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## Effect of nutrient solution (NPK) on biochemical changes and yield of hydroponic maize fodder cultivar

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### Abstract

An experiment was conducted to study the effect of a nutrient solution (NPK 19:19:19) on the amylase activity and starch concentration in hydroponically grown maize cultivars (African tall, Ganga safed-2, Manjari composite and Panchganga). This study involved applying different levels of the NPK 19:19:19 solution spray and evaluation at 0-day, 7<sup>th</sup> day and 14<sup>th</sup> day of growth. It was observed that alpha-amylase activity (mg of maltose released/g of sample/min) for African tall, Ganga safed-2, Manjari composite and Panchganga was 1.13, 1.19, 0.93 and 1.07 mg/g/min, respectively, on day 0 (i.e., sprouted grains in hydroponically grown maize fodder). The amylase activity values were 2.40, 2.49, 2.17 and 2.31 mg/g/min on the 7<sup>th</sup> day and 1.95, 2.06, 1.80 and 1.90 mg/g/min on the 14<sup>th</sup> day, for African tall, Ganga safed-2, Manjari composite and Panchganga, respectively. It was concluded that the highest percentage of starch was recorded for African tall, Ganga safed-2, Manjari Composite and Panchganga at 0 day, with values of 64.60%, 60.38%, 54.70% and 65.69%, respectively. The starch content decreased on the 7<sup>th</sup> day to 49.29%, 43.28%, 32.19% and 50.56% and further declined on the 14<sup>th</sup> day to 46.59%, 48.37%, 41.15% and 30.46%, respectively, for the same cultivars. During the growth (germination) period, there was a decline in dry matter (DM) and starch content, while amylase activity increased, with the highest levels observed in Ganga safed-2 at 0 day (1.19 mg/g/min) and 7<sup>th</sup> day (2.49 mg/g/min), followed by a slight decrease at the 14<sup>th</sup> day (2.06 mg/g/min). Similarly, African tall showed the highest total sugar content of 8.66%, 10.21% and 11.24% at 0, 7<sup>th</sup> and 14<sup>th</sup> days, respectively. The nutrient solution significantly affected enzymatic activity and total sugar concentration. The application of 0.75% NPK to African tall was found to yield more fodder compared to other varieties.

**Keywords:** Hydroponics, amylase activity, starch concentration, nutrient solution, sprouted

### Introduction

The word *hydroponics* has been derived from two Greek words: 'hydro' means 'water' and 'ponic' means 'working'. Thus, fodder produced by growing plants in water or a nutrient solution, without using any soil, is known as hydroponic fodder, sprouted grains or sprouted fodder (Dung *et al.*, 2010) [5]. Hydroponic fodder is produced in greenhouses under controlled environment conditions within a short period. Hydroponic green fodder production is an option that helps solve the problem of feed scarcity by producing fodder during drought and scarcity periods, with acceptable yields and high nutritional value. Research shows that hydroponically sprouted grain provides significant nutritional benefits and is suitable for all livestock, including sheep and cattle, it supports improved animal growth and overall health.

Hydroponic green fodder plays an important role in the conservation of soil, water and time. It requires only about 3-5% of the water needed to produce the same amount of forage under field conditions (Al-Karaki, G. N. and M. Al-Hashimi, 2012) [1]. For producing one kilogram of maize fodder, approximately 1.50 to 3.00 liters of water is required. Hydroponic fodder production emerges as an eco-friendly cultivation method. It is economical for farmers as it significantly reduces costs related to electricity and chemical fertilizers. Hydroponics allows cultivators to target the root system more precisely and directly. The interference of soil-borne adulterants and contaminants is completely eliminated in a hydroponic cultivation system. The entire hydroponics setup is ideally suited for protected cultivation technology, making it adoptable by farmers who already use greenhouses (Dubey, 2012). Bjorck *et al.*, (1990) studied

the nutritional properties of starch and dietary fiber in barley genotypes containing different levels of amylose. They found that protein content ranged between 10 to 14%, starch content from 53 to 59% and dietary fiber from 20 to 23% (dry weight basis). The amylose content varied from 7.9% in waxy barley to 34.9% in high-amylose varieties.  $\alpha$ -amylase activity increased progressively in control seeds up to the 7<sup>th</sup> day of germination. The maximum  $\alpha$ -amylase activity, with nearly a 100-fold increase, was observed in 4.5 mg/g-treated seeds on the 3<sup>rd</sup> day of germination, followed by a gradual decline. A similar pattern of activity was observed with  $\beta$ -amylase.

## Materials and Methods

### Experimental Details

For this experiment, a hydroponic unit was constructed using wooden racks for placing the hydroponic trays. In this non-automated system, spraying was performed with a manually operated knapsack sprayer. Four different fodder maize varieties - African tall, Ganga safed-2, Manjari composite and Panchganga were selected to evaluate the growth performance of hydroponically grown fodder maize. Additionally, the 19:19:19 (NPK) fertilizer was used to study the effect of a nutrient solution on the yield of hydroponically grown maize fodder.

### The experiment was designed with two factors

- **Factor A:** Levels of NPK through 19:19:19
- **Factor B:** Maize fodder varieties

Four trays were used for each maize variety, making a total of 16 trays. In each set, the first tray received only water (control), while the remaining three trays were treated with foliar applications of NPK at concentrations of 0.25%, 0.50% and 0.75%, respectively. Observations were recorded daily throughout the experimental period. For determining nitrogen concentration, the standard micro-Kjeldahl method was followed.

