# GROWTH, YIELD AND ECONOMIC BENEFITS OF RADISH AS INFLUENCED BY MANURES AND MULCHING

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## GROWTH, YIELD AND ECONOMIC BENEFITS OF RADISH AS INFLUENCED BY MANURES AND MULCHING

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## ABSTRACT

An experiment was carried out at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period of November 2015 to February 2016 to study the growth, yield and economic benefits of radish as influenced by different organic manures and mulch materials. The experiment consisted of four levels of organic manure *viz*. $T_0$ = Control (No manure), $T_1$ = Cowdung (20 t $ha^{-1}$), $T_2$ = Poultry manure (15 t $ha^{-1}$) and $T_3$ = Mustard oil cake (3 t $ha^{-1}$) and three levels mulch materials *viz*. $M_0$ = Control (No mulch materials), $M_1$ = Black polythene and $M_2$ = Ash. The experiment was laid in Randomized Complete Block Design with three replications. Combined effect of poultry manure @ 15 t $ha^{-1}$ with wood ash as mulch materials represented the best performance in terms of root length (28.1 cm), fresh weight of root $plant^{-1}$ (348.9 g) and fresh weight of whole plant (513.5 g). Gross yield $ha^{-1}$ (43.62 t $ha^{-1}$) and the highest marketable yield $ha^{-1}$ (42.37 t $ha^{-1}$) were also found with wood ash. Highest net return (240645 Tk $ha^{-1}$) with highest BCR (3.45) were also found by the same treatment combination.

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## ABBREVIATIONS AND ACRONYMS

| | | |
|---|---|---|
| AEZ | = | Agro-Ecological Zone |
| BBS | = | Bangladesh Bureau of Statistics |
| BCSRI | = | Bangladesh Council of Scientific Research Institute |
| CV % | = | Percent Coefficient of Variation |
| DAS | = | Days After Sowing |
| DMRT | = | Duncan's Multiple Range Test |
| *et al.,* | = | And others |
| FAO | = | Food and Agricultural Organization |
| LSD | = | Least Significant Difference |
| M.S. | = | Master of Science |
| SAU | = | Sher-e-Bangla Agricultural University |
| NaOH | = | Sodium hydroxide |
| GM | = | Geometric mean |
| USA | = | United States of America |
| WHO | = | World Health Organization |

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# CERTIFICATE

This is to certify that the thesis entitled **“GROWTH, YIELD AND ECONOMIC BENEFITS OF RADISH AS INFLUENCED BY MANURES AND MULCHING”** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE**, embodies the result of a piece of *bona fide* research work carried out by **KAZI SHAFIUL ISLAM,** Registration No. **10-04087** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

**Dated:** June, 2016
**Dhaka, Bangladesh**

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## CHAPTER I

## INTRODUCTION

Radish (*Raphanus sativus* L.) is a vegetable under the family Cruciferae. It is a herbaceous plant. Its stem is called underground-modified root, which is fusiform in shape. Flower may be white or sometimes-pink. Fruit is called pod, which is 3-8 cm long containing 6-12 seeds (Rashid, 1999). Radish is mainly a winter vegetable crop but available in the markets from early September to May. At present it can be grown any time of the year in Bangladesh (Rashid, 1983). The crop is becoming popular day by day among all classes of people. This is one of the top ranking vegetables in Japan, in respect of acreage under cultivation and its consumption (Rashid, 1983). Radish is cultivated everywhere in Bangladesh and is grown mainly as a kitchen garden crop for home consumption. The fleshy root and young leaves are edible portion and nutritionally not so poor as commonly believed. Rashid (1976) mentioned that a hundred gram of edible root contains l% protein, 4% carbohydrate, little fat, 15 calories, negligible vitamin A, 0.03 mg thiamine, 0.03mg riboflavin, 0.30mg niacine, 25mg vitamin C, 30mg calcium and 1.00mg iron. The leaves are also nutritionally rich. 100 g of edible leaf contains 18660 IU vitamin A, 103 mg vitamin C and 310 mg calcium. In Bangladesh the root is eaten mainly in curries or as salad.

Organic manures play major role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization and improving physical and chemical properties of soils (Chaterjee *et al*., 2005). Organic manures such as cowdung, poultry manure, vermicompost and spent mushroom compost (SMC) improves the soil structure, aeration, slow release nutrient which support root development leading to higher growth and yield of radish (Abou *et al*., 2006). Cowdung contain 0.5-1.5% N, 0.4-0.8% P and 0.5-1.5% K, poultry manure contain 1.6% N, 1.5% P and 0.85% K. Mustard oil cake contain 5% N, 1.8% P and

1.2% K. It is a matter of fact that the modern agriculture is based on the use of high yielding varieties of seeds, chemical fertilizer, irrigation water, pesticides etc. to satisfy the ever growing demand for food grains not only to fulfil the problem of food security but also to earn foreign exchange at the cost of environmental quality which cannot be sustainable in future because of the adverse changes being caused to the environment and ecosystem (IJIRSET, 2014).

Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. Organic matter reduces soil erosion, increasing water holding capacity and physio-chemical and biological conditions of the soil (Anonymous, 1983). It is economically feasible to practice when the farmers are able to get premium price for their product. The cost of cultivation will be reduced by not depending upon the purchased off-farm inputs (IJIRSET, 2014).

Mulching is an agricultural and horticultural technique and this technique is very useful in protecting the roots of the plants from heat and cold. Mulch is used to cover soil surface around the plants to create congenial condition for the growth. This may include temperature moderation, reduce salinity and weed control. It exerts decisive effects on earliness, yield and quality of the crop. Mulching is also applicable to most field crops. However, it is preferred in fruit orchard, flower and vegetable production, nurseries and forest where frequent cultivation is not required for raising the crops (Bhardwaj, 2013). Mulching is an important practice that reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and reduces water evaporation. Thus, it facilitates more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops (Dilip Kumar *et al.,* 1990). Therefore, mulching may be helpful in conserving soil moisture of the preceding season and may be exploited to produce radish successfully particularly where rainfall and irrigation facilities are scarce. The aim of the investigation was to evaluate the growth and yield performance of radish influenced by organic manures and mulching. Considering above factors, the present study was undertaken with the following objectives:

1) To find out the effect of different organic manures on growth and yield of radish
2) To study the effect of different mulch materials on growth and yield of radish
3) To find out the suitable combination of organic manures and mulch material on growth and yield of radish
4) To find out the economic benefits with the consideration of different organic manures and mulch materials

# CHAPTER II

# REVIEW OF LITERATURE

Radish (*Raphanus sativus* L.) is a plant which is important vegetables of the world as well as Bangladesh. It received much attention to the researchers of different countries including Bangladesh. Like many other root and tuber crops, the growth and yield of radish are influenced by organic nutrients and different mulch application. Different factors like type of soil, temperature, soil moisture are involved with organic nutrients and mulch products which ultimately influence the growth and yield of a crop. Radish is also known to be a heavy absorber of soil moisture which should be ensured through proper soil moisture management such as irrigation and organic manures. But irrigation is a costly practice and organic manure uses of mulch may be an alternative proposition for successful radish production. There is a little combined research work to the influence of organic manures and mulch practices on growth and yield of radish in Bangladesh. The literature related to the present study is reviewed in this chapter.

## 2.1 Effect of organic manure

The organic manure not only provides nutrients to plants but also improves the soil texture by binding effect to soil aggregates. Organic manure increases CEC, water holding capacity and phosphate availability of the soil, besides improving the fertilizer use efficiency and microbial population of soil; it reduces nitrogen loss due to slow release of nutrients (Kumari *et al*. (2017).

Kumari *et al*. (2017) conducted a field experiment to identify the "Effect of organic, inorganic fertilizers and plant densities on performance of radish (*Raphanus sativas* L.)". The experiment consisted three treatment of organic manures (control, VC @ 5 t/ha and FYM @ 15 t/ha) and two treatment of plant densities (20 x 10 cm and 30 x 10 cm). Results indicated that application of vermicompost @ 5 t/ha significantly higher yield attributes, yield and quality of radish over control.

Kumar *et al*. (2014) conducted a field experiment to study the influence of organic source of nutrients on growth and yield of radish cv. Japanese White. The experiment consisted of 11 treatments laid out in randomized block design with three replications. It was seen that the plant height was significantly increased by the application of organic manures and it was maximum under treatment of vermicompost + poultry manure (50% each). Similarly, vermicompost+poultry manure 50% each recorded highest number of leaves. Root length and root diameter were significantly influenced by organics at harvest. Highest root length (18.91 cm) and better fresh and dry weight of plant was recorded with vermicompost (50%) + poultry manure (50%). The study suggested that application of poultry manure (50%) + vermicompost (50%) was found more beneficial and significantly improved growth and yield of radish var. Japanese White grown under Lucknow condition.

Kezia and David (2013) conducted a field experiment to study the effect of various compositions of organic, inorganic fertilizers and their interactions on the growth of white radish plant. Four unique combinations of organic and inorganic fertilizers were applied. The parameters measured to study the growth are weight, number of leaves and the length of the bulb. The study reveals that inorganic fertilizer had significant impact on the weight and number of leaves but not on the length of the root of the radish plant. The individual and interaction of the organic and inorganic fertilizers had a significant effect on the length of the root of the radish plant.

Among different combinations of FYM (10, 15 and 20 t ha-1), vermicompost (0.5 and 1.0 t $ha^{-1}$) and neem cake (0.5 and 1.0 t $ha^{-1}$), Umesha et al. (2012) recorded the maximum plant height, total dry matter, fresh and dry herbage yield with the application of FYM ® 20 t $ha^{-1}$ + vermicompost ® 1.0 t $ha^{-1}$+ neem cake @ 1.0 t $ha^{-1}$ in Solanum nigrum. Ranuma *et al.* (2012) recorded the highest plant height and leaf yield in mulberry with vermicompost application.

Juan *et al*. (2010) observed radish plant height and yield with the treatments were combinations of cultivars (25 and 19), cattle manure doses (0, 25, 50, and 75 t $ha^{-1}$ dry basis) and N doses (0, 60, 120 and 180 kg $ha^{-1}$). Increased cattle manure and urea doses provided higher plant height and commercial yield in both cultivars, but the N produced more significant effects than the cattle manure. The maximum commercial yield of cultivar (cv) 19 (20.34 t $ha^{-1}$) was obtained using 75 t $ha^{-1}$ of cattle manure and 139 kg $ha^{-}$

$^{1}$ of N, whereas that of cv 25 (11.90 t $ha^{-1}$) occurred with 75 t $ha^{-1}$ of cattle manure and 180 kg $ha^{-1}$ of N. The maximum economic efficiency doses for cv. 25 were 65.1 t $ha^{-1}$ and 180 kg $ha^{-1}$ of cattle manure and N, respectively, whereas those for cv 19 were 63.6 t $ha^{-1}$ and 144.7 kg $ha^{-1}$ of cattle manure and N, respectively.

Japanese radish in the treatment plots were 90 to 95 per cent of the yield obtained in the control plot. N content in Pak-Choi and Japanese radish was highest in the control plot and lowest in plots treated with 3 t farmyard manure. Nitrate nitrogen concentration of the vegetables decreased with decrease in N application. Whereas, the total sugar content increased. Ascorbic acid content increased with application of farmyard manure.

Reddy and Reddy (2005) found the effect of different levels of vermicompost (0, 10, 20 and 30 t/ha) and nitrogen fertilizer (0, 50, 100, 150 and 200 kg/ha) on the growth and yield of onion (cv. N-53) and their residual effects on succeeding radish in an onion-radish (cv. Sel-7) cropping system with a study. The plant height, number of leaves per plant, leaf area, bulb length, diameter and weight and yield of onion increased significantly with increasing level of vermicompost (from 10 to 30 t/ha) and nitrogen fertilizer from 50 to 200 kg per ha. A similar increase in radish yield was also observed due to the residual effect of different levels of vermicompost and nitrogen applied to the preceding crop (onion). Among the various treatment combinations, vermicompost at 30 t per ha plus 200 kg N per ha recorded the highest plant height and number of leaves per plant with the treatment with vermicompost at 30 t per ha + 50 kg N per ha in terms of bulb length, bulb weight and onion yield were recorded.

Zhou-Dongmei *et al*. (2005) evaluated the effect of livestock and poultry manures on growth of radish (*Raphanus sativus* L.) and pakchoi (*Brassica chinensis* L.). The results exhibit that the manure improved the growth of radish and pakchoi. In addition, application of the livestock and poultry manure significantly increased soil pH and electrical conductivity (EC) compared with the control which ascribed that these manures had high pH and contained large amounts of inorganic ions.

Bakthavathsalam *et al*. (2004) observed the vegetative growth of radish using vermicomposts obtained from the culture study of earthworm (*Lampito mauritii*) using paddy chaff and weed plants. The results revealed a different effect on the height and weight of radish plant cultivated in fresh organic manures and vermicompost. Plants that were grown in PSR media of fresh organic manures showed relatively lesser growth values than the plants raised in vermicompost. The results proved that the application of vermicompost had a positive role on the growth parameters of radish.

Rahman (2000) carried out an experiment at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh, and found that plant height of TPS seedlings was significantly influenced by the application of cowdung. The highest plant height (75.28 cm.) at 100 days was obtained from the highest dose of cowdung (100 t/ha).

