YIELD AND QUALITY OF DIFFERENT TURNIP VARIETIES INFLUENCED BY VERMICOMPOST

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JUNE, 2022

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A Thesis

Submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE
SEMISTER: JANUARY-JUNE, 2022

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*This is to certify that the thesis entitled, **"YIELD AND QUALITY OF DIFFERENT TURNIP VARIETIES INFLUENCED BY VERMICOMPOST."** submitted to the Department of Horticulture, Faculty of Agriculture, 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 **NASRIN AKTER,** Registration No. **14-06207** under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2022

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ACKNOWLEDGEMENTS

First of all, the author expresses her sincere gratitude to the Almighty ALLAH, the supreme ruler of the universe for never ending blessings for the successful completion of the present research work and to prepare the thesis.

*I express my deepest sense of gratitude, love and ever indebtedness to my revered teacher and honorable supervisor, **Professor Dr. Jasim Uddain,** Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for his ingenious suggestions, encouragement, guidance and direction whenever I needed it to complete this study and also for his constructive criticism and meticulous reviewing of the manuscript.*

*I sincerely express my heartfelt respect, deepest gratitude and profound appreciation to my dignified co-supervisor **Dr. Shormin Choudhury, Associate Professor,** Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for her co-operation and helpful suggestions to conduct the research work and in the preparation of this manuscript.*

*I also sincerely express my heartiest admiration, deepest sense of gratefulness and profound appraisement to my honorable teacher **Professor Dr. Khaleda Khatun**, Chairman, Examination committee, Sher-e-Bangla Agricultural University, Dhaka, for her co-operation and helpful suggestions to conduct the research work and in the preparation of this manuscript.*

The author also expresses her special thanks to all the teachers of the Dept. of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for their help, valuable suggestions and encouragement during the period of study.

The author also acknowledges the lab and farm attendants who helped her wholeheartedly during the experimental setup.

Finally, I express my most sincere gratitude to my beloved parents, brothers and my only sister, friends, well-wishers, and relatives for their blessings, inspiration and co-operation throughout the period of my study.

June, 2022 *The Author*

YIELD AND QUALITY OF DIFFERENT TURNIP VARIETIES INFLUENCED BY VERMICOMPOST[1]

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ABSTRACT

An experiment was carried out at the Horticulture research field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2020 to March 2021 to find out the yield and quality of different turnip varieties influenced by vermicompost. The experiment was laid out in two factorial RCBD with 3 (three) replications. Factor A (Three different turnip varieties) viz. V_1 = Purple Top White Globe; V_2 = Pusa Chandrima; V_3 = Early Milan Red Top and Factor B (Four different levels of vermicompost) viz. F_1 = 0 t/ha; F_2 = 2 t/ha VC doses, F_3 = 4 t/ha VC doses and F_4 = 6 t/ha VC doses. Significant variation was found in all parameter due to the effect of different turnip variety and different amount of vermicompost application. In case of different variety, the maximum yield (17.84 t ha^{-1}) was recorded from the Purple Top White Globe (V_1) as it is a high yielding variety. One the other hand, the lowest root yield (11.02 t ha^{-1}) was recorded from Pusa Chandrima (V_2) which is a moderate early variety. In case of different levels of vermicompost, results exposed that the highest roots yield (17.22 t ha^{-1}) was recorded from F_3 (4 t ha^{-1} VC) which was statistically different from all other treatments, where the lowest yield (10.75 t ha^{-1}) was achieved from F_1 (0 t ha^{-1} VC i.e. control). Finally, root yield as t ha^{-1} was the output of different varietal treatments applied as well as the effect of different level of vermicompost (VC) doses. The maximum roots yield (21.24 t ha^{-1}) was found from V_1F_3 (Purple Top White Globe with 4 t/ha VC doses) which was statistically different from others. Again, the minimum roots yield (7.80 t ha^{-1}) was observed from V_2F_1 (Pusa Chandrima with 0 t/ha VC doses i.e. Control) which was statistically similar with V_2F_2 (Pusa Chandrima with 2 t/ha VC doses). The findings of the present investigation clearly indicates that the use of Purple Top White Globe turnip variety and optimum level of vermicompost for growing turnip root is a viable option for improved cultivation.

Keywords: Turnip, Varieties, Vermicompost

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LIST OF ABBREVIATIONS

Abbreviation	=	Full word
%	=	Percent
VC	=	Vermicompost
RDF	=	Recommended Doses of Fertilizer
@	=	At the rate
°C	=	Degree Centigrade
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
CV	=	Coefficient of Variance
HSD	=	Honestly Significant Difference
e.g.	=	(For example) example gratia
et al.	=	(And Others) et alibi
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
G	=	Gram
i.e.	=	That is
Kg	=	Kilogram
no.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
NPK	=	Nitrogen, Phosphorus and Potassium
t/ha	=	Ton per Hectare
UNDP	=	United Nation Development Program
wt.	=	Weight
Mg	=	Milligram
CHO	=	Carbohydrate
Conc.	=	Concentration

CHAPTER I

INTRODUCTION

Turnip (*Brassica rapa* sub sp. rapifera) belongs to the family of Cruciferae is an herbaceous biennial and winter vegetable crop. It has a crisp white flesh and a zesty mustard-like flavor and a rapidly maturing crop. It's an underground modified root, which is spherical in shape (Langer and Hill, 1983). Turnip has considerable nutritive value compared to other Cole crops that we commonly use in our daily diet. The fleshy root and young leaves are the main edible portion.

It has been cultivated since about 2000 years in a vast range of climate from west Europe to China and from Norway to the African desert (Zohary and Hopf, 2000). Turnip can be used for human consumption as well as feed for livestock. It has considerable nutritive value considering other cole crops. 100 gram of turnip bulb contains 0.12 % Fat, 34 calories, 2.2 % fibers, 7.84 % carbohydrates, no cholesterol and 1.10 % protein (Susan, 2010). And thousand grams edible roots contain 0.6 g mineral salt, 0.03 mg vitamin B-1, 0.02 mg vitamin B-2, 15 mg Vitamin-C, 24 mg calcium, 0.4 mg iron and 21 Kilocalories (Purseglove *et al*, 1988).

Turnip varieties are divided into 2 groups- Asiatic or tropical types and European or temperate. These can further be classified on the basis of root shape as well as skin and flesh color. Purple Top White Globe is a heavy-yielder and large-rooted variety. The roots are nearly round, upper part purplish, lower portion is creamy depending on the variety. The flesh is white, firm, crisp and mildly sweet flavored. Top is small, erect with cut leaves. It is suitable for growing during cooler months. Early Milan Red Top's roots are deep flat with purplish red top and white underneath. The flesh is pure white, well grained, crisp and mildly pungent. The top is very small with 4–6 sessile leaves. It is an extra early and very high yielding variety. Pusa Chandrima's roots are medium to large, nearly flattened globe to globular, smooth, pure white skin with fine grains. The flesh is sweet and tender. Top medium and leaves not so deeply cut. It is an early maturing (50–60 days), heavy cropper with an average yield of 8-10 t/acre. It is suitable for sowing from October to December in plains.

Vermicompost, a bodily waste made by earthworm under specialized condition, which is capable of improving soil health and nutrient status and is an excellent soil additive made up of digested compost (Adhikary, 2012). Earthworms consume and fragment the organic wastes into finer particles by passing them through a grinding gizzard and derive their nourishment from microorganisms that grow upon them. Vermicompost can increase crop production and prevent harmful pests, is eco-friendly, and is ideal organic manure for better growth and yield of many plants (Reddy *et al*., 1998; Joshi *et al*., 2015). The new approaches to the use of Vermicompost in farming has proven to be effective means of improving soil structure, enhancing soil fertility and increasing crop yields. Organic matter is excellent source of plant-available nutrients and their addition to soil could maintain high microbial populations and activities with increased values of biomass C, basal respiration, biomass C: total organic C ratio, and metabolic quotient (CO_2).

Uses of vermicompost as fertilizer in different turnip variety production, to at least partially supplement its nutrient demand and to improve soil fertility by the way of integration of different sources of plant nutrients is desired. Turnip has a good response for vermicompost inoculation due to real nature of their root morphology.

Vermicompost application and varietal differences are important factors that influence turnip productivity. Keeping the above stated facts in view, the present study was undertaken in achieving the following objectives:

i) To find out the suitable level of vermicompost on the growth and quality yield of turnip;

ii) To compare the growth, yield and quality of different turnip varieties using different level of vermicompost & find out suitable variety with higher yield and quality;

iii) To compare interactional effect of varieties and vermicompost level on growth, yield and quality of turnip.

CHAPTER II

REVIEW OF LITERATURE

In this chapter an attempt has been made to review the available information in home and abroad regarding the study on different level of vermicompost doses in turnip varieties. Many research organizations of our country have information about the effect of vermicompost on turnip as well as other underground modified roots/stems yielding vegetable crops such as radish, potato, carrot etc. A review of the previous research and findings of researchers having relevance to this study which were gathered from different sources like literature, journals, thesis, reports, newspaper etc. will be represented by this chapter. However, some of the literature related to this investigation are reviewed in this chapter are given below:

2.1 Review related to vermicompost

No available work has been found regarding the sole effect of vermicompost on turnip varieties. Turnip is closely related to root crops and vegetable crops. Therefore, reports related to the effect of vermicompost to the related crops are reviewed here:

The beneficial impacts of vermicompost on soil (Sinha, 2014):

1. Increase the 'Soil Organic Matter' (SOM), soil structure and prevent soil erosion.
2. Increase beneficial soil microbes, microbial activity and essential nutrients.
3. Improve cation exchange capacity.
4. Reduces bulk density of soil, prevents soil compaction and erosion.
5. Suppression of soil-born plant diseases.
6. Increase water holding capacity of soil.
7. Remove soil salinity and sodicity.
8. Maintain optimal pH value of soil

Important feedback from farmers who have used vermicompost (Sinha *et al.*, 2009):

1. Reduced use of 'water for irrigation';
2. Reduced 'pest attack' (by at least 75%);
3. Reduced 'termite attack';
4. Reduced 'weed growth';

5. Faster rate of 'seed germination' and rapid seedlings growth and development;

6. Greater numbers of fruits per plant (in vegetable crops) and greater numbers of seeds per ear (in cereal crops), heavier in weight-better in both, quantity and quality as compared to those grown on chemicals;

7. Fruits and vegetables had 'better taste' and texture and could be safely stored up to 6–7 days, while those grown on chemicals could be kept at the most for 2–3 days.

Peter *et al.*, (2022) concluded that the rising quantity of vermicompost in the soil substrate, the weight of carrot roots and leaves also increased. As the dose of VC in the treatments increased, the differences in phytomass percentage increases got smaller. Surprisingly, the high proportion of VC in the soil substrate did not have a negative effect on the formation of both carrot roots and leaves. VC increased the weight of roots more than leaves. The values of TR in carrot roots or leaves increased proportionally with the increasing quantity of VC in the substrate. VC increased the water content in the roots.

Dipesh *et al.*, (2021) conducted a field experiment at Horticulture farm of Nepal Polytechnic Institute (NPI) Bharatpur-11, Chitwan to study the effects of different doses of vermicompost on growth, yield and quality of radish (*Raphanus sativus* L. cv. Mino Early) from January 2020 to March 2020. Five different doses (0 ton, 5 ton, 10 ton, 15 ton, and 20 ton per hectare) of vermicompost were taken as treatments and the experiment was replicated four times. The experiment was set up in Randomized Complete Block Design (RCBD). The result of the study showed that there was a significant effect of different doses of vermicompost on plant height, the number of leaves per plant, spreading of the plant, root length, root weight per plant, root diameter, and root yield at harvesting. The maximum plant height, the maximum number of leaves per plant and maximum plant spreading in radish plant on vermicompost application was recorded every 30, 45 and 60 days after sowing (DAS). The maximum root length (29.60 cm), maximum root diameter (36.27 mm), maximum root weight (191.8 g), maximum biomass weight (241.6 g/plant), maximum root yield (47.9 ton/ha), were recorded on applying 15 ton/ha vermicompost at 60 DAS. The control treatment showed the minimum vegetative growth and yield. Among the different doses of vermicompost, the overall performance of radish was found better in

15 tons/ha of vermicompost. Statistical analysis showed no differences among (5 tons, 10 tons, 15 tons, 20 tons per hectare of vermicompost) applications. Hence, 5 tons per hectare of vermicompost application will be best for radish production in Chitwan.

Anand and Gupta (2018) conducted an experiment to study the effect of vermicompost and chemical fertilizers on growth and yield of Radish (*Raphanus sativus*). From this experiment it is clear that vermicompost is a better nutrient source than other fertilizers due to the quantitative availability of nutrients in vermicompost and also due to it's eco-friendly nature which helps in bringing sustainability of agriculture sector. The sustainability of agriculture is more important for food securities of peoples of a country. In that analysis the plant heights were found to be 50cm in vermicompost, 41cm in cow dung, 39cm in urea and 17cm in control treatment. Weight of the tuber was observed to be 152g in vermicompost, 133g in cow dung, 120 gm in urea, and 49g in control treatment. The number of fruits/plant was found to be 44 in vermicompost, 36 in cow dung, 25 in urea and 15 in control treatment. The stem diameters were observed to be 1.40cm in vermicompost, 1.16cm in cow dung, 0.96cm in urea and 0.76cm in control treatment. The dry matters yield was 41.36 g in vermicompost, 39.92g in cow dung, 35.25g in urea and 21.50g control treatment.