### Seed Treatment before Planting

The seeds were thoroughly cleaned to remove debris and foreign materials. The clean seeds were then surface sterilized by soaking them in a 20% sodium hypochlorite solution (household bleach) for 30 minutes to prevent mould formation. After sterilization, the seeds were rinsed thoroughly with clean water to remove bleach residues and then soaked in tap water for 6-7 hours before planting.

### Seed Planting and Irrigation

Seeds were sown in plastic-lined planting trays with drainage holes at the bottom to allow excess water to escape. The seeding rate was approximately 1 kg per tray for each of the four maize varieties. The trays were sprayed with the nutrient solution (19:19:19) at different concentrations 0% (control), 0.25%, 0.50% and 0.75% as per the treatment plan.

### Watering of Maize Varieties

Clean water was provided to each tray during the experiment. Nutrient solution was applied using a manually operated knapsack sprayer according to the respective treatment levels.

### Treatment Details

#### Factor A: Levels of NPK through 19:19:19 (Water Soluble)

- **T<sub>0</sub>** = Hydroponic growth using only water (Control)
- **T<sub>1</sub>** = Foliar application of NPK (19:19:19) @ 0.25%

- **T<sub>2</sub>** = Foliar application of NPK (19:19:19) @ 0.50%
- **T<sub>3</sub>** = Foliar application of NPK (19:19:19) @ 0.75%

### Factor B: Maize Fodder Varieties

1. African tall
2. Ganga safed-2
3. Manjari composite
4. Panchganga

### Statistical Analysis

The data generated during the experiment were analyzed using a Factorial Completely Randomized Design (FCRD). There were 16 treatment combinations and 2 replications in the experiment.

## Results and Discussion

### Effect of nutrient solution spray (19:19:19) on periodical amylase activity in maize varieties grown hydroponically

According to Shipard (2005) <sup>[1]</sup>, sprouts are the most enzyme-rich food on the planet and the period of greatest enzyme activity in sprouts is generally between germination and 7 days of age (Chavan and Kadam, 1989) <sup>[3]</sup>. The potential health benefits of hydroponic fodder have been well known for a long time (Sneath and McIntosh, 2003) <sup>[13]</sup>. Dry grains contain abundant enzymes, which are mostly inactive due to the presence of enzyme inhibitors. During sprouting, the activity of these inactive enzymes in the grains increases due to the neutralization of the enzyme inhibitors and these enzymes ultimately break down the reserve chemical constituents, such as starch, protein and lipid, into various metabolites, viz. sugars, amino acids and free fatty acids. Furthermore, these are used to synthesize new compounds or are transported to other parts of the growing seedling, including the breakdown of nutritionally undesirable constituents (Chavan and Kadam, 1989) <sup>[3]</sup>. Higher amylase activity of 1.19, 2.49 and 2.06 mg of maltose released/g of sample/min were recorded in the Ganga safed-2 variety at 0, 7<sup>th</sup> and 14<sup>th</sup> days, respectively. It has been observed from Table 1 that the amylase activity in hydroponic maize was primarily low in sprouted seed, increased up to the 7<sup>th</sup> day and gradually decreased by the 14<sup>th</sup> day of the growth period. There was a significant effect of nutrient solution spray on amylase and starch concentrations at 7 and 14 days, except on the 0 day (Table 1 & 2). Higher starch contents of 65.69%, 50.56% and 49.08% were recorded in the Panchganga variety at 0, 7 and 14 days of the hydroponic study, respectively (Table 2).

There was a significant effect of nutrient solution spray at 7 and 14 days, except at 0 day. Spraying with 0.75% 19:19:19 solution recorded significantly higher amylase activity 2.42 and 1.97 mg of maltose released/g of sample/min at 7<sup>th</sup> and 14<sup>th</sup> day, respectively (Table 1) and a similar trend was observed for starch content. Spraying with 0.75% 19:19:19 resulted in significantly higher starch contents 44.59% and 42.15% at 7<sup>th</sup> and 14<sup>th</sup> day, respectively (Table 2). The interaction study between different maize varieties and various levels of nutrient solution spray showed significant effects on amylase activity at 7<sup>th</sup> and 14<sup>th</sup> day, except at 0 day. Higher amylase activity was observed in the Ganga safed-2 variety 2.58 and 2.10 mg of maltose released/g of sample/min with 0.75% spray at 7<sup>th</sup> and 14<sup>th</sup> day, respectively (Table 1). Similarly, the interaction effect was significant for starch content at 7<sup>th</sup> and 14<sup>th</sup> day, except at 0 day. Higher starch content was observed in Ganga safed-2 51.45% and 49.75% with 0.75% spray at 7<sup>th</sup> and 14<sup>th</sup> day, respectively (Table 2).

It was concluded that with 0.75% spray of nutrient solution, higher amylase activity was observed at 7<sup>th</sup> and 14<sup>th</sup> day under

hydroponic conditions. This trend in amylase activity was observed because starch is the only source of energy for germinating seeds. Amylases begin degrading starch in the seed embryo after 24 hours, reaching maximum activity at 96 hours. After 96 hours, as the seedling starts to emerge and starch concentration in the embryo decreases, amylase activity begins to decline (Prakash *et al.*, 2015) <sup>[9]</sup>.

