EFFECT OF BIO-FERTILIZER MIXED NUTRIENT SOURCES ON GROWTH, SEED YIELD AND QUALITY OF RADISH VARIETIES

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*This is to certify that the thesis entitled, "**EFFECT OF BIO-FERTILIZER MIXED NUTRIENT SOURCES ON GROWTH, SEED YIELD AND QUALITY OF RADISH VARIETIES** submitted to the, Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN INSTITUTE OF SEED TECHNOLOGY,** embodies the result of a piece of bona fide research work carried out by* **UZZAL KUMAR RAY** *Registration No. **14-05878** under my supervision and 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.

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Dedicated to
My
Beloved Parents

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The Author

EFFECT OF BIO-FERTILIZER MIXED NUTRIENT SOURCES ON GROWTH, SEED YIELD AND QUALITY OF RADISH VARIETIES

ABSTRACT

The experiment was conducted at the Central Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during the period from November, 2019 to April, 2020 to investigate the effect of bio-fertilizer mixed nutrient sources on the quality seed production of radish varieties. The seeds of BARI mula-1, BARI mula-2 and BARI mula-4 were collected from the Bangladesh Agricultural Research Institute, Gazipur, Dhaka. This experiment was conducted with two factors: Factor-A (Varieties)- (i) V_1- BARI mula-1 (ii) V_2- BARI mula-2 (iii) V_3- BARI mula-4; Factor-B: (Nutrients in absence or presence of bio-fertilizer) – (i) N_0- NPKS (standard dose) + without bio-fertilizer (ii) N_1- NPKS (standard dose) + Bio-fertilizer (iii) N_2- 50% CD+ 50% Vermicompost (iv) N_3- 50% CD + 50% Vermicompost + Bio-fertilizer. There are 12 treatment combinations such as V_1N_0, V_1N_1, V_1N_2, V_1N_3, V_2N_0, V_2N_1, V_2N_2, V_2N_3, V_3N_0, V_3N_1, V_3N_2 and V_3N_3. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. BARI recommended the following doses of manures and fertilizer: Cowdung-25 kg/ha, Urea-300 kg/ha, TSP-200 kg/ha, MP-200 kg/ha, Gypsum-50 kg/ha and Bio-fertilizer- 4kg/ha were applied. Seeds were sown on 15 November and distance to be maintained 30cmX30cm, respectively. In case of different variety, maximum number of siliqua per inflorescence (132.42), number of seeds per siliqua (6.58), seed yield per hectare (1.38 t) were observed from V_3 treatment and minimum number of siliqua per inflorescence (67.50), number of seeds per siliqua (3.62) and seed yield per hectare (0.75 t) were obtained from V_2 treatment. For different nutrients, maximum number of siliqua per inflorescence (125.67), number of seeds per siliqua (6.20) and seed yield per hectare (1.33 t) were observed from N_1 treatment and minimum number of siliqua per inflorescence(93.11), number of seeds per siliqua (4.97) and seed yield per hectare (0.97 t) were observed from N_2 treatment. Due to combined effect, at harvest the maximum number of siliqua per per inflorescence (154.33), number of seeds per siliqua (7.27) and seed weight per hectare (1.59t) were obtained from V_3N_1 treatment combination and the minimum number of siliqua per inflorescence (61.0), number of seeds per siliqua (3.27) and seed weight per hectare (0.63 t) were produced from V_2N_2 treatment combination. So, the V_3N_1 treatment combination appeared to be the best for achieving the higher growth and seed yield of radish.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
FRG	=	Fertilizer Recommendation Guide
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Radish (*Raphanus sativus* L.) belongs to genus Raphanus, family Brassicaceae or Cruciferae having chromosome number 2n=18 originated from the Central and Western China and India (Thamburaj and Singh, 2005). The main edible portion of radish is fleshy roots which develop from both the primary root and the hypocotyl. The pungency of radish is due to isothiocynates and red color is due to anthocyanin pigment (Basnet *et al*., 2021). Its leaves are rich in minerals and vitamins A and C and are also cooked as leafy vegetable. Its edible fusiform roots are eaten raw as salad or cooked vegetable. It is a good source of vitamin C and minerals like calcium, potassium and phosphorus (Jilani *et al*., 2010, Sahu *et al*., 2018 and Basnet *et al*., 2021). Its edible fusiform roots are eaten raw as salad or cooked vegetable. It is a good source of vitamin C and minerals like calcium, potassium and phosphorus (Jilani *et al*., 2010, Sahu *et al*., 2018 and Basnet *et al*., 2021). Flower may be white or sometimes pink in colour and fruit is called siliqua, which is 3-8 cm long with 6-12 seeds (Rashid, 2000). Radish is a popular and important vegetable crop in Bangladesh. Besides, tender leaves which are used as greens are rich in vitamin A and C. Roots are also rich in carbohydrate and protein (Gopalan and Balasubramanium, 1966).

In Bangladesh, farmers generally cultivate radish in large scale in the field but urban farmers generally cultivate the crop in their homesteads. Production statistics of radish in Bangladesh is covering an area of 22052 ha and producing 200840 tones of edible roots. It ranks second both in acrage and among the major vegetables crop of Bangladesh (BBS, 2018).The Radish is in two distinct genetical groups. The Asiatic varieties, which are primarily for tropical climates, produce edible roots in the first season and seed in the second season as a biennial crop. On the other hand, the exotic or European varieties produce roots in the plains of tropical and subtropical climate and seeds in the hills of temperate climate (Singh *et al*., 2019).

There are a number of factors like variety, growing environment and season, availabilities of irrigation and nutrition, disease and insect pest infestation etc. which play key role in quantity as well as quality production (Politud, 2016, NARC, 2017). The most important

quality characteristics of root vegetables for fresh market are root shape and size, uniformity, color, texture and sensory quality (Larsen and Wold, 2016).

There are several open pollinated and hybrid radish variety seeds available in the market, having different varietal characters such as root color, taste, length, size, yield potential and quality parameters (Dahal *et al*., 2021). Farmers buy radish seed according to the information provided by the seed traders. The productivity and quality of these different varieties are not yet tested scientifically (Dahal *et al*., 2021). This research focused on the selection of superior radish variety having high seed yield potential with better quality.

