Fundamental and Applied Agriculture
Vol. 7(4), pp. 276–284: 2022
doi: 10.5455/faa.93286

HORTICULTURE | ORIGINAL ARTICLE

Enhancing growth and yield of squash (*Cucurbita pepo* L.) through mulching and inorganic fertilizers

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ARTICLE INFORMATION

Article History
Submitted: 18 Oct 2022
Accepted: 22 Dec 2022
First online: 30 Dec 2022

Academic Editor
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ABSTRACT

An experiment was carried out to evaluate the effects of mulching and inorganic fertilizers on growth and yield of squash at the Horticultural Farm of the Bangladesh Agricultural University, Mymensingh during the period from November 2021 to February 2022. The experiment consisted of three types of mulching *viz.*, M0 (Control), M1 (Black polythene) and M_2 (Rice straw), and five levels of inorganic fertilizers *viz.*, T0 = Control, T1 = N : P : K: S @ 70: 70: 80: 10 kg/ha, T2 = N : P : K: S @ 80: 80: 90: 15 kg/ha, T3 = N : P : K: S @ 90: 90: 100: 20 kg/ha, T4 = N : P : K: S @ 100: 100: 110: 25 kg/ha. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The highest yield per plot (6.06 kg) and highest yield per hectare (33.65 t) were observed from M1 (Black polythene) while the lowest yield per plot (4.11 kg) and yield per hectare (22.85 t) were found from M0 (Control). T3 treatment (N: P: K: S @ 90: 90: 100: 20 kg/ha) produced the maximum yield per plot (7.14 kg m^{-2}) and yield per hectare (39.65 t) while T0 (Control) treatment produced the minimum yield per plot (3.22 kg m^{-2}) and yield per hectare (17.86 t). The maximum yield per plot (8.36 kg) was obtained from M1T3 (Black polythene and N: P: K: S @ 90: 90: 100: 20 kg/ha) treatment while the minimum yield per plot (2.14 Kg) was recorded from M0T0 (Control) treatment. The maximum yield per hectare (46.43 t) was obtained from M1T3 (Black polythene and N : P : K: S @ 90: 90: 100: 20 kg/ha) treatment while the minimum yield per hectare (11.89 t) was recorded from M0T0 (Control) treatment. Therefore, combined application of black polythene mulch along with N : P : K: S @ 90: 90: 100: 20 kg/ha was found to be better in respect of growth and yield of squash compared to other treatments.

Keywords: Mulching, inorganic fertilizer, growth, yield, squash

Cite this article: Islam Z, Rashid MHA. 2022. Enhancing growth and yield of squash (*Cucurbita pepo* L.) through mulching and inorganic fertilizers. Fundamental and Applied Agriculture 7(4): 276–284. doi: 10.5455/faa.93286

1 Introduction

Squash (*Cucurbita pepo* L.) belongs to the family Cucurbitaceae is grown throughout the world in both temperate and tropical climatic zones. Squash has various health benefits to human as well as medicinal potentials (Sarhan et al., 2011). It is rich in nutrients and bioactive compounds contents such as phenolics, flavonoids, vitamins (including β-carotene, vitamin A, vitamin B2, α-tocopherol, vitamin C, and vitamin E), amino acids, carbohydrates and minerals (especially potassium), and it is low in energy content (about 17 Kcal/100 g of fresh squash) and has large amount of fiber (Tamer et al., 2010).

In Bangladesh, this crop is relatively new but is increasingly gaining high levels of economical importance both in generation of income and provision of nutritional value. It is known as Zucchini in Europe and as Kochi in Saudi Arabia. It is tasty, high yielding, short-lived pumpkin tribe vegetable. Two colours of squash are found in Bangladesh like green and yellow. Squash is generally cooked or fried before eating. Because of being a new to the vegetable list, the profits become double than other crops. Squash is cultivated in Bangladesh during the winter season. Squash farm-

ing becomes a new trend to the Bangladeshi farmers though it is known as a foreign vegetable. However, the yield and quality of squash is low in Bangladesh because of environmental condition, lack of soil moisture, recurrent use of intercultural practices and judicious application of inorganic fertilizers, etc.

