Influence of seed cake as organic fertilizer on growth, dry matter production and root development of two cultivars of C4 plant, Maize (Zea mays) under lab condition

Abstract:

An indoor pot culture experiment was conducted with the C4 plant (Zea mays) in the lab during the period of vegetative growth to evaluate the influence of organic fertilizer in the form of mustard oil seed cake on growth, biomass yield and root development of two maize cultivars, hybrid yellow and hybrid purple. The seed cake fertilizer treatments imposed in the experiment were control (T0), and others at 2.6%, 3.5% and 4.4% of soil weight respectively against T1, T2 and T3 treatment. The results indicated moderately elevated seed cake application showed considerable improvement in vegetative growth and the plant biomass components including height and other morphological parameters as leaf no, leaf length, no of node and internodal distance per plant, root yields and fresh weight & dry matter production including the root shoot ration of the plants, in both the cultivars and in most of the cases found highest in hybrid yellow compared to hybrid purple. Among the plant components, shoot root dry wt and root shoot ratio had the greatest decrease under fertilizer deficiency at control (T0) treatment interaction at different doses of seed cake and recorded the highest values at moderate treatments for most of the parameters during both at vegetative growth and post-harvesting after 3 months of experiment .The result shows that under controlled environment morphological parameters, biomass yield and its components of the plant were maximum when fertilized with seed cake at 2.6 % and 3.5% of soil weight in treatment 1 &2, found to be the perfect doses of fertilizer for the maize vegetative growth and biomass yield compared to T0 and other treatments. So, based on the result it can be concluded that T1 and T2 treatment is the best fertilizer treatment for the hybrid yellow maize yield.

Key words: Maize, organic fertilizer, mustard oil Seed cake, growth, dry matter, Root development

Introduction:

Bangladesh is an agrarian country, where crops especially maize (Zea mays L.), one of the most important, demandable and widely grown cereal crops in recent years. Globally, maize is among the three leading staple food grains. (Pandita et al 2023) and contains the highest genetic potential among all other grains (Choudhary et al 2020). As the leading producer, the United States, contributes to over 40% of the world's maize production (Moniruzzaman, 2009). It is a C4 plant, called "Queen of Cereals" ranks next to wheat and rice in context of grain production grown in irrigated and rainfed areas (Anon 2008, Irshad et al., 2002). It can be harvested as fodder within 50 days, green cobs within 60-80 days and grain within 100-130 days of planting. It has one of the highest numbers of consumers not only in Bangladesh but also worldwide (Dewan et al. 1998, Hasan et al., 2018, Adnan, et al., 2015, 2021). It has a huge commercial potential due to subtropical monsoonal climate of Bangladesh suitable for maize cultivation (Ali

et al. 2008). Maize production in Bangladesh increased significantly in between 2011- 2020, which peaked in 2019 at 17.14% before falling to 14.63% in 2020 ((Hasan, 2008; Ahmed and Islam,2018; Islam and Hoshnain 2022,). In 2020 was 9 tons per hector with an average yearly growth rate of 2.98% (Rahman and Zhang, 2018). Demand and production in Bangladesh would be more than doubled between 2050 (Adnan, et al. 2015).

Maize as a potential and multipurpose cereal grain crop for human consumption with a variety of prepared food items as well as fodder and feed for animals, livestock, poultry and especially uses of baby corn by humans including processed products as loaf, flat bread, bun, pop corn, corn flex, cornmeal, corn flour are increasing day by day across the country and all over the world with great nutritional value of the grain having 66.70% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 7% ash (Mehta & Dias, 1999, Chaudhry, 1983).It grows at diverse seasons and having different types as normal yellow/white, hybrid yellow, hybrid purple, sweet corn etc.

Morphological features including growth and development are generally hampered by disruption in the cell cycle machinery including cultivation under rainfed areas with lower rainfall than the critical level to obtain optimum yield (Sah et al., 2020, Carneiro et al., 2021). Generally loamy soil texture is suitable for producing maize, however adding fertilizer might boosts up plant growth, where organic fertilizer is more suitable and beneficial for plant and soil health (Ayeni et al., 2012 and 2015).

In a developing country like Bangladesh, the cultivated soils are generally deficient in Organic matter and major essential nutrients as nitrogen (N), phosphorus (P) and Potassium (K). So low crop productivity in the mentioned country is common feature because of very low O.M and nutrient contents, poor soil physical condition including unbalanced use of synthetic fertilizers and low nutrient-use-efficiency (Rashid, 1994; Anon, 2006).

Farmers using both organic and inorganic/synthetic fertilizers in their crop fields however organic fertilizer boosts the plant growth in case of maize more than inorganic fertilizer (Adediran et al. 2005, Ayeni et al., 2012). The excessive and long-term use of chemical fertilizers deteriorate the quality and contaminate the soil including degradation of air, surface as well as groundwater through leaching of nutrients affects human body as the chemicals moves through the food chain, responsible for developing chronic diseases in humans. On the other hand, organic fertilizers are slow releasing and beneficial for soil, plant growth but also for human health. (Sugiyanto, 2011; Sharma and Chetani, 2017; Lokanadhan et al., 2012).