Seed is the ultimate economic input in any crop production programmed because production potential of any crop is totally dependent upon quality seed. Radish is a short duration and quick growing crop, so, the root growth and development should be uninterrupted. For this, optimum nutrition should be provided through organic, inorganic and bio-fertilizer sources. Chemical fertilizers are expensive and resulted in poor health condition of soil and water if used repeatedly. So, alternative cheap organic sources of nutrients including bio-fertilizers with or without chemical fertilizers should be considered (Kumar *et al*., 2014) for higher yield and quality root or seed of radish.

Integrated use of fertilizer, manure and bio-fertilizer improve soil fertility and crop growth. Bio-fertilizers are natural fertilizers that are microbial inoculants of bacteria, algae and fungi, which can help biological nitrogen fixation for the benefit of plants. Hence, for the production of good quality radish seed, optimum nutrition through organic, inorganic and bio-fertilizers are essential for sustainable production. Use of bio-fertilizers in integrated plant nutrient management correct multiple deficiencies of plant nutrients and improves physical, chemical and biological properties of soil. Being environment friendly and low cost input, greater emphasis has been given on application of bio-fertilizer with organic and inorganic fertilizers as part of an integrated nutrient management strategy, which play significant role in plant nutrition (Sharma *et al*., 2013) which also resulted higher seed yield and quality.

Appropriate variety selection and use of optimum amount of nutrient is a crucial factor for obtaining higher yield from radish (both root and seed). For the optimum growth of radish

roots inside the soil, optimum fertilization with inorganic, organic and bio-fertilizers sources of nutrient is necessary (Chapagain, *et al*., 2010).

Keeping in view the above facts in mind, the present studies have been planned to study the effect of nutrients in absence or presence of bio-fertilizer with or without organic and inorganic nutrient sources and different varieties on growth, seed yield and quality of radish seed production with the following objectives:

1. To identify the suitable variety for maximum growth, seed yield and quality of radish
2. To observe nutrients with or without bio-fertilizer for maximum growth, seed yield and quality of radish
3. To optimize the better combination of variety with nutrients for maximum growth, seed yield and quality of radish

CHAPTER II

REVIEW OF LITERATURE

Radish (*Raphanus sativus* L.) is considered as an important popular vegetable crop of the world and also in Bangladesh. Limited research works have been done in different parts of the world to study the effect of bio-fertilizer mixed nutrient sources on growth, seed yield and quality of radish. However, some of the literatures relevant to the above mentioned aspects are reviewed in this chapter.

Dahal *et al*. (2021) carried out an experiment to identify the suitable radish (*Raphanus sativus* L.) variety having high yield potential with better quality roots for off season. Eight treatments, i.e. five improved (Vedetar Local, Miyasinge, Tokinasi, Pusa Chetki and All Season) and three hybrid varieties (Mino Early Long White F1, Ivory White F1 and MAHY 22 F1) of radish were assigned. Miyasinge variety showed the highest plant height (43.91 cm), biomass yield (73.22t ha^{-1}) and fresh shoot weight per plant (127.15 g) whereas the highest number of leaves per plant (20.54) was recorded in MAHY 22 F1. Ivory White F1 variety showed the highest root length (19.51cm), root circumference (9.31cm), root to shoot ratio per plant (1.29) and fresh root yield (30.87 t ha^{-1}).

Sawant *et al*. (2021) conducted a field experiment to evaluate the integrated nutrient management on growth, yield and quality of radish (*Raphanus sativus* L.). The experiment was laid out in Randomized Block Design with seven different levels of treatment of integrated nutrients and three cultivars replication thrice. Results revealed that yield parameters significantly affected with the application of varying levels of integrated nutrients as well as cultivars. Among the treatment plant height per plant (37.4 cm), number of leaves per plant (21.0), higher root length per plant (28.81 cm), root weight of plant (267.33 g) and root diameter (3.38 cm) was recorded at RDF (90:50:90) kg ha^{-1} + farm yard manures (5 t ha^{-1}) + verimicompost (3 t ha^{-1})+ arka microbial constrioum (17 kg ha^{-1}) was cultivar Japanese white.

Kushwah *et al*. (2020) carried out a study on influence of organic manures, inorganic fertilizers and their combinations on growth and yield of radish. The results showed that the application of 75 percent NPK + 25 percent nitrogen through vermicompost resulted in significantly higher values of plant height, number of leaves per plant, length of leaves, root length, diameter of root, days to harvest, average root weight, yield and harvest index.

Pandey *et al*. (2020) conducted an experiment to study the effect of different organic manure in Mino Early variety of radish. This experiment resulted maximum plant height in mustard cake application followed by FYM + mustard cake application, maximum number of leaves at 65 days after sowing were obtained in mustard cake application followed by poultry manure application. There was significantly higher root yield and shoot weight with application of mustard cake.

Singh *et al*. (2019) conduct an experiment to find out the character association in radish genotypes. Observations *viz*., plant height, no. of leaves per plant, leaves length, leaves width, leaf weight, root length, root thickness, fresh weight of root, leaf: root length ratio, leaf: root weight ratio, and root yield, recorded at 15, 30 and 45 DAS. The silent findings of the experimentation are as Using 9 genotype namely, Suneha, Pusa hillqueen, Panjob Pasand, Hongkong-11, Snow white, Pusa Reshmi, White icicle, Pusa Himani, Japanese White of radish the early stages Pusa Himani, Pusa hill queen and Pusa Reshmi a rapid increase in plant height was noted during early stages of growth up to 30 DAS. There was a significant variation regarding the plant height between the nine varieties. The lowest leaf weight was recorded in Hong kong-11 (T-4, 10.4 g) and maximum in Pusa Himani (T-3, 17.56 g) at 15 DAS. At the harvesting stage maximum number of leaves per plant was recorded in Pusa Himani (T-3, 13.66) variety and was found significantly superior to other varieties. Data on the leaf length were recorded maximum leaf length in Pusa Reshmi (T-2, 18.80 cm) and minimum leaf length was recorded in Suneha (T-1, 11.63 cm). At 30 DAS maximum leaf width recorded in Pusa Reshmi (T-2, 7.43 cm) and minimum leaf width in Suneha (T-1, 5.26 cm) at harvesting stage maximum root length was recorded in variety Pusa Himani (T-3, 24.40 cm) and minimum root length recorded in Suneha (T-1, 19.00 cm). Maximum root thickness recorded in Pusa Himani (T-3, 5.26 cm) at harvesting stage. The maximum yield at harvest time was recorded in the variety Pusa Himani (T-3, 33.14

t/ha) which was followed by Pusa Reshmi (T-2, 32.65 t/ha) and Japanese white (T-8, 32.28 t/ha).