Similar results were reported by Juliano and Varner (1969) <sup>[6]</sup>; they found a low level of amylase activity during the first 6 days, followed by a gradual reduction in activity up to day 15. They attributed the basal level of amylase activity to  $\beta$ -amylase present in the seed before germination and the peak in activity to the rapid appearance of  $\alpha$ -amylase. They also provided evidence for the activation of an additional  $\beta$ -amylase component during germination. Rapid degradation of starch in the cotyledons coincided with the production of  $\alpha$ -amylase. The highest starch percentage was recorded at 0 day (65.69%), i.e., in the sprouted seed, which decreased to 50.56% and 49.08% at 7<sup>th</sup> and 14<sup>th</sup> day, respectively, in the Panchganga variety. Similar trends were observed in the other three maize varieties. This decreasing trend occurred due to the correlation between starch decline and the presence of isoenzymes (Reddy *et al.*, 1984) <sup>[10]</sup>. Amylase activity was calculated by the colorimetric method and starch content was estimated by the calorimetric method using anthrone reagent.

#### **Effect of nutrient solution spray (19:19:19) on periodical starch concentration in maize varieties grown hydroponically**

Starch content in different maize varieties was significantly influenced by the nutrient solution spray during all the periods of the study. While the foliar application of different concentrations of nutrient solution showed non-significant effect on starch content at 0 day, it had a significant effect at the 7<sup>th</sup> and 14<sup>th</sup> days of the study. Significantly higher starch contents 65.69%, 50.56% and 49.08% were recorded in the Panchganga variety at 0, 7<sup>th</sup> and 14<sup>th</sup> day, respectively, under hydroponic conditions. Conversely, significantly lower starch contents 54.70%, 32.19% and 30.46% were observed in the Manjari composite variety at 0, 7<sup>th</sup> and 14<sup>th</sup> day, respectively. At 0 day, spraying with either water or nutrient solution concentrations of 0.25%, 0.50% or 0.75% (19:19:19) did not significantly affect starch content in any maize variety. However, spraying with 0.75% NPK (19:19:19) resulted in significantly higher starch contents of 44.59% and 42.15% at the 7<sup>th</sup> and 14<sup>th</sup> day, respectively. Though there was a non-significant effect of nutrient spray treatments at 0 day, significantly higher starch content 51.45% and 49.75% was recorded in Ganga safed-2 with 0.75% spray at 7<sup>th</sup> and 14<sup>th</sup> day, respectively, which was superior among all four maize varieties under hydroponic conditions. The interaction between different maize varieties and various levels of nutrient spray was significant for starch content at 7<sup>th</sup> and 14<sup>th</sup> day, but non-significant at 0 day. Notably, Ganga safed-2 exhibited higher starch content 51.45% and 49.75% with 0.75% spray at 7<sup>th</sup> and 14<sup>th</sup> day, respectively (Table 2). It was concluded that application of 0.75% nutrient solution spray led to higher starch concentration at the 7<sup>th</sup> and 14<sup>th</sup> days under hydroponic conditions. The highest starch percentage (65.69%) was recorded at 0 day in the Panchganga variety (i.e., sprouted seed), followed by a decreasing trend to 50.56% and 49.08% at 7<sup>th</sup> and 14<sup>th</sup> day, respectively. Similar trends were observed in the other three maize varieties. This decrease in starch content was associated with the correlation between starch degradation and the activity of isoenzymes (Reddy *et al.*, 1984) <sup>[10]</sup>. The data

values for starch content were statistically less significant overall, likely because the study was conducted under controlled hydroponic conditions using four maize varieties (African tall, Ganga safed-2, Manjari composite and Panchganga) all bred for fodder purposes. Therefore, the starch content values among varieties did not differ drastically, although they were still influenced by the nutrient solution spray.

#### **Effect of nutrient solution spray (19:19:19) on periodical total sugar in maize varieties grown hydroponically**

Total sugar content in different maize varieties was significantly influenced by the nutrient solution spray during all the periods of the study. While the foliar application of different nutrient concentrations had a non-significant effect on total sugar content at 0 day, it showed a significant impact at the 7<sup>th</sup> and 14<sup>th</sup> days. Significantly higher total sugar contents 8.66, 10.21 and 11.24 mg/g were recorded in the African tall variety at 0, 7<sup>th</sup> and 14<sup>th</sup> day of the hydroponic study, respectively. In contrast, significantly lower total sugar contents 6.20, 8.37 and 9.51 mg/g were observed in the Manjari composite variety at 0, 7<sup>th</sup> and 14<sup>th</sup> day, respectively. At 0 day, spraying with water or nutrient solution concentrations of 0.25%, 0.50% or 0.75% (19:19:19) did not significantly affect total sugar content. However, spraying with 0.75% NPK (19:19:19) resulted in significantly higher total sugar contents 9.57 and 10.64 mg/g at the 7<sup>th</sup> and 14<sup>th</sup> day, respectively. Although there was a non-significant effect of nutrient spray at 0 day, African tall recorded the highest total sugar content 10.30 and 11.35 mg/g with 0.75% spray at the 7<sup>th</sup> and 14<sup>th</sup> day, respectively and was found to be superior among all four maize varieties under hydroponic conditions. The interaction between different maize varieties and various nutrient spray concentrations showed significant effects on total sugar content at the 7<sup>th</sup> and 14<sup>th</sup> day, but not at 0 day. African tall exhibited the highest total sugar content of 10.30 and 11.35 mg/g with 0.75% spray at the 7<sup>th</sup> and 14<sup>th</sup> day, respectively (Table 3). It was concluded that the application of 0.75% nutrient solution spray resulted in higher total sugar content at the 7<sup>th</sup> and 14<sup>th</sup> day under hydroponic conditions. However, data values in respect to total sugar content were statistically less variable, possibly because all four maize varieties used in the experiment African tall, Ganga safed-2, Manjari composite and Panchganga are fodder-purpose varieties. As a result, the range of variation in total sugar among them was not highly pronounced, though it was still influenced by the nutrient solution spray.