Therefore, the objective of this present research work is to assess the benefits of adding seed cake as organic fertilizer with application of different doses to investigate the growth, dry matter and root development performances and find out a suitable maize variety out of two in terms of growth, plant height, leaf no, biomass yield, root development and root shoot ratio performances under controlled condition.

Materials and methods:

A pot culture experiment was conducted from June -September, 2022 to investigate the influence of mustard oil seed cake application on maize plant growth and development, performed under controlled environment at the Laboratory, Department of environmental science and management, North South University, Bangladesh, were kept at a temperature of 25 °C under 14/10 h light and dark photoperiod. The experiment was laid out in a completely randomized block design with four fertilizer levels as treatments and 3 replications

Seeds was sown on 170 g of soil was filled in each plastic container with 5.5 inches height and 2.5 inches width. To conduct the lab trials, the treatments imposed on the soil were T0 (control), T1, T2 and T3. The fertilizer was added in 2-time intervals, one during the sowing and another after 32 days of germination.

The first doses of organic fertilizer added in the soil during the sowing of seeds at the rate of no fertilizer (T0),1.5g/pot (T1), 2 g/pot (T2) and 2.5g/pot (T3) gm respectively and the 2nd doses on day 32 at the rate of control (T0), T1 (3 g/pot), T2 (4 g/pot) and T3 (5 g/pot). As a result, the total seed cake fertilizer added during the experiment were control and others 4.5g/pot (2.6%), 6g/pot (3.5%) and 7.5 g/pot (4.4%) by soil weight respectively against T0, T1, T2 and T3 treatments.

The experiment was done with sandy loam soil for 81 days, where the hybrid yellow and hybrid purple maize cultivars were the test crops, and mustard oil seed cake as organic fertilizer, used in this experiment to evaluate the influence of fertilizer on vegetative growth, dry matter production, and root development of the plants

Identification of the plant:

Scientific name: Zea mays L, **Kingdom:** Plantae, **Division:** Magnoliophyta, **Class:** Liliopsida, **Order:** Poales, **Family:** Poaceae, **Genus:** Zea, **Species:** mays

Analysis of Mustard oil seed cake:

Total Nitrogen (N)-3.01%, Phosphorus (P)- 1.15% and Potassium (K)- 1.22%

Physiochemical properties of soil:

The soil has the following characteristics. Texture – Sandy loam. Sand- 61.26%, Silt -32.62% and Clay – 6.12%. pH -6.9, EC - 793 µS/cm, Nacl - 1.0%, moisture content - 2%, Organic

carbon (OC) -0.81%, Total Nitrogen- 0.05%, Available Phosphorus – 33.84 ppm, Exchangeable potassium – 0.09 meq/100 g soil

Mustard oil seed cake as a potential soil amendment and organic fertilizer could enhance the maize growth and biomass yield. Therefore, experiment with 2 varieties of maize plants were carried at lab condition to study the effects of organic fertilizer at four levels on the hybrid purple and hybrid yellow cultivars on yield components.

Fig 1. Seeds were soaked in water (ESM lab) Department of Environmental Science and management, North South University

Figure 2. 11 days old seedlings at the lab

In these 81days' experimental periods, different parameters of plants, such as plant height, number of leaves, leaf length, number of nodes and internodal distance etc were measured from time to time and finally fresh and dry weight of shoot and root including root shoot ratio after harvesting of the plants.

This study was conducted to find out the best dose of organic fertilizers for the maize yield so that a specific amount of dose can be applied to find the best result.

Results and Discussion:

Morphological features of hybrid yellow and hybrid purple cultivars at 32 and 72 days with different fertilizer treatments at vegetative growth:

After 32 days of germination, result shows that highest plant height was found in yellow hybrid at treatment T2 (Fig 3) followed by T3, T1 and lowest at T0, also same in case of T2 treatment at purple hybrid, which was highest followed by T1, T3 and T0 at the lowest. In both the cultivars control treatment means no added fertilizer showed lowest plant height (Fig 3).

