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Influence of foliar application of cow urine and NAA on growth parameters (AGR, CGR, RGR, NAR) of *Kharif* sweet corn (*Zea mays* L. var. Saccharata)

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Abstract

An on-site investigation carried out at the Cotton Research Station, Junagadh Agricultural University, Junagadh during the *kharif* season in 2021 intended to explore the influence of foliar application of cow urine and NAA on various parameters related to the morpho-physiological, biochemical, and yield aspects of *kharif* sweet corn. The study employed a randomized block design with a factorial concept, incorporating different concentrations of cow urine (control, 2%, 4%, and 6%) and NAA (control, 15 ppm, and 30 ppm), and three replications. The research focused on assessing growth parameters such as AGR, CGR, RGR, and NAR factors. The findings indicated that the treatment involving 4% cow urine and 15 ppm NAA exhibited the highest mean values for growth characters AGR, CGR, RGR, and NAR. The positive effects observed are attributed to the additional nutrients supplied through the foliar application of cow urine, potentially enhancing chlorophyll synthesis in the sweet corn crop.

Keywords: Cow urine, growth, NAA, sweet corn, AGR, CGR, RGR, and NAR

Introduction

Within the category of cereals, maize (*Zea mays* L.) holds significance as a crucial crop for both food and animal feed. Globally, it stands as the third most essential crop, following wheat and rice. Maize is renowned for its adaptability, thriving in diverse climatic conditions. It plays a predominant role in the agricultural and economic landscapes of the Asian region. Most experts agree that the primary region where maize originated is Central America and Mexico. Sweet corn (*Zea mays* L. *var. Saccharata*) is a monocotyledonous crop classified within the Poaceae family. It originates from the United States and falls under the Zea genus. This variety of maize is genetically closely linked, characterized by its elevated sugar content. As per USDA national nutrient data base, Sweet corn possesses significant nutritional value, as indicated by research. In every 100 grams of sweet corn, there are sources of energy like 18.70 g carbohydrates, 3.27 g protein, 1.35 g total fat, 2.00 g dietary fiber and vitamins like 6.80 mg vitamin C, 0.200 mg Thiamine (B_1), 1.700 mg Niacin (B_3) and also contain iron and magnesium minerals 0.52 mg and 37 mg respectively. (Anon., 2018) [1].

Sweet corn holds a significant position in India, serving various purposes such as food (25%), animal feed (12%), poultry feed (49%) and contributing to industrial products, particularly starch (12%). Additionally, it plays a minor role in brewery and seed production (2%), as reported by Das *et al.* (2008) [5].

In ancient Ayurveda, significant emphasis is placed on the pharmacological importance of cow urine. Cow urine exhibits potent germicidal, antibiotic, and antimicrobial properties, thereby possessing the capability to eliminate a wide range of germs. Additionally, it has the potential to enhance immunity, as reported by Chauhan *et al*. in 2001 [4]. NAA, or 1-naphthaleneacetic acid, belongs to the auxin family and is a synthetic plant hormone. It serves as a key component in various commercial horticultural products designed for plant rooting. This substance acts as a rooting agent and is utilized in the vegetative propagation of plants through stem and leaf cuttings. It is also used for plant tissue culture. NAA (Naphthalene acetic acid) promotes the elongation of cells, stimulates cell division in the cambium, encourages the differentiation of phloem and xylem, and is employed to induce flowering.

Its impact on cell elongation and division leads to various outcomes in plant growth and development. NAA is crucial in modifying plant growth behavior, ultimately enhancing the growth rates of both shoots and roots, resulting in increased yield, as highlighted by Patil and Patel in 2010 [10]. Its significant role extends to the development of roots and shoots, as well as the promotion of seed germination and the initiation of flower buds.

Materials and Methods

The study took place at the Cotton Research Station, Junagadh Agricultural University, Junagadh, during the *kharif* season of 2021. Junagadh is situated in the South Saurashtra Agro-climatic region of Gujarat state, at 21.50 N latitude and 70.50 E longitudes, with an altitude of 60 m above mean sea level. The rainy season typically starts in the second fortnight of June and concludes by mid-September, characterized by an average rainfall of 1094 mm (averaged over the last 10 years). Periodic partial monsoon failures every three or four years are common in this area. The field experiment employed a Factorial Randomized Block Design with three replications. Twelve treatments were randomly allotted to the plots as per the lay out plan incorporating different concentrations of cow urine (control, 2%, 4%, and 6%) and NAA (15 ppm, and 30 ppm). sweet-16 variety of sweet corn is used here. The dimension of experimental area was 38.25 X 19.00 m^2 with each sub plot dimension. While gross and net plot sizes were 5.0 × 2.7 m^2 and 4.6 × 1.8 m^2 respectively. Cow urine and growth regulator NAA was sprayed as per the treatment schedule at 30 and 50 days after sowing. In order to evaluate the effect of treatments on growth parameters, biochemical parameters, yield attributes, yield and other aspects of sweet corn, observation were recorded during 40 DAS, 60 DAS and 80 DAS and at harvest. AGR, RGR, CGR, NAR observations were recorded by destructive method.

