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Effects of organic and inorganic fertilizers, and mulching on growth and yield of cabbage (*Brassica oleracea* var. *capitata* L.)

Saleha Farjana[1], M. Ashraful Islam[2]* and Tamanna Haque[3]

1, 2, 3 Department of Horticulture, Bangladesh Agricultural University (BAU), Mymensingh-2202, Bangladesh

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***Corresponding author:**
Department of Horticulture, Bangladesh Agricultural University (BAU), Mymensingh-2202, Bangladesh
E-mail: **ashrafulmi@bau.edu.bd**

ABSTRACT

Purpose: Cabbage is important fresh vegetable crop in most of the countries of the world. The experiment was conducted to evaluate the growth and yield of cabbage (*Brassica oleracea* var. *capitata* L. cv. Atlas-70) as influenced by organic and inorganic fertilizers, and mulching. **Research methods**: The experiment comprised of two different factors such as, factor-A; four different types of fertilizers viz. F_0 (control, no fertilizer), F_1 (vermicompost), F_2 (inorganic fertilizer), and F_3 (mixed of organic and inorganic fertilizer) and factor-B; types of mulches viz. M_0 (control, no mulch), M_1 (water hyacinth), M_2 (rice straw), M_3 (black polythene). This two factors experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. **Findings:** Significant variation was found among the treatments. Result showed F_3M_3 (combination organic and inorganic fertilizer with black polythene) had the highest growth (plant height, stem length, root length, number of roots etc.) and yield (105.93 t/ha) in cabbage. The yield was 63.92% higher from the combined effect of fertilizer and mulch as black polythene (F_3M_3) compared to control (F_0M_0). So, mineral fertilizer and vermicompost with black polythene had the best performance considering the growth and yield of cabbage. **Research limitations:** Evaluation of different ratios of organic and inorganic fertilizers with mulching could have better outcome or findings of this work. **Originality/Value:** Combination of organic and inorganic fertilizers with black polythene as mulch have showed the highest growth and yield outcome of cabbage compared to other treatments combinations. This work has the opportunity to reduce the application of inorganic fertilizer to improve the soil health and environment in long run.

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) is a vegetable crop commonly suited in low land culture and normally grown in Rabi season (15 October to 16 March). It is an important biennial cole crop of the family Cruciferae that generally cultivated in Bangladesh. Soil is an important factor for better cabbage production but common agricultural practices are reducing soil quality and degrading the environment which hampering balanced ecosystem. Improper use of inorganic fertilizer, herbicide and pesticide for the crops are not so good for health as well as for environment. On the other hand, proper combination of organic and inorganic fertilizers in addition mulch can improve the soil health and physical properties to increase the crop productivity of soil as well as crop quality and yield (Tindall, 2000). Inorganic fertilizers supply the nutrient quickly for the crop production and organic fertilizer release the nutrient slowly for the crop. It gives the opportunity to supply the all nutrients to crop during their production period.

Among the various factors to influence production of cabbage, nutrient availability to plant is an important criteria to increase the production. Experimental evidence showed that the response of cabbage is high to nitrogen application and moderate to phosphorus application. That is why soil management practices have recently changed dramatically including an increased use in synthetic fertilizers and pesticides to help crop yields. However, some studies have suggested that the excessive use of these agrochemicals may actually increase pest problems in the long run (Evenson & Gollen, 2003; Jackson et al., 2007). Overall, these results propose a hypothesis that higher synthetic fertilizer inputs may lead to higher levels of herbivore damage to crops and unexpected harmful effects of environment (Adesemoye & Kloepper, 2008; Kirchmann & Thorvaldsson, 2000; Letourneau, 1996). Excessive use of chemical fertilizers causes unforeseen environmental impacts, sensitivity to pests and diseases and most importantly reduce soil fertility as well as soil quality. On the other hand, combined applications of organic and inorganic sources of nutrients are more productive and sustain soil fertility. Combination of organic and inorganic fertilizer increased the yield of cabbage and tomato (Islam et al., 2017a, b). Mulching is an important factor for successful crop yield. It absorbs the heat from the solar radiation, increases the soil temperature and helps to increase the crop production especially in the winter season. Also, it reduces the cost through reducing the weed infestation in the field and moisture conservation (Chakraborty et al., 2008). Growth and yield of the vegetable crop is remarkably influenced by organic and inorganic nutrients management along with mulching to control weed and conserve soil moisture (Döring et al., 2005; Murungu et al., 2011; Ramakrishna et al., 2006). Also, it improves soil quality, productivity and quality of product for consumption. Mulching helps to control weeds effectively by reducing physiological functions of weed like germination, root, shoot and stem growth etc., ultimately reduce the production cost (Duppong et al., 2004).