Akbasova *et al.*, (2015) reported that the impact of vermicompost which was obtained on the basis of camel manure, yield and quality of potatoes, turnip and beets was investigated. The increase of root crops yields 1.2-1.5 times by making 8t/ha vermicompost in gray soils was established. It was shown that the use vermicompost as a fertilizer was more expedient, as it contains more nutrients (N,P,K) and organic humic acids compared to conventional compost. Vermicompost has a direct physiological effect on plants; it stimulates the development of root systems and reduces the harmful effects of pollutants.

Application of organic fertilizers, vermicompost, compost, biofertilizer, and low-dose chemical fertilizer has increased the production parameters of radish (Subramani *et al.*, 2010; Kiran *et al.*, 2016)

Blouinl (2019) found that vermicompost brought about average increases of 26% in commercial yield, 13% in total biomass, 78% in shoot biomass, and 57% in root 5 biomass. The positive effect of vermicompost on plant growth reached a maximum when vermicompost represented 30 to 50% of the soil volume.

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.

Chandan and Azad (2015) reported that vermicomposting is a promising method of transforming unwanted and virtually unlimited supplies of organic wastes into usable substrates. In this process, the digestive tracts of certain earthworm species (e.g., *Eisenia fetida*) are used to stabilize organic wastes. The final product is an odorless peat-like substance, which has good structure, moisture-holding capacity, relatively large amounts of available nutrients, and microbial metabolites that may act as plant growth regulators. For these reasons, vermicompost has the potential to make a valuable contribution to soilless potting media. The objective of this study was to evaluate the transplant quality and field performance of vegetable transplants grown in vermicompost. Tomato (*Lycopersicon esculentum* Mill.), Eggplant (*Solanum melongena* L.), Pepper (*Capsicum annuum* L.), Potato, Sweet corn hybrids, Pak choi, Spinach and Turnip. Growth of vegetable transplants was positively affected by addition of vermicompost, perhaps by altering the nutritional balance of the medium. Transplant quality was improved in peppers and eggplants while tomato transplant quality was slightly reduced. There were no significant differences in field performance. Hence, vermicomposting is a sustainable technique for solid waste disposal. Vermicomposting is the science of producing compost from biodegradable organic matters through earthworms. Vermicompost contains significant quantities of nutrients, a large beneficial microbial population and biologically active metabolites, particularly gibberellins, cytokines, auxins and group B vitamins which can be applied alone or in combination ith organic or inorganic fertilizers so as to get better yield and quality of diverse crops.

Shirzadi (2015) conducted a study in order to evaluate the use of organic fertilizers (Vermicompost and Chicken manure) on the plant's height and number and weight of micro tuber Marfona cultivator potato (diameter of 25 to 35mm) with 2 factors of vermicompost in 4 levels (0,3,6 and 9 t ha^{-1}) and chicken manure in 4 levels (0,10,12 and 14 t ha^{-1}). The result showed that with increasing Vermicompost fertilizer, plant's height was reduced. The highest number and weight of tubers with a diameter of 25- 35mm belonged to 12 tons Chicken manure treatment without Vermicompost.

Ramamurthy *et al.* (2015) conducted an experiment to show the influence of different percentages of vermicompost (25%, 50%, 75% and 100%) on the tuber length, width, circumference and weight of the radish plant (Raphanus sativus L.) was carried out at different period of exposures (30, 60 and 90 days). The maximum tuber length (20.67, 23.67 and 27.55cm) and weight (189.31, 215.31 and 244.64gm) were noticed in 75% of vermicompost concentration at 30, 60 and 90 days respectively except tuber width and circumference. During 60 and 90 days of exposure the maximum width and circumference were noticed in 50% of vermicompost and thereafter both width and circumference decreased in commensurate with increasing vermicompost concentration. The study reveals the 75% concentration of the vermicompost influence the tuber yield status of Radish plant

Panwar and Wani (2014) introduced a field experiment in the sweet potato field with Nitrogen, Potash, and Phosphorus was applied in form of organic manure Farm Yard Manure, Vermicompost, and Neemcake. (Vermicompost) recorded highest survival percent, length of vine, number of branches/vine, shoot fresh weight, shoot dry weight, tuber yield plot^{-1}, number of tuber plot-1 under poplar trees. The maximum Gross return was noticed in with Rs. 99204.00. The maximum Benefit cost ratio was noticed in with 1:1.37.

Kumar *et al*. (2014) conducted an experiment to study the influence of organic source of nutrients on growth and yield of radish cv. Japanese White. The experiment consisted 5 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, the number of leaves, and the length of the bulb. The study reveals that inorganic 8 fertilizer had a 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*.

Raja and Veerakumari (2013) conducted an experiment and found the impact of vermicomposts viz. Cowdung vermicompost, leaf ash vermicompost and poultry feather vermicompost on the yield and alkaloid content of medicinal plant, *Withania somnifera* were assessed 40 and compared with the plants cultivated in the soil amended with chemical fertilizer and the plants cultivated without any fertilizer (control). The plant growth parameters such as shoot length, root length, shoot dry weight, root dry weight, shoot wet weight, root wet weight, shoot: root ratio and the alkaloid withaferin A and withanolide D were significantly increased in the plants cultivated in the soil amended with poultry feather vermicompost.

Mária *et al*. (2013) conducted an experiment with maize grown for grain were 4 treatments established – a control treatment and three treatments with dose increasing of granulated vermicompost (4.6; 9.2; 11.6 t ha^{-1}, respectively), which supplied 57, 114 and 142 kg. ha^{-1} total nitrogen to 38 the soil, respectively. The experiment was not irrigated. The experiment with potatoes included 7 treatments of fertilization. The first treatment was a control treatment, i.e., without the appliance of dry granulated vermicompost. In treatment 2 to 6 increasing doses of vermicompost (3.3; 6.6; 9.9; 13.2 and 19.8, respectively) were applied. Through the following doses of granulated vermicompost were applied to the soil 40, 80, 120, 160, 240 kg ha^{-1} N. Not only was the granular vermicompost applied in treatment 7, but also the industrial NPK fertilizer (150 kg urea + 200 kg ha^{-1} NPK 15-15-15. The grain yield was increased with the dose increasing of vermicompost. A thousand kernel weight, starch content and magnesium content parameters with the increasing dose of vermicompost were reduced. A dose of 4.6 t ha^{-1} vermicompost seems like the most appropriate for the parameters of a thousand kernel weight, starch and magnesium content. The increasing doses of vermicompost significantly increased the yield of potato tubers, starch content and dry matter content in tubers. The application of granulated vermicompost reduced vitamin C content in potato tubers. The use of fertilizers resulted to increasing the nitrate content in potato tubers however the application of granulated vermicompost has increased the contents of nitrates to a lesser extent than the joint application of NPK fertilizer and granulated vermicompost.

Zandonadi and Busato (2012) reported that vermicomposting and its products represents a crucial ecofriendly technology capable of recycling organic wastes to be used as fertilizers. Through its hormone-like substances, vermicompost, liquid humus or worm bed leachate stimulates plant growth. Additionally, manipulation of microbial population presents in vermicompost and its products may increase both nutrient content and availability

Vermicompost has a positive effect on vegetative growth, stimulating the shoot and the root development (Edwards *et al.,* 2004). The effects include alterations in seedling morphology such as an increased leaf area and root branching (Lazcano *et al*., 2009).

Padmavathiamma *et al.* (2008) opined that the addition of vermicompost improved soil environment and encouraged the proliferation of roots that drew more water and nutrients from a larger area.

Ansari (2008). Present investigations were carried out during 1998-2000 at Shivri farm of Uttar Pradesh Bhumi Sudhar Nigam, Lucknow, India, to study the effect of vermicompost application in reclaimed sodic soils on the productivity of potato (Solanum tuberosum), spinach (Spinacia oleracea) and turnip (Brassica campestris). The soil quality was monitored during the experiment followed by productivity. The treatments were 4, 5 and 6 tonnes/ha of vermicompost as soil application in plots already reclaimed by Vermitechnology. Among the different dosages of vermicompost applied there has been a significant improvement in the soil quality of plots amended with vermicompost @ 6 tonnes per ha. The overall productivity of vegetable crops during the two years of the trial was significantly greater in plots treated with vermicompost @ 6 tonnes per ha. The present investigation showed that the requirement of vermicompost for leafy crops like spinach was lower (4 tonnes/ha), whereas that for tuber crops like potato and turnip was higher (6 tonnes/ha).

Alam *et al*. (2007) conducted an experiment to study the effect of vermicompost and NPKS fertilizers on growth and yield of potato (cv. Cardinal) in Level Barind Tract (AEZ-25) soils of Bangladesh. The organic matter of the experimental field soil was very low and in case of N, P, K and S also low. 1 The land was medium fertile and PH was 5.4. There were 12 treatments viz. control, vermicompost 2 3 4 5 (VC) 2.5 t ha^{-1}, VC 5.0 t ha^{-1}, VC 10.0 t ha^{-1}, VC 2.5 t $ha-^{1}$ +50% NPKS. VC 5 t ha^{-1} +50% 6 7 8 9 NPKS, VC 10 t ha^{-1} +50% NPKS, VC 2.5 t ha^{-1} +100% NPKS, VC 5 t ha^{-1} +100% NPKS, 10 11 12 VC 10 t ha^{-1} +100% NPKS 50% NPKS and 100% NPKS. The experiment was laid out in RCBD with three replications. The doses of N-P-K-S were 90-40-100-18 kg ha-1 for potato. Application of 10 vermicompost and NPKS significantly influenced the growth and yield of potato. The treatment produced the highest (25.56 t ha^{-1}) tuber yield of potato. The lowest yield and yield contributing parameters recorded in control. Application of various amounts of vermicompost (2.5, 5, 10 t ha^{-1}) with NPKS fertilizers (50% and 100%) increased the vegetative growth and yield potato. Vermicompost at 2.5 5 and 10 t $ha-^{1}$ with 50% of NPKS increased tuber yield over control by 78.3, 96.9 and 119.5 t ha^{-1} respectively. And vermicompost at 2.5, 5 and 10 t ha^{-1} with 100% of NPKS increased tuber 37 yield by 146.8, 163.1 and 197.9 %, respectively. The results indicated that vermicompost (10 t ha^{-1}) with NPKS (100%) produced the highest growth and yield of potato.

Ansari (2005) studied the effect of organic farming on soil nutrients and quality of carrot. Composted cow dung, poultry manure, vermicompost, rice straw compost, recommended fertilizers were used. Among the treatments, poultry manure was superior to other organic treatments for soil moisture, organic matter, total N, and available S in soil. Poultry manure and composted cow dung, poultry 9 manure + vermicompost was superior for enrichment in the nutritional quality of carrot.

Bakthavathsalam and Geetha(2004) observed the vegetative growth of radish using vermicompost obtained from the culture study of earthworm (*Lampito mauritii*) using 7 paddy chaff and weed plants. The results revealed a different effect on the height and weight of the radish plant cultivated in fresh organic manure 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 in the growth parameters of radish.

Oliveira *et al*. (2001) studied the effect of earthworm compost and mineral fertilizer on root production in carrot and found that the different levels (0, 15, 20, 25 and 30 t/ha) of earthworm compost, in the presence or absence of mineral fertilizers, on the production (cv. *Brasilla Nova Selocoa*) roots was evaluated in a field experiment conducted in Areia (Praibaj), Brazil during July-October 1997. Earthworm compost at 25 t/ha produced the highest total (70.1 t/ha) and marketable (31.1 t/ha) yields and the lowest non-marketable yield of roots (39.0 t/ha). The presence of mineral fertilizers increased root yields and increased the production of Extra-A and Extra grade, special and first grade roots by 4.9, 5.6, 1.7 and 19.4 t/ha, respectively compared to its absence.

Ndegwa and Thompson (2001) observed that Vermicompost carried high levels of soil enzymes and plant growth hormones which enhanced microbial populations and held more nutrients over longer periods.

2.2 Review related to turnip varieties

Turnip thrives well in a fertile, clay loam soil because it requires considerable amounts of nutrients to sustain rapid growth in short time. A large quantity of manures and fertilizer is required for the growth of the non-heading leaves (Opena *et al*., 1988).

Sadia *et al.* (2013) evaluated the different levels of N on the growth and root yield of turnip and obtained better growth and root yield at higher N level (100 kg ha^{-1}) coupled with vermicompost.

Mojarad *et al*. (2014) evaluated the performance of 16 turnip varieties against 4 salinity levels (0.60, 120, 180 and 240 mM). They reported that increasing levels of salinity significantly affected the mean germination and seedling growth.

Chandan and Azad (2015)

Brassica rapa is a species in the angiosperm family Brassicaceae. The Brassicaceae family consists of 338 genera and approximately 3710 species (Beilstein *et al*. 2008) of which several are agronomically important. In the Brassica genus six species are agronomically important. Three of them are diploid: Brassica rapa (AA genome, 2n=20), containing three main morphotypes (turnip types, leafy types and oil types); *Brassica nigra* (BB genome 2n=16) (black mustard) and Brassica oleracea (CC genome 2n=18) including cabbages, broccoli, cauliflower and kohlrabi (above ground turnip).Three of those six are amphidiploids: Brassica juncea (AABB genome, 2n=36) (Indian or brown mustard and several leafy types); Brassica napus (AACC genome, 2n=38) including oilseed rape and the turnip forming Swede, and Brassica carinata (BBCC genome, 2n=34) (Ethiopian mustard). The relationships between these Brassica species and their genomes are summarized in the triangle of U (U 1935) Within those six species Brassica rapa is the species that was domesticated first. It has been cultivated for many years from central Asia to Europe and northern America (Gomez Campo 1999).