Pre-harvest assessments involve the examination of tagged plants, with three selected from each plot. Data on plant height, branch count, total leaf count, and leaves in the main shoot are recorded at 20-day intervals. For leaf area data, sample plants are gathered, and measurements include leaf area, dry weight of shoot and root, leaf count, number and weight of nodules, as well as various growth parameters such as Absolute Growth Rate (AGR), Crop Growth Rate (CGR), Relative Growth Rate (RGR), and Net Assimilation Rate (NAR). The significance of differences between treatments for all these characteristics is assessed through analysis of variance, following the methodology proposed by Panse and Sukhatme in 1954 [9].

Crop growth parameters

Various indicators of crop development include Absolute Growth Rate (AGR), Crop Growth Rate (CGR), Relative Growth Rate (RGR), and Net Assimilation Rate (NAR).

Absolute growth rate (AGR)

It represents the production of dry matter per unit of time (g day^{-1}) and is computed using the formula provided by Radford (1967) [11], expressed as g day-1.

$$AGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

W_1 and W_2 denote the dry matter at the earlier and later stages, while t_1 and t_2 indicate the respective time periods when the measurements of W_1 and W_2 were taken.

Crop growth rate (CGR)

The Crop Growth Rate (CGR) was determined by applying the formula provided by Watson (1952) [12] to the overall dry matter of the plant, and it is expressed in units of g m^{-2} day^{-1}.

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

In this context, W_1 and W_2 denote the dry matter at earlier and later stages, while t_1 and t_2 indicate the respective time periods when W_1 and W_2 were measured. GA refers to the ground area.

Relative growth rate (RGR)

It signifies the rate at which the existing dry weight increases per unit of dry weight and is quantified as g $g^{-1}day^{-1}$, as described by Blackman in 1919.

$$RGR = \frac{(\log W_2 - \log W_1)}{(t_2 - t_1)}$$

In this context, W_1 and W_2 represent the dry weight (in grams) recorded at times t_1 and t_2, respectively, and "log" refers to the natural logarithm.

Net assimilation rate (NAR)

The net assimilation rate refers to the growth in plant dry weight per unit leaf area over a specific time period. It was computed using the formula recommended by Watson (1952) [12] and is presented in units of mg cm^{-2} day^{-1}.

$$NAR = \frac{W_2 - W_1}{(t_2 - t_1)} \text{ X } \frac{\text{Log } A_2 - \text{Log } A_1}{(A_2 - A_1)}$$

In this context, A_1 and A_2 represent the total leaf area at times t_1 and t_2, while W_1 and W_2 denote the total dry weight at times t_1 and t_2, respectively.

Result and Discussion

Absolute growth rate (g day^{-1})

Growth analysis serves as a metric for assessing a plant's seed yield. The physiological foundation for variations in yield can be gauged by examining disparities in growth parameters and their influence on yield. Different concentrations of cow urine exhibited notable effects, particularly in terms of absolute growth rate at various stages.

At 40-60 DAS, 60-80 DAS and 80 DAS-at harvest, maximum absolute growth rate (2.015 g day^{-1}, 4.149 g $day^{-1}$and 1.058 g day^{-1}, respectively) was observed with application of 4% cow urine. At 40-60 DAS, absolute growth rate was at par with 6% cow urine (1.891 g day^{-1}). During 40-60 DAS, 60-80 DAS and 80 DAS-at harvest were found significantly maximum absolute growth rate (1.958, 4.106 and 0.961, respectively) with application of 15 ppm NAA. Interaction between various concentration of cow urine and NAA in the current investigation was resulted non-significant. Jadhav (2011) [7] observed that combined application of 4% cow urine with 10 ppm NAA on maize was found most effective increased AGR over control.

Crop growth rate (g m^{-2} day^{-1})

Data pertaining to crop growth rate is found significant at all stages except 40 DAS. Significantly maximum crop growth rate (0.1492 g m^{-2} day^{-1}, 0.3274 g m^{-2} day^{-1} and 0.0754 g m^{-2} day^{-1}) was recorded at 40-60 DAS, 60-80 DAS and 80 DAS-at harvest, respectively with application of 4% cow urine. At 40-60 DAS it was at par with 6% cow urine (0.1400 g m^{-2} day^{-1}).