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Khede *et al*. (2019) conducted a study on effect of organic manures, fertilizers and their combinations on growth, yield and quality of radish (*Raphanus sativus* L.) cv. Japanese White. The plant height, length of leaves, fresh weight of root, dry weight of root, root length, diameter of root, average weight of root and yield of root was recorded maximum in treatment with 50 percent RDF + 25 percent vermicompost + 25 percent poultry manure.

Kiran *et al*. (2019) conducted two years pot experiments comprising 6 treatments (control, NPK + FYM, NPK + PM, NPK + GM, NPK + PrM and NPK + SS) and 3 replications. Data for leaves' count plant^{-1}, leaf length (cm), leaves weight (g plant^{-1}), root size (length and diameter), root weight (g plant^{-1}), total biomass (g plant^{-1}), root yield (t ha^{-1}) were collected and analysed. Results showed significant improvement in almost all studied parameters with the application of NPK and different organic manures. Highest mean data for all the parameters studied were recorded in NPK + PM, as maximum leaves' count (21.67 and 22.33 plant^{-1}), leaf length (32.20 and 38.33 cm), leaves weight (66.00 and 63.67 g plant^{-1}), root length (29.87 and 29.37 cm), root diameter (4.01 and 3.83 cm), root weight (285.00 and 274.00 g plant^{-1}), total biomass (351.00 and 337.67 g plant^{-1}) and root yield (80.42 and 77.80 t ha^{-1}) were produced in it both the years, respectively. It was trailed by NPK + GM and NPK + SS amongst all the other treatments used.

Poonkodi *et al*. (2019) conducted a field experiment to study the effect of inorganic fertilizers and organic manures on the growth and yield of Radish (*Raphanus sativus* L.). Inorganic fertilizers, organic manures *viz*., farm yard manure, poultry manure, goat manure were applied in different combinations. The results of the experiment revealed that the combined application of 75% RDF + goat manure @ 2.5 t ha^{-1} + poultry manure @ 2.5 t ha^{-1} (T_7) recorded the maximum leaf length, leaf breadth, number of leaves plant $^{-1}$ and yield of radish.

Dongarwar *et al*. (2018) carried out a study to investigate growth, yield and qualitative parameters of various radish varieties. Seven varieties of radish, used for the study as treatments were *viz*., PusaDesi, PusaHimani, PusaReshmi, Pusa Chetaki, ArkaNishant, Japanese White, IHR-1-1. The growth parameters like plant height was maximum at 28.29 cm in Arka Nishant, while it was minimum at 22.70 cm in PusaHimani, also the chlorophyll content of leaves was 3.10 mg g^{-1} recorded in ArkaNishant. However, the minimum leaf area was 85.04 cm^2 recorded in Pusa Himani and minimum chlorophyll content of leaves was 1.61 mg g^{-1} in variety Pusa Desi. The substantial variations in weight of total fresh weight of plant (190.06 g to 226.60 g) were observed. It was maximum in variety ArkaNishant, whereas, minimum in variety PusaDesi. The values of root diameter were minimum in IHR-1-1 (2.60 cm) and maximum (3.69 cm) in variety ArkaNishant. The maximum root yield per plot was 32.34 kg plot-^{1} produced in variety ArkaNishant.

Mani and Anburani (2018) revealed that application of farm yard manure @ 25 t/ha along with consortium biofertilizer @ 2 kg/ha and EMI (Effective microbial innoculants) @ 1:1000 dilution per hectare as foliar application to radish resulted in highest growth parameters viz., shoot length, number of leaves and shoot weight. The physiological parameters viz., leaf area and chlorophyll content were recorded maximum in the same treatment.

Naik and Sreedhar (2018) conducted an experiment in radish cv. Pusa Himani, consisting of 15 treatment combinations, replicated thrice. The results revealed that, significantly taller plant (28.55 cm), higher leaf count per plant (19.02), leaf area (106.74 cm^2), longer root (34.07 cm), root diameter (16.44 cm) and maximum yield (52.46 t ha^{-1}) were recorded with the application of Azospirillum (5 kg ha^{-1}) + PSB (7.5 kg ha^{-1}) + VAM (12.5 kg h^{a-}) + 50% NPK (T_{14}).

A field experiment was conducted by Kumar *et al*. (2018) to study the effect of organic and inorganic sources of nutrients on growth and yield attributing chatacters of mustard (*Brassica juncea* L.) variety Pusa Mustard 30 (LES-43). The experimental results revealed that maximum growth parameters (plant height, branches per plant, dry matter accumulation and leaf area index), yield attributes (siliqua length, siliquae per plant, seeds per siliqua and test weight) and grain yield were recorded with application of 50 percent RDF+ FYM @ 6 t/ha + Vermicompost @ 2 t/ha + biofertilizer.

Rajwade and Bahadur (2018) conducted a study on effect of organic manures and inorganic fertilizer on growth attributes of Radish (*Raphanus sativus* L.). The significantly more plant height (64.34 cm) at 45 days after sowing was observed in treatment combination of 50 percent recommended dose of nutrients + 50 percent primary manure. The maximum number of leaves per plant, highest shoot weight and maximum leaf length at 45 days after sowing was recorded in this treatment.

Mali *et al*. (2018) conducted a study on effect of organic manures and bio-fertilizers on growth and yield of radish (*Raphanus sativus* L.) cv. Japanese White. The application of Phosphate Solubilizer Bacteria @ 4 kg/ha + vermicompost @ 5 t/ha resulted in maximum values of growth and yield parameters viz., plant height, number of leaves per plant, root length, root diameter, root weight and yield per plot.

Jaisankar (2018) studied the effect of integrated nutrient management on growth and yield of radish (*Raphanus sativus* L.) cv. Pusa Chetki and found that the application of vermicompost @ 12.5 t/ha + Azospirillum @ 5 kg/ha + humic acid @ 0.2 percent per hectare resulted in maximum values of growth and yield attributes viz., days taken for germination (3.12), shoot length (43.5 cm), number of leaves per plant (14.68), shoot weight (56.23 g), root length (15.63 cm), root girth (3.11 cm), root weight (161.59 g) and root yield per plot (4.09 kg) and this treatment was recommended to get higher yields in radish.