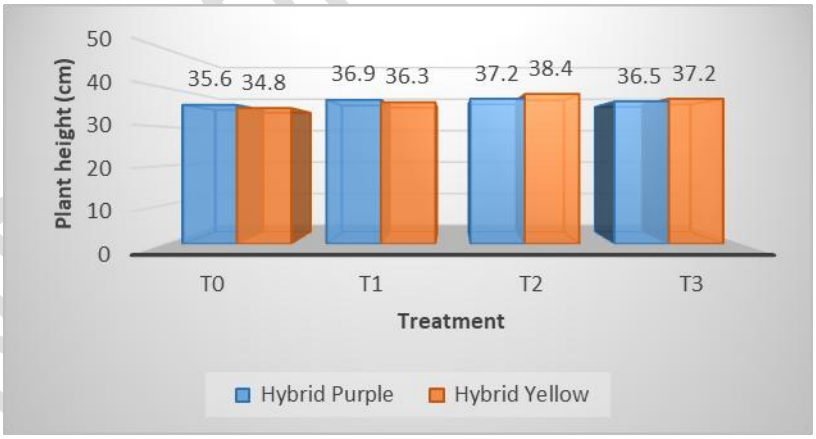


Fig. 3 Effect of fertilizer treatments on plant height

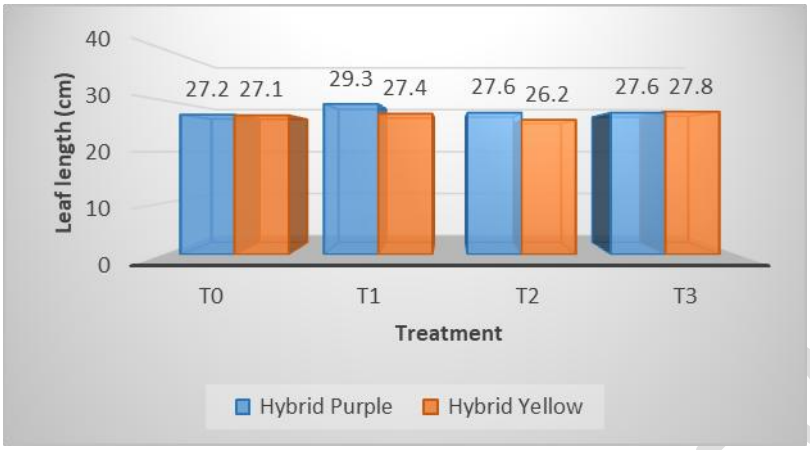
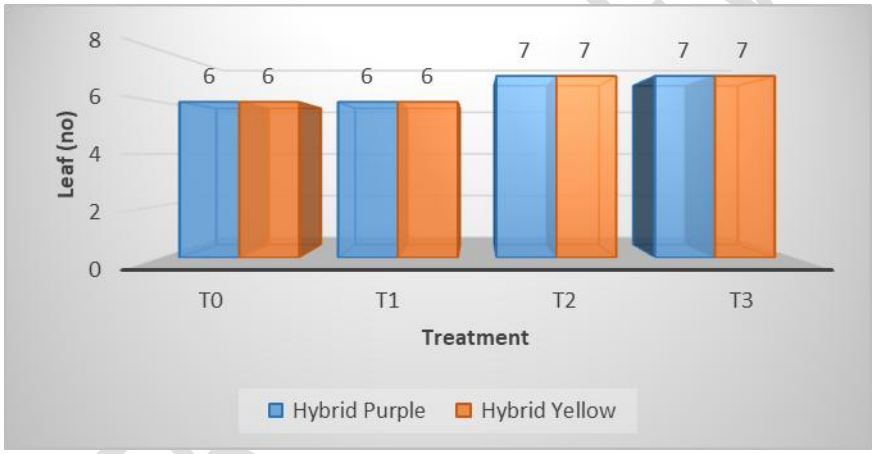


Fig 4. Effect of fertilizer treatments on leaf length

In case of leaf length, highest value was obtained at T1 in hybrid purple followed by hybrid yellow at T3 and T2&T3 at hybrid purple (Fig 4)



. **Fig 5. Effect of fertilizer treatments on no of leaves**

Different fertilizer treatments showed that the no of leaves was found higher at T2 and T3 and lower at T1 and T0 in both the cultivars (Fig 5)

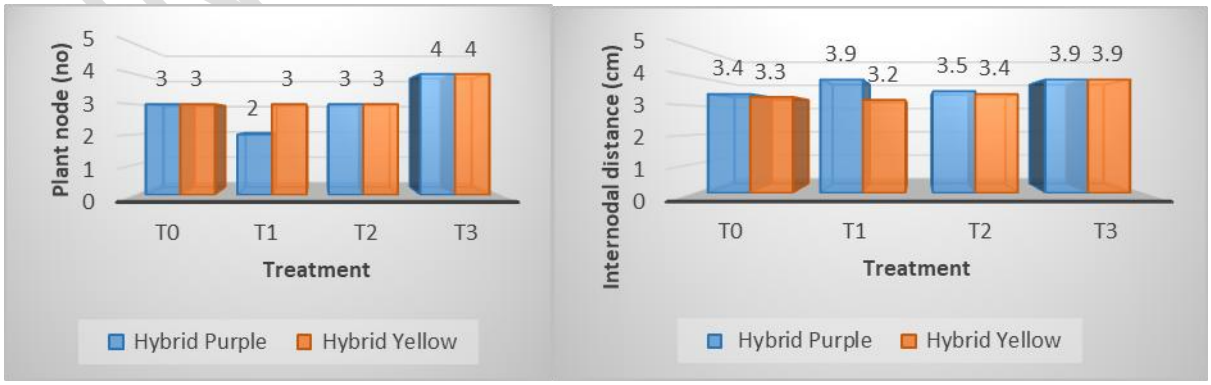


Fig 6. Effect of fertilizer treatments on Plant node and internodal distance

Plant node was found highest at T3 both in yellow and purple hybrid followed by T2, T0 but less in no at T1 in case of purple, however hybrid yellow was found same at T0 and T2.Also internodal distance was highest in T3 in both yellow and purple cultivars (Fig 6).