Salminen *et al*. (2001) showed the effect of plant growth in carrot with the application of digested poultry slaughterhouse waste as nitrogen source, gave the higher yield. Katyal and chandha (1985) recommend 40 t/ha of FYM for radish besides a high dose of fertilizers.

Anonymous (1977) reported that application of compost to the soil increases water holding capacity, reduces soil erosion and improves the physio-chemical and biological condition of the soil, besides providing with plant nutrients.

Edmond *et al*. (1977) reported that organic matter increases the pore space of the soil and thus improve the rate of gas exchange in the soil.

Russell (1966) emphasized the widely accepted opinion that organic matter plays a positive role on soil productivity and this effect was attributed mainly to the release of nutrients of the organic matter during decomposition to the improvement of soil physio-chemical condition.

Huang *et al*. (1993) found that radish yield was l2.3-15.5 % lower, respectively, in the organic farming system than in the conventional system. Appearance of organic products was poor but eating quality was superior to conventional crops. Net income was lower in the organic system due to higher costs of organic fertilizers and labour. They concluded that yields and pest control in organic farming were unsatisfactory and that an intermediate system (organic plus limited inputs of chemical fertilizers and pesticides) should be used as the first stage of transition from conventional to organic farming.

Kale *et al*. (1991) observed that use of vermicompost is helpful reducing basal dose of fertilizer to 25 percent in tomato, radish, carrot and brinjal.

### 2.2 Effect of mulches

Pongsa-Auntin *et al*. (2007) observed the effects of mulching on soil moisture and temperature and sugar metabolism in Japanese radish (*Raphanus sativus* L.). Radish roots grown in plots with mulch were heavier than those without one. However, the enzyme activity was higher in roots grown in mulched plots. The acid invertase activity in SF gradually increased during growth and development while no specific inclining or decling pattern was found in CWBF. Mulching did not show significant effect the amount of fructose (Fru) and glucose (Glc) contents during growth and development. This soil condition favored the growth of roots as indicated by higher root weight in plants grown in plots with mulch than those without mulch throughout the growing period.

Besides beneficial effects on earliness, polyethylene film as a mulch can enhance plant growth and development, increase yield, decrease soil evaporation and nutrient leaching, reduce incidence of pests and weeds and improve fruit cleanliness and quality yield and finally increase gross return, net return and benefit : cost ratio of fruit and vegetable crops (Lamont, 1993; Farias-Larios and Orozco-Santos, 1997; Walters, 2003; Decoteau, 2007; Diaz-Perez *et al*., 2007; Hutton and Handley, 2007).

The presence of crop residue mulch at the soil-atmosphere interface has a direct influence on infiltration of rainwater and evaporation. Mulch cover reduces surface runoff and holds rainwater at the soil surface thereby giving it more time to infiltrate into the soil (Khurshid *et al*., 2006).

Warm season vegetables such as cucumbers, muskmelons, watermelons, eggplant, peppers, usually respond to mulching in terms of early maturity and higher yields. An early maturity is probably due to maintenance of favourable temperatures during growing season. Black mulch applied to the planting bed prior to planting will warm the soil and promote faster growth in early season, which generally leads to early harvest (Tarara, 2000 and Lamont, 2005).

The practice of applying mulches for the production of vegetables is thousands of years old (Lightfoot, 1994; Rowe-Dutton, 1957). Typically mulching involves placing a layer of material on the soil around the crop of interest to modify the growing environment to improve crop productivity. The primary purpose for using mulches is for weed suppression in the crop to be grown. Mulches typically function by blocking light or creating environmental conditions which can prevent germination or suppress weed growth shortly after germination. However, numerous other benefits are often obtained including: increased earliness, moisture conservation, temperature regulation of the root zone and above-ground growing environment, reduced nutrient leaching, altered insect and disease pressures and in some instances, reduced soil compaction or improved soil organic matter (Lamont, 2005; Lamont, 1993; Ngouajio and McGiffen, 2004; Rowe-Dutton, 1957). The use of mulches typically results in higher yields and quality in vegetable crops enhancing profitability for the grower.

Organic-based mulches such as plant waste, straw, sawdust, and manure have also been used to a great extent for vegetable production. Traditionally, organic mulches have consisted of materials which are locally plentiful. Organic-based mulches can be as diverse as the region in which they are used. For instance, banana (Musa sp.) leaves and water hyacinth (*Eichhornia crassipes*) have been used for mulching different vegetables in Bangladesh (Kayum *et al*., 2008).

After the plastic is laid in the field, transplants can be placed by hand or using a mechanized transplanter. Plastic mulches must fit tightly against the soil; not only to obtain the maximum benefit of heat transfer from mulch to soil; but also because warm air, when trapped under the mulch, can escape through the holes where transplants are placed, desiccating and damaging the crop (Lamont, 2005). Due to the increased productivity of plastic mulches, in-row spacing of plants is often less compared to bare-ground production systems. Crops which may normally be planted in a single row fashion when grown without mulches are often planted in double rows with plastic mulches

(Lamont, 1991). Plant populations per unit area may also be increased in plastic-mulch production systems.

White and black-colored mulches are now coextruded forming white-on-black mulch. This mulch is popular because it combines the weed control properties of black mulches (Johnson and Fennimore, 2005) with the soil cooling properties of white-reflective mulch. Ham *et al*. (1993) reported that white-on-black and silver mulches reflect 48% and 39% of shortwave radiation, respectively. The reflection of shortwave radiation can result in slightly lower root-zone temperatures in reflective mulches compared to bare soil (Diaz Perez, 2010; Diaz Perez *et al*., 2005; Ham *et al*., 1993; Tarara, 2000).

Black plastic is the predominate mulch utilized in vegetable production today. Much of this popularity is due to a lower cost per acre compared to other mulches. However, blackplastic mulch also effectively warms the soil, improving early crop production and eliminates most in-row weed growth. Unlike clear mulches, black plastic absorbs nearly all shortwave radiation to heat the soil (Ham *et al*., 1993). By absorbing radiation, black-plastic mulch heats the soil through conduction. A tightly formed plant bed where the mulch makes consistent contact with the soil is necessary for optimal soil warming (Lamont, 1993; Tarara, 2000). By absorbing nearly all shortwave radiation, the surface temperatures of black plastic mulches can reach 55$^{o}$C (Tarara, 2000). Soil temperatures 10 cm under the mulch may increase 3-5$^{o}$C (Ham *et al*., 1993). Once crop canopies develop, shading of the mulches increases and soil temperatures under mulches often decrease compared to bare-ground treatments. Though weed seeds may germinate under black-plastic mulch, subsequent weed growth is limited, with the notable exception of yellow and purple nutsedges (*Cyperus* spp.) (Patterson, 1998).

Srivastava and Singh (1992) carried an experiment on residual effect of organic mulches and conclude that the residual effect of mulches had not significantly influenced the performance of radish.

An investigated result suggest that mulching could increase crop yield by producing heavier root weight and improve product quality such as sweetness due to higher sucrose content of the roots. In addition, the black polyethylene plastic prevented the flow of evaporation from coming out of the plot (Begum *et al*., 2001).

Beneficial effects of plastic mulches such as conservation of soil moisture, less soil compaction, weed control, higher $CO_2$ levels around the young plants of radish, reduced fertilizer leaching and increased soil temperature have been well documented (Richard and William, 1987 and Dilip Kumar *et al*., 1990). Further the authors opined that mulching boosts the yield by 50 to 70% over no mulching.

The conservation of soil moisture through mulching due to modification of favourable micro-climatic conditions in soil. When soil surface is covered with organic mulch it helps to prevent weed growth, reduce evaporation and increase infiltration of rain water during growing season. In addition plastic mulch helps in shedding excessive water away from the crop root zone during periods of excessive rain fall. This can reduce irrigation frequency and amount of water used; it may help to reduce the incidence of soil moisture related physiological disorders such as blossom end rot in mulberry (Das *et al*., 1990).

Purohit *et al*., (1990) observed that use of polyethylene mulch in the field, increased the soil temperature especially in early spring, reduced weed problems, increased moisture conservation, reduction in certain insect pest population, higher crop yield and more efficient use of soil nutrients.

Crop residues or mulch on the soil surface act as shade; serve as a vapour barrier against moisture losses from the soil, causing slow surface runoff and conserves sufficient water in the soil for better development of crops (Rathore *et al*., 1998).

Hatfield *et al*. (2001) reported a 34-50 percent reduction in soil water evaporation as a result of crop residue mulching. Mulch slows down evaporation and reduces the irrigation requirement (Anonymous, 2003). Chawla (2006), Khurshid *et al*. (2006), Muhammad *et al*. (2009) stated the same results that mulching improves the ecological environment of the soil and it avoids decrease in soil water levels.

Abu-Awwad (1999) showed that covering of soil surface reduced the amount of irrigation water required by the pepper and the onion crop by about 14 to 29 and 70 percent, respectively. Trials conducted in the higher potential areas of Zimbabwe indicated that mulching significantly reduced surface runoff and infiltration (Erenstein, 2002).

As excessive rainfall is shed drained the root zone, fertilizer loss due to leaching is reduced. This is particularly true in sandy soils. This allows the grower to place more pre plant fertilizer in the row prior to planting the crop. Mulching with coconut fronds increased leaf N, P and K content in chilli (Hassan *et al*., 1994).

Mulch protects the surface of the soil against unfavorable factors, reduces nutrient leaching and improves growing conditions for vegetables (Baumann *et al*., 2000; Kolota and Adamczewska- Sowiñska, 2004).

Organic mulches return organic matter and plant nutrients to the soil and improve the physical, chemical and biological properties of the soil after decomposition, which in turn increases crop yield. Soil under the mulch remains loose, friable and leading to suitable environment for root penetration. The organic mulches not only conserve the soil moisture, but they also increase the soil nutrients through organic matter addition (Dilip Kumar *et al*., 1990).

Mulching provides a favourable environment for growth which results in more vigorous, healthier plants which may be more resistant to pest injury. Increase in soil temperature and moisture content stimulate root growth which leads to greater plant growth. Therefore, mulched plants usually grow and mature more uniformly than unmulched plants (Bhardwaj *et al*., 2011; Sarolia and Bhardwaj 2012).

Organic mulches induced earliness in flowering, less days to fruit set and harvest in tomato crop over control (Ravinderkumar and Shrivastava, 1998). Applications of polyethylene films as mulch have shortened growing season and enhanced earliness and yield in different vegetable crops (Goreta *et al*., 2005; McCann *et al*., 2007).

Mulch helps keep fruits clean from contacting the ground, reduces soil rot, fruit cracking and blossom end rot in many cases. The yield and chemical composition of cucumbers, muskmelons, eggplant, were found to be improved. The yield and keeping quality of early potatoes, radish, cabbage and other vegetables may be improved by straw mulch.

Application of straw mulch @ 6 t $ha^{-1}$ increased yield of tomato and okra by 100 and 200 percent, respectively over control (Gupta and Gupta, 1987).

Marketable fruit yield from mulched plot was significantly higher than those produced on bare soil. This difference can be attributed to moisture conservation, higher soil temperature, weed control and increased mineral nutrient uptake in the mulched plot through improved root temperatures as reported by Orozco *et al*. (1994).

Aref *et al*. (1996) reported that application of hairy vetch mulch recorded significantly higher yield of tomato (32 percent) than bare soil. Lourduraj *et al*. (1996) obtained highest number of fruits (42), average fruit weight (31.8 g) and yield (12.73 t $ha^{-1}$) in tomato cv. CO-3 with application of black LLDPE mulch compared to organic and no mulch. Mulching increased crop weight by 16 percent compared with non-mulched plots in leek (Benoit and Ceustermans, 1998).

Thakur *et al*. (2000) reported that the use of different mulches on the performance of *Capsicum annuum* L. under water deficit of 75 percent, the lantana mulch gave the highest fruit yield of 7.34 t $ha^{-1}$ over unmulched plots (3.69 t $ha^{-1}$). They also reported that yield levels increased by 198 percent in plastic mulch, 164 percent in lantana leaves and 141 percent in grass mulched plants over unmulched plants of capsicum. These findings are in agreement with Gangwar *et al*. (2000) who reported that paddy straw mulch on mulberry showed maximum leaf yield (46%) compared to sorghum (32.4%) and blackgram mulching (23.08%) over control.

Vander Zaag *et al*. (1986) observed by providing a physical barrier, mulching reduces the germination and nourishment of many weeds. The mulching operation favours in the reduction of weed seed germination, weeds growth and keeps the weed under control.

Merwin *et al*. (1995) found that covering or mulching the soil surface can prevent weed seed germination or physically suppress seedling emergence. Loose materials such as straw, bark and composted municipal green waste can provide effective weed control.

Waterer (2000) observed that saw dust is a soil improver and weed suppressor as it conserves soil moisture, decreases run-off, increases infiltration and percolation, decreases evaporation and weed growth can be substantial under clear mulch.

Akand (2003) conducted an experiment with mulching and organic manure trial on carrot in BAU, Bangladesh and observed that black polythene mulch and organic manure (cowdung) significantly resulted the highest yield of carrot of his experiment.

# CHAPTER III

# MATERIALS AND METHODS

This chapter deals with the materials used and methodology followed in conducting the experiment. The location of the experiment, climate, materials used and methods followed in different operations during conducting the experiment as well as in data collection are described here under the following sub-heads:

## 3.1 Experimental site

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to February 2016. The site is situated between 23°41′N latitude and 90°22′E longitude and at a altitude of 8.6 m from sea level.