Singh *et al*. (2018) conducted a study to investigate the effect of INM on mustard crop and concluded that integrated use of 100 percent RDF along with organic sources of nutrients resulted in significantly higher number of branches per plant, siliquae per branch, seeds per siliqua and seed yield of mustard as compared to application of 100 percent RDF (NPK) alone.

Yadav *et al*. (2018) conducted an experiment to study the effect of integrated nutrient management on growth and yield in mustard [*Brassica juncea* (L.) Czern & Cosson]. Results found that significantly better growth attributes (plant height and dry weight), yield attributes (number of silique per plant and length of siliqua) and yield was obtained with combined application of RDN 50 percent + 25 percent FYM + 25 percent vermicompost + 30 kg S + Azotobacter over rest of the treatments.

Kumar and Gupta (2018) evaluated the effects of vermicompost on growth and yield parameters of vegetable crop radish (*Raphanus sativus* L.). The plant height was found to be 50 cm in vermicompost, 41 cm in cow dung, 39 cm in urea and 17 cm in control treatment. Weight of the root was observed to be 152 g in vermicompost, 133 g in cow dung, 120 g in urea, and 49 g in control treatment. Finally it was observed that vermicompost was better in comparison to other nutrient sources.

Shah *et al*. (2018) recorded maximum radish plant height, leaves/plant, root length, diameter and yield per hectare with the combined application of NPK 50% along with poultry manure. Highest values for the parameters regarding radish growth and production were recorded when vermicompost (12.5 t/ha) + Azospirllum (5 kg ha) + Humic acid (0.2% ha) were used (Jaisankar, 2018).

Pathak *et al*. (2018) conducted an experiment entitled 'Performance of organic manures, inorganic fertilizer and biofertilizer of yield and quality of radish'. In all eight treatments were imposed. The result of present investigation indicated that the yield plot^{-1} as well as hectare^{-1} and the NPK content in leaves and roots of radish were found highest in treatment with either safe production (Recommended FYM @ 20t ha^{-1} + fertilizer @ 80:60:80 NPK kg ha^{-1} + PP with organic methods) + IIHR microbial consortium @ 12.5 kg ha^{-1} or conventional practices (Conventional practices (Recommended FYM @ 20 tha^{-1} + fertilizer @ 80:60:80 NPK kg ha^{-1} +PP chemicals+ IIHR microbial consortium @ 12.5 kg ha^{-1}) with application of 296.28 q ha^{-1}.

Singh *et al*. (2017) evaluated the influence of different time of transplanting and organic fertilizers on plant growth and seed yield parameters of radish (*Raphanus sativus* L.) and found that all growth and seed yield parameters like minimum days to 50 percent bolting and days to 50 percent flowering, maximum number of branches per plant and maximum number of pods per plant were recorded with treatment vermicompost @ 50 q/ha + Azotobacter @ 2.5 kg/ha (root dip) + PSB @ 2.5 kg/ha (root dip) + NSKE @ 5 percent and pod length, plant height, number of seeds per pod, seed yield per plant, seed yield per plot and seed yield per hectare was recorded maximum with treatment RDF + Malathion @ 0.05 percent in 4th November transplanting.

Singh *et al*. (2017) carried out an investigation during two consecutive years (2014-15 and 2015-16) at experimental farm of Department of Seed Science and Technology, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H. P.) to study the effect of different organic inputs and transplanting dates on seed quality parameters of radish. The study revealed that all the seed quality parameters like germination %, seedling length, shoot length, root length, seedling dry weight, seed vigour index I and seed vigour index II were found maximum with treatment Vermicompost + Azotobacter + PSB + NSKE and maximum 1000 seed weight was found with treatment FYM + Azotobacter + PSB+ NSKE in 4th November transplanting.

Kumar *et al*. (2017) conducted an experiment to study the influence of biofertilizer and farm yard manure on growth, yield and seed quality of mustard (*Brassica juncea* L.) cultivar Kranti. The results revealed that plant height, number of primary branches per

plant, number of secondary branches per plant, number of siliquae per plant, number of seed per siliqua, 1000 seed weight and higher seed yield were maximum with the application of 50 percent recommended dose of fertilizers along with farmyard manure and Azotobacter (seed treatment). Significantly higher germination percentage, root length, shoot length and seed vigour index was recorded with 50 percent recommended dose of fertilizers with farmyard manure and Azotobacter than over control.

Eric (2016) conducted a study on the growth and yield performance of radish (*Raphanus sativus* L.) cv. Snow White in response to varying levels of vermicast applications. Results revealed that treatment with 15 t/ha vermicast obtained the tallest plant (39.67 cm) and maximum number of leaves (14).

Mehwish *et al*. (2016) studied the impact of organic manures and inorganic fertilizers on growth and yield of radish (*Raphanus sativus* L.). The results revealed that all growth and yield parameters were significantly enhanced by the application of organic manures and NPK. The highest values were found in NPK treated plants followed by poultry manure, goat manure, sewage sludge, press mud and FYM (farm yard manure) respectively.

Kumar *et al*. (2016) carried out an experiment entitled studies on effect of inorganic fertilizers and bio-fertilizers on growth, yield and quality of radish (*Raphanus sativus* L.). The treatment combinations were control, recommended dose of fertilizers, Azotobacter, Azospirillum, PSB, 50 per cent RDF + 50 percent Azotobacter, 50 percent RDF + 50 per cent Azospirillum, 50 percent RDF + 50 percent PSB, 50 percent Azotobacter + 50 percent Azospirillum, 50 percent Azotobacter + 50 percent PSB, 25 percent PSB+25 percent Azospiriluum + 25 percent RDF+25 percent Azotobacter, 50 percent PSB + 50 percent Azospirillum. The observations were recorded i.e. plant height (cm), number of leaves, length of leaves (cm), length of root (cm), root diameters (cm), fresh weight of leaves (g), dry weight of leaves (g), root weight (q/ha) and yield (t/ha). From the analysis of data, it can be concluded that the application of 25 percent PSB + 25 percent Azospirillum + 25 percent RDF+ 25 percent Azotobacter showed the maximum plant height (37.21 cm), leaves plant^{-1} (l7.42) and length of leaves (l8.35 cm) at 60 DAS of radish.