Morphological parameters after 72 days of germination:

Results after 72 days found same as 32 days where plant height was highest at treatment T2 in hybrid yellow followed by T2 and T1 in hybrid purple and lowest at T0 in both the cultivars. In case of purple hybrid among the treatments found highest at T2 but loer in comparison to hybrid purple, followed by T1 (Fig 7)

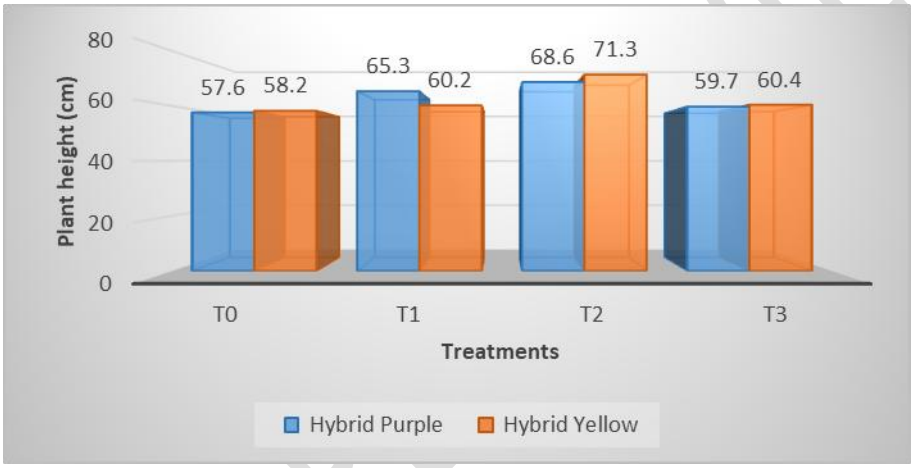


Fig 7. Effect of fertilizer treatments on plant height

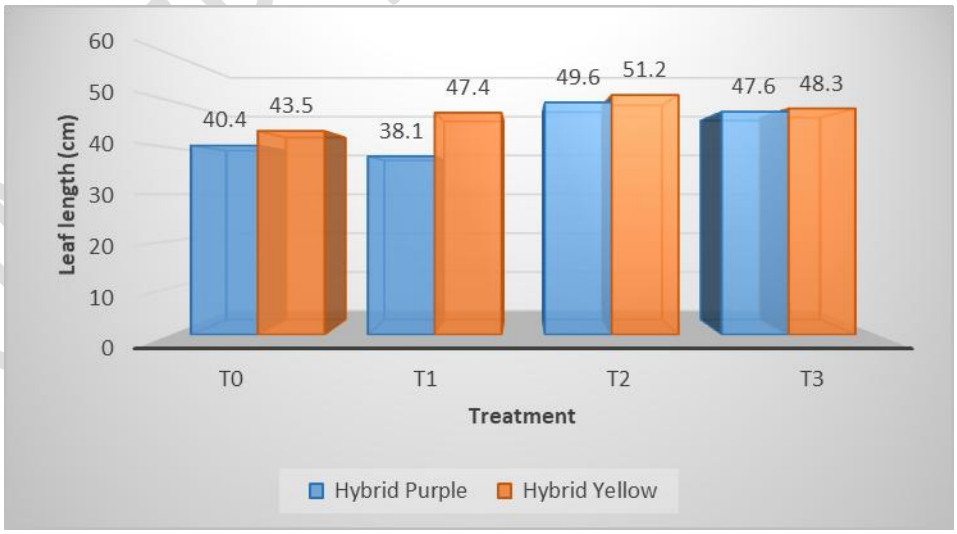


Fig 8. Effect of fertilizer treatments on leaf length

In case of leaf length, it was found highest in yellow hybrid at T2 treatment followed by T2 in purple and T3, T1 & T0 in yellow hybrid (Fig 8)

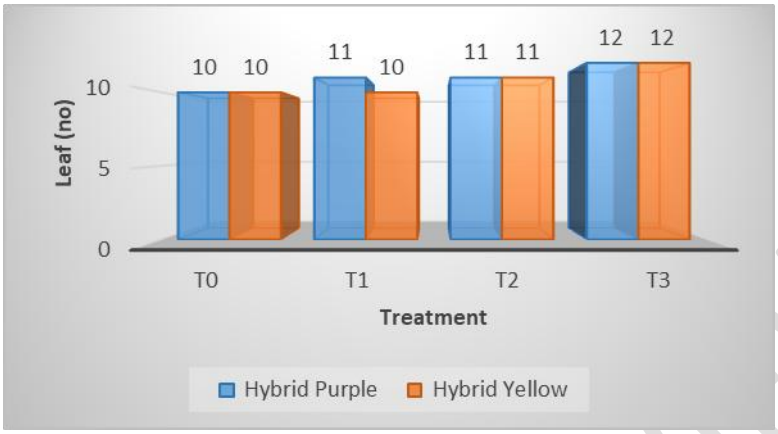


Fig 9. Effect of fertilizer treatments on leaf number

Fertilizer treatments showed highest leaf no in both the cultivars at T3 followed by T2 and lowest at T0 and the node was found highest at T1 in yellow hybrid followed by purple at T3 and same in all others among the treatments and between the cultivars (Fig 9).

