112.5 kg ha^{-1} (7.92 cm) However, minimum stem diameter (7.23 cm) was recorded in plants received 90 kg N ha^{-1}(Table 1). The higher nitrogen concentration likely stimulated cell division, leading to a consistent increase in stem diameter (Mahdi *et al*., 2011) [12].

Table 1: Growth parameters as influenced by different levels of nitrogen and potassium on fodder maize

Treatment	Plant height (cm)	Number of leaves	Leaf area (cm^2)	Dry matter accumulation (g $plant^{-1}$)	Stem girth (cm)
Nitrogen Levels (N)					
N_1	256.45	12.86	4,290.11	106.31	7.23
N_2	285.65	15.01	4,509.79	121.18	7.92
N_3	316.07	15.94	4,636.98	131.29	8.53
S.Em (±)	15.45	0.38	79.98	2.03	0.21
C.D (P = 0.05)	46.31	1.13	239.79	6.08	0.64
Potassium Levels (K)					
K_1	277.49	13.86	4,346.59	115.45	7.46
K_2	285.43	14.65	4,432.42	120.21	7.94
K_3	295.26	15.30	4,645.87	123.12	8.28
S.Em (±)	15.45	0.38	79.98	2.03	0.21
C.D (P = 0.05)	NS	1.13	239.79	6.08	0.64
Interactions (N X K)					
C.D at 5%	NS	NS	NS	NS	NS

Effect of potassium

The plant height at varying levels of potassium showed non-significant results. However, numerically taller plants were recorded in application 45 kg ha^{-1} (295.26 cm) at all the growth stages of the plant as compared 37.5 kg ha^{-1} potassium application. While shorter plants were recorded in application of 30 kg ha^{-1} (277.49 cm).

The growth parameters of fodder maize, including the number of leaves, leaf area, and dry matter accumulation, varied with different potassium levels, as shown in Tables 1. The application of 45 kg ha^{-1} (K_3) resulted in a significantly higher number of leaves (15.30), leaf area (4645.87 cm²), stem girth (8.28 cm) and maximum dry matter accumulation (123.12 g per plant). The application of 37.5 kg ha^{-1} (K_2) yield results that were statistically similar to those of the highest treatment. Potassium promotes cell formation, enhances plant growth, accelerates leaf development, increases solar energy capture, and improves nitrogen utilization, leading to better growth attributes. These findings align with the results reported by Alias *et al*. (2003) [2] and Naomi *et al*. (2021) [16].

3.2 Yield parameters

Effect of Nitrogen

3.2.1 Green fodder yield

Plants received the 135 kg N ha^{-1} produced maximum green fodder yield (438.03 t ha^{-1}) followed 112.5 kg N ha^{-1} (404.60 t ha^{-1}). However, minimum green fodder yield (355.08 t ha^{-1}) was recorded in 90 kg N ha^{-1} (Table 2). The increased green fodder yield with 150 percent nitrogen is attributed to improved growth and yield attributes, including plant height, leaf area, leaf number per plant, and dry matter production. Nitrogen, being a key component of plant tissues, enhances cell division and elongation, which positively affects growth and, consequently, yield. These findings align with those of Panwar *et al*. (2020) [17].

Effect of potassium

Significantly higher green fodder yield was recorded with the application of 45 kg ha^{-1} (420.74 q ha^{-1}) followed by K_2 *i.e.*, the application of 37.5 kg ha^{-1} (401.90 q ha^{-1}). The lowest green fodder yield was noticed in K_1 treatment *i.e.*, application of 30 kg ha^{-1} (375.07 q ha^{-1}). These findings align with Kajal *et al*. (2001), who noted that higher potassium applications likely promoted greater nutrient mobilization in the soil and plants, enhanced enzymatic activities, and improved the translocation of photosynthesis within the plant, resulting in increased green and dry matter yields. The results also support the findings of Amrutsagar and Sonar (1999) [3] and Ebrahimi *et al*. (2011) [8] for sorghum and maize crops, respectively.

3.3 Economics

The obtained data from the experiment is presented in Table 2. The results showed that, among nitrogen levels, higher gross returns (₹ 87,606 ha^{-1}), net returns (₹ 45,457 ha^{-1}) and B: C ratio (2.07) were recorded in application of 135 kg N ha^{-1} and it was on par with 112.5 kg N ha^{-1} (₹ 80,919 ha^{-1}, ₹ 39,042 ha^{-1} and 1.93, respectively). However, significantly lower gross, net returns were noticed in 90 kg N ha^{-1} (₹ 71,016 ha^{-1}, ₹ 29,391 ha^{-1} and 1.70, respectively). Among the potassium levels, the application of 45 kg ha^{-1} resulted in the significantly higher gross returns of ₹ 84,147 ha^{-1}, net returns of ₹ 42,103 ha^{-1} and B: C ratio of 2.00 and it was on par with 37.5 kg ha^{-1} (₹ 80,380 ha^{-1}, ₹ 38,503 ha^{-1} and 1.91, respectively). However, 30 kg ha^{-1} recorded lowest gross returns of ₹ 75,014 ha^{-1}, net returns of ₹ 33,285 ha^{-1} and B: C ratio of 1.79. This increased economic returns, was due to improvement in green fodder yield of fodder maize. The results are in conformity with that of Vyas *et al*. (2015) [21] and Akram *et al*. (2007) [1].

Table 2: Yield and economics as influenced by different levels of nitrogen and potassium on fodder maize

Treatment	Green fodder yield (q ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Nitrogen Levels (N)					
N_1	355.08	41,614	71,016	29,391	1.70
N_2	404.60	41,877	80,919	39,042	1.93
N_3	438.03	42,149	87,606	45,457	2.07
S.Em (±)	12.01	-	2,393	2,257	0.03
C.D (P = 0.05)	36.01	-	7,176	6,767	0.08
Potassium Levels (K)					
K_1	375.07	41,719	75,014	33,285	1.79
K_2	401.90	41,876	80,380	38,503	1.91
K_3	420.74	42,044	84,147	42,103	2.00
S.Em (±)	12.01	-	2,393	2,257	0.03
C.D (P = 0.05)	36.01	-	7,176	6,767	0.08
Interactions (N X K)					
C.D at 5%	NS	NS	NS	NS	NS

4. Conclusion

The study has been revealed that application of nitrogen level at 150 per cent *i.e.,*135 kg ha^{-1} and Potassium level at 150 per cent *i.e.,* 45kg ha^{-1}, resulted in obtaining higher productivity of green fodder maize compared to recommended dose of fertilizer in the coastal regions.

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