#### **Effect of nutrient solution spray (19:19:19) on periodical reducing sugar in maize varieties grown hydroponically**

Reducing sugar content in different maize varieties was significantly influenced by the nutrient solution spray during all periods of the study. While the application of different nutrient concentrations had a non-significant effect on reducing sugar content at 0 day, it showed a significant impact at the 7<sup>th</sup> and 14<sup>th</sup> days. Significantly higher reducing sugar contents 0.45, 1.11 and 2.24 mg/g were recorded in the African tall variety at 0, 7<sup>th</sup> and 14<sup>th</sup> day of the hydroponic study, respectively. In contrast, significantly lower reducing sugar values 0.15, 0.92 and 2.10 mg/g were observed in the Manjari composite variety at the corresponding time intervals. At 0 day, spraying with water or nutrient solution (0.25%, 0.50% or 0.75%) did not significantly affect reducing sugar content across the varieties. However, spraying with 0.75% NPK (19:19:19) resulted in significantly higher reducing sugar values 1.14 mg/g at 7<sup>th</sup> day and 2.24 mg/g at 14<sup>th</sup> day. At the 7<sup>th</sup> day, the highest reducing sugar content

(1.20 mg/g) was recorded in African tall, followed closely by Panchganga (1.16 mg/g). At 14<sup>th</sup> day, African tall recorded the highest reducing sugar content of 2.32 mg/g, which was significantly superior to the other three maize varieties under hydroponic conditions. The interaction between maize varieties and various levels of nutrient spray had a significant effect on reducing sugar content at the 7<sup>th</sup> and 14<sup>th</sup> day, but was non-significant at 0 day. African tall recorded the highest reducing sugar levels 1.20 and 2.32 mg/g with 0.75% spray at 7<sup>th</sup> and 14<sup>th</sup> day, respectively (Table 4). It was concluded that application of 0.75% nutrient solution spray led to higher reducing sugar content at 7<sup>th</sup> and 14<sup>th</sup> days under hydroponic conditions. However, data values for reducing sugar were statistically less variable overall, likely because the study was conducted using four maize varieties African tall, Ganga safed-2, Manjari composite and Panchganga all bred for fodder purposes. As a result, the range of variation in reducing sugar content among the varieties was relatively narrow, although it was still influenced by the nutrient solution spray.

### Periodic growth and yield

#### Effect of nutrient solution spray (19:19:19) on periodical height of maize varieties grown hydroponically

The height of different maize varieties was significantly influenced by the nutrient solution spray at all stages of the study. While the application of different concentrations of nutrient solution had a non-significant effect on plant height at 0 day, it showed a significant impact at the 7<sup>th</sup> and 14<sup>th</sup> days. Significantly greater plant heights 0.41 cm, 5.76 cm and 21.95 cm were recorded in the African tall variety at 0, 7<sup>th</sup> and 14<sup>th</sup> day of the hydroponic study, respectively. In contrast, the lowest plant heights 0.25 cm, 4.63 cm and 18.91 cm were observed in the Manjari composite variety at the same intervals. At 0 day, spraying with water or different concentrations (0.25%, 0.50%, 0.75%) of NPK (19:19:19) had no significant effect on plant height across all varieties. However, application of 0.75% nutrient solution resulted in significantly higher heights 5.66 cm at 7<sup>th</sup> day and 21.26 cm at 14<sup>th</sup> day. Among the interactions, African tall sprayed with 0.75% recorded the highest plant height 6.35 cm at 7<sup>th</sup> day and 22.85 cm at 14<sup>th</sup> day, which was superior to the other three maize varieties under hydroponic conditions. The interaction between maize varieties and different nutrient spray concentrations showed a significant effect on plant height at the 7<sup>th</sup> and 14<sup>th</sup> day, but was non-significant at 0 day. Notably, African tall showed the maximum height 6.35 cm and 22.85 cm with 0.75% NPK spray at 7<sup>th</sup> and 14<sup>th</sup> day, respectively (Table 5). It was concluded that foliar application of 0.75% NPK solution significantly enhanced plant height at 7<sup>th</sup>

and 14<sup>th</sup> days under hydroponic conditions. These results are in agreement with Naik *et al.* (2016) [8], who reported that the height of hydroponic maize ranged from 20-30 cm. However, the data values regarding plant height showed less statistical variation, likely due to the controlled experimental conditions and the use of four fodder maize varieties (African tall, Ganga safed-2, Manjari composite and Panchganga). As these are all fodder-type genotypes, the variation in plant height among them was not highly pronounced, although still influenced by the nutrient solution spray.