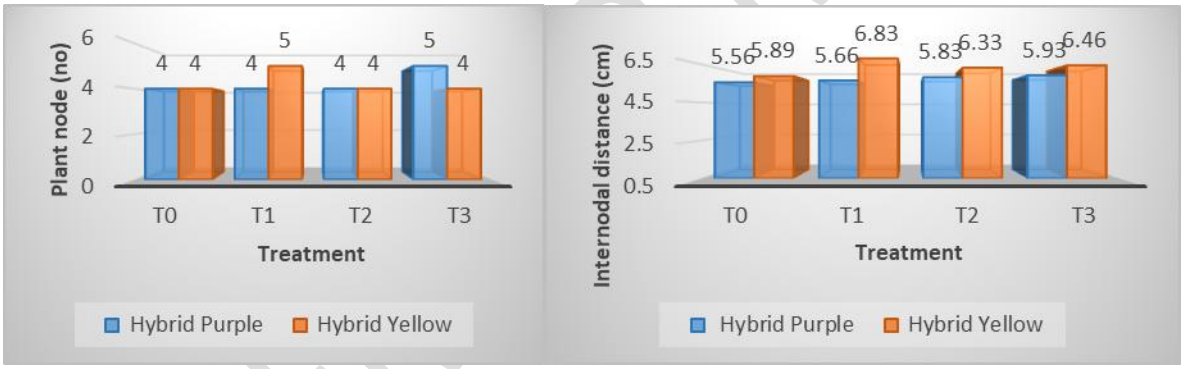


Fig 10. Effect of fertilizer treatments on plant node and internodal distance

In case of internodal distance, like node no also found highest in yellow hybrid at treatment T1 followed by T3, T2 and T0, whereas found lowest in case of purple in all the treatments compared to yellow one. Purple shows less internodal distance compared to yellow one (Fig 10)

Parameters after 81 days of germination at harvasting :

After harvesting at 81 days, shoot fresh and dry weight were found highest at T3 followed by T2 in hybrid yellow compared to hybrid purple whereas at T0 both the cultivars showing the lower performances compared to other treatments (Fig 11)

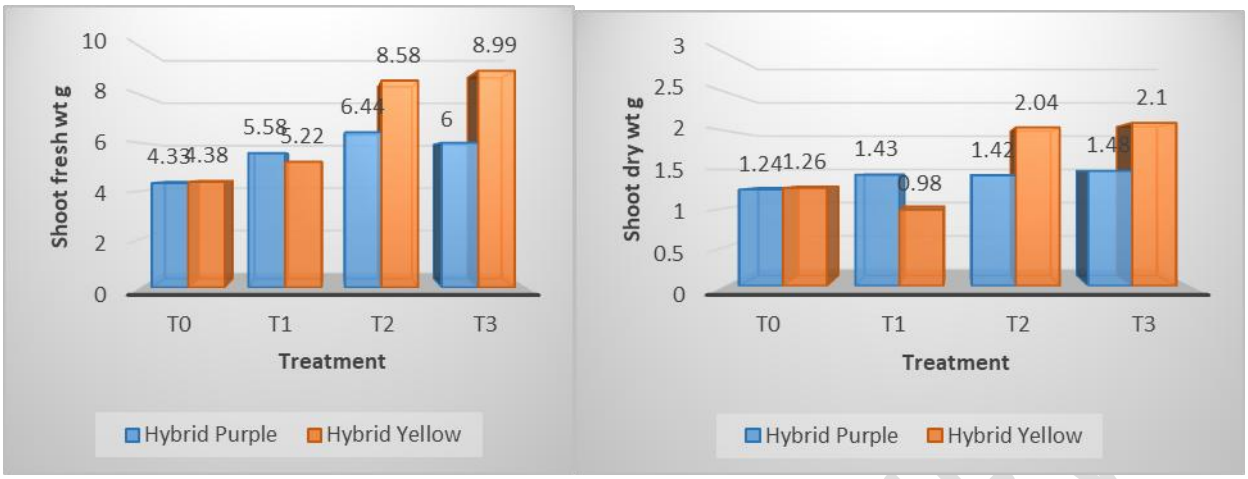


Fig 11. Effect of fertilizer treatments on shoot fresh and dry weight

In Hybrid yellow**,** shoot fresh wt (8.99g) and dry weight (2.1g) was higher at T3 treatment followed by T2 and lowest in T0 in both the entities.