For squash cultivation mulching is an important alternative to organic fertilizers and increases the soil temperature, conserves soil moisture, texture and fertility (Iqbal et al., 2020). Organic mulches are better than any other mulch materials because they provide nutrients and water to newly grown plant roots. When done correctly, mulching returns about 4% nitrogen, 2% potassium, and 1% phosphorus. Those are the same three nutrients contained in virtually every fertilizer. In essence, mulching can feed your lawn 25% of its total nutritional needs for the year, which is enough to cut out one entire fertilizer treatment. Application of different mulches such as black polythene, water straw, water hyacinth, saw dust, leaves, hay, shredded bark, shells, woodchips, newspaper, cardboard etc. has been reported to have improved fruit quality, increased growth and subsequent yield.

Mulching helps to control weeds effectively by reducing physiological functions of weed like germination, root, shoot and stem growth etc., ultimately reduce the production cost (Duppong et al., 2004). The benefits from the use of plastic mulches include earlier and higher yields, reduced weed populations, reduced soil evaporation, reduced fertilizer leaching, greater water use efficiency, reduced soil compaction, control of certain pests, and a cleaner harvested product (Lamont, 2017). Squash is cultivated in Bangladesh during the winter season when rainfall is scanty and its growth and development is required optimum temperature within 18-25 °C. Most of the time irrigation and weed management increases the total cost of production of crops and ultimately growers can be frustrated. Mulching can reduce the water loss from the soil by evaporation that can minimize the requirement of water, suppression of weed and is thus, helpful in conserving soil moisture for the succeeding season to produce squash successfully particularly where rainfall and irrigation facilities are limited.

Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh. The plant needs chemical substance to increase its growth. These chemical substances are inorganic fertilizer. Synthetic fertilizer made from perfect strength of solution of micro and macronutrient. Fertilizers are the nutrient source, which will provide sufficient nutrients for the plant growth. Fertilizers are essential for commercial farming and tremendous yields. The optimum doses of inorganic fertilizers (N, P, K, etc.) could increase the nutrient availability and productivity of squash. Fertilizers influenced of plant growth, yield and quality of horticultural crops, particularly color, shape, size, taste, shelf life and processing characteristics. Overall growth and development is highly influenced by different management practices like mulching, inorganic fertilizer and others. With this view in mind, the current experiment was conducted to find out the effects of mulching and inorganic fertilizers on growth and yield of squash.

2 Materials and Methods

2.1 Study location

The experiment was conducted at the Horticultural Farm of Bangladesh Agricultural University, Mymensingh, during the period from November 2021 to February 2022. The experiment was carried out on a medium high land belonging to the soil series of Old Brahmaputra Flood Plain Alluvial Tract (UNDP, 1988) of AEZ - 9. The texture of the soil was silty loam with pH 6.5. The climate of the experimental area was subtropical in nature, which was characterized by high temperature, heavy rainfall, high humidity and relatively long day during the months of April to September and low rainfall associated with moderately low temperature, low humidity and short day during the rest of the year.

2.2 Plant materials

Hybrid squash seeds were used for this experiment named 'Alaska seed'. Certified seed of Alaska variety were collected from local market, Mymensingh.

2.3 Experimental design and layout

The experiment comprised three levels M0: Control, M1: Black polythene M2: Rice straw and five levels of different doses of inorganic fertilizer T0 = Control, T1 = N: P: K: S @ 70: 70: 80: 10 kg/ha, T2 = N : P : K: S @ 80: 80: 90: 15 kg/ha, T3 = N : P : K: S @ 90: 90: 100: 20 kg/ha, T4 = N : P : K: S @ 100: 100: 110: 25 kg/ha. The experiment was laid out in randomized complete block design with three replications. Each block consists of 15-unit plots. The total number of plots was 45 ($3 \times 5 \times 3$). The size of a unit plot was 1.8 m^2 (1.5 m $\times$ 1.2 m). Entire block and entire plot distance was 1 m and 0.5 m, respectively.