Peter *et al*, (2009) reported that eleven F_2 populations were evaluated for turnip formation (TuF) and flowering time (FT). The goal was to select populations which form turnips with a wide range in size for studying the genetic basis of turnip formation. Besides the turnip formation FT is important because in previous studies FT and turnip formation are negatively correlated and QTLs for both traits are mapped in the same genomic region. The major finding on the FT-TuF correlation topic was that the correlation was present when the parents differ greatly in flowering time, on the other hand the FT-TuF correlation was absent when the parents did not differ in flowering time. In the evaluated populations a distinction can be made between the origin of the turnips in the populations. Populations with turnips from the Asian and European centers of variation were represented in this study. The phylogenetic relationship between different turnips suggests that different genes could underlie turnip formation in both centers of variation. This hypothesis is confirmed; in a population between turnips from both centers of variation other genomic regions correlate with turnip size than regions in populations with only the Asian turnips. This indicates that different genes underlie the same trait in different centers of variation.

However, this is only one population and therefore the conclusion is still fragile. Therefore, new crosses have to be made between European turnips with RC-144 and PC-105 for comparison with the best populations in this study (VT-115 x RC-144 and VT-115 x PC-105).

Jones *et al,* (2007) observed that turnip greens (*Brassica rapa*) are commonly consumed in the southern U.S.A. Typically, they have a bitter taste, which increases with maturity, probably because of increased levels of glucosinolates. While glucosinolate degradation products have been isolated from various members of the Brassica family, the effect of variety and maturity on these products has not been determined. This study focused on the glucosinolate degradation products of three varieties of turnip greens: Purple Top, Seven Top and Tokyo Cross, harvested 45, 60 and 75 days after planting. Four volatile components (benzene acetonitrile, benzene propane nitrile, 1H-indole-3-acetonitrile and benzene ethyl isothiocyanate) were isolated, identified and quantified. All increased significantly ($P < 0.05$) as the greens matured; however, only benzene propane nitrile and 1H-indole-3-acetonitrile were significantly affected ($P < 0.05$) by variety.

Purple Top and Seven Top are the two most popular varieties of turnip greens grown in Alabama. Tokyo Cross is an F1 hybrid that has been cited as being mild in flavor (Carlson *et al*. 1987). Although several researchers have isolated glucosinolate degradation products from Brassica, there is no information on the relationship between variety and maturity. Therefore, this study examined the glucosinolate degradation products of three varieties (Purple Top, Seven Top and Tokyo Cross) of turnip greens harvested at 45, 60 and 75 days after planting.

CHAPTER III

MATERIALS AND METHODS

This chapter briefly describes the materials and methods that were used in performing the research work. The chapter is presented under the following heads: Location, Soil characteristics, Climate and weather, Planting material, Land preparation, Treatments under investigation, Experimental design, Layout of the experimental plots, Fertilizer application, Seedling collection, Sowing of seedlings, Intercultural operations, Sampling and harvesting, Data collection, Post-harvest plant sampling and Statistical analysis.

3.1 Location of the experiment

The field experiment was conducted at the Horticulture research field, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2020 to March 2021. Geographically the experimental field is located at 23°46' N latitude and 90° 22' E longitude at an elevation of 8.2 m above the sea level belonging to the Agro-ecological Zone "AEZ-28" of Madhupur Tract. The location of the experimental site has been shown in Appendix I.

3.2 Soil characteristics

The soil of the research field found to be slightly acidic in reaction with low organic matter content. The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. The experimental plot was also high land, having pH 5.5. The physicochemical property and nutrient status of soil of the experimental plots are given in Appendix II.

3.3 Climate and weather

The climate of experimental site is sub-tropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix III.

3.4 Planting material

In the experiment there were three different turnip variety namely Purple Top White Globe, Pusa Chandrima and Early Milan Red Top used as planting material. Planting time Rabi, last week of November to January for root production and yield should be varied according to varieties.

3.5 Treatments under investigation

It is a two factors study consisting of 12 treatment combinations.

Factor A: Three different turnip varieties viz.

V_1 = Purple Top White Globe

V_2 = Pusa Chandrima

V_3 = Early Milan Red Top

Factor B: Four different level of vermicompost (VC) doses.

F_1 = 0 t/ha

F_2 = 2 t/ha VC doses

F_3 = 4 t/ha VC doses

F_4 = 6 t/ha VC doses

Treatment combinations

V_1F_1 = Purple Top White Globe with 0 t/ha (Control) VC doses,

V_1F_2 = Purple Top White Globe with 2 t/ha VC doses,

V_1F_3 = Purple Top White Globe with 4 t/ha VC doses,

V_1F_4 = Purple Top White Globe with 6 t/ha VC doses,

V_2F_1 = Pusa Chandrima with 0 t/ha(Control) VC doses,

V_2F_2 = Pusa Chandrima with 2 t/ha VC doses,

V_2F_3 = Pusa Chandrima with 4 t/ha VC doses,

V_2F_4 = Pusa Chandrima with 6 t/ha VC doses,

V_3F_1 = Early Milan Red Top with 0 t/ha (Control)VC doses,

V_3F_2 = Early Milan Red Top with 2 t/ha VC doses,

V_3F_3 = Early Milan Red Top with 4 t/ha VC doses and

V_3F_4 = Early Milan Red Top with 6 t/ha VC doses.

3.6 Layout of the experimental plots

Total number of plots	:	36
Individual plot size (1.2×0.9) m^2	:	1.08 m^2
Combine Treatments	:	12
Replication	:	3
Drainage width	:	0.38 m

The layout of the experimental plots shown in figure 1

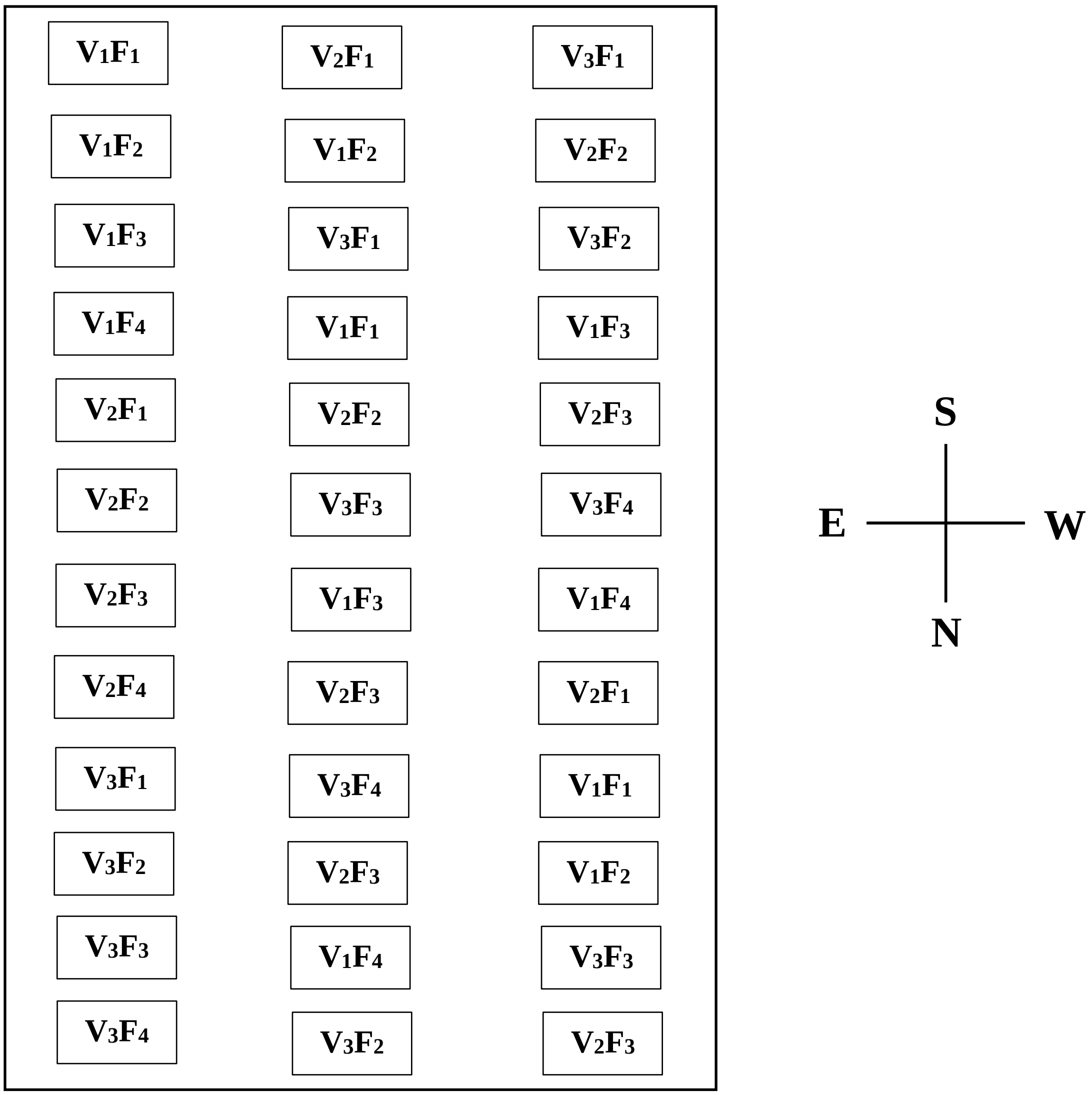

Figure 1: Field layout of the experiment

3.7 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD). All the treatments were replicated three times. There were altogether 36 = (12×3) units of plots.

3.8 Land preparation

The land was ploughed thoroughly and made weeds and clods free by raking. Added well prepared vermicompost as per treatments and mixed thoroughly in the soil at the time of land preparation. The land was properly irrigated before ploughing. After getting ‘joe’ condition the land was first opened with a tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 3 ploughing and cross-ploughing followed by harrowing and laddering. Stubbles and weeds were removed. The first ploughing and the final land preparation were done on 29th November and 3rd December, 2020, respectively. Experimental land was divided into unit plots following the design of experiment.

3.9 Fertilizer application

Vermicompost was applied at the time of final land preparation.

3.10 Sowing of seedlings in the field

Seedlings were sown in each hill at a depth of 1.5 cm. The sowing was done on 08th December, 2020 in the main field. Used row to row spacing of 30cm and plant to plant spacing of 30 cm also.

3.11 Intercultural operations

3.11.1 Gap filling

Seedlings were transferred to fill up the gap where seedlings were damages. All gaps were filled up within two weeks after damages of seedlings.

3.11.2 Weeding and earthing up

The experimental plots were kept weed free by hand weeding. Weeding and mulching were done two times as and when necessary. After weeding, carried out earthing up operation.

3.11.4 Irrigation

Irrigation was done whenever necessary. The young plants were irrigated by watering can. Beside this, irrigation, was given six times at 12days intervals were depending on soil moisture content. Excessive irrigation was avoided as it may cause ugly shape of roots and numerous hair growth.

3.12 Plant protection

3.12.1 Insect pests

At the early stage of growth, some plants might be attacked by some soil borne insect, and as a preventive measure Carbofuran 3G was applied during land preparation.

3.12.2 Diseases

Some seedlings were attacked by crown rot due to environmental anomalies and as a remedy on 7^{th} and 15^{th} day after sowing, drenched soil around seedlings with Captan@200 gm in 100 liters' water.

3.13 Sampling and harvesting

Depending upon variety uprooting of turnip roots were done after attaining marketable size i.e. when they were 5-10 cm in diameter. Maturity of crop was determined when 95 % of the roots were fully formed. Roots have reached to marketable size in 45-65 days depending upon the variety after sowing. Ten sample plants were collected from each plot before harvesting for taking yield attributes data. Harvesting was done between 25 January, 2021 and 10 February, 2021. The harvested crops from each plot were tied up into bundles separately, tagged and brought to the clean threshing floor. The same procedure was followed for sample plants also. Harvesting was carried out in the evening.

3.14 Data collection

Five plants from each plot were selected and tagged. All the growth data (except dry weight) were recorded from those ten selected plants.

The following data were collected –

I. Plant Height
II. Number of leaves plant^{-1}
III. Fresh weight of leaves plant^{-1}
IV. Days after maturity
V. Root length
VI. Root diameter
VII. Root fresh weight plant^{-1}
VIII. Root dry weight plant^{-1}
IX. Yield

3.15 Procedure of data collection

3.15.1 Plant height

The plant height was recorded at harvest only. The plant height was taken from the ground level to the tip of the largest leaf of the plants. Plant height was recorded from 10 randomly sampled plants, and the mean was calculated and recorded in centimeter (cm).

3.15.2 Number of leaves plant^{-1}

The number of compound leaves of 10 randomly selected plants were counted from each unit plot at harvest only and the means were calculated.

3.15.3 Fresh weight of leaves plant^{-1}

The average leaves fresh weight of ten randomly taken matured bulbs were measured by using sensitive balance and finally expressed in grams.

3.15.4 Days after maturity

The days were counted from seedling stage to harvesting stage.

3.15.5 Root length

This was measured at physiological maturity from the bottom to tip of a harvested root from the ten roots of the representative plants by using a cm scale.

3.15.6 Root diameter

The mean diameter of ten sample roots was measured at the maximum wider portion of the matured harvested roots using veneer calipers.

3.15.7 Root fresh weight plant^{-1}

The average fresh weight of ten randomly taken mature roots was measured by using sensitive balance and finally expressed in grams.

3.15.8 Root dry weight plant^{-1}

The average dry weight of ten randomly taken mature roots was measured by using sensitive balance and then expressed in grams.

3.15.9 Yield

The total bulb yield was measured from the total harvest attained from the plots as a sum weight of marketable and unmarketable yields, and it was measured in kg per plot and finally converted into t ha^{-1}.

3.16 Post harvest plant sampling

After harvest plant samples were collected on 12 February from each plot. Plant samples from each plot were air-dried, crushed and passed through a two mm (10 meshes) sieve on 05 March, 2021. The plant samples were kept in plastic container to determine the chemical properties of the plants.