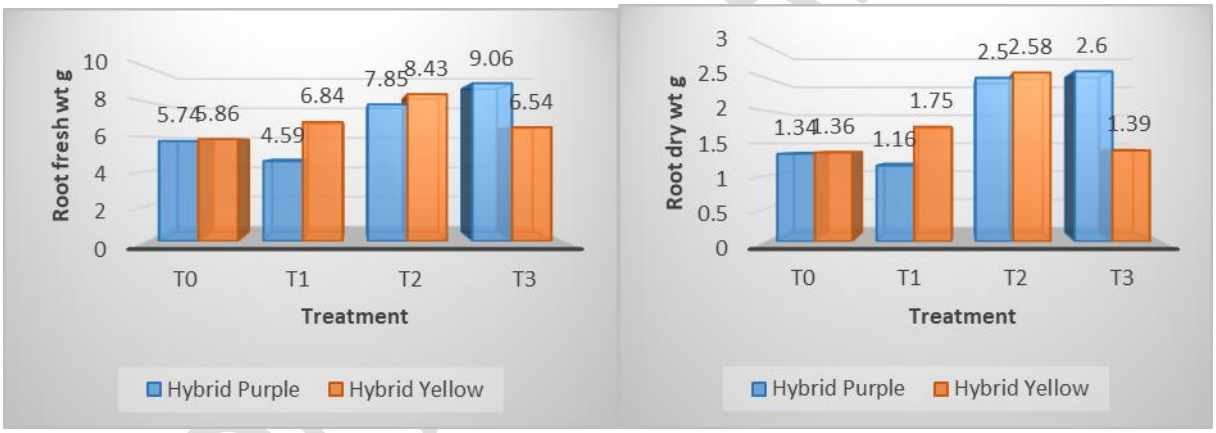


Fig 12. Effect of fertilizer treatments on root fresh and dry weight

In case of root performances, highest values were obtained in root fresh and dry weight at T3 in hybrid purple followed by T2 in hybrid yellow and lowest at control in both the cultivars (Fig 12)

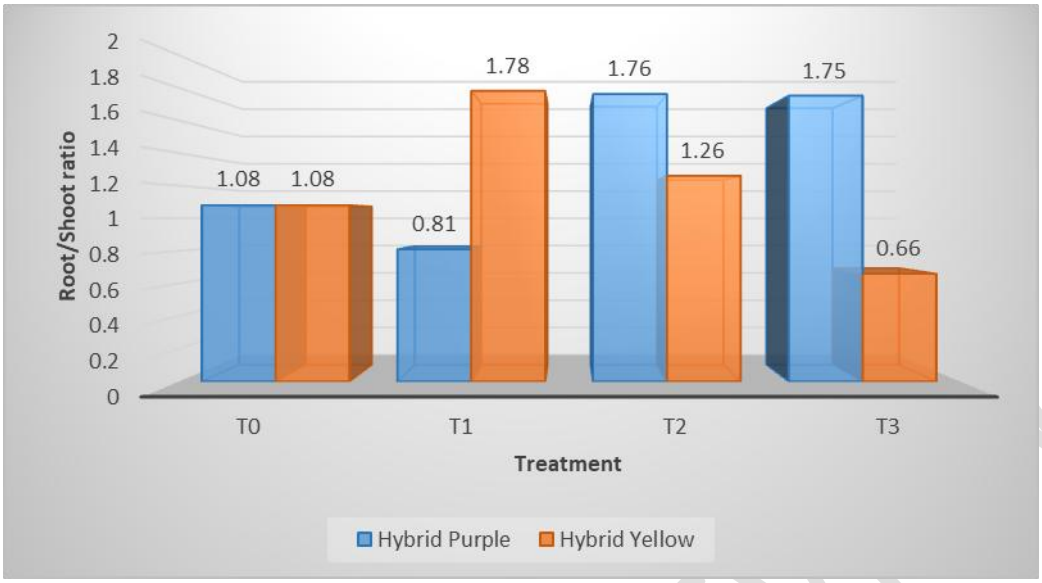


Fig 13. Effect of fertilizer treatments on root shoot ratio

Root shoot ratio was found highest (1.78g) in hybrid yellow at T1 treatment, followed by T2(1.76g), and T3(1.75 g) in hybrid purple whereas no differences found at control treatment which was lowest at T0 (1.08g) in both the cultivars (Fig 13).

The results of this trial indicated organic fertilizer increased organic matter content of the soil. However moderate rates of fertilizer application is cost saving and favored vegetative growth as well as biomass including formation of strong root structure. The incorporation of mustard oil seed cake has the ability of increasing the essential nutrient contents to improve the physiochemical properties of soil and thus aided growth as well as development of the plants. In the research investigation the fertility status of the soil justifies adding of seed case as organic low-cost soil amendment to improve fertility of soil and thus growth and biomass yield in plants.

The results of this experiment are in agreement with other researchers (Adediran et al.,2005; Cahill et al., 2007; Rafiq et al., 2010; Soro et al.,2015; Jjagwe et al., 2020 those who found that slow releasing organic fertilizer has a positive impact more than the inorganic fertilizer to improve nitrogen use efficiency (NUE) and boost the growth, development and yield of maize crops

In the experiment, fertilizers were applied at 2.6% and 3.5% of soil weight in Treatment 1 and 2, found to be the perfect doses of fertilizer for the maize yield compared to controlled and other treatments.