2.4 Methods of squash cultivation

The land was ploughed and cross-ploughed followed by laddering to obtain good tilth. All the weeds and stubbles were removed from the field. The entire dose of cowdung, TSP, gypsum, zinc, 1/2 dose of MoP and 1/3 dose of urea were applied during final land preparation, the rest of the dose of urea and MoP were applied at 30 and 45 DAP followed sowing according

Plate 1. Different phases of crop matriculation and harvesting

to guidelines of KPH, 2019. The seeds of squash (var. Alaska) were sown on November 21, 2022 maintaining spacing of 50 cm × 50 cm. Mulching was done after 7 days of sowing.

The dibbled seedlings in the experimental plot were treated carefully. Very few seedlings were damaged and new seedlings taking from the border seedlings replaced such seedlings. Replacement was done with healthy seedlings having ball of earth and watering was done for 5 days for their proper establishment. Weeding and irrigation was provided as and when necessary. Dithane M-45 @ 20 g/10 L water was sprayed after complete emergence of the crop at an interval of 15 days as preventive fungicide. At 40 and 55 DAS Metaril 72 WP @ 10 g/10 L water was applied as a protective fungicide. Darsbun 20 EC and Imitaf 20 SL @ 2 mL/L water was applied at 40 and 60 DAS to control insects. Mature fruits at proper size were harvested at 60 DAS by hand picking when the plants became mature. The crop was harvested on January 20 and February 02, 2007 as per treatment specifications. Different stages of crop cultivation are shown in Plate 1.

2.5 Statistical analysis

The data in respect of growth and yield characteristics were statistically analyzed using MSTAT computer program to find out the statistical significance of the experimental results. The means of all the treatments were calculated and the analysis of variance was performed by F (Variance ratio) test (Gomez and Gomez, 1984). The differences among the treatment means were evaluated by Least Significant Difference (LSD) test at 1 and 5% levels of probability.

3 Results and Discussion

3.1 Plant height

Plant height is an important character of squash plant. Plant height was recorded at 30, 40, 50, and 60 days after sowing (DAS). The plant height was increased gradually during growth stages. The tallest plant (49.34 cm) was recorded from black polythene mulch and the shortest (45.99 cm) was recorded from control at 60 DAS (Fig. 1). The application of different levels of inorganic fertilizers markedly influenced the height of plant. The plant height was increased gradually with the advancement of time and continued up to 60 DAS. The maximum plant height (55.92 cm) was recorded from the application of T3 (N : P : K: S @ 90: 90: 100: 20 kg/ha) treatment and the lowest (40.67 cm) was obtained from the T0 (Control) at 60 DAS (Fig. 2). Black polythene mulch maintained higher moisture content and a more uniform temperature than control soil, which ultimately promoted plant growth (Sakthivel et al., 2019). The combined effects of different doses of mulching and inorganic fertilizers on plant height were found to be statistically significant at different DAS. The maximum plant height (59.60 cm) was obtained from the treatment combination of M1T3 (Black polythene and N : P : K: S @ 90: 90: 100: 20 kg/ha) and the lowest (40.20 cm) one was recorded with the treatment combination of M2T0 (data not presented). The present findings are similar to the results as replied by Bhatt et al. (2011).