3.17 Bio-chemical Analysis

Plant(root) samples were sent to Bangladesh Agricultural Research Institution (BARI) lab to determine Ca, Mg and S content. The analysis was done using Atomic Absorption method.

3.18 Statistical analysis

The recorded data were compiled and analyzed by two factorial design to find out the statistical significance of experimental results by using the "Analysis of variance" (ANOVA) technique with the help of statistix 10; which is an analysis software.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter represents the results of the screening of turnip varieties with different rate of vermicompost doses which are presented in in several Figures and Tables for better understanding. The findings of the study and interpretation of the results under different critical sections comprising growth, yield contributing characteristics, yield and quality parameters are also presented and discussed in this chapter under the following sub-headings to achieve the objective of the study.

4.1 Effect of different varieties and level of vermicompost on yield and quality on turnip.

4.1.1 Plant height

Plant height of turnip was recorded from the ground surface to the tip of the leaf in five plants of all the treatments. The plant height was significantly varied due to the different varieties of turnip at harvest (Figure 2).

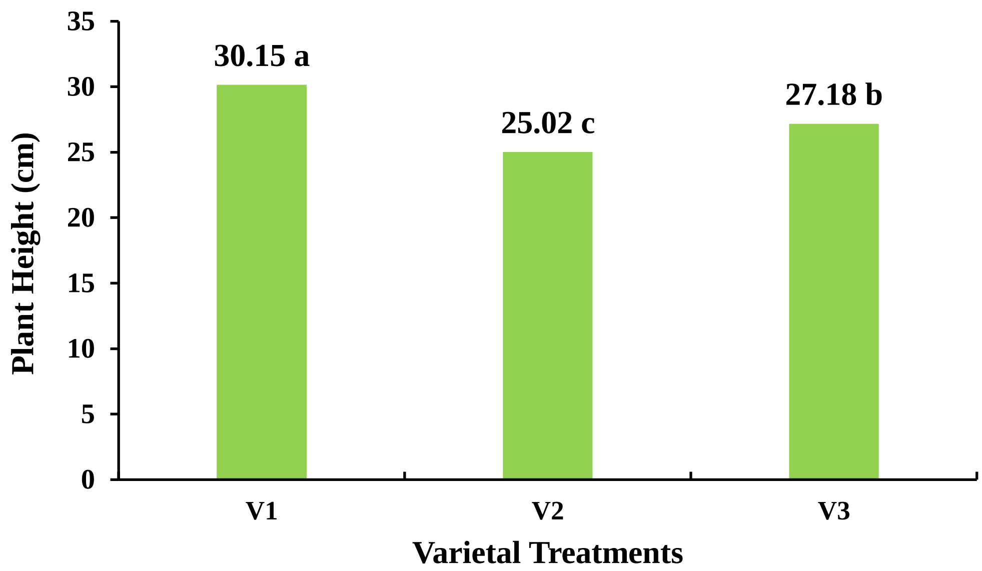

Figure 2: Effect of varieties on plant height (cm) of turnip at harvest.

Here,
V_1 = Purple Top White Globe, V_2 = Pusa Chandrima and V_3 = Early Milan Red Top

The tallest plant (30.15 cm) was recorded from V_1 (Purple Top White Globe), whereas the shortest plant (25.02 cm) was found from V_2 (Pusa Chandrima) treatments at harvest.

In case of different level vermicompost doses, plant height of turnip was significantly influenced by different level of vermicompost (VC) doses at harvest (Figure 5). Statistically significant variation was observed in terms of plant height of turnip at harvest as per treatment management under the present trial. The longest plant height (32.48 cm) was observed where vermicompost applied @4 t ha^{-1} (F_3) which followed by F_4 treatment (30.37 cm) where @6 t ha^{-1} VC was applied and the shortest plant height (19.99 cm) was observed in F_1 when plots that was control**.** Kumar *et al*. (2014) reported that the plant height was significantly increased by the application of organic manures and it was maximum under treatment of vermicompost in case of radish.

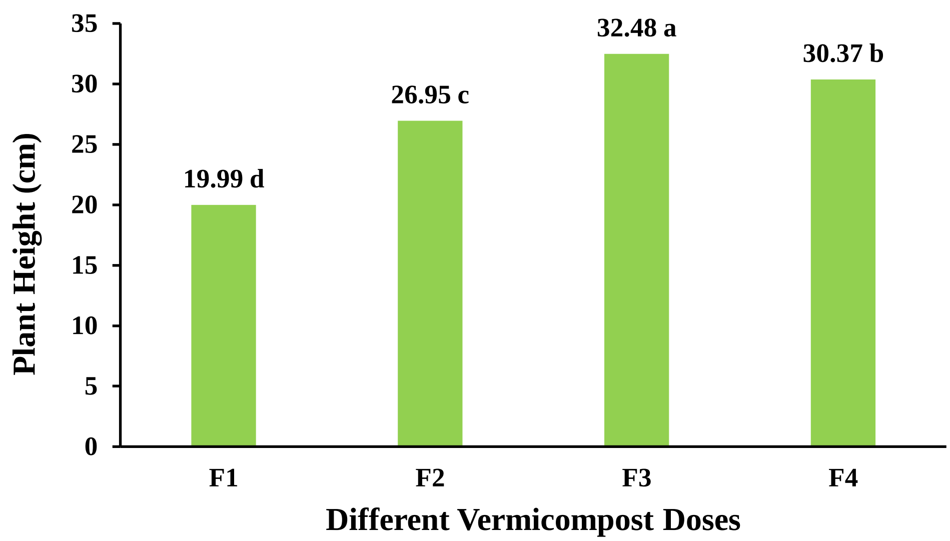

Figure 3: Effect of different vermicompost (VC) doses on plant height (cm) of turnip at harvest.

Here,
F_1= 0 t/ha (Control) VC doses, F_2= 2 t/ha VC doses, F_3= 4 t/ha and F_4= 6 t/ha VC doses

Combined effects of variety and vermicompost doses showed significant variation in terms of plant height of turnip at the harvest (Figure 4). At harvest, the highest plant height (35.84 cm) was found from V_1F_3 (Purple Top White Globe with 4 t/ha VC doses) which was statistically similar with V_1F_4 and the lowest plant height 17.50 cm was recorded from V_2F_1 (Pusa Chandrima with 0 t/ha VC doses) which was statistically different from others. Jat (2015) also reported the greatest plant spreadings in the vermicompost treated plots.

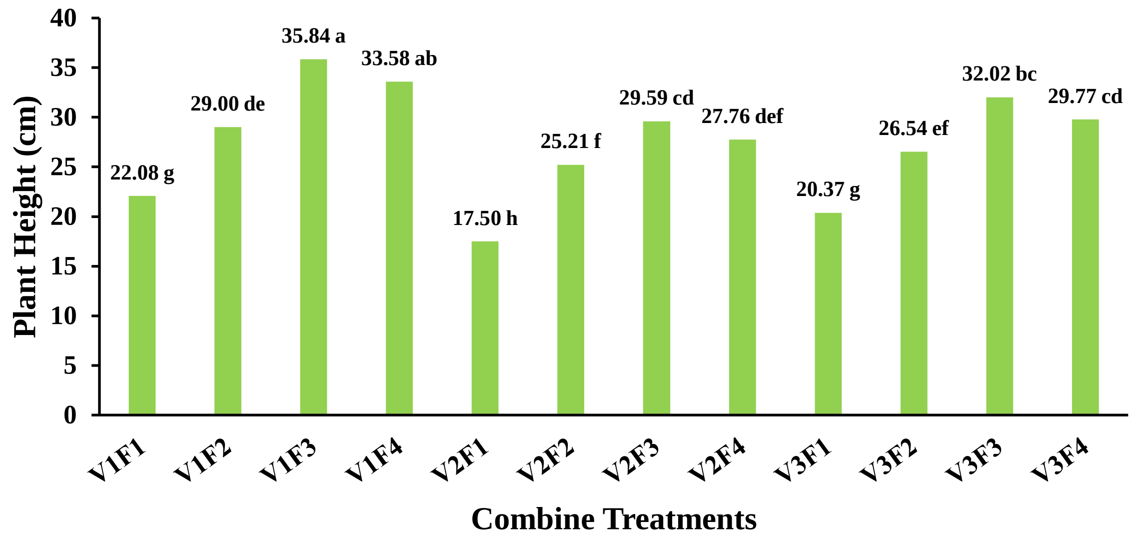

Figure 4: Combined effect of varieties and vermicompost (VC) on plant height of turnip at harvest.

Here,
V_1F_1 = Purple Top White Globe with 0 t/ha(Control) VC doses, V_1F_2 = Purple Top White Globe with 2 t/ha VC doses, V_1F_3 = Purple Top White Globe with 4 t/ha VC doses, V_1F_4 = Purple Top White Globe with 6 t/ha VC doses, V_2F_1 = Pusa Chandrima with 0 t/ha(Control) VC doses, V_2F_2 = Pusa Chandrima with 2 t/ha VC doses, V_2F_3 = Pusa Chandrima with 4 t/ha VC doses, V_2F_4 = Pusa Chandrima with 6 t/ha VC doses, V_3F_1 = Early Milan Red Top with 0 t/ha (Control)VC doses, V_3F_2 = Early Milan Red Top with 2 t/ha VC doses, V_3F_3 = Early Milan Red Top with 4 t/ha VC doses and V_3F_4 = Early Milan Red Top with 6 t/ha VC doses.

4.1.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} is one of the most important quality detecting characters in turnip. The number of leaves per plant was significantly influenced due to the different varieties at harvest (Table 1). The highest number of leaves per plant (12.93) was recorded from the variety Purple Top White Globe (V_1) which was followed by Early Milan Red Top (V_3). The minimum number of leaves per plant (10.83) was found in the variety Pusa Chandrima (V_2). Leaf number per plant of a cultivar depends on nutrient availability during reproductive stage as well as on genetic factors.

Significant variation was evident in case of number of leaves plant^{-1} with different level of VC doses (Table 2). The maximum number of leaves plant^{-1} (14.73) was recorded from the plot where 4 t ha^{-1} VC (F_3) applied. Whereas, lowest number of leaves plant^{-1} (8.87) was obtained from the plot where VC was not applied. It was concluded that the total leaves plant^{-1} have shown significant variation at 1% level of probability. Similarly, vermicompost recorded highest number of leaves in case of radish (Kumar *et al*. (2014)). Dipesh *et al.*, (2021) showed that there was a significant effect of different doses of vermicompost on the number of leaves per plant of radish. Jaisankar (2018) also reported highest number of leaves per plant in the plot applied with higher dose of vermicompost. Uddain *et al.* (2019) also found a higher leaf number in vermicompost treatment among other organic fertilizer treatments in radish crops. Mohmmad *et al.* (2017) also reported the highest number of leaves per plant on application of vermicompost and RDF which may be due to slow release of nutrients through vermicompost.

Table 1: Effect of variety on number of leaves plant $^{-1}$, fresh weight of leaves plant^{-1} (g) and days after maturity of turnip.

Treatments	Number of leaves plant^{-1}	Fresh weight of leaves plant^{-1} (g)	Days after maturity
V_1	12.93 a	227.61 a	62.53 a
V_2	10.83 c	192.97 c	57.37 b
V_3	11.93 b	211.86 b	47.22 c
SE(±)	0.28	1.79	0.65
CV (%)	5.70	2.08	2.85

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

***Significant at 1% probability level.*
** Significant at 5% probability level.*
SE= Standard Error
CV= Co-efficient of variance

Legend,
V_1 = Purple Top White Globe
V_2 = Pusa Chandrima
V_3= Early Milan Red Top

Number of leaves plant^{-1} is an important growth contributing character which was greatly influenced by different varieties with various level of vermicompost (VC) doses (Table 3). It was found that V_1F_3 (Purple Top White Globe with 4 t/ha VC doses) supported plant to produce maximum number of leaves plant^{-1} (15.98) which was followed by V_1F_4 (Purple Top White Globe with 6 t/ha VC doses). The lowest number of leaves plant^{-1} (7.87) was given by the combination of V_2F_1 (Pusa Chandrima with 0 t/ha VC doses) which was statistically different from all other treatments.

4.1.3 Fresh weight of leaves plant^{-1}

Fresh weight of leaves plant^{-1} is one of the most important yield attributing characters of turnip. Different variety had significant effect on fresh weight of leaves plant^{-1} of turnip (Table 1). The maximum fresh weight of leaves plant^{-1} (227.61 g) was measured from V_1 (Purple Top White Globe) and the minimum fresh weight of leaves plant^{-1} (192.97 g) was found from V_2 (Pusa Chandrima). It was concluded that the fresh weight of leaves plant^{-1} has shown significant variation at 5% level of probability; different varieties having different capacity to produce fresh weight of leaves plant^{-1}.

Significant variation was evident in case of fresh weight of leaves plant^{-1} of turnip with different level of vermicompost doses (Table 2). The maximum fresh weight of leaves plant^{-1} (225.20 g) was found in F_3 (4 t ha^{-1}) which was statistically different from all other treatments. On the other hand, the minimum fresh weight of leaves plant^{-1} (194.23 g) was also produced when it was observed in control (F_1) treatment which is also statistically different from all other treatments.

Table 2: Effect of different level of vermicompost doses on number of leaves plant^{-1}, fresh weight of leaves (g plant^{-1}) and days after maturity of turnip.