Significantly maximum crop growth rate was observed (0.1450 g m^{-2} day^{-1}, 0.3042 g m^{-2} day^{-1} and 0.0712 g m^{-2} day^{-1}) with application of 15 ppm NAA at 40-60 DAS, 60-80 DAS and 80 DAS-at harvest, respectively. At 40-60 DAS it was at par with 30 ppm NAA (0.1351 g m^{-2} day^{-1}). Interaction between various concentration of cow urine and NAA in the current investigation was resulted non-significant.

Relative growth rate (g g^{-1} day^{-1})

The peak rate of Relative Growth Rate (RGR) signifies the capacity to generate the maximum dry matter for growth. The increase in RGR may be linked to the extensive expansion of leaf area and the growth of stems and roots. Significant data regarding relative growth rate was observed at all recorded stages. Relative growth rate varied significantly and found maximum (0.0744 g g^{-1} day^{-1}) at 40-60 DAS, with application of 4% cow urine, which was at par with 6% cow urine (0.0725 g g^{-1} day^{-1}).

60-80 DAS, Relative growth rate varied significantly and found maximum with application of 4% cow urine (0.0495 g g^{-1} day^{-1}) which was at par with 6% cow urine (0.0470 g g^{-1} day^{-1}). At harvest, Relative growth rate varied significantly and found maximum with application of 4% cow urine (0.0065 g g^{-1} day^{-1}).

With application of 15 ppm NAA, data recorded at 40-60 DAS, 60-80 DAS and 80 DAS-at harvest, significantly maximum (0.0740 g g^{-1} day^{-1}, 0.0477 g g^{-1} day^{-1} and 0.0062 g g^{-1} day^{-1}) and at 60 DAS it was at par with 30 ppm NAA (0.0702g g^{-1} day^{-1}) relative growth rate was observed.

The interaction between different concentrations of cow urine and NAA in the current study did not yield significant results. In a previous experiment, Korade *et al.* (2019) [8] investigated the impact of two foliar sprays with 25 ppm and 50 ppm NAA, as well as 4%, 6%, 8%, and 10% cow urine, both independently and in combination, on wheat crops. The data revealed that the treatment involving 10% cow urine with 25 ppm NAA significantly enhanced various parameters, including plant height, number of tillers, row length, leaf area, dry weight, RGR, NAR, seed yield per hectare, and harvest index. Additionally, Basole (2003) [2] concluded from their study that the foliar application of $FeSO_4$, KNO_3, and $ZnSO_4$ in combination with NAA resulted in significantly higher RGR and NAR in soybean.

Net assimilation rate (mg cm^{-2} day^{-1})

This is a metric representing the net photosynthesis of plants, computed in relation to the overall leaf area. Data pertaining to net assimilation rate was found significant and it was maximum (0.0560 mg cm^{-2} day^{-1}, 0.0636 mg cm^{-2} day^{-1} and 0.0119 mg cm^{-2} day^{-1}) was recorded at 40-60 DAS, 60-80 DAS and 80 DAS-at harvest, respectively with application of 4% cow urine and it was at par with 6% cow urine and 2% cow urine 0.0544 mg cm^{-2} day^{-1} and 0.0555 mg cm^{-2} day^{-1}, respectively).

80 DAS, with application of 4% cow urine significantly maximum net assimilation rate (0.0636 mg cm^{-2} day^{-1}) which was at par with 6% cow urine (0.0619 mg cm^{-2} day^{-1}) and at harvest, with application of 4% cow urine significantly maximum net assimilation rate (0.0119 mg cm^{-2} day^{-1}).

Significantly maximum net assimilation rate was observed (0.0558 mg cm^{-2} day^{-1}, 0.0631 mg cm^{-2} day^{-1} and 0.0117 mg cm^{-2} day^{-1}) with application of 15 ppm NAA at 40-60 DAS, 60-80 DAS and 80 DAS-at harvest, respectively. Data observed at 40 DAS was found non-significant, and at 60 DAS it was at par with 30 ppm NAA (0.0557 mg cm^{-2} day^{-1}). Interaction between various concentration of cow urine and NAA in the current investigation was resulted non-significant.

Deotale *et al*. (2008) [6] reported comparable results. They tried foliar sprays of 4, 6, 8 and 10% cow urine and 50 ppm NAA on groundnut and found that foliar sprays of 4% cow urine + 50 ppm NAA increased NAR and RGR significantly.