3.2 Number of leaves per plants

Good foliage indicates higher growth, development and productivity of plant and the number of leaves per plant at maximum vegetative stage was significantly influenced by mulching (Joshi et al., 2022). The maximum number of leaves per plant (39.52) was acquired from the black polythene and the lowest (35.96) was found from control mulch at maximum vegetative stage (Fig. 3). The number of leaves per plant was increased mainly for black polythene, which helps for conserving soil moisture and high temperature. The number of squash leaves per plant also showed highly significant response to different levels of inorganic fertilizers. The maximum number of leaves per plant (43.37) was noted from T3 (N : P : K: S @ 90: 90: 100: 20 kg/ha) treatment while the lowest number of leaves per plant (31.76) was obtained from T0 (Control) treatment at maximum vegetative stage (Fig. 4). Combined application of mulching and inorganic fertilizers showed statistically significant interaction effect on the number of leaves per plant. The maximum number of leaves per plant (49.18) was produced by the treatment combination of M1T3 (Black polythene and N : P : K: S @ 90: 90: 100: 20 kg/ha) whereas the minimum number of leaves per plant (30.96) was recorded from the treatment combination of M0T0 (control) at 60 DAS at maximum vegetative stage (data not presented). The number of leaves per plant was increased mainly owing to increased vegetative growth of the plant. Most similar findings have also obtained from Ibraheem et al. (2019).

3.3 Number of primary branches per plant

Mulching significantly influenced number of primary branches per plant. The maximum number of primary branches per plant (2.68) was acquired from the black polythene and the lowest (2.16) was found from control mulch at maximum vegetative stage (Fig. 5). The number of primary branches per plant was increased mainly for black polythene which helps for conserving soil moisture and high temperature. The number of primary branches per plant showed highly significant response to different levels of inorganic fertilizers. The maximum number of primary branches

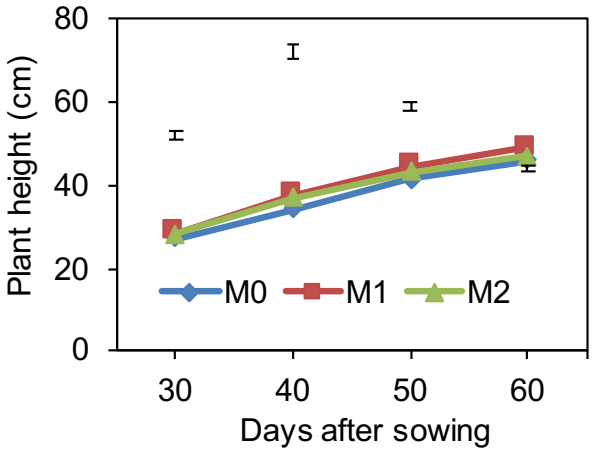

Figure 1. Effect of mulching on plant height of squash plant. Vertical bars represent LSD at 1% level of significance; M0 = Control, M1 = Black polythene, M2 = Rice Straw

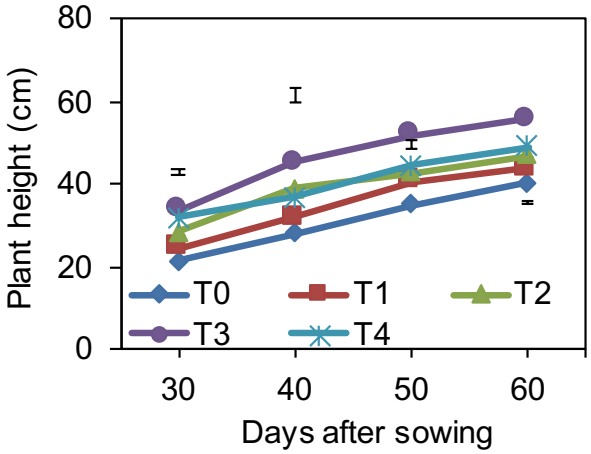

Figure 2. Effect of inorganic fertilizer doses on plant height of squash plant. Vertical bars represent LSD at 1% level of significance; T0 = Control, T1 = N : P : K: S @ 70: 70: 80: 10 kg/ha, T2 = N : P : K: S @ 80: 80: 90: 15 kg/ha, T3 = N : P : K: S @ 90: 90: 100: 20 kg/ha, T4 = N : P : K: S @ 100: 100: 110: 25 kg/ha