However, farmers are now showing interest in organic farming because of, they are more aware about the residual effect of chemical substances used in the crop field and environmental degradation. Besides, the excess application of inorganic fertilizers and herbicides cause hazard to public health and to the environment. But the combined application of both organic and inorganic fertilizers can increase the yield as well as keep the environment sound (Hsieh et al., 1995). On the other hand, different types of mulch like natural or artificial mulch can have the influence on crop production. It is necessary to identify which will be beneficial for higher production of cabbage. Because, natural mulch

helps to add organic matter to soil and artificial mulch increase the temperature of soil, conserve soil moisture and reduce the weed competition (Murungu et al., 2011).

Cabbage is important fresh and processing vegetable crop in most of the countries of the world. It is an excellent source of vitamin C, potassium and calcium in diet (Pennington & Fish, 2010). In recent years vegetable consumption has increased. However, the productivity of cabbage per unit area is quite low in Bangladesh as compared to the developed countries of the world. Considering this, it is very much important to sustain the production of cabbage. Fertilizers and mulch are important factors which can have the influence on cabbage production. The objective of the work was to find out the better growth and yield of cabbage by using different types of organic and inorganic fertilizers with mulch.

MATERIALS AND METHODS

Plant material and treatments

The experiment was carried out at Horticulture farm, Bangladesh Agricultural University (BAU), Mymensingh during October, 2016 to February, 2017 to study the effects of organic and inorganic fertilizer, and mulching on growth and yield of cabbage. Cabbage (Atlas-70: hybrid F1, Sakata seed corporation, Japan) seed was used for the experiment. The experimental area was well drained sandy loam soil belonged to the Agro Ecological Zone-9 (AEZ-9) of Old Brahamaputra Flood Plain. The land had good irrigation facilities. Two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. The factors were consisted of four different types of fertilizers viz. F_0 (control, no fertilizer), F_1 (vermicompost @15 t ha^{-1}), F_2 (inorganic fertilizer; Urea @330 kg ha^{-1}, Triple Super Phosphate (TSP) @ 200 kg ha^{-1}, Muriate of Potash (MoP) @ 250 kg ha^{-1}) and F_3 (2/3rdVermicompost +1/3rd Mineral fertilizer) and, four different types of mulches viz. M_0 (control, no mulch), M_1 (water hyacinth), M_2 (rice straw), M_3 (black polythene). Here, 15 µM of black high density polyethylene (HDPE) film was used and the thickness of natural mulch (water hyacinth and rice straw) was about 6-10 cm. Inorganic fertilizer (F_2) was applied according the fertilizer recommendation guide where soil status and region of the experiment was considered (FRG, 2012). N (%) of the vermicompost was 1%. Although, nutrient of vermicompost composition varies to determine the quality of vermicompost in Bangladesh (N: 0.5%–4%, P: 0.5%–3%, K: 0.5%–3%, and S: 0.1%–0.5%, personal contact with BARC, Bangladesh).

In the experimental plot (2m × 1.8 m), 25 days old seedlings were transplanted on 13 November 2016, with spacing 50 cm × 45 cm. Seedlings were raised in the horticulture farm, Bangladesh Agricultural University, Mymensingh under special care in seedbed and the size of this bed was 3m×1m. Opened land was sun exposed for one week then harrowed, ploughed and cross-ploughed and treated with fungicide cupravit @ 2 ml/L after getting good tilth. All the fertilizers except urea (in two splits at 15 days interval) were applied at the time of final land preparation. Over-head irrigation was provided with a watering can twice every day at early morning and evening for the establishment of the seedlings up to one week. Further irrigation was done as and when needed. Flood irrigation was given before using mulch. Mulching material was given 15 days after transplanting (DAT) of seedlings. Gap filling was done after 3 days of transplanting and 7 days after first gap filling from border side transplanted plant. Weeding was done to keep the plots free from weeds, easy aeration of soil and breaking the crust of the soil followed by mulching. Harvesting was done two times according to maturity index (head compactness and firmness to the touch, arrangement of the wrapper leaves) and it was on 5 to 12 February 2017. To collect data, five plants were