Treatments	Number of leaves plant^{-1}	Fresh weight of leaves (g plant^{-1})	Days after maturity
F_1	8.87 d	194.23 d	58.87 a
F_2	11.35 c	206.63 c	56.41 b
F_3	14.73 a	225.20 a	52.97 c
F_4	12.63 b	217.19 b	54.58 bc
SE(±)	0.32	2.07	0.75
CV (%)	5.70	2.08	2.85

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

***Significant at 1% probability level.*
** Significant at 5% probability level.*
SE= Standard Error
CV= Co-efficient of variance

Legend,
F_1= 0 t/ha (Control) VC doses
F_2= 2 t/ha VC doses
F_3= 4 t/ha VC doses
F_4= 6 t/ha VC doses

The interaction effects of different variety and different level of VC doses practices were significant on fresh weight of leaves plant^{-1} of turnip. It was found that Purple Top White Globe with 4 t/ha VC doses (V_1F_3) produce maximum fresh weight of leaves plant^{-1} (242.61 g) which was followed by V_1F_3 (Purple Top White Globe with 6 t/ha VC doses) (236.69

g) (Table 3). On the contrary, the lowest fresh weight of leaves plant^{-1} (179.73 g) was also produced when it was observed in the combination of Pusa Chandrima with 0 t/ha VC doses (V_2F_1) which was statistically different from all other treatments.

4.1.4 Days after maturity

It was shown (Table 1) that the days after maturity was significantly varied due to different turnip varieties. The maximum days after maturity (62.53) was observed from V_1 (Purple Top White Globe) treatment, while the minimum days after maturity (47.22) was found from V_3 (Early Milan Red Top) treatment. Whereas moderate days after maturity (57.37) was found from V_2 (Pusa Chandrima) treatment.

Table 3: Combined effect of variety and vermicompost doses on number of leaves plant^{-1}, fresh weight of leaves (g plant^{-1}) and days after maturity of turnip.

Combine Treatments	Number of leaves plant^{-1}	Fresh weight of leaves (g plant^{-1})	Days after maturity
V_1F_1	9.64 fgh	208.69 de	65.71 a
V_1F_2	12.02 de	222.47 c	63.40 ab
V_1F_3	15.98 a	242.61 a	59.66 bcd
V_1F_4	14.73 ab	236.69 ab	61.36 abc
V_2F_1	7.87 h	179.73 h	60.87 bcd
V_2F_2	10.58 efg	190.69 gh	57.80 cde
V_2F_3	13.47 bcd	203.97 ef	54.65 ef
V_2F_4	11.40 ef	197.50 efg	56.17 de
V_3F_1	9.10 gh	194.28 fg	50.03 fg
V_3F_2	11.45 ef	206.73 def	48.02 gh
V_3F_3	14.08 abc	229.02 bc	44.61 h
V_3F_4	12.43 cde	217.39 cd	46.21 gh
SE(±)	0.55	3.58	1.30
CV (%)	5.70	2.08	2.85

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, SE= Standard Error and CV= Co-efficient of variance

Legends,

V_1F_1 = Purple Top White Globe with 0 t/ha(Control) VC doses, V_1F_2 = Purple Top White Globe with 2 t/ha VC doses, V_1F_3 = Purple Top White Globe with 4 t/ha VC doses, V_1F_4 = Purple Top White Globe with 6 t/ha VC doses, V_2F_1 = Pusa Chandrima with 0 t/ha(Control) VC doses, V_2F_2 = Pusa Chandrima with 2 t/ha VC doses, V_2F_3 = Pusa Chandrima with 4 t/ha VC doses, V_2F_4 = Pusa Chandrima with 6 t/ha VC doses, V_3F_1 = Early Milan Red Top with 0 t/ha (Control)VC doses, V_3F_2 = Early Milan Red Top with 2 t/ha VC doses, V_3F_3 = Early Milan Red Top with 4 t/ha VC doses and V_3F_4 = Early Milan Red Top with 6 t/ha VC doses.

The important quality evaluating character of turnip was days after maturity. The different level of vermicompost treatments have not statistically influenced days after maturity of turnip (Table 2). The largest days after maturity (58.87) was found from F_1 (0 t ha^{-1}) and the shortest days after maturity (52.97) was found from F_3 (4 t ha^{-1}). which was statistically similar (54.58) with F_4 (6 t ha^{-1}).

The interaction effect of different variety and vermicompost (VC) doses applications on days after maturity of turnip was found significantly different (Table 3). The maximum days after maturity of turnip (65.71) was recorded from the treatment V_1F_1 (Purple Top White Globe with 0 t/ha VC doses) which was significantly followed by V_1F_2 (Purple Top White Globe with 2 t/ha VC doses). On the other hand, minimum days after maturity of turnip (44.61) was recorded from the treatment V_3F_3 (Early Milan Red Top with 4 t/ha VC doses) which was significantly followed by V_3F_4 (Early Milan Red Top with 6 t/ha VC doses) and V_3F_2 (Early Milan Red Top with 2 t/ha VC doses) due to early variety plants.

4.1.5 Root length

The root length in centimeters is one of the significant indicators of physiological and metabolic activities of the plant. It is a vital parameter to calculate the final biological yield of turnip. Among different varietal treatments the root length of turnip observed significantly varied showed in figure 4. The largest root (9.94 cm) was recorded from the V_1 (Purple Top White Globe) due to superior varietal characteristics. One the other hand, the shortest root of turnip (7.66 cm) was recorded from the treatment V_2 (Pusa Chandrima). The important yield evaluating character of turnip was root length. Result showed that different level of vermicompost doses treatment had significant effect on root length of turnip (Figure 5). However, numerically the highest root length (9.95 cm) was recorded from F_3 (4 t ha^{-1}) which was statistically similar with F_4 (6 t ha^{-1}). The lowest root length of turnip (7.17 cm) was recorded from F_1 (0 t ha^{-1}). Gupta *et al*, 2011 recorded radish grown in vermicompost applied plots gained higher root length which supports the findings of our study. The results also agreed with the findings of Dipesh *et al.* (2021), Kumar *et al*. (2014) and Raja and Veerakumari (2013).

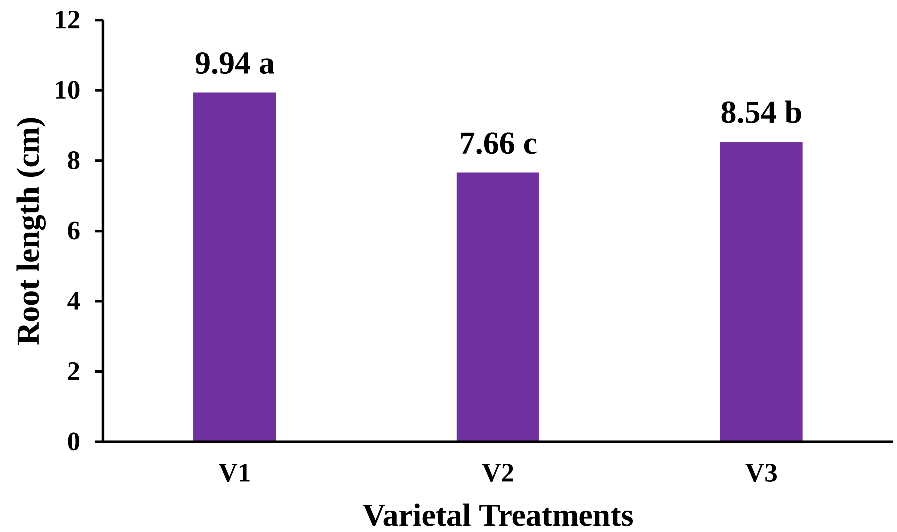

Figure 5: Effect of varieties on root length (cm) of turnip at harvest.

Here, V_1 = Purple Top White Globe, V_2 = Pusa Chandrima and V_3= Early Milan Red Top

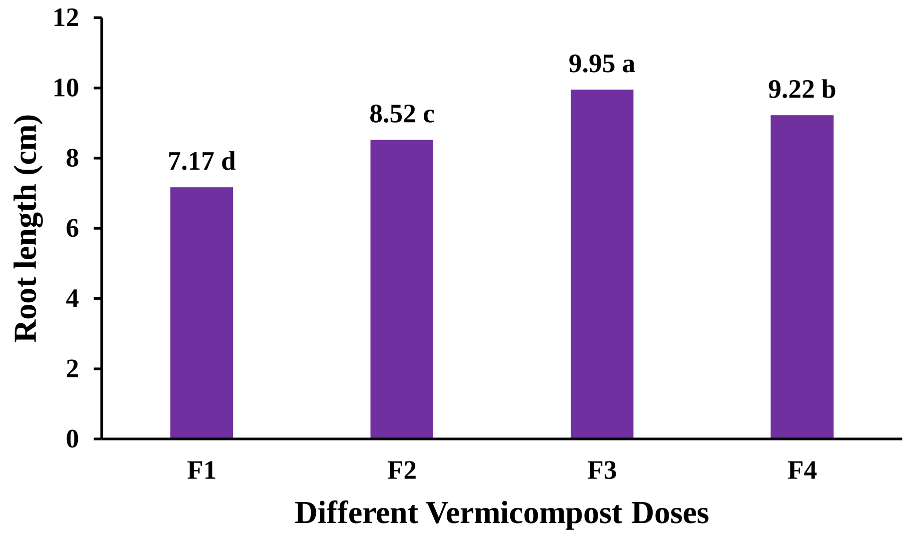

Figure 6: Effect of different vermicompost doses on root length (cm) of turnip at harvest.

Here, F_1= 0 t/ha (Control) VC doses, F_2= 2 t/ha VC doses, F_3= 4 t/ha and F_4= 6 t/ha VC doses

It was evident from the figure 6 that the root length as cm was significantly varied due to interaction effect of varieties and vermicompost (VC) treatments. The longest root (11.62 cm) was observed from V_1F_3 (Purple Top White Globe with 4 t/ha VC doses) which was statistically followed by V_1F_4 (Purple Top White Globe with 6 t/ha VC doses) and the shortest roots (10.44 cm) was observed from V_2F_1 (Pusa Chandrima with 0 t/ha VC doses) which was statistically different from other combinations. It was concluded that the root length (cm) has shown significant variation at 1% level of probability.

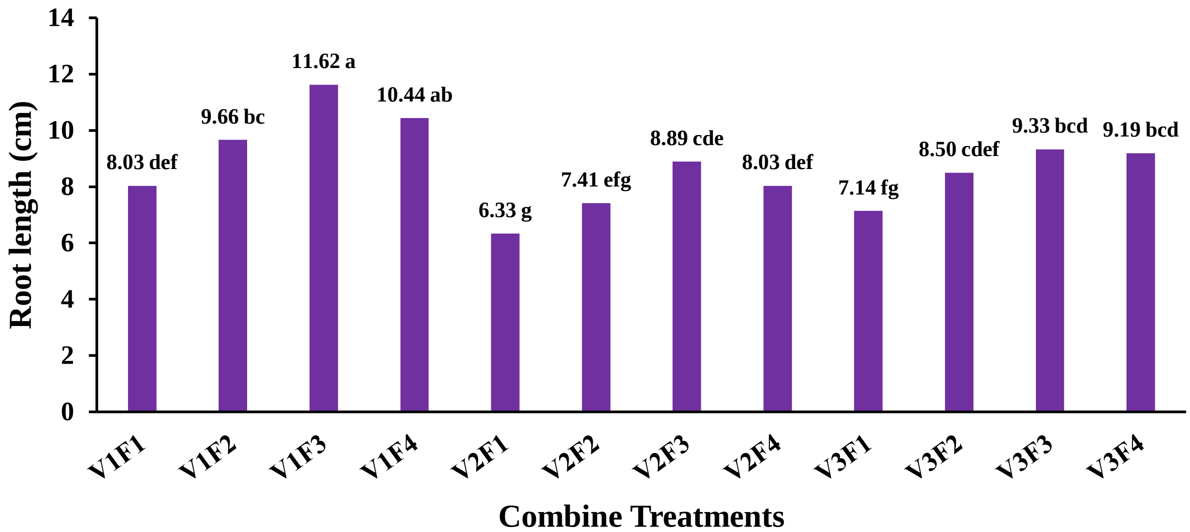

Figure 7: Combine effect of varieties and vermicompost doses on root length (cm) of turnip at harvest.

Here,
V_1F_1 = Purple Top White Globe with 0 t/ha(Control) VC doses, V_1F_2 = Purple Top White Globe with 2 t/ha VC doses, V_1F_3 = Purple Top White Globe with 4 t/ha VC doses, V_1F_4 = Purple Top White Globe with 6 t/ha VC doses, V_2F_1 = Pusa Chandrima with 0 t/ha(Control) VC doses, V_2F_2 = Pusa Chandrima with 2 t/ha VC doses, V_2F_3 = Pusa Chandrima with 4 t/ha VC doses, V_2F_4 = Pusa Chandrima with 6 t/ha VC doses, V_3F_1 = Early Milan Red Top with 0 t/ha (Control)VC doses, V_3F_2 = Early Milan Red Top with 2 t/ha VC doses, V_3F_3 = Early Milan Red Top with 4 t/ha VC doses and V_3F_4 = Early Milan Red Top with 6 t/ha VC doses.

4.1.6 Root diameter

The root diameter was calculated from the root at harvesting time and expressed in cm. Root diameter varied significantly due to different varietal treatments (Table 4). It was observed the Purple Top White Globe (V_1) produced the highest root diameter (8.58 cm) numerically while Pusa Chandrima (V_2) produced the lowest root diameter (7.45 cm) of turnip.