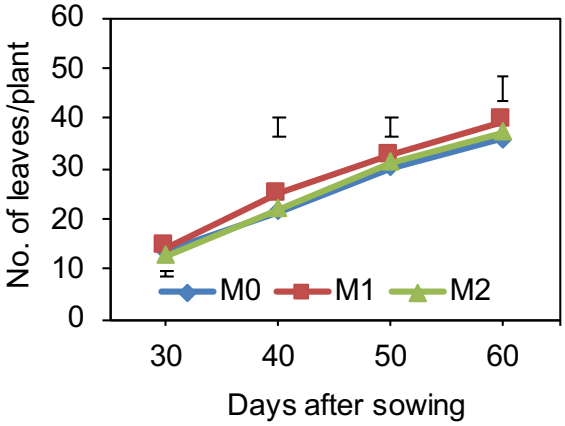

Figure 3. Effect of mulching on number of leaves per squash plant. Vertical bars represent LSD at 1% level of significance; M0 = Control, M1 = Black polythene, M2 = Rice Straw

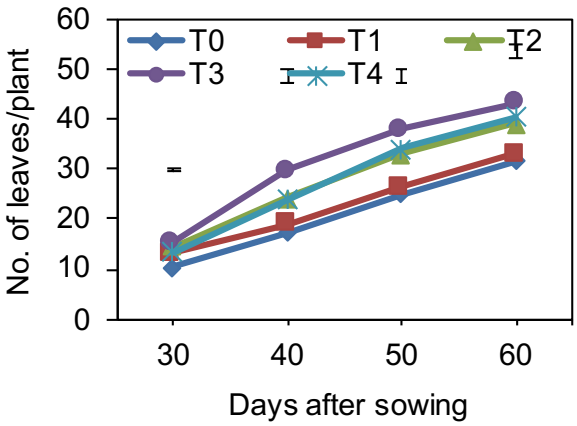

Figure 4. Effect of inorganic fertilizer doses on number of leaves per plant. Vertical bars represent LSD at 1% level of significance; T0 = Control, T1 = N : P : K: S @ 70: 70: 80: 10 kg/ha, T2 = N : P : K: S @ 80: 80: 90: 15 kg/ha, T3 = N : P : K: S @ 90: 90: 100: 20 kg/ha, T4 = N : P : K: S @ 100: 100: 110: 25 kg/ha

per plant (2.99) was noted from T3 (N : P : K: S @ 90: 90: 100: 20 kg/ha) treatment while the lowest number of primary branches per plant (1.77) was obtained from T0 (Control) treatment at maximum vegetative stage (Fig. 6). The number of primary branches per plant was increased mainly owing to increased vegetative growth of the plant. Combined application of mulching and inorganic fertilizers showed statistically significant interaction effect on the number of primary branches per plant. The maximum number of primary branches per plant (3.58) was produced by the treatment combination of M1T3 (Black polythene and N : P : K: S @ 90: 90: 100: 20 kg/ha) whereas the minimum number of primary branches per plant (1.81) was recorded from the treatment combination of M0T0 (control mulch and control fertilizer) at 60 DAS at maximum vegetative stage (data not presented). Most similar findings have also obtained from Kumar and Sharma (2018).

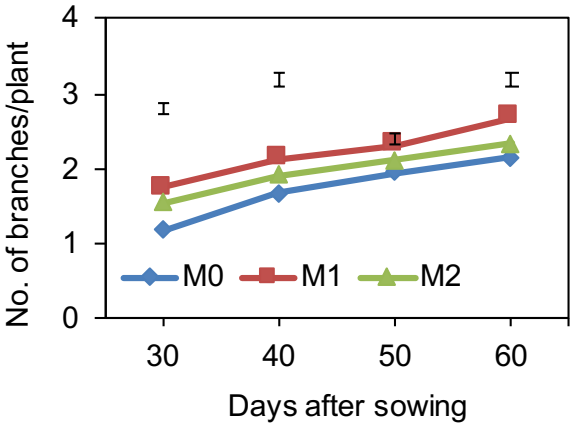

Figure 5. Effect of mulching on number of branches per plant. Vertical bars represent LSD at 1% level of significance; M0 = Control, M1 = Black polythene, M2 = Rice Straw