#### Effect of nutrient solution spray (19:19:19) on periodical weight of maize varieties grown hydroponically

The weight of different maize varieties was significantly influenced by the nutrient solution spray at all stages of the study. While the application of different concentrations of nutrient solution had a non-significant effect on fodder weight at 0 day, it showed a significant effect at the 7<sup>th</sup> and 14<sup>th</sup> days. Significantly higher fresh weights of 1.35 kg, 6.94 kg and 10.33 kg were recorded in the African tall variety at 0, 7<sup>th</sup> and 14<sup>th</sup> day of the hydroponic study, respectively. In contrast, significantly lower weights 1.17 kg, 6.30 kg and 9.82 kg were observed in the Manjari composite variety at the corresponding intervals. At 0 day, spraying with water or 19:19:19 nutrient solution at 0.25%, 0.50% or 0.75% concentrations did not significantly affect fodder weight in any variety. However, application of 0.75% NPK solution resulted in significantly higher weights 6.72 kg at 7<sup>th</sup> day and 10.28 kg at 14<sup>th</sup> day. Among the combinations, African tall treated with 0.75% nutrient spray showed the highest fresh weights 7.17 kg at 7<sup>th</sup> day and 10.52 kg at 14<sup>th</sup> day, which was superior to the other three maize varieties under hydroponic conditions. The interaction between maize varieties and nutrient spray levels was significant at the 7<sup>th</sup> and 14<sup>th</sup> days, but non-significant at 0 day. African tall with 0.75% spray recorded the highest fodder yield 7.17 kg and 10.52 kg at 7<sup>th</sup> and 14<sup>th</sup> days, respectively (Table 6). It was concluded that 0.75% NPK spray led to significantly higher fresh fodder yield at the 7<sup>th</sup> and 14<sup>th</sup> days under hydroponic conditions. However, the overall variation among the maize varieties was statistically less significant, likely due to the controlled experimental conditions and the fact that all four varieties African tall, Ganga safed-2, Manjari composite and Panchganga are fodder maize types. Hence, the differences in fodder yield among them were not markedly large, though still influenced by nutrient spray concentration. These findings are in agreement with those of Naik *et al.*, (2013) [7], who reported that hydroponically grown maize fodder can yield 5-6 times the weight of the seed used (i.e., 1 kg seed produces 5-6 kg of fresh fodder).

**Table 1:** Effect of nutrient solution spray on Amylase activity in maize varieties grown hydroponically (mg of maltose release/g. of sample/min)

| Varieties (V)<br>Fertilizer (F) | Table 1 (A): 0-Days |               |                   |            |        |
|---------------------------------|---------------------|---------------|-------------------|------------|--------|
|                                 | African tall        | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 1.14                | 1.18          | 0.93              | 1.07       | 1.08   |
| F2 (0.25%)                      | 1.15                | 1.20          | 0.94              | 1.08       | 1.09   |
| F3 (0.50%)                      | 1.13                | 1.20          | 0.94              | 1.07       | 1.08   |
| F4 (0.75%)                      | 1.13                | 1.19          | 0.93              | 1.08       | 1.08   |
| Mean                            | 1.13                | 1.19          | 0.93              | 1.07       |        |
|                                 | V                   |               | F                 |            | V X F  |
| SE                              | 0.0028              |               | 0.0028            |            | 0.0057 |
| CD at 1%                        | 0.0118              |               | NS                |            | NS     |
| Varieties (V)<br>Fertilizer (F) | Table 1 (B): 7-Days |               |                   |            |        |
|                                 | African tall        | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 2.32                | 2.42          | 2.12              | 2.25       | 2.27   |
| F2 (0.25%)                      | 2.37                | 2.47          | 2.15              | 2.27       | 2.31   |

|                                 |                      |               |                   |            |        |
|---------------------------------|----------------------|---------------|-------------------|------------|--------|
| F3 (0.50%)                      | 2.43                 | 2.51          | 2.20              | 2.33       | 2.36   |
| F4 (0.75%)                      | 2.49                 | 2.58          | 2.24              | 2.39       | 2.42   |
| Mean                            | 2.40                 | 2.49          | 2.17              | 2.31       |        |
|                                 | V                    |               | F                 |            | V X F  |
| SE                              | 0.0025               |               | 0.0025            |            | 0.005  |
| CD at 1%                        | 0.0103               |               | 0.0103            |            | 0.0206 |
| Varieties (V)<br>Fertilizer (F) | Table 1 (C): 14-Days |               |                   |            |        |
|                                 | African tall         | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 1.92                 | 2.02          | 1.75              | 1.84       | 1.88   |
| F2 (0.25%)                      | 1.94                 | 2.05          | 1.78              | 1.89       | 1.91   |
| F3 (0.50%)                      | 1.96                 | 2.08          | 1.81              | 1.92       | 1.94   |
| F4 (0.75%)                      | 1.99                 | 2.10          | 1.86              | 1.96       | 1.97   |
| Mean                            | 1.95                 | 2.06          | 1.80              | 1.90       |        |
|                                 | V                    |               | F                 | V X F      |        |
| SE                              | 0.0023               |               | 0.0023            | 0.0046     |        |
| CD at 1%                        | 0.0096               |               | 0.0096            | 0.0193     |        |