selected randomly from each unit plot. Average value of five plants in one plot considered as one replication. Data were collected on plant height (cm), number of leaves per plant, length of root (cm), length of stem (cm), number of roots per plant, fresh weight of root (g), thickness of head (cm) and diameter of head (cm), gross yield (weight of cabbage head including loose leaves and roots) and marketable yield (only head) per plot. Plant height and the number of leaves were recorded from the five selected plants at random from the inner rows of each plot at 30, 45 and 60 days after transplanting (DAT). The height was measured from the ground level to the tip of the growing point by placing a meter scale. Thickness and diameter of head was measured from five plants with a scale as the vertical and horizontal distance from one side to another side of the head when it was harvested and then value was recorded and expressed in centimeter (cm). Gross yield (weight of loose leaves + weight of head + weight of stem) and marketable yield (only head) of cabbage per plot was measured and expressed in kg and converted into gross yield and marketable yield per hectare which was expressed in ton (t). Fresh weight of cabbage head (100 g) was taken from each treatment with three replications. Dry weight of cabbage head were recorded after drying at 65 °C until a constant mass was reached. Total dry matter (DM) was calculated from the total sum of dry weight of cabbage head.

Statistical analysis

Effects of treatments on growth and yield cabbage were analyzed by analysis of variance (General Linear Model procedure) and Tukey's pair wise comparison test ($p \leq 0.05$) using Minitab Version 16 (Minitab Inc., State College, PA, USA).

RESULTS AND DISCUSSION

The average growth and yield was significantly influenced by the organic and inorganic fertilizers and mulching. Soil quality at the Horticulture farm of Bangladesh Agricultural University is medium quality and the inorganic fertilizer has been applied according the Fertilizer Recommendation Guide (FRG, 2012). Different treatment combination viewed different plant height at different days after transplanting (Table 1). It was observed that highest plant height was achieved with the treatment combination of vermicompost ($2/3^{rd}$) and inorganic fertilizer ($1/3^{rd}$) with black polythene as mulch (F_3M_3) and plant height was 17.33, 22.50 and 27.33 cm at 30, 45 and 60 days after transplanting (DAT), respectively. On the other hand, the lowest plant height; 14.33, 19.00 and 24.33 cm at 30, 45 and 60 DAT was with control (F_0M_0). Thus, plant height was found 10.90 to 12.33 % higher under different treatments compared to control. The combination of vermicompost and inorganic fertilizer with mulching was given better plant growth because, inorganic fertilizer provide the quick nutrient release for the cabbage. At the same time, plant is getting nutrient all the time of crop growth due to application vermicompost which release slowly nutrients for the plant. Plant height result of this experiment support the result of Souza et al. (2008) are also supportive of the present findings and reported that when organic fertilizer mixed with metallic trace elements used in the soil, it stimulated the root growth that ultimately increases the dry biomass yield of kale crop.

Combined effect of manure and fertilizer with mulching had significant effect on stem length (Table 2). Length of stem was the highest (14 cm) with F_3M_3 and F_2M_3 where the lowest (10.33 cm) was with F_0M_0. This result indicated that combined application of organic and mineral fertilizer supplied adequate available plant nutrients and provided better growing condition which was helpful for proper vegetative growth. Vegetative growth ultimately influences the yield of crop. Similarly, the application of organic and inorganic fertilizer

significantly increased the vegetative growth of cabbage and yield as well (Islam et al., 2017a).