Table 1: Effect of cow urine and NAA on Absolute growth rate (g day^{-1})

	Absolute growth rate (g day^{-1})			Crop growth rate (g m^{-2} day^{-1})		
Treatments	**40-60 DAS**	**60-80 DAS**	**80 DAS- At harvest**	**40-60 DAS**	**60-80 DAS**	**80 DAS- At harvest**
C_0 (Control)	1.309	2.132	0.374	0.0970	0.1580	0.0277
C_1 (2% cow urine)	1.710	2.803	0.568	0.1267	0.2076	0.0421
C_2 (4% cow urine)	2.015	4.419	1.058	0.1492	0.3274	0.0784
C_3 (6% cow urine)	1.891	3.889	0.763	0.1400	0.2881	0.0565
'F' test	S	S	S	S	S	S
SE(m) ±	0.054	0.087	0.022	0.0040	0.0065	0.0016
CD at 5%	0.158	0.256	0.065	0.0117	0.0189	0.0048
N_0 (Control)	1.412	2.484	0.464	0.1046	0.1840	0.0344
N_1 (15 ppm NAA)	1.958	4.106	0.961	0.1450	0.3042	0.0712
N_2 (30 ppm NAA)	1.824	3.342	0.647	0.1351	0.2476	0.0479
'F' test	S	S	S	S	S	S
SE(m) ±	0.047	0.076	0.019	0.0035	0.0056	0.0014
CD at 5%	0.137	0.221	0.056	0.0102	0.0164	0.0042
Interaction						
'F' test	NS	NS	NS	NS	NS	NS
SE(m) ±	0.094	0.151	0.038	0.0069	0.0112	0.0028
CD at 5%	-	-	-	-	-	-
CV%	9.36	7.90	9.64	9.36	7.90	9.64

Table 2: Effect of cow urine and NAA on Relative Growth Rate (g g^{-1} day^{-1}) and Net assimilation rate (mg cm^{-2} day^{-1})

	Relative growth rate (RGR) (g g^{-1} day^{-1})			Net assimilation rate (mg cm^{-2} day^{-1})		
Treatments	**40-60 DAS**	**60-80 DAS**	**80 DAS-At harvest**	**40-60 DAS**	**60-80 DAS**	**80 DAS-At harvest**
C_0 (Control)	0.0605	0.0374	0.0041	0.0486	0.0558	0.0090
C_1 (2% cow urine)	0.0688	0.0396	0.0049	0.0555	0.0587	0.0101
C_2 (4% cow urine)	0.0744	0.0495	0.0065	0.0560	0.0636	0.0119
C_3 (6% cow urine)	0.0725	0.0470	0.0053	0.0544	0.0619	0.0099
'F' test	S	S	S	S	S	S
SE(m) ±	0.0016	0.0008	0.0002	0.0019	0.0016	0.0004
CD at 5%	0.0047	0.0025	0.0006	0.0056	0.0048	0.0012
N_0 (Control)	0.0629	0.0396	0.0045	0.0493	0.0581	0.0096
N_1 (15 ppm NAA)	0.0740	0.0477	0.0062	0.0558	0.0631	0.0117
N_2 (30 ppm NAA)	0.0702	0.0429	0.0049	0.0557	0.0587	0.0094
'F' test	S	S	S	S	S	S
SE(m) ±	0.0014	0.0007	0.0002	0.0017	0.0014	0.0004
CD at 5%	0.0040	0.0021	0.0005	0.0049	0.0042	0.0011
Interaction						
'F' test	NS	NS	NS	NS	NS	NS
SE(m) ±	0.0028	0.0014	0.0003	0.0033	0.0029	0.0007
CD at 5%	-	-	-	-	-	-
CV%	6.93	5.78	11.42	10.70	8.25	12.35

Conclusion

The absolute growth rate exhibited values of 1.958 g day^{-1}, 4.106 g day^{-1}, and 0.961 g day^{-1}, while the relative growth rate recorded values of 0.0740 g g^{-1} day-1, 0.0477 g g^{-1} day^{-1}, and 0.0062 g g^{-1} day^{-1} at 60 DAS, 80 DAS, and at harvest, respectively, with the application of 15 ppm NAA. Similarly, the crop growth rate was observed at 0.1450 g m-2 day-1, 0.3042 g m^{-2} day^{-1}, and 0.0712 g m^{-2} day^{-1}, and the net assimilation rate recorded values of 0.0558 mg cm^{-2} day^{-1}, 0.0631 mg cm-2 day-1, and 0.0117 mg cm^{-2} day^{-1} at the same respective time points. Notably, the treatment with 4% cow urine and 15 ppm NAA, identified as the higher yielding treatment, significantly increased essential growth parameters, namely AGR, CGR, RGR, and NAR, in comparison to the control.

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