\*Each value is average of 2 figures

**Table 2:** Effect of nutrient solution spray on Starch concentration in maize varieties

grown hydroponically (%)

| Varieties (V)<br>Fertilizer (F) | Table 2 (A): 0-Days  |               |                   |            |        |
|---------------------------------|----------------------|---------------|-------------------|------------|--------|
|                                 | African tall         | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 64.60                | 60.40         | 54.65             | 65.65      | 61.33  |
| F2 (0.25%)                      | 64.65                | 60.35         | 54.80             | 65.60      | 61.35  |
| F3 (0.50%)                      | 64.50                | 60.35         | 54.65             | 65.75      | 61.31  |
| F4 (0.75%)                      | 64.65                | 60.40         | 54.70             | 65.75      | 61.38  |
| Mean                            | 64.60                | 60.38         | 54.70             | 65.69      |        |
|                                 | V                    |               | F                 |            | V X F  |
| SE                              | 0.0286               |               | 0.0286            |            | 0.0572 |
| CD at 1%                        | 0.1183               |               | NS                |            | NS     |
| Varieties (V)<br>Fertilizer (F) | Table 2 (B): 7-Days  |               |                   |            |        |
|                                 | African tall         | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 48.75                | 42.40         | 31.45             | 49.75      | 43.09  |
| F2 (0.25%)                      | 49.15                | 42.75         | 31.85             | 50.25      | 43.50  |
| F3 (0.50%)                      | 49.45                | 43.70         | 32.60             | 50.80      | 44.14  |
| F4 (0.75%)                      | 49.80                | 44.25         | 32.85             | 51.45      | 44.59  |
| Mean                            | 49.29                | 43.28         | 32.19             | 50.56      |        |
|                                 | V                    |               | F                 |            | V X F  |
| SE                              | 0.0242               |               | 0.0242            |            | 0.0484 |
| CD at 1%                        | 0.0999               |               | 0.0999            |            | 0.1999 |
| Varieties (V)<br>Fertilizer (F) | Table 2 (C): 14-Days |               |                   |            |        |
|                                 | African tall         | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 45.75                | 40.40         | 30.30             | 48.45      | 41.23  |
| F2 (0.25%)                      | 46.25                | 40.85         | 31.50             | 48.70      | 41.83  |
| F3 (0.50%)                      | 46.90                | 41.45         | 30.55             | 49.40      | 42.08  |
| F4 (0.75%)                      | 47.45                | 41.90         | 29.50             | 49.75      | 42.15  |
| Mean                            | 46.59                | 41.15         | 30.46             | 49.08      |        |
|                                 | V                    |               | F                 |            | V X F  |
| SE                              | 0.0279               |               | 0.0279            |            | 0.0559 |
| CD at 1%                        | 0.1154               |               | 0.1154            |            | 0.2309 |

\*Each value is average of 2 figures

**Table 3:** Effect of nutrient solution spray (19:19:19) on periodical total sugar in maize

varieties grown hydroponically (mg/g).

| Varieties (V)<br>Fertilizer (F) | Table 3 (A): 0-Days |               |                   |            |        |
|---------------------------------|---------------------|---------------|-------------------|------------|--------|
|                                 | African tall        | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 8.65                | 7.45          | 6.25              | 8.25       | 7.65   |
| F2 (0.25%)                      | 8.65                | 7.40          | 6.15              | 8.35       | 7.64   |
| F3 (0.50%)                      | 8.65                | 7.50          | 6.25              | 8.35       | 7.69   |
| F4 (0.75%)                      | 8.70                | 7.50          | 6.15              | 8.35       | 7.68   |
| Mean                            | 8.66                | 7.46          | 6.20              | 8.33       |        |
|                                 | V                   |               | F                 |            | V X F  |
| SE                              | 0.0279              |               | 0.0279            |            | 0.0559 |
| CD at 1%                        | 0.1154              |               | NS                |            | NS     |
| Varieties (V)<br>Fertilizer (F) | Table 3 (B): 7-Days |               |                   |            |        |
|                                 | African tall        | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 10.15               | 9.21          | 8.31              | 10.03      | 9.42   |
| F2 (0.25%)                      | 10.17               | 9.27          | 8.35              | 10.07      | 9.46   |
| F3 (0.50%)                      | 10.23               | 9.33          | 8.39              | 10.14      | 9.52   |

|                                 |                      |               |                   |            |        |
|---------------------------------|----------------------|---------------|-------------------|------------|--------|
| F4 (0.75%)                      | 10.30                | 9.37          | 8.44              | 10.18      | 9.57   |
| Mean                            | 10.21                | 9.29          | 8.37              | 10.10      |        |
|                                 | V                    |               | F                 |            | V X F  |
| SE                              | 0.0028               |               | 0.0028            |            | 0.0057 |
| CD at 1%                        | 0.0118               |               | 0.0118            |            | 0.0236 |
| Varieties (V)<br>Fertilizer (F) | Table 3 (C): 14-Days |               |                   |            |        |
|                                 | African tall         | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 11.13                | 10.21         | 9.43              | 11.10      | 10.47  |
| F2 (0.25%)                      | 11.21                | 10.27         | 9.49              | 11.15      | 10.53  |
| F3 (0.50%)                      | 11.28                | 10.34         | 9.55              | 11.18      | 10.59  |
| F4 (0.75%)                      | 11.35                | 10.39         | 9.58              | 11.25      | 10.64  |
| Mean                            | 11.24                | 10.30         | 9.51              | 11.17      |        |
|                                 | V                    |               | F                 |            | V X F  |
| SE                              | 0.0027               |               | 0.0027            |            | 0.0054 |
| CD at 1%                        | 0.0112               |               | 0.0112            |            | 0.0225 |