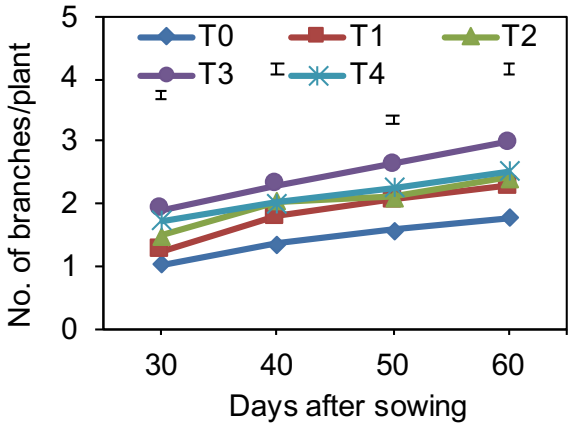

Figure 6. Effect of inorganic fertilizer doses on number of branches per plant. Vertical bars represent LSD at 1% level of significance; T0 = Control, T1 = N : P : K: S @ 70: 70: 80: 10 kg/ha, T2 = N : P : K: S @ 80: 80: 90: 15 kg/ha, T3 = N : P : K: S @ 90: 90: 100: 20 kg/ha, T4 = N : P : K: S @ 100: 100: 110: 25 kg/ha

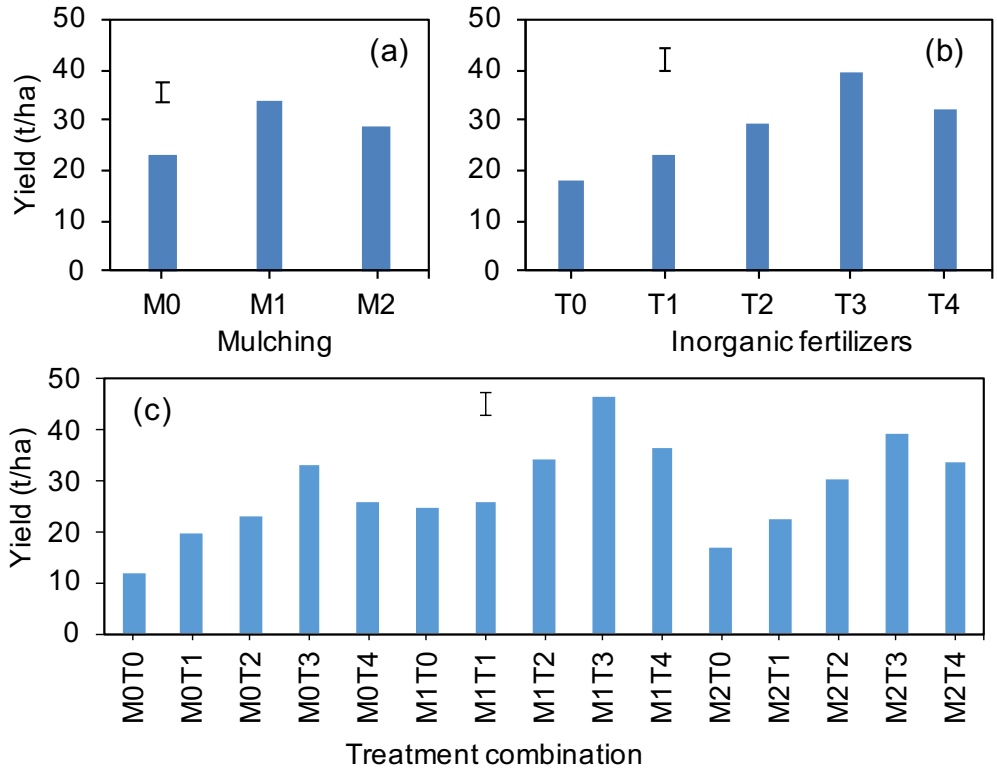

Figure 7. Effect of (a) mulching, (b) inorganic fertilizers, and (c) their interactions on fruit yield per hectare. Vertical bar represents LSD at 1% level of significance; M0 = Control, M1 = Black polythene, M2 = Rice Straw, T0 = Control, T1 = N : P : K: S @ 70: 70: 80: 10 kg/ha, T2 = N : P : K: S @ 80: 80: 90: 15 kg/ha, T3 = N : P : K: S @ 90: 90: 100: 20 kg/ha, T4 = N : P : K: S @ 100: 100: 110: 25 kg/ha