Table 1. Combined effects of organic and inorganic fertilizer and mulching on plant height of cabbage at different days after transplanting (DAT)

Treatment combination	Plant height (cm) at DAT		
	30	45	60
F_0M_0	14.33	19.00	24.33
F_0M_1	15.00	19.50	25.00
F_0M_2	15.67	20.83	25.67
F_0M_3	16.50	21.00	26.67
F_1M_0	14.33	19.33	24.67
F_1M_1	15.00	19.67	25.33
F_1M_2	15.67	20.83	25.83
F_1M_3	16.67	21.50	27.00
F_2M_0	15.17	20.00	25.00
F_2M_1	15.67	20.00	25.33
F_2M_2	15.83	21.00	26.33
F_2M_3	16.83	22.00	27.33
F_3M_0	15.47	20.33	25.33
F_3M_1	15.67	20.67	25.50
F_3M_2	16.33	21.33	27.00
F_3M_3	17.33	22.50	27.33
$LSD_{0.05}$	0.22	0.26	0.38
Level of significance	*	*	*

*=Significant at 5% level of probability

F_0: Control, F_1: Vermicompost, F_2: Mineral fertilizer, F_3: 2/3rdVermicompost +1/3rd Mineral fertilizer and M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene

Table 2. Effects of organic and inorganic fertilizer and mulching on growth and yield contributing characters of cabbage

Treatment combination	Length of stem/ plant (cm)	Length of root/ plant (cm)	No. of root/ plant	Thickness of head (cm)	Diameter of head (cm)	Dry matter (%) of cabbage head	Gross yield (t ha^{-1})	Marketable yield (t ha^{-1})
F_0M_0	10.33	16.00	16.33	10.33	18.00	5.02	50.22	38.22
F_0M_1	11.00	16.00	19.67	11.00	18.00	6.17	90.67	60.00
F_0M_2	12.00	16.00	20.00	11.00	19.00	7.10	92.89	77.78
F_0M_3	13.33	16.33	21.00	11.33	20.00	7.33	96.89	79.56
F_1M_0	11.00	16.00	17.33	11.00	18.00	5.38	84.00	49.04
F_1M_1	11.00	16.33	19.67	11.00	18.33	6.69	94.67	72.89
F_1M_2	13.00	17.00	20.00	11.33	19.00	7.22	97.78	78.67
F_1M_3	13.67	18.00	21.67	11.50	21.00	7.59	101.33	94.22
F_2M_0	11.00	17.00	19.00	11.00	18.00	5.80	90.22	53.78
F_2M_1	11.33	17.00	21.00	11.33	18.67	6.98	104.44	75.11
F_2M_2	13.00	17.67	21.67	11.50	20.67	7.32	108.44	88.00
F_2M_3	14.00	18.00	22.00	12.50	21.33	7.79	118.22	99.56
F_3M_0	12.00	17.00	21.00	11.00	18.33	6.11	102.96	63.56
F_3M_1	12.67	17.33	22.00	11.33	18.67	7.08	109.33	78.67
F_3M_2	13.33	18.00	23.00	12.00	21.00	7.55	109.33	90.37
F_3M_3	14.00	18.67	24.00	13.00	21.67	8.97	130.37	105.93
$LSD_{0.05}$	0.55	0.53	0.56	0.42	0.70	0.39	6.24	3.25
Level of significance	*	*	*	*	*	*	*	*

*=Significant at 5% level of probability

F_0: Control, F_1: Vermicompost, F_2: Mineral fertilizer, F_3: 2/3rdVermicompost +1/3rd Mineral fertilizer and M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene

Table 3. Effect of fertilizers on gross yield and marketable yield of cabbage

Fertilizers	Gross wt./ plant (kg)	Marketable wt./ plant (kg)	Gross yield (t ha^{-1})	Marketable yield (t ha^{-1})
F_0	1.86	1.44	82.67	64.00
F_1	2.13	1.66	94.67	73.78
F_2	2.37	1.78	105.33	79.11
F_3	2.54	1.90	112.88	83.44
$LSD_{0.05}$	0.07	0.05	3.09	1.61
Level of significance	*	*	*	*

* = Significant at 5% level of probability, F_0 = Control, F_1 = Vermicompost 15 t/ha , F_2 = Inorganic fertilizer, F_3 = Mixed fertilizer 2/3rdVermicompost +1/3rdInorganic fertilizer