The results indicated that the application of organic fertilizer significantly affected the plant morphology as plant height, leaf length including node and internode/plant, fresh and dry weight of straw and root yields, in both the cultivars, and found more in hybrid yellow compared to/ hybrid purple. The interaction between seed cake (at different doses) recorded the highest values for most of the parameter at T1 and T2 during the 3 months of experiment at lab scale.

The result shows that under controlled environment morphological parameters and biomass yield and its components of maize were maximum when fertilized with moderately higher amount of seed cake, mostly at T1 and T2 treatments, indicated considerable increases at vegetative growth and the plant biomass components and had the greatest decrease under deficiency, however leaf no showed not much decreased under fertilizer deficiency as T0 shows some tendency of the crop to adjust with lower fertilizer levels in production of leaves for photosynthesis activities in plants

It is evident from the results that the moderate fertilizer treatments in yellow hybrid performed better in boosting the maize growth including parameters of shoot and root development

So, based on the result it can be concluded that T1 and T2 treatment is the best fertilizer treatment for the hybrid yellow maize yield.

Fig 14. Harvested hybrid yellow and hybrid purple cultivar after 3 months

Hybrid yellow found healthier compared to hybrid purple in terms of above ground and belowground parts of the plants (Fig 14)

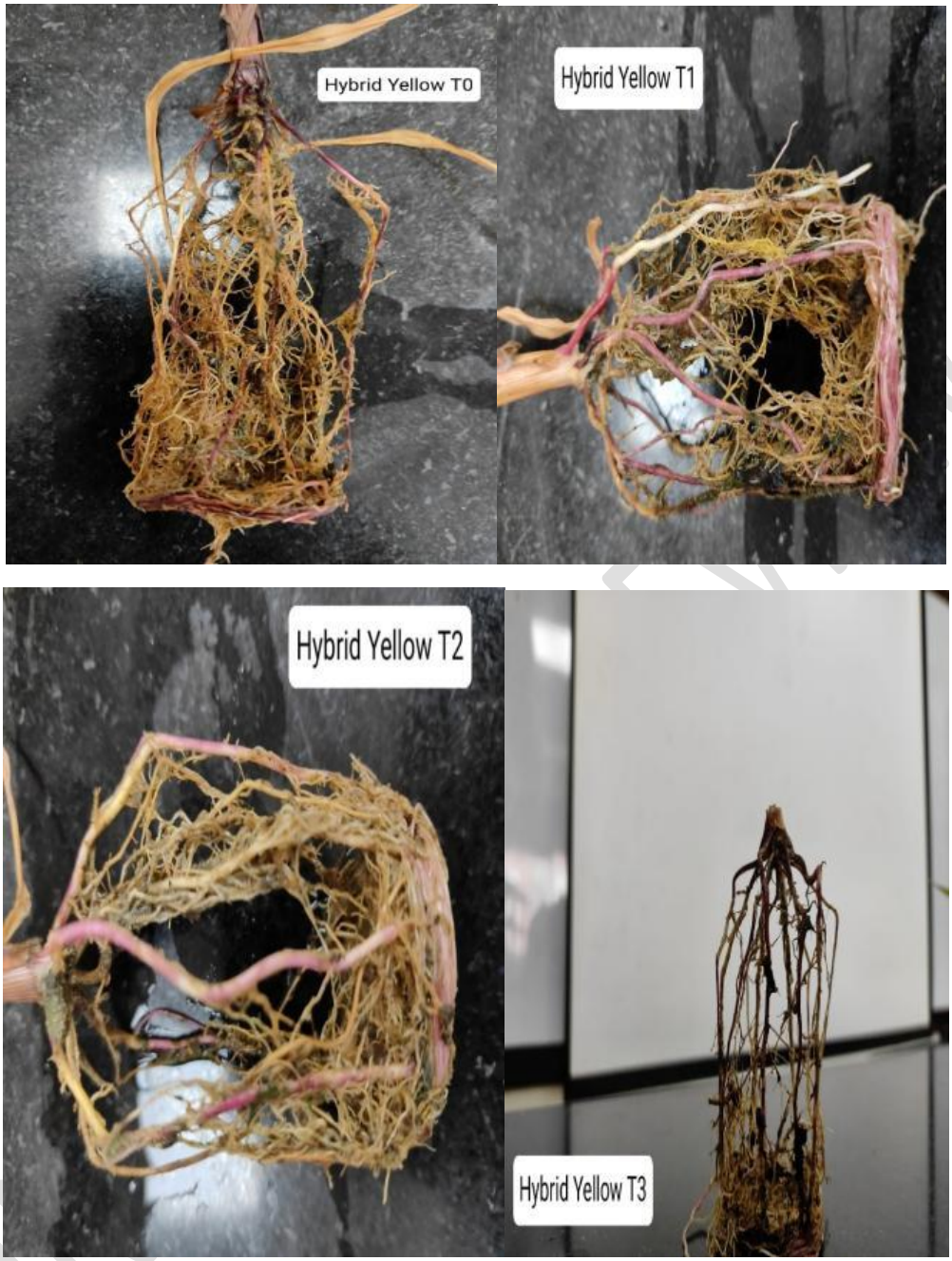


Fig 15. Root structures of Hybrid yellow with different treatments (after harvesting)