Table 1. Effect of mulching, inorganic fertilizer managment, and their combination on fruit length, fruit diameter, total number of fruits per plant, individual fruit weight and yield per plot of squash

Treatment	Fruit length (cm)	Fruit dia (cm)	Nu. fruits/ plant	Individual fruit wt. (g)	Yield per plot (kg)
Mulching (M)					
M0	20.46	15.82	2.87	280.17	4.11
M1	27.01	18.89	3.27	366.2	6.06
M2	24.37	18.38	3.14	322.01	5.15
$LSD_{0.05}$	0.61	0.55	0.16	10.22	0.26
$LSD_{0.01}$	0.82	0.74	0.21	13.78	0.34
Sig. level	**	**	**	**	**
Fertilizer management (T)					
T0	17.79	13.27	2.64	240.53	3.22
T1	21.05	15.8	2.75	299.12	4.11
T2	22.68	18.19	3.15	332.9	5.28
T3	31.02	21.47	3.65	389.81	7.14
T4	27.2	19.76	3.28	351.61	5.8
$LSD_{0.05}$	0.78	0.71	0.2	13.19	0.33
$LSD_{0.01}$	1.06	0.95	0.27	17.79	0.44
Sig. level	**	**	**	**	**
M × T					
M0T0	14.67	10.93	2.42	177.22	2.14
M0T1	18.6	14.92	2.73	261.65	3.57
M0T2	19.03	15.58	2.89	286.72	4.15
M0T3	25.6	20.07	3.39	355.13	6.01
M0T4	24.4	17.62	2.93	320.13	4.7
M1T0	19.02	13.47	2.83	316.86	4.49
M1T1	22.73	16.27	2.73	340.81	4.64
M1T2	26.87	20.97	3.34	371.37	6.2
M1T3	35.2	22.33	3.94	424.85	8.36
M1T4	31.23	21.4	3.5	377.13	6.6
M2T0	19.68	15.4	2.66	227.52	3.01
M2T1	21.82	16.23	2.79	294.9	4.11
M2T2	22.15	18.02	3.22	340.6	5.49
M2T3	32.27	22	3.62	389.47	7.04
M2T4	25.96	20.27	3.41	357.55	6.1
$LSD_{0.05}$	1.36	1.22	0.35	22.84	0.57
$LSD_{0.01}$	1.83	1.65	0.47	30.82	0.77
Sig. level	**	**	**	**	**

** = Significant at 1% level of probability; M0 = Control, M1 = Black polythene, M2 = Rice Straw, T0 = Control, T1 = N : P : K: S @ 70: 70: 80: 10 kg/ha, T2 = N : P : K: S @ 80: 80: 90: 15 kg/ha, T3 = N : P : K: S @ 90: 90: 100: 20 kg/ha, T4 = N : P : K: S @ 100: 100: 110: 25 kg/ha