**Table 4:** Effect of nutrient solution spray (19:19:19) on periodical reducing sugar in maize varieties grown hydroponically (mg/g).

| Varieties (V)<br>Fertilizer (F) | Table 4 (A): 0-Days  |               |                   |            |        |
|---------------------------------|----------------------|---------------|-------------------|------------|--------|
|                                 | African tall         | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 0.45                 | 0.30          | 0.15              | 0.40       | 0.33   |
| F2 (0.25%)                      | 0.45                 | 0.35          | 0.15              | 0.35       | 0.33   |
| F3 (0.50%)                      | 0.40                 | 0.35          | 0.10              | 0.30       | 0.29   |
| F4 (0.75%)                      | 0.50                 | 0.30          | 0.20              | 0.40       | 0.35   |
| Mean                            | 0.45                 | 0.33          | 0.15              | 0.36       |        |
|                                 | V                    |               | F                 |            | V X F  |
| SE                              | 0.0165               |               | 0.0165            |            | 0.0330 |
| CD at 1%                        | 0.0683               |               | NS                |            | NS     |
| Varieties (V)<br>Fertilizer (F) | Table 4 (B): 7-Days  |               |                   |            |        |
|                                 | African tall         | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 1.03                 | 0.85          | 0.65              | 1.01       | 0.88   |
| F2 (0.25%)                      | 1.08                 | 1.05          | 0.90              | 1.09       | 1.03   |
| F3 (0.50%)                      | 1.15                 | 1.09          | 1.05              | 1.12       | 1.10   |
| F4 (0.75%)                      | 1.20                 | 1.12          | 1.09              | 1.16       | 1.14   |
| Mean                            | 1.11                 | 1.02          | 0.92              | 1.09       |        |
|                                 | V                    |               | F                 |            | V X F  |
| SE                              | 0.0091               |               | 0.0091            |            | 0.0182 |
| CD at 1%                        | 0.0376               |               | 0.0376            |            | 0.0753 |
| Varieties (V)<br>Fertilizer (F) | Table 4 (C): 14-Days |               |                   |            |        |
|                                 | African tall         | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 2.16                 | 2.09          | 2.03              | 2.11       | 2.09   |
| F2 (0.25%)                      | 2.21                 | 2.13          | 2.10              | 2.14       | 2.14   |
| F3 (0.50%)                      | 2.27                 | 2.17          | 2.13              | 2.19       | 2.19   |
| F4 (0.75%)                      | 2.32                 | 2.22          | 2.17              | 2.25       | 2.24   |
| Mean                            | 2.24                 | 2.15          | 2.10              | 2.17       |        |
|                                 | V                    |               | F                 |            | V X F  |
| SE                              | 0.0021               |               | 0.0021            |            | 0.0043 |
| CD at 1%                        | 0.0089               |               | 0.0089            |            | 0.0178 |

**Table 5:** Effect of nutrient solution spray (19:19:19) on periodical height of maize varieties grown hydroponically (cm)

| Varieties (V)<br>Fertilizer (F) | Table 5 (A): 0-Days |               |                   |            |      |
|---------------------------------|---------------------|---------------|-------------------|------------|------|
|                                 | African tall        | Ganga safed-2 | Manjari composite | Panchganga | Mean |
| F1 (0.00%)                      | 0.35                | 0.35          | 0.25              | 0.25       | 0.30 |
| F2 (0.25%)                      | 0.45                | 0.30          | 0.25              | 0.30       | 0.33 |
| F3 (0.50%)                      | 0.40                | 0.35          | 0.25              | 0.35       | 0.34 |
| F4 (0.75%)                      | 0.45                | 0.35          | 0.25              | 0.25       | 0.33 |
| Mean                            | 0.41                | 0.34          | 0.25              | 0.29       |      |
|                                 | V                   |               | F                 | V X F      |      |
| SE                              | 0.0225              | 0.0225        |                   | 0.0450     |      |
| CD at 1%                        | 0.0930              | NS            |                   | NS         |      |
| Varieties (V)<br>Fertilizer (F) | Table 5 (B): 7-Days |               |                   |            |      |
|                                 | African tall        | Ganga safed-2 | Manjari composite | Panchganga | Mean |
| F1 (0.00%)                      | 5.25                | 4.75          | 4.25              | 4.55       | 4.70 |
| F2 (0.25%)                      | 5.60                | 5.05          | 4.55              | 4.85       | 5.01 |
| F3 (0.50%)                      | 5.85                | 5.45          | 4.75              | 5.25       | 5.33 |
| F4 (0.75%)                      | 6.35                | 5.70          | 4.95              | 5.65       | 5.66 |
| Mean                            | 5.76                | 5.24          | 4.63              | 5.08       |      |
|                                 | V                   |               | F                 | V X F      |      |