Kiran *et al*. (2016) revealed that all the growth and production parameters were considerably enhanced by the application of organic manures and NPK. However,

maximum leaves/plant, tallest leaves, leaf weight, root length, diameter and yield was observed in NPK treated plots for carrot and radish (Kiran *et al*., 2016).

According to Khalid *et al*. (2015), application of integrated nutrient like inorganic (NPK @ 80:60:60 kg ha^{-1}), organic (FYM @ 20 t ha^{-1}) and biofertilizers (Azotobacter @ 5 kg ha^{-1}) + PSB (S kg ha^{-1}) recorded the maximum plant height (66.02 cm), number of leaves $plant^{-1}$ (13.47), length of leaves (41.39 cm) and maximum fresh weight of leaves (146.07 g) in radish.

Integrated application of both chicken manure and inorganic fertilizers (50% of RDF) recorded the highest values of most of plant growth characteristics of radish such as plant height (25.15cm), dry weight of leaves (2.89 g $plant^{-1}$), dry weight of root (2.68 g $plant^{-1}$) and chlorophyll content (18.85) (Zeid *et al*., 2015). Similarly, application of 20 t ha^{-1} compost and reduced level of chemical fertilizers as basal with top dressing gave highest mean value in all the parameters like canopy height (20.47cm), number of leaves (13.26) and leaf area (639.10 cm^2), fresh weight of leaves (45.54 g), dry weight of leaves (4.79 g) and leaf production (15.18 t ha^{-1}) in radish (Imthiyas *et al*., 2015).

Jadhav *et al*. (2014) studied the effect of different level of vermicompost on growth and yield of radish cv. local variety and revealed that the treatment (1.2 kg vermicompost + RDF + FYM) was significantly higher with respect to growth parameters. i.e. highest leaf length (37.5 cm), leaf weight (13.2 g) and total number of leaves $plot^{-1}$ (10.60).

Singh *et al*. (2014) carried out an experiment to evaluate the effect of integrated nutrient management on yield, quality and nutrient uptake by Indian mustard (*Brassica juncea* L.). The results revealed that integration of FYM, Azotobacter and sulphur with 100 percent recommended dose of NPK produced significantly higher grain yield of mustard. The yield parameters like number of branches per plant, number of siliquae per plant, number of seeds per siliqua, length of siliqua (cm) and 1000 seed weight (g) increased significantly by increasing fertility levels from 75 to 100 percent RDF and by the integration of FYM, Azotobacter and sulphur at each level of fertility.

Ghosh *et al*. (2014) concluded that, the highest shoot weight (257.94g) and leaf width (7.93 cm) was observed in radish cv. Tasakisan Mula-1, and was statistically on par with cv. Druti and the minimum was recorded with Red Bombay (246.30g).

Singh *et al*. (2014) conducted an experiment to study the performance of Indian mustard (*Brassica juncea* L.) in response to integrated nutrient management. The pooled analysis revealed that maximum seed yield was obtained with the use of higher doses of N fertilizer in combinations with bio fertilizers and FYM in both years. The yield attributes and seed yield increased significantly with the application of FYM (5.0 t/ha) over control.

Kumar *et al*. (2014) conducted a study on the efficacy of organic manures on growth and yield of radish. It was observed that plant height was significantly increased by the application of organic manures and also was maximum when applied in combination of vermicompost + poultry manure (50 % each). The study suggested that application of poultry manure (50 %) + vermicompost (50 %) was found more beneficial and significantly improved growth and yield of radish cv. Japanese White grown under Lucknow condition.

Kumar *et al*. (2013) conducted a study on the effect of integrated nutrient management practices on seed yield and yield contributing characters in radish (*Raphanus sativus* L.) cv. Chinese Pink. The study revealed that the maximum seed yield, pod length, number of seeds per pod and average seed weight per pod was recorded with the application of vermicompost (40 q/ha) + biovita (2 ml/l) + 75 percent recommended dose of NPK.

Shukla *et al*. (2012) assessed the fifteen treatment combinations comprising of inorganic (N, P and K) and bio-fertilizers (Azospirillum, phosphorus solubilizing bacteria and vesicular arbuscular mycorrhizae). It was noticed that combined maximum values for most of the characters like seed yield, 1000-seed weight and seedling vigour index of radish were recorded with the application of Azospirillum + recommended NPK. This treatment also recorded maximum seed yield i.e. 10.2 q per ha.

Tripathi *et al*. (2011) conducted a field experiment to study the effect of integrated nutrient management (INM) on growth, yield and quality of Indian mustard cultivar Kranti and found that application of 100 percent recommended dose of fertilizers along with farmyard manure, sulphur, zinc, boron and Azotobacter (seed treatment) resulted in maximum plant height, dry matter accumulation, total branches plant per plant, siliquae per plant, seeds per siliqua, 1000 seed weight and higher seed yield.

Subramani *et al*. (2010) conducted an experiment to study the effect of organic nutrients and bio-stimulants on growth and yield parameters in radish cv. Pusa chetki and reported that the growth parameters such as number of leaves and leaf area were resulted the highest value due to application of FYM @ 25 t ha^{-1} plus consortium of bio-fertilizers @ 2 kg ha^{-1} combine with EM (effective microorganism) @ 1=1000 litre ha^{-1} and MMT (Mixed microbial technology) @ 3% for both seasons.

Lamo (2009) investigated the effect of organic and biofertilizers on seed production of radish (*Raphanus sativus* L.) cv. Chinese Pink. The observations were recorded on survival percentage, number of primary branches, days to 50 percent bolting and flowering, pod length, number of seeds per pod, seed yield per plant and plot, 1000 seed weight, seed germination and vigour index. The results showed that among organic manures vermicompost was found comparatively better for all the traits.

Nitrogen significantly influences number of leaves and leaf area index but not dry matter content of leaves. Increasing rates of K significantly increased yield, where all N treatments increased yield.

According to Asghar *et at.* (2006) application of compost + 75% recommended N (45 kg ha^{-1}) recorded highest number of leaves (11.79) and leaf area (235.82 cm^2) in radish.