Root structures of hybrid yellow found more stronger compared to hybrid purple (Fig 15 and 16)

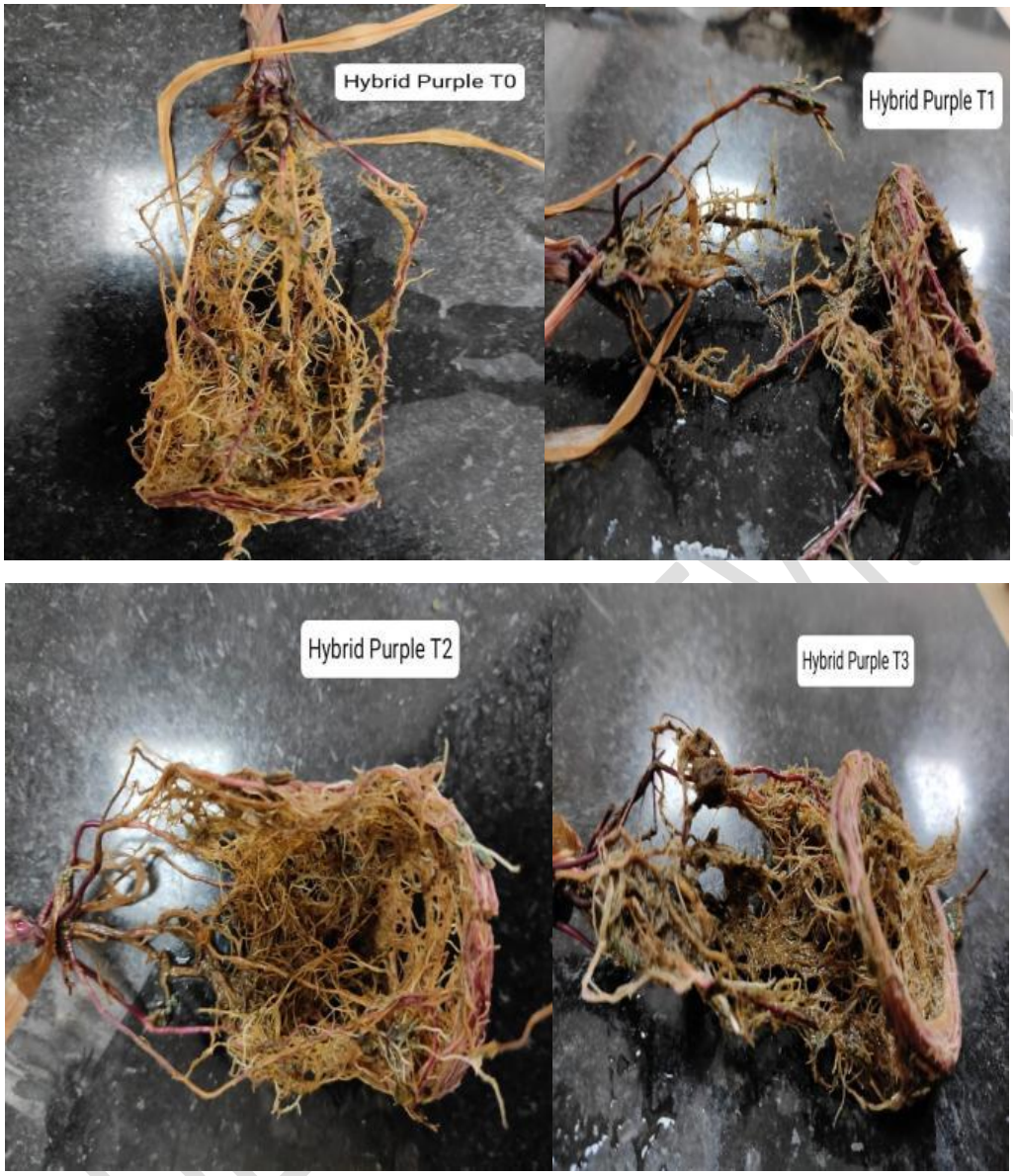


Fig 16. Root structures of Hybrid purple with different treatments (after harvesting)

Conclusion:

At fertilizer treatments T1 and T2, the cost will be deducted and production will be increased, maximum benefits at a minimum cost. For this reason, it will be very helpful for the small farmers as well as the general people who want to grow maize in the pot or on rooftop gardens in an effective way. The findings will serve as a stepping stone for more studies on maize cultivation in the future that will consider our limitations and find variable solutions.

From the results it is found that organic fertilizer application can provide significant positive enhancement to maize growth and development as compared to duration especially in vegetative growth and biomass yield. It is recommended that moderate application of mustard oil seed cake as organic fertilizer should be encouraged to the farmers for vegetative growth of maize at the expanse of dry matter production. So, based on the result it could be concluded that in a developing country like Bangladesh, effective fertilizer treatment could be cost-effective with resourceful output in large agricultural areas to maintain their sustainability.

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