## 3.2 Climate

The experimental area is situated in the subtropical zone, characterized by heavy rainfall during Kharif season (April to September) and scanty in Rabi season (October to March). Rabi season is characterized by plenty of sunshine. Information regarding average monthly maximum and minimum temperature, rainfall, relative humidity and soil temperature as recorded by the Bangladesh Meterological Department (climate division) Agargaon, Dhaka, during the period of study have been presented in Appendix I.

## 3.3 Soil

The soil of the experimental area was medium high land type and belongs to the Modhupur Tract and AEZ No. 28 (FAO, 1988). The analytical data of the soil sample collected from the experimental area were determined from the Soil Resource Development Institute (SRDI), Farmgate, Dhaka have been presented in Appendix II.

### 3.4 Treatments of the experiment

The experiment was designed to study the growth, yield and economic benefits of radish as influenced by different organic manure and mulch materials. The experiment consisted of two factors which are as follows:

**Factor A: Organic manure – 4 treatments**

1. $T_0$ = Control (No manure)
2. $T_1$ = Cowdung (20 t $ha^{-1}$)
3. $T_2$ = Poultry manure (15 t $ha^{-1}$)
4. $T_3$ = Mustard oil cake (3 t $ha^{-1}$)

**Factor B: Mulch materials – 3 treatments**

1. $M_0$ = No mulch materials
2. $M_1$ = Black polythene
3. $M_2$ = Ash

**Combined effect:** There were altogether 12 treatment combinations such as:

$T_0M_0$, $T_0M_1$, $T_0M_2$, $T_1M_0$, $T_1M_1$, $T_1M_2$, $T_2M_0$, $T_2M_1$, $T_2M_2$, $T_3M_0$, $T_3M_1$, $T_3M_2$.

### 3.5 Experimental Materials

Summer white (hybrid variety) of radish will be used as experimental plant material. The seeds of this variety were collected from "Malek Seed Store", Siddique Bazar, Dhaka.

### 3.6 Experimental design and layout

The two-factor experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 117 $m^2$ was divided into three equal blocks. Each block was divided in to 12 plots where 12 treatments were allotted at random. Thus, there were 36 (12 × 3) unit plots altogether in the experiment field. The size of each plot was 1.6 m × 1 m. The distance between blocks and between plots were kept 1m and 0.5 m, respectively. A layout of the experiment is shown in Appendix III.

### 3.7 Land preparation

The land which was selected to conduct the experiment was opened on 20 November, 2015 with the help of a power tiller and then it was kept open to sun for 7 days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. Deep ploughing was done to have a good tilth, which was necessary for getting better yield of this crop. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth.

### 3.8 Manuringing

Crop was fertilized with organic manures which were applied as per treatment. Under the present study Cowdung, Poultry manure and Mustard oil cake were used for the experiment as per treatment.

The following rates of different organic manure were used:

| Organic manure | Doses $ha^{-1}$ | Composition |
|---|---|---|
| Cowdung | As per treatment (20 t $ha^{-1}$) | 0.5-1.5% N, 0.4-0.8% P, 0.5-1.5% K |
| Poultry manure | As per treatment (15 t $ha^{-1}$) | 1.6% N, 1.5% P, 0.85% K |
| Mustard oil cake | As per treatment (3 t $ha^{-1}$) | 5% N, 1.8% P, 1.2% K |

Well-decomposed organic manures were applied to the plots as per treatment. Total amount of organic manure was applied as basal dose during final land preparation. They were mixed with the soil by spading.

### 3. 9 Sowing of seeds

The collected seed sample were soaked in water for 24 hours and then wrapped with piece of thin cloth. The socked seed were then spreaded over polythene sheet for 2 hours to dry out the surface water. This treatment was given to help quick germination of seeds. The treated seeds were sown is field on 28 November 2015.

Seeds were sown in the unit plot maintaining plant spacing of 40cm × 20cm. After germination each unit plot of the experiment field was with 20 plants.

### 3.10 Intercultural operations

#### 3.10.1 Thinning out

Seedlings emergence was completed within ten days and when the attained a height about 20 cm were thinned out two times. First thinning was done after 20 days of sowing. The second thinning was done ten days after first thinning, keeping only one seedling in each hill.

#### 3.10.2 Weeding

Weeding was done four or five times in plots to keep plots free from weeds.

#### 3.10.3 Pest management

Soil of each plot was treated by sevin 85 WP @ 0.2% at 15 days interval for two times to protect the young plants from the attack of field cricket, mole cricket, cutworm and ants.

#### 3.10.4 Diseases management

The crop was healthy and fungicide was used when and as necessary.

### 3.11 Harvesting

Randomly selected five plants were harvested from each plot for data collection. First harvest was done at 40 DAS (days after sowing) and second at 50 DAS, third 60 DAS and finally at 70 DAS. The soil adhering to the roots after harvest was rubbed odd and the roots were cleaned before weighting. The leaves were separated from the roots by a sharp knife and weight of leaves and roots was taken separately.

### 3.12 Data collection

Data were collected on different growth, yield and yield contributing characters. The plants in the outer rows and at the extreme end of the middle rows were excluded from the random selection to avoid the border effect. The following observations were made regarding plant growth, yield and yield attributes as affected by different types of organic manure and mulch materials. The following parameters were recorded:

1. Plant height (cm)
2. Number of leaves plant$^{-1}$
3. Leaf length (cm)
4. Leaf breadth (cm)
5. Fresh weight of leaves plant$^{-1}$
6. Root length (cm)
7. Root Diameter (cm)
8. Fresh weight of root (g)
9. Dry matter (%)
10. Fresh weight of whole plant (g)
11. Gross yield (t ha$^{-1}$)
12. Marketable yield (t ha$^{-1}$)

### 3.13 Procedure of recording data

#### 3.13.1 Plant height (cm)

Plant heights of 5 randomly selected plants were measured in centimeter (cm) by a meter scale at 25, 40, 55 days after sowing (DAS) and at harvest from the bottom of root to the tip of the longest leaf.

### 3.13.2 Number of leaves per plant:

Numbers of leaves of 5 randomly selected plants were counted at 25, 40, 55 days after sowing (DAS). All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. The average number of leaves of 5 plants gave the number of leaves per plant.

### 3.13.3 Leaf length (cm)

Leaf length of five randomly selected plants was measured in centimeter (cm) by a meter scale at 25, 40, 55 days after sowing (DAS) and at harvest from the base to top of the leaf.

### 3.13.4 Leaf breadth (cm)

Leaf breadth of 5 randomly selected plants was measured in centimeter (cm) by a meter scale at 25, 40, 55 days after sowing (DAS) and at harvest. Breadth of leaf was calculated by average distance end to end of mid, top and bottom length of a leaf.

### 3.13.5 Fresh weight of leaves per plant (g)

Leaves were detached by a sharp knife and fresh weight of the leaves was taken by a triple beam balance at harvest and was recorded.

### 3.13.6 Root length (cm)

Root length of five randomly selected plants was measured in centimeter at harvest by a meter scale. The average length of roots of 5 plants gave the length of roots per plant in centimeter.

### 3.13.7 Root Diameter (cm)

Root diameter of 5 randomly selected plants was measured in centimeter at harvest by a virnear scale. The average diameter of roots of 5 plants gave the root diameter per plant in centimeter.

### 3.13.8 Fresh weight of root per plant (g)

Underground modified radish roots of the ten selected plants were detached by uprooting and after cleaning soil and fibrous root fresh weight was taken by a balance. The average weight of roots was expressed as fresh weight of root per plant in gram (g).

### 3.13.9 Dry matter (%) of root

100 g slice fresh weight was randomly collected from each plot to determine the dry matter content of root. Roots were sliced and dried under shading place and kept in an oven at 70°C for 72 hours until constant weight. Finally dry weight was taken with an electric balance and dry matter percentage was calculated by the following formula:

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of root}}{\text{Fresh weight of root}} \times 100$$

### 3.13.10 Fresh weight of whole plant (g plant$^{-1}$) at harvest

Randomly selected five plants were taken from each replication. After cleaning it were weighed with a electric balance. Average weight was then expressed as fresh weight of whole plant. It was expressed in gram per plant.

### 3.13.11 Fresh weight of root per plot (kg)

Total fresh roots from three replication of each treatment was collected and average weight was expressed as fresh weight of roots per plot. It was measured in kg per plot.

### 3.13.12 Gross yield (t ha$^{-1}$)

All leaves were removed from the plant by a sharp knife and weight of the roots was taken in kilogram (kg) by using electric balance from each unit plot. The yield of roots per hectare was calculated in ton by converting the total yield of roots per plot.

### 3.13.12 Marketable yield (t ha$^{-1}$)

It consisted of only good quality roots plot$^{-1}$ other than cracked, rotten or branched roots. The marketable roots were weighed per plot and expressed in kilogram (kg). Marketable yield of roots ha$^{-1}$ was calculated by conversion of the marketable of root yield plot$^{-1}$ and recorded in ton.

$$\text{Marketable root yield (t ha}^{-1}\text{)} = \frac{\text{Root yield per plot (kg)}}{\text{Plot size (m}^2\text{)}} \times 10$$

## 3.14 Statistical analysis

The data obtained from the experiment were analyzed statistically using MSTAT computer package program to find out the significance of the difference among the treatments. The significance of the differences among the pairs of treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984) for the interpretation of results.

### 3.15 Cost and return analysis

Cost and return analysis in detail was done according to the procedure of Alam *el. al*. (1989). The cost production was analyzed in order to finds out most economic value of radish. All input cost and interest on fixed (land) and running capital were considered for computing the cost of production. Gross return, net return and benefit cost ration (BCR) was calculated for the effectiveness of the production system.

#### 3.15.1 Gross return

Gross return was measured by total marketable yield and unit cost of product by the following formula

$$\text{Gross return (Tk. ha}^{-1}\text{)} = \text{Marketable yield (kg ha}^{-1}\text{)} \times \text{unit cost (Tk. kg}^{-1}\text{)}$$

#### 3.15.2 Net return

Net return was measured by total cost of production and total input cost by the following formula

$$\text{Net return (Tk. ha}^{-1}\text{)} = \text{Gross return} - \text{Total cost of production (Tk. ha}^{-1}\text{)}$$

#### 15.5.3 BCR

Benefit cost ratio was measured by total cost of production and gross return by the following formula:

$$\text{BCR} = \frac{\text{Gross return}}{\text{Total cost of production}}$$

# CHAPTER IV

# RESULTS AND DISCUSSIN

The present study was conducted to investigate the growth, yield and economic benefits of radish as influenced by different organic manure and mulch materials. The analysis of variance (ANOVA) of the data on different yield contributing characters and yield of radish as influenced by different organic manure and mulch materials presented in Appendix-IV-IX, Figure-1-8 and Table-1-7. The results on main and combined effect of different treatments have been presented and discussed in this chapter.

## 4.1 Growth parameters

### 4.1.1 Plant height

Plant height at 25, 40, 55 and at harvest was significantly affected by organic manures. Plant height was quickly increased within 25-55 days but after 55 DAS it was increased slowly (Table 1 and Appendix IV). At harvest the tallest plant (45.38 cm) was observed in $T_3$ (Mustard oil cake; 3 t $ha^{-1}$) which was statistically identical with $T_2$ (Poultry manure; 15 t $ha^{-1}$) during the period of plant growth. The shortest plant (35.73 cm) was obtained from the control treatment ($T_0$) followed by $T_1$ (Cowdung; 20 t $ha^{-1}$). It may be that applied manures improve the physical condition of soil which increase the adequate absorption of all the nutrient required by the plant and helpful in increasing the height of the plant. The results obtained from Kumar *et al*. (2014) were conformity with present study. They found that plant height was significantly increased by the application of organic manures and it was maximum under treatment of Vermicompost + poultry manure (50% each).

Plant height was also significantly affected by different mulch materials at different growth stages (Table 1 and Appendix IV). Results revealed that the tallest plant (44.76 cm) was observed from $M_1$ (Black polythene) followed by $M_2$ (Wood ash). The shortest plant (39.48 cm) was obtained from the control treatment $M_0$ (No mulch materials). The increase in plant height due to mulching may be accounted for providing favorable soil moisture and favorable temperature conditions for proper plant growth. Hassan *et al*. (1994) and Yamaguchi *et al*. (1996), Gao *et al*. (2001) and Chawla (2006) also found similar results.