The variation in root diameter was found to be statistically significant due to the applications of different doses of vermicompost (VC) (Table 5). The maximum root diameter (9.20 cm) was obtained from the plot where 4 t ha^{-1} VC (F_3) was applied. On the other hand, minimum root diameter (6.63 cm) was obtained from the plot where VC (F_1) was not applied. The result was ranked from the maximum to the minimum bulb diameter was $F_3 > F_4 > F_2 > F_1$. The formation of bigger root with the application of appropriate levels of VC doses might be done to higher synthesis of carbohydrate and their translocation to the bulb, which subsequently helped in the formation of higher root of turnip. Similar results were obtained in a study conducted by Politud (2019) who observed a greater root diameter of radish on applying vermicompost. Shirzadi (2021) has also shown that with increasing vermicompost fertilizer, diameter of root crops increase significantly.

Table 4: Effect of variety on root diameter (cm), root fresh weight (g plant^{-1}) and root dry weight (g plant^{-1}) of turnip.

Treatments	Root diameter (cm)	Root fresh weight (g plant^{-1})	Root dry weight (g plant^{-1})
V_1	8.58 a	79.98 a	8.11 a
V_2	7.45 c	53.15 c	5.01 c
V_3	8.06 b	61.18 b	6.15 b
SE(±)	0.16	1.72	0.23
CV (%)	4.98	6.54	8.83

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

***Significant at 1% probability level.*
** Significant at 5% probability level.*
SE= Standard Error
CV= Co-efficient of variance

Legend,
V_1 = Purple Top White Globe
V_2 = Pusa Chandrima
V_3= Early Milan Red Top

The interacting effect of different variety and vermicompost (VC) doses on the root diameter (in cm) of turnip was found significantly different (Table 6). The maximum root diameter (9.64 cm) was found from Purple Top White Globe with 4 t/ha VC doses (V_1F_3) which was statistically similar to Early Milan Red Top with 4 t/ha VC doses (V_3F_3) (9.32 cm). Again, the minimum root diameter (6.00 cm) was observed from V_2F_1 (Pusa Chandrima with 0 t/ha VC doses) which was statistically different from others. It was concluded that the root diameter has shown significant variation at 5 % level of probability.

4.1.7 Root fresh weight

It was showed (Table 4) that the root fresh weight plant^{-1} was significantly varied among different turnip variety treatments. The maximum root fresh weight plant^{-1} (79.98 g) was recorded from the V_1 (Purple Top White Globe) treatment. On the other hand, the minimum root fresh weight plant^{-1} (53.15 g) was recorded from the V_2 treatment where Pusa Chandrima was applied.

Table 5: Effect of different level of vermicompost doses on root diameter (cm), root fresh weight (g plant^{-1}) and root dry weight (g plant^{-1}) of turnip.

Treatments	Root diameter (cm)	Root fresh weight (g plant^{-1})	Root dry weight (g plant^{-1})
F_1	6.63 c	50.73 d	4.88 d
F_2	7.94 b	62.26 c	6.09 c
F_3	9.20 a	78.02 a	7.83 a
F_4	8.34 b	68.10 b	6.89 b
SE(±)	0.19	1.99	0.26
CV (%)	4.98	6.54	8.83

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

***Significant at 1% probability level.*
** Significant at 5% probability level.*
SE= Standard Error
CV= Co-efficient of variance

Legend,
F_1= 0 t/ha(Control) VC doses
F_2= 2 t/ha VC doses
F_3= 4 t/ha VC doses
F_4= 6 t/ha VC doses

Among different levels of vermicompost (VC) treatments the root fresh weight plant^{-1} observed significant variation (showed in figure 5). Maximum root fresh weight plant^{-1} (78.02 g) was recorded from the plot where @4 t/ha VC doses (F_3) was applied. On the other hand, lowest root fresh weight plant^{-1} (50.73 g) was obtained from the plot where no VC (F_1) was applied. Dipesh *et al.*, (2021) reported that there was a significant effect of different doses of vermicompost root weight per plant in carrot (*Daucus carota).*

The root fresh weight plant^{-1} in gram was found significantly varied due to interactional effect of variety and vermicompost (VC) applications (Table 4). The maximum root fresh weight plant^{-1} (96.05 g) was recorded in the plot where Purple Top White Globe seedlings were planted with @4 t/ha VC doses (V_1F_3). On the other hand, the minimum root fresh weight (43.13 g) plant^{-1} was recorded in the plot where Pusa Chandrima seedlings were planted with @0 t/ha VC doses applied (V_2F_1) which differ from other combined treatments.

4.1.8 Root dry weight

Root dry weight per plant of turnip was significantly varied by different varietal treatments (Table 5). It is one of the directly yield contributing characteristics to measure benefit from turnip cultivation. The highest root dry weight per plant (8.11 g) was obtained in V_1 (Purple Top White Globe) treatment and the lowest root dry weight per plant (5.01 g) was obtained in V_2 treatment that was Pusa Chandrima.

Table 6: Combined effect of variety and vermicompost doses on root diameter (cm), root fresh weight (g plant^{-1}) and root dry weight (g plant^{-1}) of turnip.

Combine Treatments	Root diameter (cm)	Root fresh weight (g plant^{-1})	Root dry weight (g plant^{-1})
V_1F_1	7.22 de	59.02 de	6.21 def
V_1F_2	8.69 abc	80.36 b	8.05 abc
V_1F_3	9.64 a	96.05 a	9.65 a
V_1F_4	8.75 abc	84.50 ab	8.53 ab
V_2F_1	6.00 f	43.13 f	3.55 g
V_2F_2	7.26 de	49.69 ef	4.88 fg
V_2F_3	8.64 abc	65.72 cd	6.25 def
V_2F_4	7.91 cd	54.06 def	5.36 ef
V_3F_1	6.68 ef	50.02 ef	4.89 fg
V_3F_2	7.88 cd	56.69 de	5.36 ef
V_3F_3	9.32 ab	72.28 bc	7.58 bcd
V_3F_4	8.36 bcd	65.72 cd	6.79 cde
SE(±)	0.33	3.46	0.46
CV (%)	4.98	6.54	8.83

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, SE= Standard Error and CV= Co-efficient of variance

Legends,
V_1F_1 = Purple Top White Globe with 0 t/ha(Control) VC doses, V_1F_2 = Purple Top White Globe with 2 t/ha VC doses, V_1F_3 = Purple Top White Globe with 4 t/ha VC doses, V_1F_4 = Purple Top White Globe with 6 t/ha VC doses, V_2F_1 = Pusa Chandrima with 0 t/ha(Control) VC doses, V_2F_2 = Pusa Chandrima with 2 t/ha VC doses, V_2F_3 = Pusa Chandrima with 4 t/ha VC doses, V_2F_4 = Pusa Chandrima with 6 t/ha VC doses, V_3F_1 = Early Milan Red Top with 0 t/ha (Control)VC doses, V_3F_2 = Early Milan Red Top with 2 t/ha VC doses, V_3F_3 = Early Milan Red Top with 4 t/ha VC doses and V_3F_4 = Early Milan Red Top with 6 t/ha VC doses.

The variation in root dry weight plant^{-1} was found to be statistically significant due to the applications of different vermicompost (VC) doses (Table 6). The maximum root dry weight plant^{-1} (7.83 g) was obtained from the plot where 4 t/ha VC (F_3) was applied. On the other hand, minimum root dry weight plant^{-1} (4.88 g) was obtained from the plot where no VC (F_0) was applied. This result is also agreed by Dipesh *et al.*, 2021 in case of radish cultivation.

Combination between variety and different level of vermicompost (VC) treatments had significant effect on root dry weight plant^{-1} of turnip (Table 6). The highest root dry weight plant^{-1} (9.65 g) was recorded from V_1F_3 (Purple Top White Globe with 4 t/ha VC doses) which was statistically differ from other combinations whereas the lowest root dry weight plant^{-1} (3.55 g) was given by the V_2F_1 (Pusa Chandrima with 0 t/ha VC doses i.e. Control) combination which was statistically dissimilar with the other treatment combinations. It was concluded that the root dry weight plant^{-1} was shown significant variation at 1% level of probability.

4.1.9 Yield

Variety had significant effect on root yield of turnip (Figure 7). However, numerically the highest root yield (17.84 t ha^{-1}) was recorded from Purple Top White Globe (V_1) due to high yielding variety also late variety. The lowest root yield (11.02 t ha^{-1}) was recorded from Pusa Chandrima (V_2) which is moderate early variety. Varieties plays an important role in producing high yield of turnip.

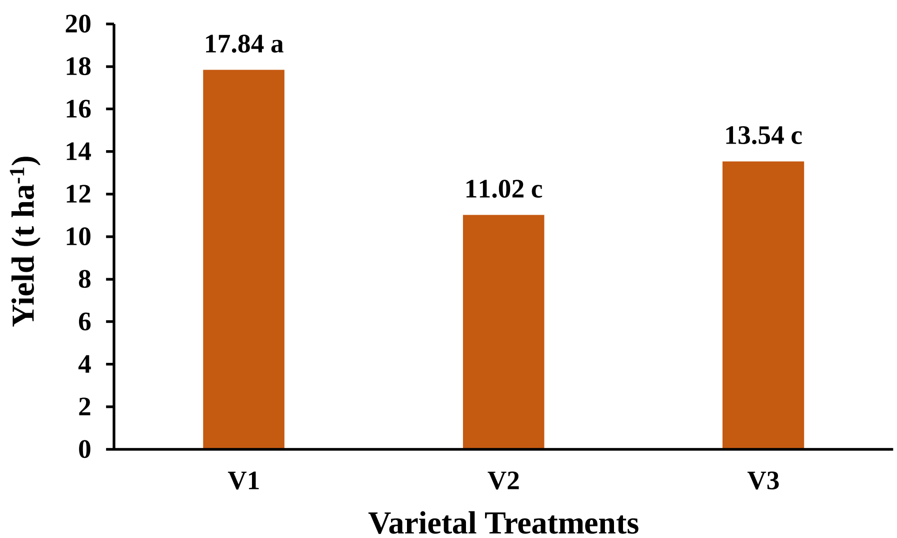

Figure 8: Effect of varieties on yield (t ha^{-1}) of turnip at harvest.

Here,
V_1 = Purple Top White Globe, V_2 = Pusa Chandrima and V_3 = Early Milan Red Top

Root yield also varied for different varieties, might be due to genetic and environmental influences as well as different vermicompost (VC) doses. There was significant variation observed on roots yield of turnip for the effect of different VC doses treatments (Figure 8). Results exposed that the highest roots yield (17.22 t ha^{-1}) was recorded from F_3 (4 t ha^{-1} VC) which was statistically different from all other treatments, where the lowest roots yield (10.75 t ha^{-1}) was achieved from F_1 (0 t ha^{-1} VC i.e. control). From the statistical analysis, the roots yield of turnip was shown significant variation at 1% level of probability. Mahorkar *et al*. (2007) and Gupta *et al.* (2011) supported these findings, as they found the better yield was observed in plots applied with vermicompost than other organic manures in radish crop. Kumar and Gupta, 2018 during the study also reported the highest yield of radish on application of vermicompost.

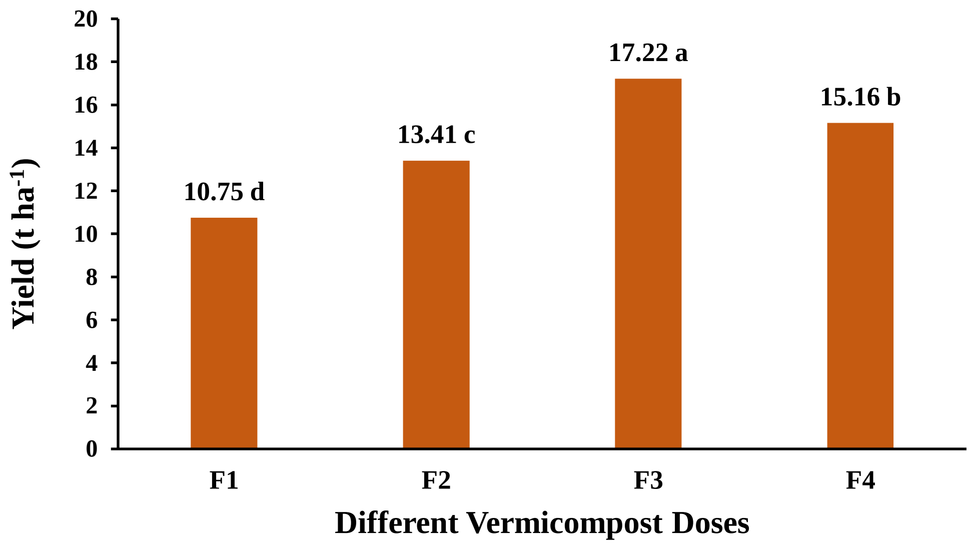

Figure 9: Effect of different vermicompost doses on yield (t ha^{-1}) of turnip at harvest.

Here,
F_1= 0 t/ha (Control VC doses), F_2= 2 t/ha VC doses, F_3= 4 t/ha and F_4= 6 t/ha VC doses

Root yield t ha^{-1} was the output of different varietal treatments applied as well as the effect of different level of vermicompost (VC) doses. It is the product of a cumulative effect of all the factors contributing to better growth and thereby effectively increasing the yield per plant and ultimately the yield per hectare. Thus, roots yield is controlled by large number of internal and external factors and any variation in them is liable to bring about variations in root yield. A significant interaction between variety and different level of VC doses treatments was observed in respect of roots yield of turnip (Figure 9). The maximum roots yield (21.24 t ha^{-1}) was found from V_1F_3 (Purple Top White Globe with 4 t/ha VC doses) which was statistically different from others. Again, the minimum roots yield (7.80 t ha^{-1}) was observed from V_2F_1 (Pusa Chandrima with 0 t/ha VC doses i.e. Control) which was statistically similar with V_2F_2 (Pusa Chandrima with 2 t/ha VC doses). It was concluded that the total roots yield was shown significant variation at 1% level of probability.