Table 4. Effect of mulching on gross yield and marketable yield of cabbage

Mulching	Gross wt./ plant (kg)	Marketable wt./ plant (kg)	Gross yield (t ha^{-1})	Marketable yield (t ha^{-1})
M_0	1.84	1.15	81.77	51.11
M_1	2.25	1.61	100.0	71.55
M_2	2.30	1.88	102.22	83.56
M_3	2.51	2.13	111.56	94.67
$LSD_{0.05}$	0.07	0.05	3.09	1.61
Level of significance	*	*	*	*

* = Significant at 5% level of probability, M_0 = Control (No mulching), M_1 = Water hyacinth, M_2 = Rice straw, M_3 = Black polythene

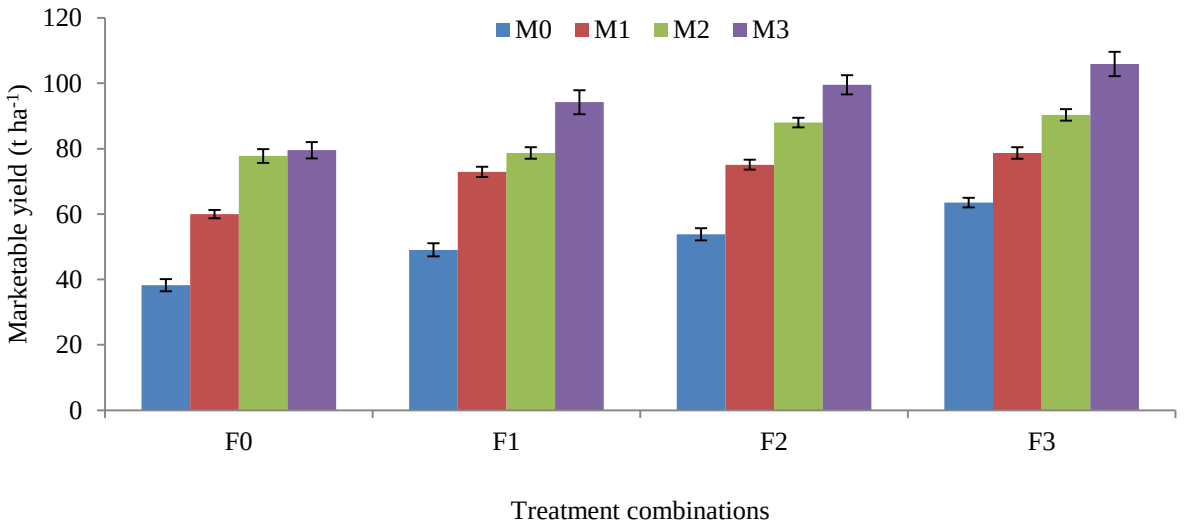

Fig. 1. Combined effect of fertilizer and mulching on marketable yield of cabbage. Vertical bars represent the mean value ± SE (standard error).
F_0: Control, F_1: Vermicompost, F_2: Mineral fertilizer, F_3: 2/3rdVermicompost +1/3rd Mineral fertilizer and M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene.

Present study found that significant variation was present in respect of organic and inorganic fertilizer with different mulching. Root length was highest (18.67 cm) with F_3M_3 and the second highest (18.00 cm) was with F_1M_3, F_2M_3 and F_3M_2 and lowest was with F_0M_0. Number of root was highest (24.00 cm) with F_3M_3 and lowest (16.33 cm) with F_0M_0. It is revealed that application of mineral fertilizer and vermicompost with mulching improve soil quality, increase moisture content, microbial activities and provide proper aeration as a result plant nutrient become available for plant and give a better growth and development of roots which ultimately increased the number of roots. Rai et al. (2013) also supported the result of present findings.