Table 1. Plant height of radish as influenced by different organic manure and mulch materials at different days after sowing

| Treatment | Plant height (cm) | | | |
|---|---|---|---|---|
| | 25 DAS | 40 DAS | 55 DAS | At harvest (70 DAS) |
| *Effect of organic manure* | | | | |
| $T_0$ | 14.02 c | 25.13 c | 34.98 c | 35.73 c |
| $T_1$ | 15.47 b | 27.36 b | 39.87 b | 42.23 b |
| $T_2$ | 16.98 a | 28.67 a | 42.82 a | 45.38 a |
| $T_3$ | 16.22 a | 28.00 a | 41.09 a | 43.20 a |
| $LSD_{0.05}$ | 0.428 | 0.711 | 1.084 | 2.316 |
| CV (%) | 7.579 | 8.326 | 8.729 | 10.544 |
| *Effect of mulching* | | | | |
| $M_0$ | 14.93 b | 26.14 c | 38.24 b | 39.48 c |
| $M_1$ | 15.20 b | 26.92 b | 38.63 b | 40.67 b |
| $M_2$ | 16.88 a | 28.82 a | 42.20 a | 44.76 a |
| $LSD_{0.05}$ | 0.337 | 0.524 | 0.788 | 0.819 |
| CV (%) | 7.579 | 8.326 | 8.729 | 10.544 |

$M_0$ = No mulch materials, $M_1$ = Black polythene, $M_2$ = Ash

$T_0$ = Control (No manure), $T_1$ = Cowdung (20 t $ha^{-1}$), $T_2$ = Poultry manure (15 t $ha^{-1}$), $T_3$ = Mustard oil cake (3 t $ha^{-1}$)

Combined effect of different organic manure and mulch materials on plant height at different growth stages showed significant variation (Table 2 and Appendix IV). At harvest the tallest plant (48.76 cm) was observed from of $T_3M_1$ which closely followed by $T_2M_2$. The treatment combination of $T_1M_2$, $T_2M_1$ and $T_3M_2$ also gave comparatively higher plant height but significantly different from other treatment combinations. At harvest the shortest plant (33.90 cm) was obtained from the control ($T_0M_0$) which was statistically identical with $T_0M_1$ followed by $T_0M_2$ and $T_3M_0$ at all growth stages.

Table 2. Combined effect of organic manure and mulch materials on plant height at different days after sowing of radish

| Treatment | Plant height (cm) | | | |
|---|---|---|---|---|
| | 25 DAS | 40 DAS | 55 DAS | At harvest (70 DAS) |
| $T_0M_0$ | 13.13 f | 24.27 d | 32.73 h | 33.90 e |
| $T_0M_1$ | 14.20 ef | 25.13 cd | 35.07 g | 34.63 e |
| $T_0M_2$ | 14.73 de | 26.00 c | 37.13 fg | 38.67 d |
| $T_1M_0$ | 14.87 de | 26.33 bc | 37.80 f | 40.49 cd |
| $T_1M_1$ | 15.00 de | 26.47 bc | 39.27 ef | 42.49 c |
| $T_1M_2$ | 16.53 bc | 29.27 a | 42.53 cd | 45.27 b |
| $T_2M_0$ | 14.93 de | 26.47 bc | 44.27 bc | 40.77 cd |
| $T_2M_1$ | 15.60 cde | 26.47 bc | 40.40 de | 41.58 c |
| $T_2M_2$ | 17.60 ab | 29.93 a | 44.87 b | 46.33 ab |
| $T_3M_0$ | 16.13 bcd | 27.60 b | 40.80 de | 40.93 cd |
| $T_3M_1$ | 18.67 a | 30.07 a | 48.20 a | 48.76 a |
| $T_3M_2$ | 16.67 bc | 29.27 a | 43.20 bc | 45.79 b |
| $LSD_{0.05}$ | 1.363 | 1.397 | 2.097 | 2.496 |
| CV (%) | 7.579 | 8.326 | 8.729 | 10.544 |

Here,

$T_0$ = Control (No manure)
$T_1$ = Cowdung (20 t $ha^{-1}$)
$T_2$ = Poultry manure (15 t $ha^{-1}$)
$T_3$ = Mustard oil cake (3 t $ha^{-1}$)

$M_0$ = No mulch materials
$M_1$ = Black polythene
$M_2$ = Ash

### 4.1.2 Number of leaves per plant

Number of leaves per plant was significantly affected by different organic manure at different growth stages (Table 3 and Appendix V). Results signified that at harvest the highest number of leaves per plant (17.32) was observed from $T_3$ (Mustard oil cake; 3 t $ha^{-1}$) which was statistically identical with $T_2$ (Poultry manure; 15 t $ha^{-1}$). The lowest number of leaves per plant (14.66) was obtained from the control treatment ($T_0$). The reason for maximum number of leaves per plant might be due mustard oil cake improves the physical condition of soil which increase the water holding capacity and better nutrient availability which uptake by the crop. This finding was also supported by Reddy and Reddy (2005) and Bakthavathsalam *et al*. (2004).

Significant variation was found from number of leaves per plant affected by different mulch materials at different growth stages (Table 3 and Appendix V). Results exposed that at harvest the highest number of leaves per plant (17.48) was observed from $M_2$ (Wood ash) which is statistically different from other treatment. The lowest number of leaves per plant (15.37) was obtained from the control treatment, ($M_0$). The higher number of leaves per plant obtained due to mulching may be attributed to high plant growth caused by the advantageous condition utilized by the plant.

Table 3. Number of leaves per plant of radish as influenced by different organic manures and mulch materials at different days after sowing

| Treatment | Number of leaves per plant | | | |
|---|---|---|---|---|
| | 25 DAS | 40 DAS | 55 DAS | At harvest (70 DAS) |
| *Effect of organic manure* | | | | |
| $T_0$ | 4.93 c | 9.42 c | 15.71 c | 14.66 c |
| $T_1$ | 5.22 b | 10.33 b | 14.89 b | 16.32 b |
| $T_2$ | 5.53 a | 10.64 a | 15.71 a | 16.90 a |
| $T_3$ | 5.55 a | 10.82 a | 15.96 a | 17.32 a |
| $LSD_{0.05}$ | 0.188 | 0.247 | 0.411 | 0.609 |
| CV (%) | 7.881 | 8.353 | 6.743 | 9.416 |
| *Effect of mulching* | | | | |
| $M_0$ | 5.10 b | 9.75 b | 15.15 b | 15.37 c |
| $M_1$ | 5.22 b | 10.05 b | 15.45 b | 16.05 b |
| $M_2$ | 5.62 a | 11.12 a | 16.10 a | 17.48 a |
| $LSD_{0.05}$ | 0.365 | 0.328 | 0.414 | 0.439 |
| CV (%) | 7.881 | 8.353 | 6.743 | 9.416 |

$M_0$ = No mulch materials, $M_1$ = Black polythene, $M_2$ = Ash

$T_0$ = Control (No manure), $T_1$ = Cowdung (20 t $ha^{-1}$), $T_2$ = Poultry manure (15 t $ha^{-1}$), $T_3$ = Mustard oil cake (3 t $ha^{-1}$)

Combined effect of different organic manure and mulch materials on number of leaves per plant was significant (Table 4 and Appendix V). At harvest the maximum number of leaves per plant (18.78) was observed in $T_2M_2$ which is statistically identical with $T_3M_2$. On the other hand, the lowest number of leaves per plant (13.77) was obtained from the control treatment combination $T_0M_0$ which was closely followed by $T_0M_1$.

Table 4. Combined effect of organic manure and mulch materials on number of leaves per plant at different days after sowing of radish

| Treatment | Number of leaves per plant | | | |
|---|---|---|---|---|
| | 25 DAS | 40 DAS | 55 DAS | At harvest (70 DAS) |
| $T_0M_0$ | 4.87 d | 9.00 f | 13.47 e | 13.77 g |
| $T_0M_1$ | 4.93 cd | 9.53 ef | 14.07 e | 14.86 f |
| $T_0M_2$ | 5.00 cd | 9.73 e | 16.93 ab | 15.35 ef |
| $T_1M_0$ | 5.00 cd | 9.87 e | 16.73 ab | 15.52 ef |
| $T_1M_1$ | 5.20 cd | 10.00 de | 14.47 de | 16.02 de |
| $T_1M_2$ | 5.47 bc | 11.13 bc | 16.13 bc | 17.42 b |
| $T_2M_0$ | 5.20 cd | 10.00 de | 14.33 de | 15.62 def |
| $T_2M_1$ | 5.33 bcd | 10.00 de | 15.27 cd | 16.30 cde |
| $T_2M_2$ | 6.13 a | 11.93 a | 17.53 a | 18.78 a |
| $T_3M_0$ | 5.33 cd | 10.13 de | 15.27 cd | 16.56 bcd |
| $T_3M_1$ | 5.40 bcd | 10.67 cd | 15.33 cd | 17.02 bc |
| $T_3M_2$ | 5.87 ab | 11.67 ab | 17.27 a | 18.38 a |
| $LSD_{0.05}$ | 0.4908 | 0.6941 | 1.007 | 0.9181 |
| CV (%) | 7.881 | 8.353 | 6.743 | 9.416 |

$T_0$ = Control (No manure)
$T_1$ = Cowdung (20 t $ha^{-1}$)
$T_2$ = Poultry manure (15 t $ha^{-1}$)
$T_3$ = Mustard oil cake (3 t $ha^{-1}$)

$M_0$ = No mulch materials
$M_1$ = Black polythene
$M_2$ = Ash

### 4.1.3 Leaf length

Leaf length was significantly affected due to different organic manure at different growth stages (Table 5 and Appendix VI). At harvest the highest leaf length (34.78 cm) was observed from $T_3$ (Mustard oil cake; 3 t $ha^{-1}$) which was statistically identical with $T_2$ (Poultry manure; 15 t $ha^{-1}$). The lowest leaf length

(29.16 cm) was obtained from the control treatment $T_0$ (no manure). Mustard oil cake supplied adequate plant nutrient for vegetative growth of the plant and this due to increase leaf length. Dilip Kumar *et al.* (1990) reported that organic mulching not only conserve the soil moisture but they also increase the soil nutrient through organic matter addition. Similar results was also observed by Reddy and Reddy (2005).

Leaf length was also significantly influenced by different mulch materials at different growth stages (Table 5 and Appendix VI). Results revealed that the highest leaf length (34.87 cm) was observed from $M_2$ (Ash) where the lowest leaf length (30.20 cm) was obtained from the control treatment ($M_0$). Similar results was also found by Chawla (2006).

Table 5. Leaf length of radish as influenced by different organic manures and mulch materials at different days after sowing

| Treatment | Leaf length (cm) | | | |
|---|---|---|---|---|
| | 25 DAS | 40 DAS | 55 DAS | At harvest (70 DAS) |
| *Effect of organic manure* | | | | |
| $T_0$ | 13.02 c | 24.22 c | 29.25 d | 29.16 d |
| $T_1$ | 14.69 b | 25.69 b | 32.95 c | 32.77 c |
| $T_2$ | 15.45 a | 26.55 a | 33.92 b | 33.76 b |
| $T_3$ | 15.58 a | 26.94 a | 34.72 a | 34.78 a |
| $LSD_{0.05}$ | 0.624 | 0.688 | 0.753 | 0.817 |
| CV (%) | 8.571 | 9.328 | 7.144 | 8.538 |
| *Effect of mulching* | | | | |
| $M_0$ | 13.48 c | 24.68 c | 30.28 c | 30.20 c |
| $M_1$ | 14.80 b | 25.95 b | 32.84 b | 32.79 b |
| $M_2$ | 15.77 a | 26.92 a | 35.01 a | 34.87 a |
| $LSD_{0.05}$ | 0.489 | 0.684 | 1.322 | 1.267 |
| CV (%) | 8.571 | 9.328 | 7.144 | 8.538 |

$M_0$ = No mulch materials, $M_1$ = Black polythene, $M_2$ = Ash

$T_0$ = Control (No manure), $T_1$ = Cowdung (20 t $ha^{-1}$), $T_2$ = Poultry manure (15 t $ha^{-1}$), $T_3$ = Mustard oil cake (3 t $ha^{-1}$)

Combined effect of different organic manure and mulch materials affected leaf length significantly at different growth stages (Table 6 and Appendix VI). At harvest, the highest leaf length (nd 37.51 cm) was observed from $T_3M_2$. The lowest leaf length (27.00 cm) at harvest was obtained from the control treatment ($T_0M_0$) combination.

Table 6. Combined effect of organic manures and mulch materials on leaf length at different days after sowing of radish

| Treatment | Leaf length (cm) | | | |
|---|---|---|---|---|
| | 25 DAS | 40 DAS | 55 DAS | At harvest (70 DAS) |
| $T_0M_0$ | 12.13 f | 23.13 f | 27.07 g | 27.00 f |
| $T_0M_1$ | 13.73 de | 24.87 e | 30.51 ef | 30.32 e |
| $T_0M_2$ | 13.20 e | 24.67 e | 30.17 f | 30.09 e |
| $T_1M_0$ | 13.80 de | 25.00 e | 30.91 ef | 30.33 e |
| $T_1M_1$ | 14.67 cd | 25.73 cde | 32.37 cd | 32.28 cd |
| $T_1M_2$ | 15.60 bc | 26.33 bc | 35.57 b | 35.69 b |
| $T_2M_0$ | 13.93 de | 25.13 de | 31.47 de | 31.27 de |
| $T_2M_1$ | 15.13 c | 26.13 bcd | 32.68 c | 32.51 c |
| $T_2M_2$ | 16.60 b | 28.27 a | 36.70 ab | 36.19 b |
| $T_3M_0$ | 14.07 de | 25.47 cde | 31.67 cde | 32.11 cd |
| $T_3M_1$ | 15.67 bc | 27.07 b | 35.80 b | 36.04 b |
| $T_3M_2$ | 17.67 a | 28.40 a | 37.60 a | 37.51 a |
| $LSD_{0.05}$ | 0.9989 | 1.007 | 1.082 | 1.132 |
| CV (%) | 8.571 | 9.328 | 7.144 | 8.538 |

$T_0$ = Control (No manure)
$T_1$ = Cowdung (20 t $ha^{-1}$)
$T_2$ = Poultry manure (15 t $ha^{-1}$)
$T_3$ = Mustard oil cake (3 t $ha^{-1}$)

$M_0$ = No mulch materials
$M_1$ = Black polythene
$M_2$ = Ash

### 4.1.4 Leaf breadth

Leaf breadth was affected significantly by different organic manure at different growth stages (Table 7 and Appendix VII). At harvest, the highest leaf breadth (3 8.06 cm) was observed from $T_3$ (Mustard oil cake; 3 t $ha^{-1}$) which was statistically identical with $T_2$ (Poultry manure; 15 t $ha^{-1}$). The lowest leaf breadth (2 6.51 cm) was obtained from $T_0$ (no manure). The increased leaf breadth with mustard oil founded may be attributed to the supply of available plant nutrient that possibly generated all division and elongation activities and producing more breadth of leave. Kumari *et al.* (2017) reported that organic manures increase CEC, water holding capacity and phosphate availability of the soil. Besides improving the fertilizer use efficiency and microbial production of the soil, it reduces nitrogen loss due to slow release of nutrients.