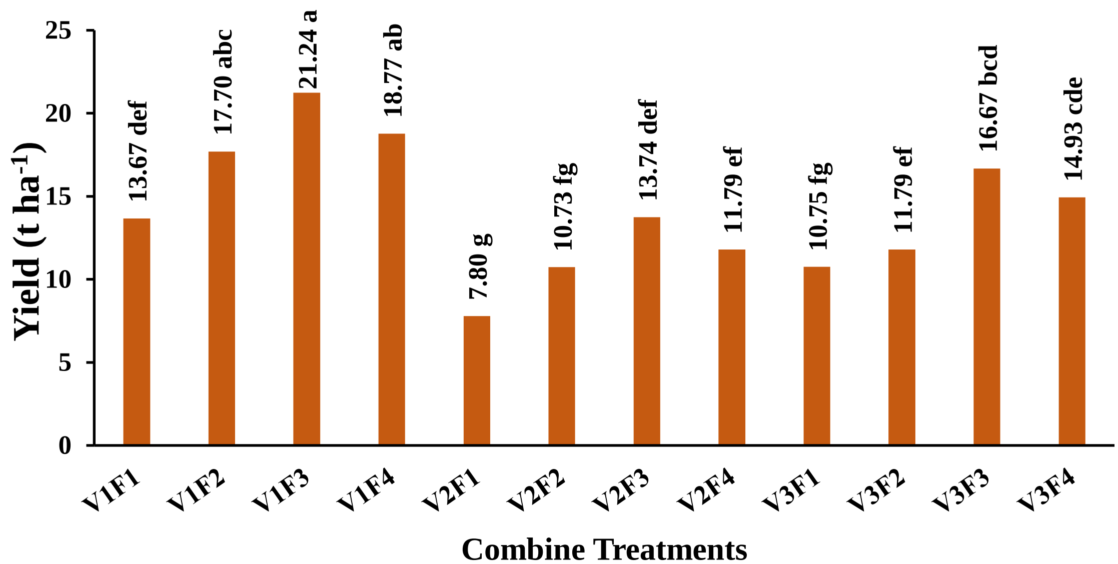

Figure10: Combine effect of varieties and vermicompost doses on yield (t ha^{-1}) of turnip at harvest.

Here,
V_1F_1 = Purple Top White Globe with 0 t/ha(Control) VC doses, V_1F_2 = Purple Top White Globe with 2 t/ha VC doses, V_1F_3 = Purple Top White Globe with 4 t/ha VC doses, V_1F_4 = Purple Top White Globe with 6 t/ha VC doses, V_2F_1 = Pusa Chandrima with 0 t/ha(Control) VC doses, V_2F_2 = Pusa Chandrima with 2 t/ha VC doses, V_2F_3 = Pusa Chandrima with 4 t/ha VC doses, V_2F_4 = Pusa Chandrima with 6 t/ha VC doses, V_3F_1 = Early Milan Red Top with 0 t/ha (Control)VC doses, V_3F_2 = Early Milan Red Top with 2 t/ha VC doses, V_3F_3 = Early Milan Red Top with 4 t/ha VC doses and V_3F_4 = Early Milan Red Top with 6 t/ha VC doses.

4.2 Chemical properties of the post-harvest plant samples

4.2.1 Available Calcium (Ca) in Plant Sample

The available Ca present in the post-harvest plant(root) sample varied considerably because of plant variety effects (Table 7). The availability Ca of the post-harvest plant sample with root ranged between 0.72 % and 0.95 %. The highest available Ca (0.95 %) was found in V_2 (Pusa Chandrima) treatment. The lowest available Ca (0.72 %) content was found in V_3 (Early Milan Red Top) treatment which was followed by V_1 (Purple Top White Globe) treatment.

Different level of vermicompost (VC) application showed the different result in available Ca (Table 8). The maximum available Ca of the post-harvest plant sample with modified root (1.12 %) was recorded in F_3 where 4 t/ha VC was applied and the lowest (0.46 %) was found in F_1 treatment where 0 t/ha VC was applied.

Combined effect of plant variety and different level of vermicompost (VC) application had significant effect on available Ca of the post-harvest plant sample with modified root (Table 9). The highest available Ca (1.31 %) was recorded from V_2F_3 while, the lowest available Ca (0.42 %) was found from V_3F_1 treatment which was statistically similar with V_1F_1 (0.45 %).

Table 7: Effect of variety on available Ca (%), available Mg (%) and available S (%) of turnip.

Treatments	Available Ca (%)	Available Mg (%)	Available S (%)
V_1	0.79 b	0.47 b	0.08 b
V_2	0.95 a	0.55 a	0.12 a
V_3	0.72 b	0.39 c	0.08 b
SE(±)	0.03	0.01	3.23
CV (%)	9.44	7.76	8.31

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

***Significant at 1% probability level.*
** Significant at 5% probability level.*
SE= Standard Error
CV= Co-efficient of variance

Legend,
V_1 = Purple Top White Globe
V_2 = Pusa Chandrima
V_3 = Early Milan Red Top

4.2.2 Available Magnesium (Mg) in Plant Sample

The available magnesium content of the post-harvest plant sample varied significantly by different treatments (Table 7). Available magnesium content in plant sample with root varied from 0.39 to 0.55 % due to applied different plant density treatments. The maximum magnesium content 0.55 % was observed in the treatment V_2 (Pusa Chandrima). And, the lowest magnesium content (0.39 %) was observed in varietal treatment V_3 (Early Milan Red Top).

Different level of VC application showed the different result in available Mg (Table 8). The maximum Mg contain of plant sample (0.64 %) was recorded in F_3 where the level of VC 4 t/ha was applied and the lowest (0.24 %) was found in F_1 treatment where VC was not applied.

Combined effect of plant variety and different level of vermicompost application had significant effect on available Mg of turnip plant sample with root (Table 9). The highest available Mg (0.75%) was recorded from V_2F_3 which was statistically followed with V_1F_3 (0.65 %) while, the lowest available Mg (0.19 %) was found from V_3F_1 treatment.

Table 8: Effect of different level of vermicompost doses on r on available Ca (%), available Mg (%) and available S (%) of turnip.

Treatments	Available Ca (%)	Available Mg (%)	Available S (%)
F_1	0.46 d	0.24 d	0.03 d
F_2	0.76 c	0.46 c	0.09 c
F_3	1.12 a	0.64 a	0.15 a
F_4	0.96 b	0.52 b	0.12 b
SE(±)	0.04	0.02	3.73
CV (%)	9.44	7.76	8.31

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

***Significant at 1% probability level.*
** Significant at 5% probability level.*
SE= Standard Error
CV= Co-efficient of variance

Legend,
F_1= 0 t/ha(Control) VC doses
F_2= 2 t/ha VC doses
F_3= 4 t/ha VC doses
F_4= 6 t/ha VC doses

4.2.3 Available Sulphur (S) in Plant Sample

The available sulphur content of the post-harvest plant sample with root varied significantly by different treatments (Table 7). Available sulphur content in plant sample varied from 0.08 to 0.12 % due to applied different plant variety treatments. The maximum sulphur content 0.12 % was observed in the treatment V_2 (Pusa Chandrima) The lowest sulphur content (0.08 %) was observed in both treatment V_1 (Purple Top White Globe) and V_3 (Early Milan Red Top) treatment

Different level of vermicompost (VC) applications showed different results in available S (Table 8). The maximum sulphur content of plant sample with root (0.15 %) was recorded in F_3 where the level of vermicompost @4 t/ha was applied and the lowest (0.03 %) was found in F_1 treatment where 0 t/ha VC was applied.

Combined effect of plant variety and different level of VC application had significant effect on available S of turnip plant sample with modified root (Table 9). The highest available S (0.19 %) was recorded from V_2F_3 while, the lowest available S (0.02 %) was found from V_1F_1 and V_3F_1 treatment which was statistically similar (0.04 %) with V_2F_1.

Table 9: Combined effect of variety and vermicompost doses on on available Ca (%), available Mg (%) and available S (%) of turnip.

Combine Treatments	Available Ca (%)	Available Mg (%)	Available S (%)
V_1F_1	0.45 fg	0.26 h	0.02 f
V_1F_2	0.70 cde	0.42 ef	0.07 e
V_1F_3	1.09 ab	0.65 ab	0.14 b
V_1F_4	0.93 b	0.53 cd	0.10 cd
V_2F_1	0.50 efg	0.28 gh	0.04 f
V_2F_2	0.91 bc	0.57 bc	0.11 cd
V_2F_3	1.31 a	0.75 a	0.19 a
V_2F_4	1.08 b	0.59 bc	0.15 b
V_3F_1	0.42 g	0.19 h	0.02 f
V_3F_2	0.66 def	0.39 fg	0.08 e
V_3F_3	0.95 b	0.52 cde	0.13 bc
V_3F_4	0.86 bcd	0.45 def	0.10 de
SE(±)	0.06	0.03	6.46
CV (%)	9.44	7.76	8.31

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, SE= Standard Error and CV= Co-efficient of variance

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, SE= Standard Error and CV= Co-efficient of variance

Legends,
V_1F_1 = Purple Top White Globe with 0 t/ha(Control) VC doses, V_1F_2 = Purple Top White Globe with 2 t/ha VC doses, V_1F_3 = Purple Top White Globe with 4 t/ha VC doses, V_1F_4 = Purple Top White Globe with 6 t/ha VC doses, V_2F_1 = Pusa Chandrima with 0 t/ha(Control) VC doses, V_2F_2 = Pusa Chandrima with 2 t/ha VC doses, V_2F_3 = Pusa Chandrima with 4 t/ha VC doses, V_2F_4 = Pusa Chandrima with 6 t/ha VC doses, V_3F_1 = Early Milan Red Top with 0 t/ha (Control)VC doses, V_3F_2 = Early Milan Red Top with 2 t/ha VC doses, V_3F_3 = Early Milan Red Top with 4 t/ha VC doses and V_3F_4 = Early Milan Red Top with 6 t/ha VC doses.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at Horticulture research field, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2020 to March 2021 to evaluate the performance of turnip under different treatments of variety and vermicompost doses. The experiment was laid out in two factorial RCBD with 3 (three) replications. Factor A (Three different variety) viz. V_1 = Purple Top White Globe; V_2 = Pusa Chandrima and V_3 = Early Milan Red Top Factor B (Four different level of vermicompost) viz. F_1 = 0 t/ha i.e. control; F_2 = 2 t/ha; F_3 = 4 t/ha and F_4 = 6 t/ha. The total number of experimental plots were 36. Seeds were sown on the 8th December, 2020. The plants were allowed to grow until maturity and was applied intercultural operations such as gap filling, irrigation, weeding and earthing up. Insect and disease controls were done whenever required in order to support normal growth of the plant. The roots were harvested at marketable age from 25th January 2021 to 10th February, 2021. Plot wise yield and yield components were recorded. Data were statistically analyzed using the “Analysis of variance” (ANOVA) technique with the help of statistix 10 software. The mean differences were analyzed by Tukey HSD test.

In case of different varietal effects, the highest plant height (30.15 cm) and number of leaves plant^{-1} (12.93) at harvest were recorded from the plots where the highest plant height and number of leaves/plant was recorded from the variety Purple Top White Globe (V_1) and the lowest plant height (25.02 cm) and number of leaves plant^{-1} (16.22) were observed were found from V_2 (Pusa Chandrima) treatment at harvest. The maximum fresh weight of leaves plant^{-1} (227.61 g) was measured from V_1 (Purple Top White Globe) and the minimum fresh weight of leaves plant^{-1} (192.97 g) was obtained from V_2 (Pusa Chandrima). The days after maturity varied significantly due to different turnip varieties. The maximum days after maturity (62.53) was observed from V_1 (Purple Top White Globe) treatment, while the minimum days after maturity (47.22) was found from V_3 (Early Milan Red Top) treatment. Whereas moderate days after maturity (57.37) was found from V_2 (Pusa Chandrima) treatment. The root length and diameter are vital parameters to calculate the final biological yield of turnip. It was observed that the Purple Top White Globe (V_1) produced the highest root length (9.94 cm) and diameter (8.58 cm) numerically while Pusa

Chandrima (V_2) produced the lowest root length (8.54 cm) and diameter (7.45 cm) of turnip. The highest root fresh weight per plant (79.98 g) and root dry weight per plant (8.11 g) were obtained in V_1 (Purple Top White Globe) treatment and the lowest root fresh weight per plant (53.15 g) and root dry weight per plant (5.01 g) were obtained in V_2 treatment that was Pusa Chandrima. Finally, variety had significant effect on root yield of turnip. However, numerically the highest root yield (17.84 t ha^{-1}) was recorded from Purple Top White Globe (V_1) as it is a high yielding variety also a late variety. The lowest root yield (11.02 t ha^{-1}) was recorded from Pusa Chandrima (V_2) which is moderate early variety. Varieties plays an important role in producing high yield of turnip.