Bio-fertilizer in combination with organic manures found as effective component in organic farming for reliable and cheap supply of nutrients. Application of Bio-fertilizer such as nitrogen fixing bacteria has led to a decrease in the use of chemical fertilizers and has provided high quality products free of harmful agrochemicals for human safety (Sharaf Eldin, 2007;Salem and Awad, 2005). Biofertilizer increases plant height by enhancing the nitrogen content and the rate of photosynthesis (Migahed *et al*., 2004).

Enhancement of plant growth and yield attributing characters may also be desscribed due to the influence of nitrogen, the chief component of protein, essential for the formation of protoplasm, which leads to cell division and cell enlargement (Bakly, 1974). The problem of high cost of chemical fertilizers fully meet out nutrient requirement of crop by single

source, therefore, Integrated Plant Nutrient System (IPNS) such as organic matters like farmyard manure, vermicompost, poultry manure and bio-fertilizer uses has become necessary.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from November, 2019 to April, 2020 to investigate on the effect of bio-fertilizer mixed nutrient sources on growth, seed yield and quality of radish varieties. This chapter includes a brief description of the experimental period, location, soil and climatic condition of the experimental area and materials that were used for conducting the experiment such as treatment and design of the experiment, growing of crops, intercultural operations, data collection procedure and procedure of data analysis that were used for conducting the experiment.

1. Experimental site

The research was conducted at the Central Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. The experiment was carried out during rabi season. The location of the experimental site is situated at 90° 22' E longitude and 23° 41' N latitude. The altitude of 8.6 meters above the sea level.

2. Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Farmgate, Dhaka and the results showed that the soil composed of 27% sand, 43% silt and 30% clay. The soil was having a texture of sandy loam with pH and organic matter 5.47 – 5.63 and 0.83%, respectively.

3. Climatic condition of the experimental site

The experimental area was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). During the experimental period the maximum temperature (29.85^0C), highest relative humidity (70.63 %) and highest rainfall (09 mm). Highest rainfall (09 mm) was recorded

in the month of February, 2019, whereas the minimum temperature (13.82^{0}C), minimum relative humidity (62.04%) and no rainfall was recorded for other three months. The climatic conditions during the period of experiment was collected from the Bangladesh Meteorological Department, Agargaon, Dhaka.

4. Agro-ecological region

The experimental field belongs to the agro-ecological region of the Madhupur Tract (AEZ-28). The landscape comprises level upland, closely or broadly dissected terraces associated with either shallow or broad, deep valleys.

5. Experimental details:

5.1 Planting materials

The seeds of BARI mula-1, BARI mula-2 and BARI mula-4 were collected from the Bangladesh Agricultural Research Institute, Gazipur, Dhaka.

5.2 Design and layout of the experiment

The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications where the experimental area was divided into three equal blocks representing the replications to minimize the soil heterogeneous effects. There were total 36 unit plots in the experiment. The size of the each plot was 1.20 m × 1.8 m. The distance maintained between two blocks and two plots were 50 cm. Both the row to row and plant to plant distances were 30cm and 30cm, respectively.

5.3 Experimental treatments

Treatments: This experiment will be conducted with two factors

Factor-A (Varieties)

V_1- BARI mula-1

V_2- BARI mula-2

V_3- BARI mula-4

Factor-B: (Nutrients in absence or presence of bio-fertilizer)

N_0- NPKS (standard dose) + without bio-fertilizer

N_1- NPKS (standard dose) + Bio-fertilizer

N_2- 50% CD+ 50% Vermicompost

N_3- 50% CD + 50% Vermicompost + Bio-fertilizer

There are 12 treatment combinations such as V_1N_0, V_1N_1, V_1N_2, V_1N_3, V_2N_0, V_2N_1, V_2N_2, V_2N_3, V_3N_0, V_3N_1, V_3N_2, and V_3N_3

6. Seed soaking and seed treatment

Radish seeds were soaked into water for 12 hours and then wrapped with a piece of thin cloth prior to sowing. Then they were spread over polythene sheet in sun for two hours to dry. The seeds were treated with Bavistin 50DF@3g/100g seed

7. Land preparation

The selected land for the experiment was first opened on 05 Novermer, 2019 by disc plough and it was exposed to sun for seven days prior to next ploughing. The land was ploughed six times by tractor to obtain good tilth. Laddering to break the soil clods and pieces was followed with each ploughing. All weeds and stubbles were removed and the land was finally prepared through addition of the basal doses of manure and fertilizers. Plots were prepared according to design and layout. Finally soil of each plot was treated by Sevin 80 WP @ 2kg/ha to protect the young plant from the attack of mole cricket, cutworm and ants, Irrigation channels were made around each block.

8. Application of manures & fertilizers

BARI recommended the following doses of manures and fertilizer:

Fertilizer/compost	**Dose /hectare**
1. Manure/compost	10-15 t
2. Urea	300 kg
3. TSP	200 kg
4. MP	200 kg
5. Gypsum	50 kg
8. Bio-fertilizer	4kg

The entire amount of compost, TSP, gypsum, bio-fertilizer and half of the Urea and MP were applied during final land preparation while rest of the urea and MP are applied in two equal installments. The first top-dressing was given at root formation stage (2 weeks after sowing) and the second at flowering stage.

According to Fertilizer recommendation Guide 2016, standard manure and fertilizer doses as follows:

Name of fertilizer and manure	Doses ha^{-1}	Nutrients			
		N (kg)	P (kg)	K (kg)	S (kg)
Cow dung	10 t	56	48	70	-
Vermicompost (50%)	3.2 t	96	64	64	-
Bio-fertilizer	4kg	-	-	-	-
Urea	300 kg	138	-	-	-
TSP	200 kg	-	95	-	-
MoP	200 kg	-	-	80	-
Gypsum	50 kg	-	-	-	18

The manures and fertilizers were applied as basal dose at final land preparation but urea was applied in three equal installments. All manures and fertilizers were applied by broadcasting and mixed thoroughly with soil.

The nutrient composition of cowdung, vermicompost and spent mushroom compost were as follows:

Manure	N (%)	P (%)	K (%)
Cowdung	0.57	0.47	0.69
Vermicompost	3.00	2.00	2.00

9. Seed rate and seed sowing

Seeds were used at the rate of 3 Kg/ha as narrated by Rashid (1993), consequently 60 g of seeds were used for the experimental area. Seeds were sown on 15 November. The seeds were sown at a distance of 30cm × 30 cm by making a shallow furrow at a depth 1.5 cm in each plot.