Significant variation was found for leaf breadth affected by different mulch materials at different growth stages (Table 7 and Appendix VII). At harvest, the highest leaf breadth (8.13 cm) was observed from $M_2$ (Ash) where the lowest leaf breadth (8.68 cm) was obtained from $M_0$ (No mulch materials). Similar results was also found by Chawla (2006).

Table 7. Leaf breadth of radish as influenced by different organic manures and mulch materials at different days after sowing

| Treatment | Leaf breadth (cm) | | | |
|---|---|---|---|---|
| | 25 DAS | 40 DAS | 55 DAS | At harvest (70 DAS) |
| *Effect of organic manure* | | | | |
| $T_0$ | 2.64 b | 6.04 c | 6.58 c | 6.51 c |
| $T_1$ | 2.99 a | 6.69 b | 7.66 b | 7.57 b |
| $T_2$ | 3.07 a | 6.93 a | 7.93 a | 7.84 a |
| $T_3$ | 3.13 a | 7.09 a | 8.16 a | 8.06 a |
| $LSD_{0.05}$ | 0.166 | 0.184 | 0.236 | 0.247 |
| CV (%) | 6.227 | 8.241 | 7.388 | 6.524 |
| *Effect of mulching* | | | | |
| $M_0$ | 2.75 c | 6.23 c | 6.90 c | 6.82 c |
| $M_1$ | 2.98 b | 6.67 b | 7.63 b | 7.54 b |
| $M_2$ | 3.15 a | 7.17 a | 8.21 a | 8.13 a |
| $LSD_{0.05}$ | 0.126 | 0.419 | 0.513 | 0.544 |
| CV (%) | 6.227 | 8.241 | 7.388 | 6.524 |

$M_0$ = No mulch materials, $M_1$ = Black polythene, $M_2$ = Wood ash

$T_0$ = Control (No manure), $T_1$ = Cowdung (20 t $ha^{-1}$), $T_2$ = Poultry manure (15 t $ha^{-1}$), $T_3$ = Mustard oil cake (3 t $ha^{-1}$)

Combined effect of different organic manure and mulch materials had significant influence on leaf breadth at different growth stages (Table 8 and Appendix VII). At harvest the highest leaf breadth (8.68 cm) was observed from $T_3M_2$ which was closely followed by $T_2M_2$ and $T_1M_2$ at all growth stages. The lowest leaf breadth (6.23 cm) was obtained from the control treatment combination $T_0M_0$.

Table 8. Combined effect of organic manures and mulch materials on leaf breadth at different days after sowing of radish

| Treatment | Leaf breadth (cm) | | | |
|---|---|---|---|---|
| | 25 DAS | 40 DAS | 55 DAS | At harvest (70 DAS) |
| $T_0M_0$ | 2.52 g | 5.87 g | 6.29 h | 6.23 h |
| $T_0M_1$ | 2.62 fg | 6.01 fg | 6.50 gh | 6.40 h |
| $T_0M_2$ | 2.78 def | 6.23 efg | 6.94 fg | 6.90 fg |
| $T_1M_0$ | 2.71 efg | 6.13 efg | 6.70 fgh | 6.64 gh |
| $T_1M_1$ | 3.03 bc | 6.67 cd | 7.79 cd | 7.66 de |
| $T_1M_2$ | 3.22 ab | 7.27 ab | 8.48 ab | 8.41 abc |
| $T_2M_0$ | 2.83 de | 6.39 def | 7.15 ef | 7.07 fg |
| $T_2M_1$ | 3.12 ab | 6.89 bc | 8.00 c | 7.94 cd |
| $T_2M_2$ | 3.27 a | 7.52 a | 8.63 ab | 8.52 ab |
| $T_3M_0$ | 2.92 cd | 6.52 cde | 7.47 de | 7.35 ef |
| $T_3M_1$ | 3.16 ab | 7.09 b | 8.23 bc | 8.16 bc |
| $T_3M_2$ | 3.32 a | 7.66 a | 8.78 a | 8.68 a |
| $LSD_{0.05}$ | 0.1855 | 0.3935 | 0.4544 | 0.4729 |
| CV (%) | 6.227 | 8.241 | 7.388 | 6.524 |

$T_0$ = Control (No manure)
$T_1$ = Cowdung (20 t $ha^{-1}$)
$T_2$ = Poultry manure (15 t $ha^{-1}$)
$T_3$ = Mustard oil cake (3 t $ha^{-1}$)

$M_0$ = No mulch materials
$M_1$ = Black polythene
$M_2$ = Ash

## 4.2 Yield contributing parameters

### 4.2.1 Root length

Root length was affected significantly by different organic manure at the time of harvest (Table 9 and Appendix VIII). The highest root length (26.12 cm) was observed in $T_2$ (Poultry manure; 15 t $ha^{-1}$) followed by $T_3$ (Mustard oil cake; 3 t ha$^{-1}$) where the lowest root length (21.20 cm) was obtained from the control treatment $T_0$ (no manure). Root length varied significantly due to different mulch materials uses (Table 9 and Appendix VIII). The highest root length (24.78 cm) was observed from $M_2$ (A ash) which was statistically identical with $M_1$ (Black polythene) where the lowest root length (22.64 cm) was obtained from the control treatment $M_0$ (No mulch materials). The increase in the root length due to different mulching treatment was possibly due to the availability of moisture which helps in the rapid cell elongation leading to longer root formulation. Begum *et al.* (2001) suggested that mulching could increase crop yield by producing heavier root weight and improve product quality.

Combined effect of different organic manure and mulch materials significant influenced the root length (Table 10 and Appendix VIII). At harvest the highest root length (28.10 cm) was observed from $T_2M_2$ which was statistically similar with $T_2M_1$. The lowest root length (20.67 cm) was obtained from the control treatment combination ($T_0M_0$) which was statistically similar with $T_0M_1$ and $T_0M_2$.

### 4.2.2 Diameter of root

Significant variation on root diameter was observed by different organic manure (Table 9 and Appendix VIII). The highest root diameter (5.28 cm) was observed in $T_2$ (Poultry manure; 15 t ha$^{-1}$) followed by $T_3$ (Mustard oil cake; 3 t ha$^{-1}$) where the lowest root diameter (4.14 cm) was obtained from the control treatment $T_0$ (no manure). So the root diameter was significantly influenced by organics at harvest.

Root diameter varied significantly with different mulch materials at the time of harvest (Table 9 and Appendix VIII). At harvest, the highest root diameter (4.96 cm) was observed from $M_1$ (Black polythene) treatment mulch material which was statistically identical with $M_2$ (Ash) where the lowest root diameter (4.48 cm) was obtained from the control treatment $M_0$ (No mulch materials). These results indicate that black polythene mulch create favorable condition for the growth of the plant by retaining moisture and control weed growth effectively, which leads to production of the maximum root diameter which control and other mulching materials. It was founded by Bhardwaj *et al.* (2011).

Combined effect of different organic manure and mulch materials affected root diameter was also significant influenced by at the time of harvest (Table 10 and Appendix VIII). The highest root diameter (5.76 cm) was observed from $T_2M_1$ followed by $T_2M_2$, $T_3M_1$, $T_3M_2$ and $T_1M_2$. The lowest root diameter (4.00 cm) was obtained from the control treatment combination ($T_0M_0$) which was statistically similar with $T_0M_2$ followed by $T_0M_1$ and $T_1M_0$ treatment combination.

### 4.2.3 Fresh weight of root per plant

Fresh weight of root per plant was affected significantly by different organic manure (Table 9 and Appendix VIII). At harvest, the highest fresh weight of root per plant (302.24 g) was observed in $T_2$ (Poultry manure; 15 t $ha^{-1}$) followed by $T_3$ (Mustard oil cake; 3 t $ha^{-1}$) where the lowest fresh weight of root per plant (194.60 g) was obtained from the control treatment, $T_0$ (no manure). Soil organic matter is the key to soil fertility. Organic manures consumed more moisture in the soil the soil and regulate air supply and kept the soil cool, loose and friable which ultimately increase the root growth.

Fresh weight of root per plant significantly influenced due to use of different mulch materials (Table 9 and Appendix VIII). At harvest the highest fresh weight of root per plant (273.34 g) was observed from $M_2$ (Ash) followed by $M_1$ (Black polythene) where the lowest fresh weight of root per plant (231.82 g) was obtained from the control treatment, $M_0$ (No mulch materials). Purohit *et al.* (1990) observed that use of mulch in the field increase the soil temperature reduced weed problems increase moisture concentration reduction certain insect pest population and higher crop yield and more efficient use of soil nutrients.

Fresh weight of root per plant was also significant affected by combined effect of different organic manure and mulch materials (Table 10 and Appendix VIII). The highest fresh weight of root per plant (348.90 g) was observed in $T_2M_2$ treatment combination followed by $T_2M_1$, $T_3M_1$ and $T_3M_2$ treatment combinations. The lowest fresh weight of root per plant (178.80 g) was obtained from the control treatment combination $T_0M_0$ followed by $T_0M_2$ and $T_0M_1$ treatment combination.

### 4.2.4 Fresh weight of leaves per plant

Significant influence was found by application of different organic manure on fresh weight of leaves per plant (Table 9 and Appendix VIII). At harvest, the highest fresh weight of leaves per plant (150.87 g) was observed in $T_2$ (Poultry manure; 20 t $ha^{-1}$) treatment followed by $T_3$ (Mustard oil cake; 5 t $ha^{-1}$) treatment where the lowest fresh weight of leaves per plant (92.13 g) was obtained from the control treatment, $T_0$ (no manure). Such effect may be attributed to the presence of sufficient plant nutrient probably lead to better performance of the crop results in producing maximum fresh weight of leaves.

Fresh weight of leaves per plant was significantly influenced by different mulch materials (Table 9 and Appendix VIII). The highest fresh weight of leaves per plant (135.25 g) was observed from $M_2$ (Ash) treatment which was statistically identical with $M_1$ (Black polythene) treatment where the lowest fresh weight of leaves per plant (120.85 g) was obtained from the control treatment $M_0$ (No mulch materials). The increased fresh weight of leaves with mulches may be attributed to the supply of moisture that possibly generated that cell division and cell elongation activities probably more leaves and their development leading to the increased fresh weight of leaves.

Sarolia and Bhardwaj (2012) supported that mulching provides a favorable environment for growth which results in more vigorous healthy plant, increase in soil temperature and moisture content stimulate root growth which leads to greater plant growth.

Significant variation was found by combined effect of different organic manure and mulch materials on fresh weight of leaves per plant (Table 10 and Appendix VIII). At harvest the highest fresh weight of leaves per plant (164.60 g) was observed in $T_2M_2$ followed where the lowest fresh weight of leaves per plant (83.33 g) was obtained from the control treatment combination $T_0M_0$ followed by $T_0M_2$ and $T_0M_1$.

### 4.2.5 Percent (%) dry weight of roots per plant

Recorded data on % dry weight of roots per plant was significant due to the application of different organic manure (Table 9 and Appendix VIII). The highest % dry weight of roots per plant (11.20%) was observed in $T_3$ (Mustard oil cake; 3 t $ha^{-1}$) which was statistically identical with $T_2$ (Poultry manure; 15 t $ha^{-1}$) where the lowest % dry weight of roots per plant (10.19%) was obtained from $T_0$ (no manure) followed by $T_1$ (Cowdung; 20 t $ha^{-1}$) treatment.

Percent (%) dry weight of roots per plant at the time of harvest was significantly influenced by different mulch materials (Table 9 and Appendix VIII). Results indicated that the highest % dry weight of roots per plant (10.97%) was observed from $M_2$ (Ash) which was statistically identical with $M_1$ (Black polythene) where the lowest % dry weight of roots per plant (10.54%) was obtained from $M_0$ (No mulch materials).

Significant variation on % dry weight of roots per plant was observed by the combined effect of different organic manure and mulch materials (Table 10 and Appendix VIII). The highest % dry weight of roots per plant (11.42%) was observed in $T_3M_2$ which was statistically identical with $T_2M_2$ and $T_2M_1$ where the lowest % dry weight of roots per plant (10.12%) was obtained from the control treatment combination $T_0M_0$ which was statistically identical with $T_0M_2$ followed by $T_0M_1$ and $T_3M_0$.