Again, the result of the research has shown that the main effect of different level of vermicompost (VC) was significant in respect of growth and yield characteristics. The highest plant height (32.48 cm) and number of leaves $plant^{-1}$ (14.73) at harvest was recorded where VC fertilizer applied @4 t ha^{-1} (F_3) which followed by F_4 treatment (30.37 cm) where @6 t ha^{-1} VC fertilizer was applied. On the other hand, the lowest plant height (19.99 cm) and number of leaves $plant^{-1}$ (8.87) was obtained from the plot where VC was not applied i.e. control treatment (F_1). Among the different doses of vermicompost (VC) F_3 (4 t ha^{-1}) showed the maximum fresh weight of leaves $plant^{-1}$ (225.20 g), whereas the minimum fresh weight of leaves $plant^{-1}$ (194.23 g) was obtained from where no VC was applied. The different level of vermicompost (VC) treatments have not significantly influenced days after maturity of turnip. The largest days after maturity (58.87) was found from F_1 (0 t ha^{-1}) and the shortest days after maturity (52.97) was found from F_3 (4 t ha^{-1}). which was statistically similar (54.58) with F_4 (6 t ha^{-1}). Other important yield evaluating characters of turnip were root length and root diameter. Result showed that different level of vermicompost (VC) doses treatment had significant effect on root length and root diameter of turnip. However, numerically the highest root length (9.95 cm) and root diameter (9.20 cm) was recorded from F_3 (4 t ha^{-1}) which was statistically similar with F_4 (6 t ha^{-1}). The lowest root length (7.17 cm) and root diameter (6.63 cm) of turnip was recorded from F_1 (0 t ha^{-1}). The variation in root fresh weight $plant^{-1}$ was found to be statistically significant due to the applications of different vermicompost (VC) doses (Table 6). The maximum root fresh weight $plant^{-1}$ (78.02 g) and root dry weight per plant (7.83 g) were obtained from the plot where 4 t/ha VC (F_3) was applied. On the other hand, minimum root fresh weight plant^{-1} (50.73 g) and root dry weight per plant (4.88 g) were obtained from the plot where no VC (F_0) was applied. Finally, there was significant variation observed on roots yield of turnip for the effect of different VC doses treatments. Results exposed that the highest roots yield (17.22 t ha^{-1}) was recorded from F_3 (4 t ha^{-1} VC) which was statistically different from all other treatments, where the lowest roots yield (10.75 t ha^{-1}) was achieved from F_1 (4 t ha^{-1} VC i.e. control).

Also, interactional effect of different variety and level of vermicompost applications on turnip had significant effect of all variables. However, the height plant height (35.84 cm) and number of leaves plant^{-1} (15.98) at harvest were recorded from V_1F_3 (Purple Top White Globe with 4 t/ha VC doses) which was statistically similar with V_1F_4 (Purple Top White Globe with 6 t/ha VC doses). On the other hand, the shortest plant height (17.50 cm) and number of leaves plant^{-1} (7.87) was given by the combination of V_2F_1 (Pusa Chandrima with 0 t/ha VC doses) which was statistically different from all other treatments. The interaction effects of different variety and different level of VC doses practices were significant on fresh weight of leaves plant^{-1} of turnip. It was found that Purple Top White Globe with 4 t/ha VC doses (V_1F_3) produce maximum fresh weight of leaves plant^{-1} (242.61 g) which was followed by V_1F_3 (Purple Top White Globe with 6 t/ha VC doses) (236.69 g) (Table 3). On the contrary, the lowest fresh weight of leaves plant^{-1} (179.73 g) was also produced when it was observed in the combination of Pusa Chandrima with 0 t/ha VC doses (V_2F_1) which was statistically different from all other treatments. The maximum days after maturity of turnip (65.71) was recorded from the treatment V_1F_1 (Purple Top White Globe with 0 t/ha VC doses) which was significantly followed by V_1F_2 (Purple Top White Globe with 2 t/ha VC doses). On the other hand, minimum days after maturity of turnip (44.61) was recorded from the treatment V_3F_3 (Early Milan Red Top with 4 t/ha VC doses) which was significantly followed by V_3F_4 (Early Milan Red Top with 6 t/ha VC doses) and V_3F_2 (Early Milan Red Top with 2 t/ha VC doses) due to early variety plants. It was evident that the root length and root diameter in cm was significantly varied due to interactional effect of varieties and vermicompost (VC) treatments. The longest root (11.62 cm) and maximum root diameter (9.64 cm) were observed from V_1F_3 (Purple Top White Globe with 4 t/ha VC doses) which was statistically followed by V_1F_4 (Purple Top White Globe with

6 t/ha VC doses) and the minimum root length (10.44 cm) and root diameter (6.00 cm) were observed from V_2F_1 (Pusa Chandrima with 0 t/ha VC doses) which was statistically different from other combinations. The highest root fresh weight plant^{-1} (96.05 g) and root dry weight per plant (9.65 g) were recorded from V_1F_3 (Purple Top White Globe with 4 t/ha VC doses) which was statistically differ from other combinations whereas the lowest root fresh weight plant^{-1} (43.13 g) and root dry weight per plant (3.55 g) were given by the V_2F_1 (Pusa Chandrima with 0 t/ha VC doses i.e. Control) combination which was statistically disimilar with the other treatment combinations. Finally, root yield t ha^{-1} is the output of different varietal treatment applied as well as the effect of different level of vermicompost (VC) doses. The maximum roots yield (21.24 t ha^{-1}) was found from V_1F_3 (Purple Top White Globe with 4 t/ha VC doses) which was statistically different from others. Again, the minimum roots yield (7.80 t ha^{-1}) was observed from V_2F_1 (Pusa Chandrima with 0 t/ha VC doses i.e. Control) which was statistically similar with V_2F_2 (Pusa Chandrima with 2 t/ha VC doses).

From the findings of this study, it may be concluded that among the three varieties tr, Purple Top White Globe turnip gave the best performance in terms of total root yield. Again, among the four vermicompost application packages, 4 t ha^{-1} gave best root yield. However, the results of the present investigation revealed that turnip can be grown successfully when vermicompost is used @4 t ha^{-1} dose.

The findings of the present investigation clearly indicated that the combined use of Purple Top White Globe turnip variety and 4 t ha^{-1} VC for growing turnip is a viable option for increasing the income of farmers. These findings will be helpful for the local farmers who will be able to grow turnip in their fields and homegardens in a more efficient and eco-friendly way. The present study also opens an avenue for more of such investigations using different plants of Cruciferae family.

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CHAPTER VII

APPENDICES

Appendix I: Map showing the experimental site under study

Appendix II: Characteristics of soil of experimental field

A. Morphological characteristics of experimental field

Morphological features	Characteristics
Location	Horticulture field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

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

B. Physiological properties of the initial soil

Characteristics	Value
Partical size analysis	
Sand%	25
Silt%	45
Clay%	30
Textural Classes	Silty -Clay
P^H	5.7
Organic carbon (%)	0.47
Organic matter (%)	0.78
Total N (%)	0.01
Available P (ppm)	23.00
Exchangeable K (meq/100g soil)	0.1

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka-1207

Appendix III. Monthly average of relative humidity, air temperature and total rainfall of experimental site during the period from November 2020 to March 2021.

Month	Average RH%	Average temperature (C^0)		Total Average Rainfall(mm)
		Min.	Max.	
November, 2020	45.01	5.01	18.25	00
December, 2020	52.41	6.04	23.35	00
January, 2021	59.13	12.45	21.32	00
February, 2021	53.66	16.34	24.12	4.34
March, 2021	46.37	19.41	28.54	1.22
April, 2021	49.16	23.21	31.42	2.17

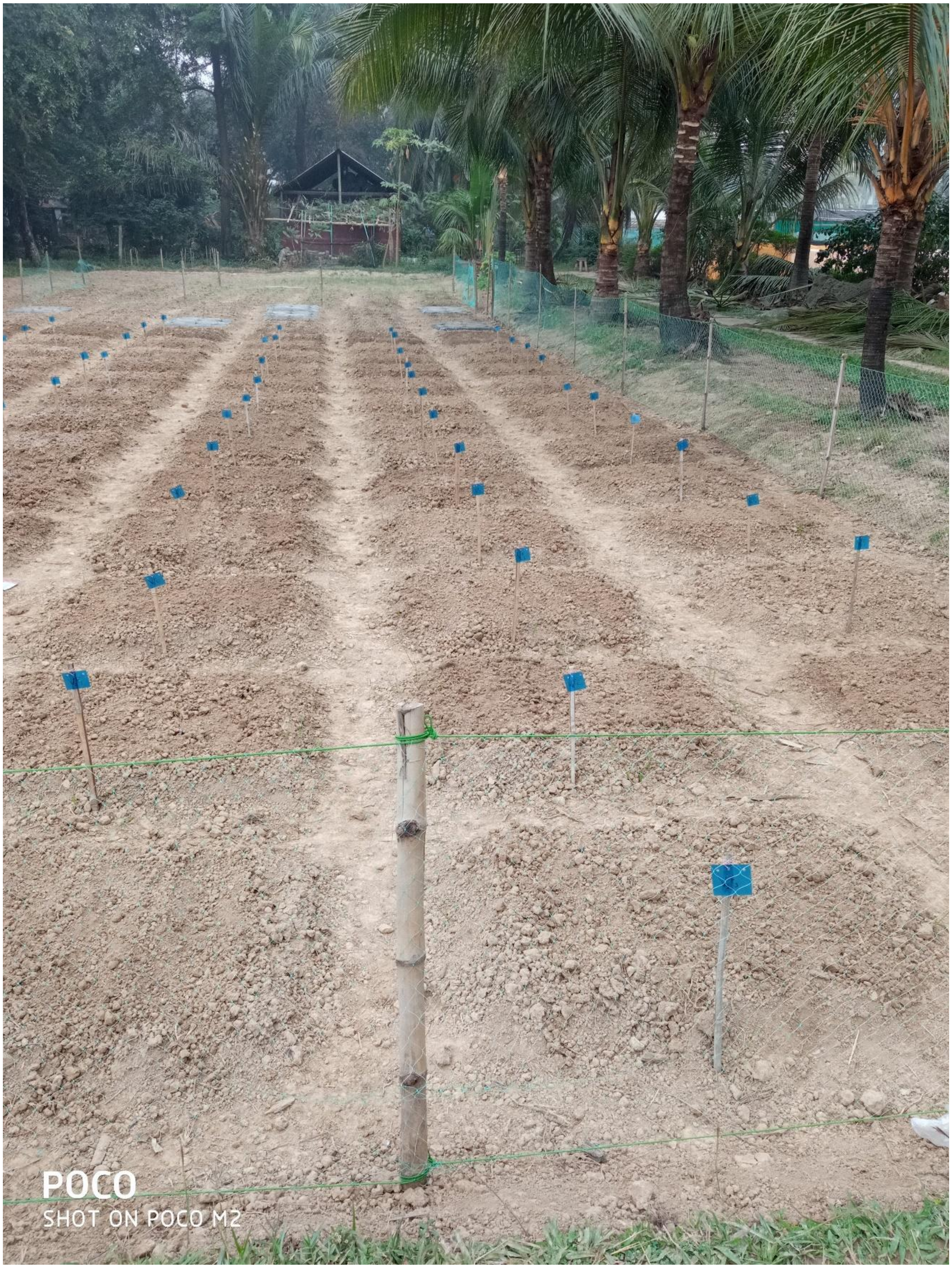
Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix V. Factorial ANOVA tables.

Source	DF	SS	MS	F-Value	P (>F)
1. Plant Height (cm)					
Replication	2	14.48	7.239		
Factor A	2	159.47	79.736	105.48	0.0000
Factor B	3	808.58	269.526	356.55	0.0000
A×B	6	8.02	1.337	1.77	0.1522
Error	22	16.63	0.756		
Total	35	1007.1			
2. Number of leaves plant^{-1}					
Replication	2	5.257	2.6285		
Factor A	2	26.499	13.2494	28.84	0.0000
Factor B	3	162.190	54.0634	117.69	0.0000
A×B	6	2.020	0.3367	0.73	0.6283
Error	22	10.106	0.4594		
Total	35	206.073			
3. Fresh weight of leaves plant^{-1} (g)					
Replication	2	949.8	474.92		
Factor A	2	7219.4	3609.72	187.55	0.0000
Factor B	3	4862.2	1620.73	84.21	0.0000
A×B	6	162.0	27.00	1.40	0.2579
Error	22	423.4	19.25		
Total	35	13616.			
4. Days after maturity					
Replication	2	12.68	6.339		
Factor A	2	1456.28	728.138	288.31	0.0000
Factor B	3	173.16	57.719	22.85	0.0000
A×B	6	1.22	0.204	0.08	0.9976
Error	22	55.56	2.526		
Total	35	1698.90			
5.Root length (cm)					
Replication	2	2.8275	1.4138		
Factor A	2	31.5945	15.7973	62.36	0.0000
Factor B	3	37.9283	12.6428	49.90	0.0000
A×B	6	2.0194	0.3366	1.33	0.2865
Error	22	5.5735	0.2533		
Total	35	79.9433			

Source	DF	SS	MS	F-Value	P (>F)
6. Root diameter (cm)					
Replication	2	1.3965	0.6982		
Factor A	2	7.5678	3.7839	23.66	0.0000
Factor B	3	30.8304	10.2768	64.26	0.0000
A×B	6	0.3774	0.0629	0.39	0.8754
Error	22	3.5186	0.1599		
Total	35	43.6906			
7. Root fresh weight plant^{-1} (g)					
Replication	2	7988	3994.2		
Factor A	2	35858	17928.8	23.40	0.0000
Factor B	3	37371	12457.0	16.26	0.0000
A×B	6	7629	1271.5	1.66	0.1783
Error	22	16854	766.1		
Total	35	105700			
8. Root dry weight plant^{-1} (g)					
Replication	2	13.483	6.7417		
Factor A	2	121.795	60.8977	152.72	0.0000
Factor B	3	82.045	27.3484	68.59	0.0000
A×B	6	8.910	1.4851	3.72	0.0104
Error	22	8.773	0.3988		
Total	35	235.007			
9. Yield (t ha^{-1})					
Replication	2	65.26	32.630		
Factor A	2	589.49	294.745	152.72	0.0000
Factor B	3	397.10	132.366	68.59	0.0000
A×B	6	43.13	7.188	3.72	0.0104
Error	22	42.46	1.930		
Total	35	1137.43			

Appendix VI. Some photos documented during the experiment

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