10. Intercultural operations

When the plants establishing in the plots they were always kept under careful observation. Various intercultural operations were accomplished for better growth and development of germinated plants.

10.1 Thinning

Emergence of seedlings started about seven days after sowing. Different number of plants per plot was found due to different sowing. Thinning was done at two stages like 15 and 30 days after sowing in order to keep a healthy plant in each hill.

10.2 Weeding

Weeding was done at two times. First weeding was done after 15 days of sowing when seedlings were thinned. Second weeding was done after 30 days of sowing.

10.3 Earthing up

After application of urea earthing up was done at different times.

10.4 **Rouging:**

Roughing was done in all growth stages like vegetative stage, flowering stage, stock formation stage and pod formation stage.

11. Plant protection

11.1 Insects and pest management

The crop was infested with cut warm (*Agrostis ipsilon*), mole cricket, field cricket during the early stage of growth of seedlings. These insects were controlled initially by beating and hooking, afterwards by spraying Dieldrin 20 EC at the contrition of 0.1%.

11.2 Disease management

Precautionary measure against Fusarium rot was taken by spraying Dithane M-45 @ 2g/litre water.

12. Harvesting

Harvesting of radish seed at proper stage of maturity is essential to fetch good price in the market. Delay in harvesting deteriorates the quality of the seeds and deteriorate for germination. Radish seed is ready to harvest when about 60 to 70% of the seed pods turn from green yellow to brown and lose their fleshy appearance, becoming papery thin and light. Plants are first cut above the ground by hand with a sickle. After harvesting the entire plants were placed it in a brown bag for avoid shattering. Hang the bag with the

plant seed dangling down into it and allow the seeds to mature naturally. Once they are completely mature, the pods are pop and the seeds drop into the bag. Threshing was done on a clear day. The dried pods were crushed by hand to separate the seeds. After thorough drying of seed, it was placed in partial sun (up to 7% moisture content). Seeds were separated from chaff or broken twigs either by winnowing and cleaned and stored.

13. Data collection procedure

Ten plants per plot were sampled in the middle rows and marked by bamboo stick for collection of per plant data while the crop of whole plot was harvested to record per plot data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random sampling to avoid the border effect.

13.1 Number of leaves per plant

Numbers of leaves were counted at 40 days after sowing. Ten plants in each plot were used to count number of leaves per plant and the average number was calculated.

13.2 Leaf length (cm)

Leaf length was measured from ten randomly selected plants with the help of a meter scale at 40 days after sowing and mean was calculated.

13.3 Leaf breadth (cm)

Leaf breadth was measured from ten randomly selected plants with the help of a meter scale at 40 days after sowing and mean was calculated.

13.4 Days to inflorescence initiation

Inflorescence data were taken to compute flowering

1st initiation of inflorescence: The time interval between the date after emergence and date on which opening of the first inflorescence appeared in each plant and total was recorded.

80% initiation of inflorescence: The time interval between the date after emergence and date on which 80% of the plants appeared inflorescence and mean was counted.

13.5. Inflorescence length (cm)

After final harvest, inflorescence length was measured from ten randomly selected plants with the help of a meter scale and mean was calculated.

13.6. Branches of inflorescence

After final harvest, average branches of inflorescence was counted from ten randomly selected plants and means were calculated.

13.7. Days to harvest

Days required to harvest of inflorescence were determined from the time of date after emergence to the maturity of 80-90% siliqua of each inflorescence.

13.8. Number of siliqua per inflorescence

Number of siliqua per inflorescence from ten randomly selected plants were counted and their mean values were calculated.

13.9. Siliqua length (cm)

Ten dry siliqua from selected plants were counted at random. Length of dry siliqua of the selected plants was measured and their mean value was calculated.

13.10. Number of seeds/siliqua

Numbers of seeds per dry siliqua were recorded from ten randomly selected dry siliqua and the mean value was calculated.

13.11. 1000 seed wt. (g)

After harvest, 1000 seeds were counted separately from each treatment. These were then sun dried up to 7-8 % moisture and then weighted.

13.12. Seed yield per plant (g)

The mature inflorescence were harvested at regular interval from each unit plot. After harvesting the mature inflorescence were placed in open area for sun drying. The total seed weight per plant was recorded after threshing and expressed in gram (g).

13.13. Seed yield per plot (g)

As harvesting was done at different interval and the total seed weights were recorded in each unit plot and expressed in gram (g).

13.14. Seed yield per hectare (t)

All the dry pods from this harvested area were collected, sun dried up to 7-8 % moisture level and weighed. The average seed yield (t/ha) was calculated from seed yield (g/ plot) basis.

13.15. Germination (%)

The germination test was conducted using petridish method. Two pieces of blotting papers (soaked with distilled water) were used in each petridish as substrate. Twenty seeds for each variety were placed in each petridish at an equal distance from one another. Each treatment was replicated three times. The petridishes were observed every day and water solutions were supplied whenever required. The petridishes were observed every day and the numbers of germinated seeds were recorded. Germination (%) test was monitored by ISTA (International Seed Testing Agency) rules (1976).

The germination percentage was calculated using the following formula-

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated} \times 100}{\text{Total no. of seeds placed in petridish}}$$

13.16. Germination energy (%)

Germination energy = Percentage of seeds germinated at 72 h (Bam *et al.,* 2006).

13.17. Germination capacity (%)

Germination capacity = Percentage of seeds germinated at 168 h (Bam *et al.,* 2006).

13.18. Speed of germination (%)

The rate/speed of germination was calculated using the following formula ((Maigure, 1962).

$$\text{Speed of germination (\%)} = \frac{\text{Percentage of seeds germinated at 72 h}}{\text{Percentage of seeds germinated at 168 h}} \times 100$$

CHAPTER IV
RESULT AND DISCUSSION

The experiment was carried out to find the influence of varieties and nutrients on seed yield and quality of radish. For quality seed production of radish, varieties and nutrients are the major yield contributing factor. The effect of different variety and nutrient with their interaction on growth and yield contributing characters also seed germination, germination energy, germination capacity, speed of germination and others have been presented and discussed in this chapter under the following heads.