Combined effect of different fertilizer and mulching had significant effect on thickness and diameter of head. Different treatment combination showed different thickness and diameter of head. Thickness and diameter of cabbage head was highest (13.00 cm and 21.67 cm) with F_3M_3 and lowest (10.33 cm and 18.00 cm) with F_0M_0. The result of this study was in agreement with Souza et al. (2008) and Vimala (2006). Gross yield and marketable yield was the highest (130.37 t ha^{-1} and 105.93 t ha^{-1}, respectively) with F_3M_3 and the lowest gross and marketable yield were 50.22 t/ha and 38.22 t/ha, respectively with F_0M_0 (Fig. 1). Interestingly, all the fertilizers treatments have shown the better combination with black polythene (M_3) as mulch. After the combination of organic and inorganic fertilizer, the subsequent yield both gross and marketable yield were found from inorganic fertilizer (M_2), vermicompost (M_1) and control (M_0), respectively with black polythene. On the other hand, black polythene (M3) with all types fertilizers has given the highest yield and subsequently, rice straw (M2), water hyacinth (M1) gave the better yield compared to control. The combination sequence of mulch with fertilizers is the same which indicates the consistency of the result of this experiment. F_3M_3 gave the 63.92% higher yield compared to control (F_0M_0). The result obtained from the experiment was partially conformed by Hsieh et al. (1995) and Chan et al. (2008). The result obtained from all other treatments was significantly different from highest and lowest yield and it was almost similar to the findings observed with Yau (2006). On the other hand, single effect of organic and mineral fertilizer had a great influence on gross yield and marketable yield under the present study (Table 3). It is evident that the highest gross yield (112.88 t ha^{-1}) and marketable yield (83.44 t ha^{-1}) was obtained with the treatment F_3 (2/3rd vermicompost +1/3rd mineral fertilizer) and the lowest gross yield (82.67 t ha^{-1}) and marketable yield (64.00 t ha^{-1}) was found from the control (F_0) treatment which was significantly different from all other treatments. Mineral (F_2) and vermicompost (F_1) have given better growth and yield compared to control. Here, mineral fertilizer has given better yield compared to vermicompost. Because, mineral fertilizer quickly avail the nutrients to crop compared to organic fertilizers like vermicompost. This might be the reason of getting better result of yield in case of sole application fertilizer mineral or organic fertilizer. The similar trend of the yield was found in tomato and cabbage (Islam et al., 2017a, b).

Gross yield and marketable yield was significantly affected by different mulches used in the present experiment (Table 4). The highest gross yield (111.56 t ha^{-1}) and marketable yield (94.67 t ha^{-1}) was obtained from black polythene (M_3) but the control (M_0) treatment viewed lowest gross yield (81.77 t ha^{-1}) and marketable yield (51.11 t ha^{-1}). Black polythene (M_3) gave the best performance out of the other mulch materials. Other mulches like rice straw (M_2), water hyacinth (M_1) and control gave the second and 3rd highest yield of cabbage. Polythene as mulch conserves the soil moisture for crop production. Also, it increases the soil temperature and prevents sunlight from reaching soil which inhibits the growth of weeds. Ultimately, it helps to reduce crop production cost.

Combined effect of different fertilizer and mulching had significant effect on dry matter percentage of cabbage heads. The highest dry matter (8.97%) was observed with the treatment combination of F_3M_3. The lowest dry weight (5.02 g) was obtained with F_0M_0. Generally, organic fertilizers contain macro and micro nutrients, vitamins, growth-promoting indole acetic acid (IAA), gibberellic acid (GA) and beneficial microorganisms (Sreenivasa et al., 2010). So, higher amount of vermicompost and lower amount of inorganic fertizer effects can be the reason of higher dry matter percentage in cabbage. The second highest dry matter was found from the same type mulching (black polythene) with mineral fertilizer (F_2).

Overall, soil organic matter is decreasing dramatically in Bangladesh due to increase the intensification of agriculture and indiscriminate use of chemical fertilizers (Muhibbullah et al., 2005). This finding can promote the application of organic fertizer and reduce the amount of inorganic fertilizer for the sustainable production of crops in Bangladesh.

CONCLUSION

Combined effect of fertilizer and mulching under the present study were significantly different in all parameters of this experiment. Black polythene can be used as mulching materials for getting higher production of cabbage. Further studies should be conducted using different ratio of organic and inorganic fertilizer for the efficient application of fertilizers in crop.

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CONFLICT OF INTEREST

The authors have no conflict of interest to report.

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