|                                 |                      |               |                   |            |        |
|---------------------------------|----------------------|---------------|-------------------|------------|--------|
| SE                              | 0.0233               |               | 0.0233            |            | 0.0467 |
| CD at 1%                        | 0.0965               |               | 0.0965            |            | 0.1931 |
| Varieties (V)<br>Fertilizer (F) | Table 5 (C): 14-Days |               |                   |            |        |
|                                 | African tall         | Ganga safed-2 | Manjari composite | Panchganga | Mean   |
| F1 (0.00%)                      | 21.15                | 20.05         | 18.15             | 19.35      | 19.68  |
| F2 (0.25%)                      | 21.55                | 20.65         | 18.55             | 19.75      | 20.13  |
| F3 (0.50%)                      | 22.25                | 21.15         | 19.15             | 20.25      | 20.70  |
| F4 (0.75%)                      | 22.85                | 21.75         | 19.80             | 20.65      | 21.26  |
| Mean                            | 21.95                | 20.90         | 18.91             | 20.00      |        |
|                                 | V                    |               | F                 |            | V X F  |
| SE                              | 0.0242               |               | 0.0242            |            | 0.0484 |
| CD at 1%                        | 0.0999               |               | 0.0999            |            | 0.1999 |

**Table 6:** Effect of nutrient solution spray (19:19:19) on periodical weight of maize varieties grown hydroponically (kg)

|                       |                             |                      |                          |                   |             |
|-----------------------|-----------------------------|----------------------|--------------------------|-------------------|-------------|
| <b>Varieties (V)</b>  | <b>Table 6 (A): 0-Days</b>  |                      |                          |                   |             |
| <b>Fertilizer (F)</b> | <b>African tall</b>         | <b>Ganga safed-2</b> | <b>Manjari composite</b> | <b>Panchganga</b> | <b>Mean</b> |
| F1 (0.00%)            | 1.35                        | 1.26                 | 1.17                     | 1.24              | 1.26        |
| F2 (0.25%)            | 1.35                        | 1.26                 | 1.17                     | 1.24              | 1.26        |
| F3 (0.50%)            | 1.35                        | 1.26                 | 1.17                     | 1.24              | 1.26        |
| F4 (0.75%)            | 1.35                        | 1.26                 | 1.17                     | 1.24              | 1.26        |
| Mean                  | 1.35                        | 1.26                 | 1.17                     | 1.24              |             |
|                       | V                           | F                    | V X F                    |                   |             |
| SE                    | 0.0007                      | 0.0007               | 0.0014                   |                   |             |
| CD at 1%              | 0.0030                      | NS                   | NS                       |                   |             |
| <b>Varieties (V)</b>  | <b>Table 6 (B): 7-Days</b>  |                      |                          |                   |             |
| <b>Fertilizer (F)</b> | <b>African tall</b>         | <b>Ganga safed-2</b> | <b>Manjari composite</b> | <b>Panchganga</b> | <b>Mean</b> |
| F1 (0.00%)            | 6.72                        | 6.34                 | 6.13                     | 6.26              | 6.36        |
| F2 (0.25%)            | 6.87                        | 6.42                 | 6.25                     | 6.36              | 6.47        |
| F3 (0.50%)            | 6.98                        | 6.54                 | 6.35                     | 6.49              | 6.59        |
| F4 (0.75%)            | 7.17                        | 6.64                 | 6.47                     | 6.61              | 6.72        |
| Mean                  | 6.94                        | 6.49                 | 6.30                     | 6.43              |             |
|                       | V                           | F                    | V X F                    |                   |             |
| SE                    | 0.0008                      | 0.0008               | 0.00016                  |                   |             |
| CD at 1%              | 0.0034                      | 0.0034               | 0.0069                   |                   |             |
| <b>Varieties (V)</b>  | <b>Table 6 (C): 14-Days</b> |                      |                          |                   |             |
| <b>Fertilizer (F)</b> | <b>African tall</b>         | <b>Ganga safed-2</b> | <b>Manjari composite</b> | <b>Panchganga</b> | <b>Mean</b> |
| F1 (0.00%)            | 10.12                       | 9.95                 | 9.62                     | 9.79              | 9.87        |
| F2 (0.25%)            | 10.29                       | 10.11                | 9.78                     | 9.89              | 10.02       |
| F3 (0.50%)            | 10.39                       | 10.23                | 9.89                     | 9.99              | 10.12       |
| F4 (0.75%)            | 10.52                       | 10.39                | 9.99                     | 10.21             | 10.28       |
| Mean                  | 10.33                       | 10.17                | 9.82                     | 9.97              |             |
|                       | V                           | F                    | V X F                    |                   |             |
| SE                    | 0.0010                      | 0.0010               | 0.0020                   |                   |             |
| CD at 1%              | 0.0041                      | 0.0041               | 0.0083                   |                   |             |

## Conclusion

During the germination period, there was a decline in dry matter (DM) and starch content. However, higher amylase activity was recorded in Ganga safed-2 at 0 and 7<sup>th</sup> day (1.19% and 2.49%, respectively), which slightly decreased at the 14<sup>th</sup> day (2.06%). Similarly, the African tall variety exhibited higher total sugar content 8.66%, 10.21% and 11.24% at 0, 7<sup>th</sup> and 14<sup>th</sup> days, respectively. The nutrient solution had a significant effect on plant enzyme activity and total sugar concentration. Application of 0.75% NPK solution to the African tall variety resulted in higher fodder yield as compared to the other maize varieties.

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