Table 9. Yield contributing parameters of radish as influenced by different organic manures and mulch materials

| Treatment | Yield contributing parameters | | | | |
|---|---|---|---|---|---|
| | Root length (cm) at harvest | Diameter of root (cm) at harvest | Fresh weight of root per plant (g) at harvest | Fresh weight of leaves per plant (g) at harvest | % dry weight of roots at harvest |
| *Effect of organic manure* | | | | | |
| $T_0$ | 21.20 d | 4.14 d | 194.60 d | 92.13 d | 10.19 c |
| $T_1$ | 23.40 c | 4.66 c | 251.58 c | 135.62 c | 10.83 b |
| $T_2$ | 26.12 a | 5.28 a | 302.24 a | 150.87 a | 11.06 a |
| $T_3$ | 25.10 b | 4.97 b | 280.24 b | 142.71b | 11.20 a |
| $LSD_{0.05}$ | 0.671 | 0.249 | 7.588 | 4.718 | 0.224 |
| CV (%) | 8.574 | 6.923 | 13.711 | 11.248 | 6.347 |
| *Effect of mulching* | | | | | |
| $M_0$ | 22.64 b | 4.48 b | 231.82 c | 120.85 b | 10.54 b |
| $M_1$ | 24.45 a | 4.96 a | 266.35 b | 134.90 a | 10.96 a |
| $M_2$ | 24.78 a | 4.85 a | 273.34 a | 135.25 a | 10.97 a |
| $LSD_{0.05}$ | 1.022 | 0.314 | 3.144 | 2.713 | 0.361 |
| CV (%) | 8.574 | 6.923 | 13.711 | 11.248 | 6.347 |

$M_0$ = No mulch materials, $M_1$ = Black polythene, $M_2$ = Ash

$T_0$ = Control (No manure), $T_1$ = Cowdung (20 t $ha^{-1}$), $T_2$ = Poultry manure (15 t $ha^{-1}$), $T_3$ = Mustard oil cake (3 t $ha^{-1}$)

Table 10. Combined effect of organic manures and mulch materials on yield contributing parameters of radish

| Treatment | Yield contributing parameters | | | | |
|---|---|---|---|---|---|
| | Root length (cm) at harvest | Diameter of root (cm) at harvest | Fresh weight of root per plant (g) at harvest | Fresh weight of leaves per plant (g) at harvest | % dry weight of roots at harvest |
| $T_0M_0$ | 20.67 f | 4.00 g | 178.80 h | 82.33 h | 10.12 g |
| $T_0M_1$ | 21.60 ef | 4.27 f | 212.10 f | 101.90 f | 10.32 ef |
| $T_0M_2$ | 21.33 ef | 4.15 fg | 192.90 g | 92.20 g | 10.14 g |
| $T_1M_0$ | 22.80 de | 4.29 f | 239.50 e | 132.70 e | 10.48 e |
| $T_1M_1$ | 23.23 de | 4.72 de | 247.20 e | 134.10 e | 10.88 d |
| $T_1M_2$ | 24.17 cd | 4.96 cd | 268.00 d | 140.00 de | 11.12 bc |
| $T_2M_0$ | 22.97 de | 4.72 e | 243.40 e | 133.40 e | 10.40 e |
| $T_2M_1$ | 27.30 ab | 5.76 a | 314.40 b | 154.60 b | 11.28 a |
| $T_2M_2$ | 28.10 a | 5.36 b | 348.90 a | 164.60 a | 11.36 a |
| $T_3M_0$ | 24.10 cd | 4.90 cde | 265.50 d | 134.90 de | 11.15 bc |
| $T_3M_1$ | 25.67 bc | 5.03 c | 291.70 c | 150.40 bc | 11.18 bc |
| $T_3M_2$ | 25.53 bc | 4.98 c | 283.50 c | 142.80 cd | 11.42 a |
| $LSD_{0.05}$ | 1.750 | 0.2272 | 8.733 | 7.936 | 0.224 |
| CV (%) | 8.574 | 6.923 | 13.711 | 11.248 | 6.347 |

$T_0$ = Control (No manure)
$T_1$ = Cowdung (20 t $ha^{-1}$)
$T_2$ = Poultry manure (15 t $ha^{-1}$)
$T_3$ = Mustard oil cake (3 t $ha^{-1}$)

$M_0$ = No mulch materials
$M_1$ = Black polythene
$M_2$ = Ash

### 4.3 Yield parameters

#### 4.3.1 Fresh weight of whole plant at harvest (g)

Average fresh weight of whole plant was affected significantly by different organic manure (Table 11 and Appendix IX). The highest fresh weight of whole plant at harvest (453.11 g) was observed in $T_2$ (Poultry manure; 15 t $ha^{-1}$) followed by $T_3$ (Mustard oil cake; 3 t $ha^{-1}$) where the lowest fresh weight of whole plant (306.18 g) was obtained from the control treatment ($T_0$).

Average fresh weight of whole plant at harvest significantly influenced due to use of different mulch materials (Table 11 and Appendix IX). The highest fresh weight of whole plant (394.40 g) was observed from $M_2$ (Wood ash) followed by $M_1$ (Black polythene) where the lowest fresh weight of whole plant (338.08 g) was obtained from the control treatment $M_0$ (No mulch materials). Baumann *et al.* (2000) reported that protect the surface of the soil against unfavorable factors reduce nutrient leaching and improve growing condition for vegetables.

Average fresh weight of whole plant was also significant affected by combined effect of different organic manure and mulch materials (Table 12 and Appendix IX). The highest fresh weight of whole plant (513.50 g) was observed in $T_2M_2$ followed by $T_2M_1$, $T_3M_1$ and $T_3M_2$. The lowest fresh weight of whole plant (261.10 g) was obtained from $T_0M_0$ followed by $T_0M_1$, $T_0M_2$, $T_1M_0$, $T_1M_1$ and $T_2M_0$.

### 4.3.2 Gross yield (t ha$^{-1}$)

Recorded data on gross yield of radish ha$^{-1}$ at harvest was significant due to application of different organic manure (Table 11 and Appendix IX). The highest gross yield ha$^{-1}$ (37.78 t ha$^{-1}$) was observed in $T_2$ (Poultry manure; 15 t ha$^{-1}$) treatment followed by $T_3$ (Mustard oil cake; 3 t ha$^{-1}$) where the lowest gross yield ha$^{-1}$ (25.47 t ha$^{-1}$) was obtained from $T_0$ (no manure). Juan *et al*. (2010) also found that increased cattle manure and urea doses provided higher commercial yield.

Gross yield of radish ha$^{-1}$ at the time of harvest was significantly influenced by different mulch materials (Table 11 and Appendix IX). Results indicated that the highest gross yield ha$^{-1}$ (35.63 t ha$^{-1}$) was observed from $M_2$ (Ash) followed by $M_1$ (Black polythene) where the lowest gross yield ha$^{-1}$ (28.12 t ha$^{-1}$) was obtained from the control treatment $M_0$ (No mulch materials). Goreta *et al*. (2005), McCann *et al*. (2007), Ravinderkumar and Shrivastava, (1998) also observed that early yield and increased yield of different vegetable crops was enhanced by using different mulch practices. The yield and keeping quality of early potatoes, radish, cabbage and other vegetables may be improved by straw mulch. Application of straw mulch @ 6 t $ha^{-1}$ increased yield of tomato and okra by 100 and 200 percent, respectively over control (Gupta and Gupta, 1987).

Significant variation was found by combined effect of different organic manure and mulch materials at harvest on gross yield of radish $ha^{-1}$ (Table 12 and Appendix IX). The highest gross yield $ha^{-1}$ (43.62 t $ha^{-1}$) was observed from $T_2M_2$ followed by $T_2M_1$, $T_3M_1$ and $T_3M_2$. The lowest gross yield $ha^{-1}$ (22.35 t $ha^{-1}$) was obtained from the control treatment combination, $T_0M_0$ followed by $T_0M_1$ and $T_1M_0$.

### 4.3.3 Marketable yield (t $ha^{-1}$)

Achieved marketable yield of radish $ha^{-1}$ was significant due to application of different organic manure (Table 11 and Appendix IX). The highest marketable yield $ha^{-1}$ (36.60 t $ha^{-1}$) was observed in $T_2$ (Poultry manure; 15 t $ha^{-1}$) followed by $T_3$ (Mustard oil cake; 3 t $ha^{-1}$) where the lowest marketable yield $ha^{-1}$ (24.20 t $ha^{-1}$) was obtained from the control treatment $T_0$ (no manure). Juan *et al*. (2010) also found that using organic manure like cattle manure with N fertilizer provided maximum economic efficiency.

Marketable yield of radish $ha^{-1}$ was significantly influenced by different mulch materials (Table 11 and Appendix IX). The highest marketable yield $ha^{-1}$ (34.36 t $ha^{-1}$) was observed from $M_2$ (Ash) treatment followed by $M_1$ (Black polythene) where the lowest marketable yield $ha^{-1}$ (24.20 t $ha^{-1}$) was obtained from the $M_0$ (No mulch materials). Marketable yield from mulched plot was significantly higher than those produced on bare soil. This difference can be attributed to moisture conservation, higher soil temperature, weed control and increased mineral nutrient uptake in the mulched plot through improved root temperatures as reported by Orozco *et al*. (1994).

Significant variation was found by combined effect of different organic manure and mulch materials on marketable yield of radish $ha^{-1}$ (Table 12 and Appendix IX). The highest marketable yield $ha^{-1}$ (42.37 t $ha^{-1}$) was observed from $T_2M_2$ followed by $T_2M_1$, $T_3M_1$ and $T_3M_2$. The lowest marketable yield $ha^{-1}$ (21.18 t $ha^{-1}$) was obtained from $T_0M_0$ which was statistically identical with the treatment combination of $T_0M_1$.

Table 11. Yield parameters of radish as influenced by different organic manure and mulch materials for the performance of growth, yield and economic benefits

| Treatment | Yield parameters | | |
|---|---|---|---|
| | Fresh weight of whole plant at harvest (g per plant) | Gross yield (t $ha^{-1}$) | Marketable yield (t $ha^{-1}$) |
| *Effect of organic manure* | | | |
| $T_0$ | 306.18 d | 25.47 d | 24.20 d |
| $T_1$ | 367.75 c | 30.30 c | 29.06 c |
| $T_2$ | 453.11 a | 37.78 a | 36.60 a |
| $T_3$ | 422.96 b | 35.03 b | 33.84 b |
| $LSD_{0.05}$ | 8.312 | 1.724 | 2.015 |
| CV (%) | 12.568 | 10.357 | 10.149 |
| *Effect of mulching* | | | |
| $M_0$ | 338.08 c | 28.12 c | 26.95 c |
| $M_1$ | 430.02 b | 32.70 b | 31.46 b |
| $M_2$ | 394.40 a | 35.63 a | 34.36 a |
| $LSD_{0.05}$ | 10.344 | 2.322 | 2.614 |
| CV (%) | 12.568 | 10.357 | 10.149 |

$M_0$ = No mulch materials, $M_1$ = Black polythene, $M_2$ = Ash

$T_0$ = Control (No manure), $T_1$ = Cowdung (20 t $ha^{-1}$), $T_2$ = Poultry manure (15 t $ha^{-1}$), $T_3$ = Mustard oil cake (3 t $ha^{-1}$)

Table 12. Combined effect of organic manure and mulch materials on yield parameters of radish

| Treatment | Yield parameters | | |
|---|---|---|---|
| | Fresh weight of whole plant at harvest (g per plant) | Gross yield ($t\ ha^{-1}$) | Marketable yield ($t\ ha^{-1}$) |
| $T_0M_0$ | 261.10 i | 22.35 i | 21.18 g |
| $T_0M_1$ | 285.10 h | 24.12 h | 22.80 g |
| $T_0M_2$ | 372.30 f | 29.94 f | 28.62 e |
| $T_1M_0$ | 313.90 g | 26.51 g | 25.33 f |
| $T_1M_1$ | 381.30 f | 30.90 f | 29.63 e |
| $T_1M_2$ | 408.00 e | 33.50 de | 32.23 d |
| $T_2M_0$ | 376.80 f | 30.43 f | 29.28 e |
| $T_2M_1$ | 469.00 b | 39.30 b | 38.14 b |
| $T_2M_2$ | 513.50 a | 43.62 a | 42.37 a |
| $T_3M_0$ | 400.50 e | 33.19 e | 32.02 d |
| $T_3M_1$ | 442.10 c | 36.47 c | 35.28 c |
| $T_3M_2$ | 426.30 d | 35.44 cd | 34.23 c |
| $LSD_{0.05}$ | 9.486 | 1.950 | 1.765 |
| CV (%) | 12.568 | 10.357 | 10.149 |

$T_0$ = Control (No manure)
$T_1$ = Cowdung (20 t $ha^{-1}$)
$T_2$ = Poultry manure (15 t $ha^{-1}$)
$T_3$ = Mustard oil cake (3 t $ha^{-1}$)

$M_0$ = No mulch materials
$M_1$ = Black polythene
$M_2$ = Ash

## 4.4 Economic analysis

The cost and return analysis were done and have been presented in Table 13 and Appendix X. Material (A), non-material (B) and overhead cost (C) were recorded for all the treatments of unit plot and calculated on per hectare basis, the price of radish per ton at the local market rates were considered.

The total cost of production ranges between Tk. 63750 $ha^{-1}$ and Tk. 119500 $ha^{-1}$ among the different treatment combination. The variation was due to different organic manures and mulch materials cost. The highest cost of production Tk. 119500 $ha^{-1}$ was involved in the treatment combination of $T_3M_2$ followed by

$T_3M_1$ while the lowest cost of production Tk. 63750 $ha^{-1}$ was involved in the combination of $T_0M_0$ followed by $T_1M_0$ (Table 13 and Appendix VII).