3.4 Yield contributing characters and yield

The effect of mulching on fruit length was significant of squash. Data presented in Table 1 showed that highest fruit length (27.01 cm), diameter (18.89 cm), fruits per plants of squash (3.27), maximum fruit weight per plant (366.20 g) and maximum yield per plot were recorded in M1 (Black polythene) and the lowest fruit length (20.46 cm), diameter (15.82 cm), fruits per plants of squash (2.87), minimum fruit weight per plant (280.17 g) and minimum yield per plot (4.11 kg) were recorded in M0 (control). Results showed that the highest fruit length (31.02 cm), diameter (21.47 cm), fruits per plants of squash (3.65), maximum fruit weight per plant (389.81 g) and maximum yield per plot (7.14 kg) were recorded in T3 (N : P : K: S @ 90: 90: 100: 20 kg/ha) treatment and the lowest fruit length (17.79 cm), diameter (13.27 cm), fruits per plants of squash (2.64), minimum fruit weight per plant (240.53 g) and minimum yield per plot (3.22 kg) were recorded from T0 (control) treatment (Table 1). The effect of combined fertilizers with mulching on fruit length found significant. The highest fruit length (35.20 cm), diameter (22.33 cm), fruits per plants of squash (3.94), maximum fruit weight per plant (424.85 g) and maximum yield per plot (8.36 kg) were recorded at M1T3 (Black polythene and N : P : K: S @ 90: 90: 100: 20 kg/ha) treatment and the lowest fruit length (14.67 cm), diameter (5.57 cm), fruits per plants of squash (2.42), minimum fruit weight per plant (177.22 g) and minimum yield per plot (2.14 kg) were recorded in M0T0 (control) treatment (Table 1). The present findings are similar to the results as replied by Mahadeen (2014) and El-Mageed et al. (2016). Akhter et al. (2018) found the highest individual fruit weight (300.4 g), plant variables and fruit yield were obtained with the use of black polythene mulch over rice straw and control treatments. Mulching significantly influenced the yield of squash per hectare. The maximum yield per hectare (33.65 t) was obtained from the M1 (Black polythene) treatment and the lowest yield per hectare (22.85 t) was observed the M0 (Control) treatment (Fig. 7a). Total yield per hectare of squash was significantly influenced by different levels of inorganic fertilizers. The highest yield per hectare (39.65 t) was noted from T3 (N : P : K: S @ 90: 90: 100: 20 kg/ha) treatment while the lowest yield per hectare (17.86 t) was recorded with T0 (Control) treatment (Fig. 7b). The combined effects of mulching and inorganic fertilizers had significant effect on the yield per hectare of squash. The highest yield per hectare (46.43 t) was found from the treatment combination of M1T3 (Black polythene and N : P : K: S @ 90: 90: 100: 20 kg/ha) while the lowest yield per hectare (11.89 t) was observed from the treatment combination of M0T0 (control) (Fig. 7c). Coolong (2010) found the highest plant height, fruit length and diameter, individual fruit weight, number of fruits per plant and yield were obtained from black polythene mulch while the lowest obtained from control. These results were in agreement with Ibraheem et al. (2019). Sarhan et al. (2011) found the highest length and diameter of squash over others and control treatments.

4 Conclusion

Different mulching also significantly influenced all the parameters studied. Different level of inorganic fertilizers played an important role on yield contributing characters and yield of squash. The appropriate combination of mulching and inorganic fertilizers varies according to the system of land use, ecological, social and economic conditions. The system enhances nutrient use efficiency, maintains soil health, enhances yield and reduces cost cultivation. In this experiment, the maximum yield 33.65 t/ha was obtained from the M1 (Black polythene) treatment while the minimum yield 22.85 t/ha was observed from the M0 (Control) treatment. The highest yield 39.65 t/ha was noted from T3 (N : P : K: S @ 90: 90: 100: 20 kg/ha) treatment while the lowest yield 17.86 t/ha was recorded with T0 (Control) treatment. The highest yield 46.43 t/ha was found from the treatment combination of M1T3 (Black polythene + N : P : K: S @ 90: 90: 100: 20 kg/ha). On the other hand, the lowest yield 11.89 t/ha was found from the treatment combination of M0T0 (control). Therefore, it can be concluded that combined application of black polythene mulch along with N : P : K: S @ 90: 90: 100: 20 kg/ha was found to be better in respect of growth and yield of squash compared to other treatments.

Acknowledgments

The authors are thankful to the Ministry of Science and Technology, Peoples Republic of Bangladesh for Providing National Science and Technology (NST) Scholarship.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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The Official Journal of the **Farm to Fork Foundation**
ISSN: 2518–2021 (print)
ISSN: 2415–4474 (electronic)
http://www.f2ffoundation.org/faa