The highest gross return Tk. 338960 $ha^{-1}$ was obtained from the treatment combination of $T_2M_2$ where the lowest gross return Tk. 169440 $ha^{-1}$ was found from the treatment combination of $T_0M_0$.

Among the different treatment combinations $T_2M_2$ gave the highest net return Tk. 240645 $ha^{-1}$ and the 2nd highest net return (Tk. 202345 $ha^{-1}$) was done from $T_2M_1$ while the lowest net return Tk. 96350 $ha^{-1}$ was obtained from the treatment combination of $T_0M_1$.

The benefit cost ratio (BCR) was found to be the highest (3.45) in the treatment combination of $T_2M_2$. The lowest BCR (2.12) was recorded from the treatment combination of $T_0M_1$. Thus it was apparent that the poultry manure @ 15 t $ha^{-1}$ with mulch materials as wood ash gave the highest radish yield (42.37 t $ha^{-1}$) and the highest net return (Tk. 240645 $ha^{-1}$).

Juan *et al*. (2010) found that using organic manure like cattle manure with N fertilizer provided maximum economic efficiency. Besides beneficial effects on earliness, mulch can enhance plant growth and development, increase yield, decrease soil evaporation and nutrient leaching, reduce incidence of pests and weeds, and improve fruit cleanliness and quality yield and finally increase gross return, net return and benefit : cost ratio of fruit and vegetable crops (Lamont, 1993; Farias-Larios and Orozco-Santos, 1997; Walters, 2003; Decoteau, 2007; Diaz-Perez *et al*., 2007; Hutton and Handley, 2007). Sutagundi (2000) reported that treatment receiving straw mulch recorded significantly higher net returns and benefit: cost ratio compared to control.

Table 13. Economic analysis of radish production as influenced by different organic manure and mulch materials for the performance of growth yield and economic benefits

| Treatment | Economic analysis | | | |
|---|---|---|---|---|
| | Cost of production (Tk. $ha^{-1}$) | Gross return* (Tk. $ha^{-1}$) | Net return (Tk. $ha^{-1}$) | BCR |
| $T_0M_0$ | 63750 | 169440 | 105690 | 2.66 |
| $T_0M_1$ | 86050 | 182400 | 96350 | 2.12 |
| $T_0M_2$ | 81590 | 228960 | 147370 | 2.81 |
| $T_1M_0$ | 77130 | 202640 | 125510 | 2.63 |
| $T_1M_1$ | 99430 | 237040 | 137610 | 2.38 |
| $T_1M_2$ | 94970 | 257840 | 162870 | 2.71 |
| $T_2M_0$ | 80475 | 234240 | 153765 | 2.91 |
| $T_2M_1$ | 102775 | 305120 | 202345 | 2.97 |
| $T_2M_2$ | 98315 | 338960 | 240645 | 3.45 |
| $T_3M_0$ | 97200 | 256160 | 158960 | 2.64 |
| $T_3M_1$ | 119500 | 282240 | 162740 | 2.36 |
| $T_3M_2$ | 115040 | 273840 | 158800 | 2.38 |
| *Cost of radish = Tk. 8000 $ton^{-1}$ | | | | |

$T_0$ = Control (No manure)
$T_1$ = Cowdung (20 t $ha^{-1}$)
$T_2$ = Poultry manure (15 t $ha^{-1}$)
$T_3$ = Mustard oil cake (3 t $ha^{-1}$)

$M_0$ = No mulch materials
$M_1$ = Black polythene
$M_2$ = Ash

# CHAPTER V

# SUMMARY AND CONCLUSION

An experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, to evaluate the growth, yield and economic benefits of radish as influenced by different organic manure and mulch materials during the period of November 2015 to February 2016. The experiment consisted of four levels of organic manure *viz*. control (no manure), cowdung (20 t ha$^{-1}$), poultry manure (15 t ha$^{-1}$) and mustard oil cake (3 t ha$^{-1}$) and three levels mulch materials *viz*. control (no mulch materials), black polythene and ash. The experiment was laid in Randomized Complete Block Design with three replications. There were all together twelve treatment combinations in this experiment. Each unit plot size was 1.6m×1m where 1.0 m and 0.5 m gap between blocks and plots respectively were maintained. The radish seeds of cv. Summer white (hybrid variety) were used as plant materials. All the intercultural operations were done as and when needed. Data of growth and yield parameters were collected and analyzed statistically.

Different types of organic manure showed significant effect on growth and yield parameters. Organic farm manure $T_2$ (poultry manure @ 15 t ha$^{-1}$) treatment gave the best performance considering growth and yield of radish. Results revealed that $T_3$ (mustard oil cake @ 3 t ha$^{-1}$) gave the tallest plant (45.38 cm), highest number of leaves plant$^{-1}$ (17.32), leaf length (34.78 cm), leaf breadth (8.06 cm) and highest % dry weight of roots plant$^{-1}$ (11.20%) at harvest but $T_2$ (poultry manure @ 15 t ha$^{-1}$) gave the highest root length (26.12 cm), root diameter (5.28 cm), fresh weight of root plant$^{-1}$ (302.24 g), fresh weight of leaves plant$^{-1}$ (150.87 g) and fresh weight of whole plant (453.11 g) at harvest and gross yield ha$^{-1}$ (37.78 t ha$^{-1}$) and the highest marketable yield ha$^{-1}$ (36.60 t ha$^{-1}$). The control treatment ($T_0$) conferred shortest plant (35.73 cm), number of leaves plant$^{-1}$ (14.66), leaf length (29.16 cm), leaf breadth (6.51 cm), root length (21.20 cm), root diameter (4.14 cm), fresh weight of root plant$^{-1}$ (194.60 g), fresh weight of leaves plant$^{-1}$ (92.13 g), % dry weight of roots plant$^{-1}$ (10.19%), fresh weight of whole plant (306.18 g), gross yield ha$^{-1}$ (25.47 t ha$^{-1}$) and lowest marketable yield ha$^{-1}$ (24.20 t ha$^{-1}$).

Different mulch materials used in the present study proved significant variation on growth and yield parameters. The mulch materials ash showed best performance on growth and yield of radish. It was found that the tallest plant (44.76 cm) and root diameter (4.96 cm) at harvest were achieved by $M_1$ (Black polythene). But the highest number of leaves plant$^{-1}$ (17.48), leaf length (34.87 cm), leaf breadth (8.13 cm), root length (24.78 cm), fresh weight of root plant$^{-1}$ (273.34 g), fresh weight of leaves plant$^{-1}$ (135.25 g), fresh weight of whole plant (394.40 g) and highest % dry weight of roots plant$^{-1}$ (10.97%) at harvest was observed from $M_2$ (ash). The highest gross yield ha$^{-1}$ (35.63 t ha$^{-1}$) and highest marketable yield ha$^{-1}$ (34.36 t ha$^{-1}$) was also achieved from $M_2$ (ash) where the shortest plant (39.48 cm), lowest number of leaves plant$^{-1}$ (15.37), leaf length (30.20 cm), leaf breadth (8.68 cm), root length (22.64 cm), root diameter (4.48 cm), fresh weight of root plant$^{-1}$ (231.82 g), fresh weight of leaves plant$^{-1}$ (120.85 g), fresh weight of whole plant (338.08 g) and lowest % dry weight of roots plant$^{-1}$ (10.54%) at harvest were obtained from the control treatment $M_0$ (No organic manure). The lowest gross yield ha$^{-1}$ (28.12 t ha$^{-1}$) and the lowest marketable yield ha$^{-1}$ (24.20 t ha$^{-1}$) were also obtained from the control treatment $M_0$ (No organic manure).

In terms of combined effect organic manure and mulch materials, the highest plant height (48.76 cm) at harvest was found from $T_3M_1$ (mustard oil cake @ 5 t ha$^{-1}$ with black polythene as mulch material) but the highest leaf length (37.51 cm), leaf breadth (8.68 cm) and % dry weight of roots plant$^{-1}$ (11.42%) at harvest were observed in $T_3M_2$ (Mustard oil cake @ 5 t ha$^{-1}$ with ash as mulch material). The highest root diameter (5.76 cm) at harvest was found from $T_2M_1$ (Poultry manure @ 15 t ha$^{-1}$ with black polythene as mulch material) where number of leaves plant$^{-}$

$^{1}$ (18.78), root length (28.10 cm), fresh weight of root plant$^{-1}$ (348.90 g), fresh weight of leaves plant$^{-1}$ (164.60 g) and fresh weight of whole plant (513.50 g) at harvest and gross yield ha$^{-1}$ (43.62 t ha$^{-1}$) and the highest marketable yield ha$^{-1}$ (42.37 t ha$^{-1}$) were observed in $T_2M_2$ (Poultry manure @ 15 t ha$^{-1}$ with ash as mulch material). Likewise, the lowest plant height (33.90 cm), number of leaves plant$^{-1}$ (13.77), leaf length (27.00 cm), leaf breadth (6.23 cm), root length (20.67 cm), root diameter (4.00 cm), root length (20.67 cm), root diameter (4.00 cm), fresh weight of root plant$^{-1}$ (178.80 g), fresh weight of leaves plant$^{-1}$ (83.33 g), fresh weight of whole plant (261.10 g), % dry weight of roots plant$^{-1}$ (10.12%), gross yield ha$^{-1}$ (22.35 t ha$^{-1}$) and the lowest marketable yield ha$^{-1}$ (21.18 t ha$^{-1}$) at harvest were obtained from the control treatment combination of $T_0M_0$ (No organic manure with no mulch materials).

Highest net return (Tk 2,40,645 ha$^{-1}$) and benefit cost ratio (BCR; 3.45) were found from the treatment combination of poultry manure @ 15 t ha$^{-1}$ with ash.

**Recommendations:**

From the above summary the following recommendation can be drawn –

1. For general point of view, poultry manure @ 15 t ha$^{-1}$ which is available to the farmers can be used in organic farming as it increases the leaf length, leaf breadth, root growth and root diameter.
2. Ash can be used as it is adding extra organic matter in the soil and increasing vegetative growth and providing higher yield.
3. From economic point of view combined treatment poultry manure and ash can be give the higher yield and net return than other organic manures and mulch materials.

4. Another research work can be conducted with this treatment combination at different locations of different AEZ.

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## APPENDICES

**Appendix I. Monthly records of air temperature, relative humidity, rainfall and sunshine during the period from November 2015 to February 2016**

| Year | Month | ** Air temperature ($^0$C) | | | **Relative humidity (%) | *Rainfall (mm) | **Sunshine (Hours) |
|---|---|---|---|---|---|---|---|
| 2015 | November | 29.21 | 19.5 | 24.36 | 80.63 | 86.2 | 230 |
| 2015 | December | 24.32 | 15.4 | 19.86 | 83.76 | 0 | 192.6 |
| 2016 | January | 22.67 | 13.17 | 17.92 | 84.05 | 0 | 161.6 |
| 2016 | February | 26.56 | 17.49 | 22.03 | 77.25 | 25.6 | 219.9 |

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

**Appendix II. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation**

Particle size constitution:

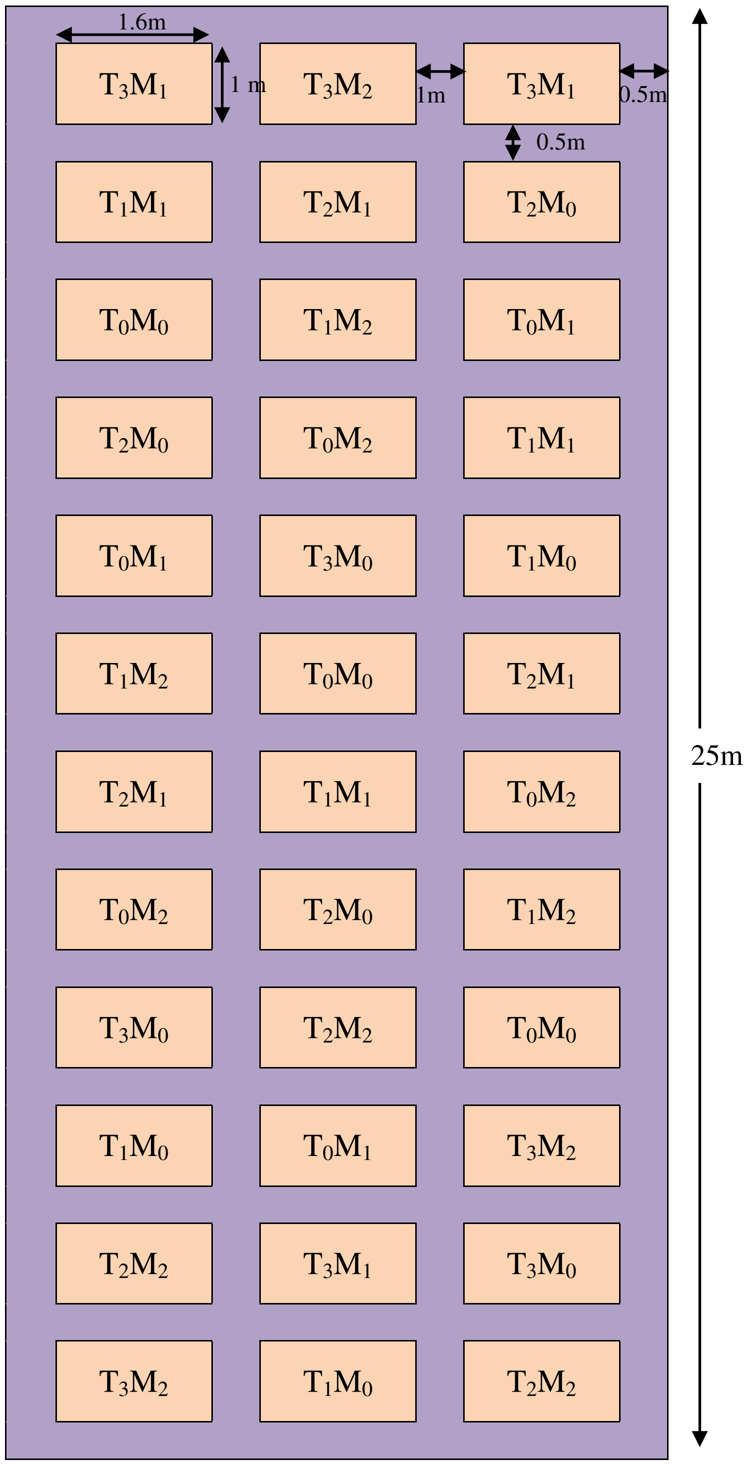
| | | |
|---|---|---|
| Sand | : | 40 % |
| Silt | : | 40 % |
| Clay | : | 20 % |
| Texture | : | Loamy |

Chemical composition:

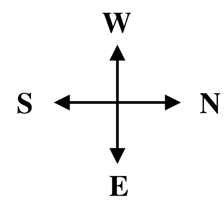
| Constituents | : | 0-15 cm depth |
|---|---|---|
| $P^H$ | : | 5.45-5.61 |
| Total N (%) | : | 0.07 |
| Available P (μ gm/gm) | : | 18.49 |
| Exchangeable K (μ gm/gm) | : | 0.07 |
| Available S (μ gm/gm) | : | 20.82 |
| Available Fe (μ gm/gm) | : | 229 |
| Available Zn (μ gm/gm) | : | 4.48 |
| Available Mg (μ gm/gm) | : | 0.825 |
| Available Na (μ gm/gm) | : | 0.32 |
| Available B (μ gm/gm) | : | 0.94 |
| Organic matter (%) | : | 0.83 |

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

**Appendix III. Layout of the experiment field**




**LEGEND**




**Layout:**

Plot size: 1.6 m × 1 m

Plot spacing: 0.5 m

Between block: 0.1 m

**Treatments:**

Factor A: Organic manures

1. $T_0$ = Control (No manure)
2. $T_1$ = Cowdung (20 t $ha^{-1}$)
3. $T_2$ = Poultry manure (15 t $ha^{-1}$)
4. $T_3$ = Mustard oil cake (3 t $ha^{-1}$)

Factor B: Mulch materials

1. $M_0$ = No mulch materials
2. $M_1$ = Black polythene
3. $M_2$ = Ash

Fig. 1. Layout of the experimental plot

**Appendix IV. Significant effect on plant height of radish as influenced by different organic manure and mulch materials**

| Source of variation | Degrees of freedom | Mean square of plant height | | | |
|---|---|---|---|---|---|
| | | 25 DAS | 40 DAS | 55 DAS | At harvest |
| Replication | 2 | 0.312 | 0.391 | 0.951 | 1.042 |
| Factor A | 3 | 5.770* | 7.40** | 8.301* | 9.684* |
| Factor B | 2 | 9.162* | 11.561* | 14.039** | 14.517* |
| AB | 6 | 2.280** | 4.033* | 3.151* | 4.663* |
| Error | 22 | 1.117 | 1.241 | 3.267 | 4.372 |

**Appendix V. Significant effect on number of leaves plant$^{-1}$ of radish as influenced by different organic manure and mulch materials**

| Source of variation | Degrees of freedom | Mean square of number of leaves plant$^{-1}$ | | | |
|---|---|---|---|---|---|
| | | 25 DAS | 40 DAS | 55 DAS | At harvest |
| Replication | 2 | 0.313 | 0.484 | 1.753 | 2.003 |
| Factor A | 3 | 0.808** | 3.098** | 3.201* | 4.261* |
| Factor B | 2 | 4.115* | 7.613* | 6.235* | 7.295* |
| AB | 6 | 2.114* | 8.898* | 10.022** | 13.034** |
| Error | 22 | 0.161 | 1.781 | 2.871 | 2.871 |

**Appendix VI. Significant effect on leaf length of radish as influenced by different organic manure and mulch materials**

| Source of variation | Degrees of freedom | Mean square of leaf length (cm) | | | |
|---|---|---|---|---|---|
| | | 25 DAS | 40 DAS | 55 DAS | At harvest |
| Replication | 2 | 1.197 | 1.313 | 2.125 | 4.880 |
| Factor A | 3 | 0.290** | 4.318** | 12.565* | 17.538* |
| Factor B | 2 | 4.179* | 7.148* | 9.507* | 13.658* |
| AB | 6 | 0.478** | 2.313* | 3.696* | 16.585* |
| Error | 22 | 0.142 | 1.051 | 2.043 | 3.459 |

**Appendix VII. Significant effect on leaf breadth of radish as influenced by different organic manure and mulch materials**

| Source of variation | Degrees of freedom | Mean square of leaf breadth (cm) | | | |
|---|---|---|---|---|---|
| | | 25 DAS | 40 DAS | 55 DAS | At harvest |
| Replication | 2 | 0.013 | 0.894 | 0.817 | 1.926 |
| Factor A | 3 | 1.565* | 5.248* | 6.043** | 11.697** |
| Factor B | 2 | 0.886** | 7.762* | 9.729* | 8.674* |
| AB | 6 | 0.324* | 2.231* | 4.644** | 13.271* |
| Error | 22 | 0.133 | 1.257 | 2.017 | 3.107 |

**Appendix VIII. Significant effect on yield contributing parameters of radish as influenced by different organic manure and mulch materials**

| Source of variation | Degrees of freedom | Mean square of yield contributing parameters | | | | |
|---|---|---|---|---|---|---|
| | | Root length (cm) at harvest | Diameter of root (cm) at harvest | Fresh weight of root plant$^{-1}$ (g) at harvest | Fresh weight of leaves plant$^{-1}$ (g) at harvest | % dry weight of roots plant$^{-1}$ (g) at harvest |
| Replication | 2 | 0.342 | 0.893 | 2.837 | 1.939 | |
| Factor A | 3 | 13.575* | 5.258* | 22.033** | 11.697** | |
| Factor B | 2 | 16.086** | 9.762* | 18.709* | 16.644* | |
| AB | 6 | 6.641* | 2.235* | 4.618** | 5.251* | |
| Error | 22 | 3.139 | 1.258 | 3.012 | 3.117 | |

**Appendix IX. Significant effect on yield parameters of radish as influenced by different organic manure and mulch materials**

| Source of variation | Degrees of freedom | Mean square of yield parameters | | |
|---|---|---|---|---|
| | | Fresh weight of whole plant at harvest (g plant$^{-1}$) | Gross yield (t ha$^{-1}$) | Marketable yield (t ha$^{-1}$) |
| Replication | 2 | 2.017 | 1.893 | 1.837 |
| Factor A | 3 | 13.584* | 15.268* | 13.031** |
| Factor B | 2 | 9.022** | 9.703* | 15.706* |
| AB | 6 | 4.671* | 6.252* | 7.613** |
| Error | 22 | 4.139 | 2.266 | 2.012 |

**Appendix X: Production cost of radish per hectare at different treatment combination**

(a) Material cost (Tk.)

| Treatment | Seed | Organic manure | Mulch materials | Pesticide | Irrigation | Subtotal (A) |
|---|---|---|---|---|---|---|
| $T_0M_0$ | 1500 | 0 | 0 | 3000 | 3500 | 8000 |
| $T_0M_1$ | 1500 | 0 | 20000 | 3000 | 3500 | 28000 |
| $T_0M_2$ | 1500 | 0 | 16000 | 3000 | 3500 | 24000 |
| $T_1M_0$ | 1500 | 12000 | 0 | 3000 | 3500 | 20000 |
| $T_1M_1$ | 1500 | 12000 | 20000 | 3000 | 3500 | 40000 |
| $T_1M_2$ | 1500 | 12000 | 16000 | 3000 | 3500 | 36000 |
| $T_2M_0$ | 1500 | 15000 | 0 | 3000 | 3500 | 23000 |
| $T_2M_1$ | 1500 | 15000 | 20000 | 3000 | 3500 | 43000 |
| $T_2M_2$ | 1500 | 15000 | 16000 | 3000 | 3500 | 39000 |
| $T_3M_0$ | 1500 | 30000 | 0 | 3000 | 3500 | 38000 |
| $T_3M_1$ | 1500 | 30000 | 20000 | 3000 | 3500 | 58000 |
| $T_3M_2$ | 1500 | 30000 | 16000 | 3000 | 3500 | 54000 |

$T_0$ = Control (No manure)
$T_1$ = Cowdung (20 t $ha^{-1}$)
$T_2$ = Poultry manure (15 t $ha^{-1}$)
$T_3$ = Mustard oil cake (3 t $ha^{-1}$)

$M_0$ = No mulch materials
$M_1$ = Black polythene
$M_2$ = Ash

**Appendix X: Production cost of radish per hectare at different treatment combination (Cont'd)**

(b) Non Material cost* (Tk.)

| Treatment | Land Preparation | Manures Fertilizer application | Irrigation practice | Seed sowing cost | Intercultural operation | Harvesting | Subtotal (B) | Total Input cost (A)+ (B) |
|---|---|---|---|---|---|---|---|---|
| $T_0M_0$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 50000 |
| $T_0M_1$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 70000 |
| $T_0M_2$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 66000 |
| $T_1M_0$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 62000 |
| $T_1M_1$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 82000 |
| $T_1M_2$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 78000 |
| $T_2M_0$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 65000 |
| $T_2M_1$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 85000 |
| $T_2M_2$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 81000 |
| $T_3M_0$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 80000 |
| $T_3M_1$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 100000 |
| $T_3M_2$ | 9000 | 3000 | 3000 | 3000 | 15000 | 9000 | 42000 | 96000 |

* Labor cost = 300 Tk.day$^{-1}$

$T_0$ = Control (No manure)
$T_1$ = Cowdung (20 t ha$^{-1}$)
$T_2$ = Poultry manure (15 t ha$^{-1}$)
$T_3$ = Mustard oil cake (3 t ha$^{-1}$)

$M_0$ = No mulch materials
$M_1$ = Black polythene
$M_2$ = Ash

**Appendix X: Production cost of radish per hectare at different treatment combination (Cont'd)**

(c) Overhead cost and total cost of production, gross return and net return (Tk.)

| Treatment | Cost of use of land (Tk. $ha^{-1}$) | Interest on running capital for 6 month (13% of total input cost) (Tk. $ha^{-1}$) | Miscellaneous Cost (5% of total input cost) (Tk. $ha^{-1}$) | Subtotal (Overhead cost) (Tk. $ha^{-1}$) (C) | Total cost of production (Tk. $ha^{-1}$) A+B+C | Yield of radish (t/ha) | Gross return (Tk. $ha^{-1}$) | Net return (Tk. $ha^{-1}$) | BCR |
|---|---|---|---|---|---|---|---|---|---|
| $T_0M_0$ | 8000 | 3250 | 2500 | 13750 | 63750 | 21.18 | 169440 | 105690 | 2.66 |
| $T_0M_1$ | 8000 | 4550 | 3500 | 16050 | 86050 | 22.80 | 182400 | 96350 | 2.12 |
| $T_0M_2$ | 8000 | 4290 | 3300 | 15590 | 81590 | 28.62 | 228960 | 147370 | 2.81 |
| $T_1M_0$ | 8000 | 4030 | 3100 | 15130 | 77130 | 25.33 | 202640 | 125510 | 2.63 |
| $T_1M_1$ | 8000 | 5330 | 4100 | 17430 | 99430 | 29.63 | 237040 | 137610 | 2.38 |
| $T_1M_2$ | 8000 | 5070 | 3900 | 16970 | 94970 | 32.23 | 257840 | 162870 | 2.71 |
| $T_2M_0$ | 8000 | 4225 | 3250 | 15475 | 80475 | 29.28 | 234240 | 153765 | 2.91 |
| $T_2M_1$ | 8000 | 5525 | 4250 | 17775 | 102775 | 38.14 | 305120 | 202345 | 2.97 |
| $T_2M_2$ | 8000 | 5265 | 4050 | 17315 | 98315 | 42.37 | 338960 | 240645 | 3.45 |
| $T_3M_0$ | 8000 | 5200 | 4000 | 17200 | 97200 | 32.02 | 256160 | 158960 | 2.64 |
| $T_3M_1$ | 8000 | 6500 | 5000 | 19500 | 119500 | 35.28 | 282240 | 162740 | 2.36 |
| $T_3M_2$ | 8000 | 6240 | 4800 | 19040 | 115040 | 34.23 | 273840 | 158800 | 2.38 |

$T_0$ = Control (No manure)
$T_1$ = Cowdung (20 t $ha^{-1}$)
$T_2$ = Poultry manure (15 t $ha^{-1}$)
$T_3$ = Mustard oil cake (3 t $ha^{-1}$)

$M_0$ = No mulch materials
$M_1$ = Black polythene
$M_2$ = Ash