4.1 Number of leaves per plant:

There was significant difference in the number of leaves per plant among the different varieties of radish (Table.1). At 40 DAS, the maximum number of leaves (12.17) was produced from V_3 (BARI mula-4) treatment and the minimum number of leaves per plant (8.14) was obtained from V_2 (BARI mula-2) treatment.

A significant variation was found incase of number of leaves per plant due to the effect of nutrients (Table.1). At 40 DAS, the maximum number of leaves (11.83) was produced from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and the minimum number of leaves per plant (9.60) was obtained from N_2 (50% CD+ 50% Vermicompost) treatment.

Combined effect of varieties and nutrients on number of leaves per plant was found statistically significant (Table.4). At 40 DAS, the maximum number of leaves per plant (13.73) was produced from V_3N_1 (BARI mula-4 with standard dose of NPKS + Bio-fertilizer) treatment combination and the minimum number of leaves per plant (7.03) was produced from V_2N_2 (BARI mula-2 with 50% CD+ 50% Vermicompost) treatment combination, which was statistically similar to V_2N_3 treatment combination.

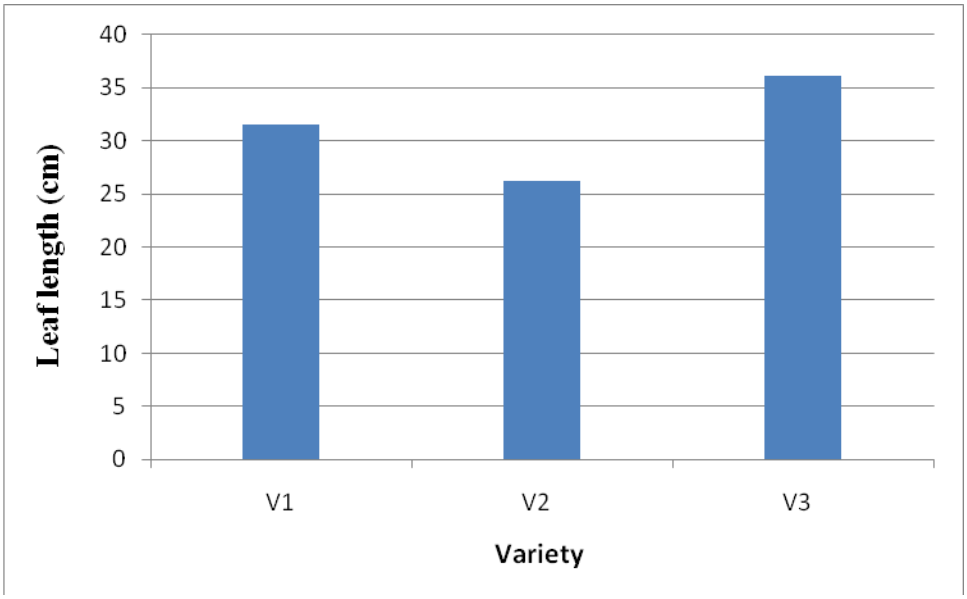
4.2 Leaf length:

A significant variation was observed on leaf length per plant among the different varieties of radish (Fig. 1). The highest leaf length per plant (36.18 cm) was obtained from V_3 (BARI mula-4) treatment and lowest leaf length (26.24 cm) was obtained from V_2 (BARI mula-2) treatment.

Leaf length exhibited a significant variation with nutrients (Fig.2). The highest leaf length per plant (35.16 cm) was obtained from N_1 (Standard dose of NPKS + Bio-fertilizer)

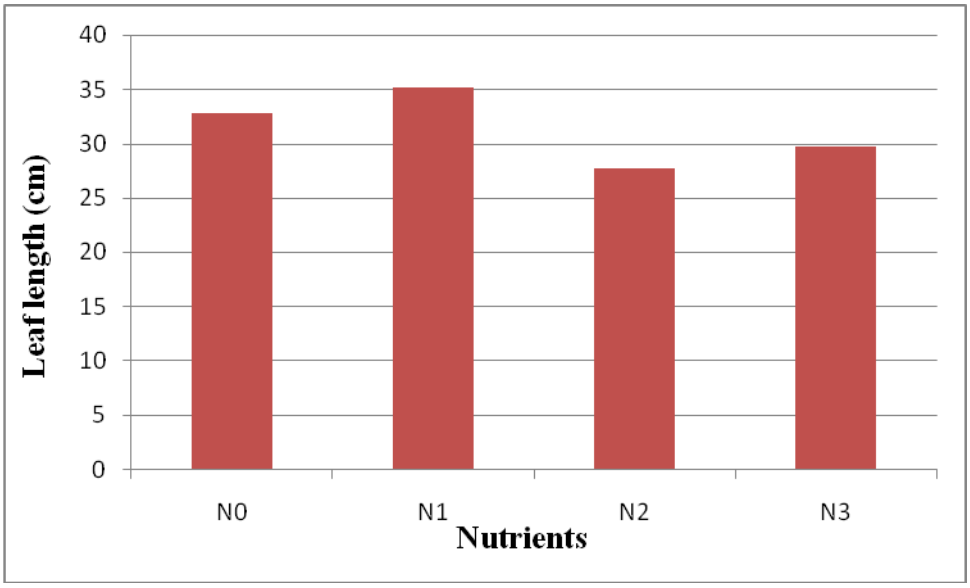
treatment and lowest leaf length (27.70 cm) was obtained from N_2 (50% CD+ 50% Vermicompost) treatment.

Combined effect of varieties and nutrients on leaf length per plant was found statistically significant (Table.4). At 40 DAS, the highest leaf length per plant (39.91cm) was obtained from V_3N_1 (BARI mula-4 with Standard dose of NPKS + Bio-fertilizer) treatment combination and the lowest leaf length per plant (22.83 cm) was produced from V_2N_3 (BARI mula-2 with 50% CD + 50% Vermicompost + Bio-fertilizer) treatment combination, which was statistically similar to V_2N_2 treatment combination.



(Where, V_1= BARI mula-1, V_2= BARI mula-2, V_3= BARI mula-4)

Fig 1. Performance of variety on leaf length of radish



(Where, N_o= NPKS (standard dose) + without bio-fertilizer, N_1= NPKS (standard dose) + Bio-fertilizer, N_2=50% CD+ 50% Vermicompost , N_3= 50% CD + 50% Vermicompost + Bio- fertilizer) at 5% LSD

Fig 2. Effect of nutrients on leaf length of radish

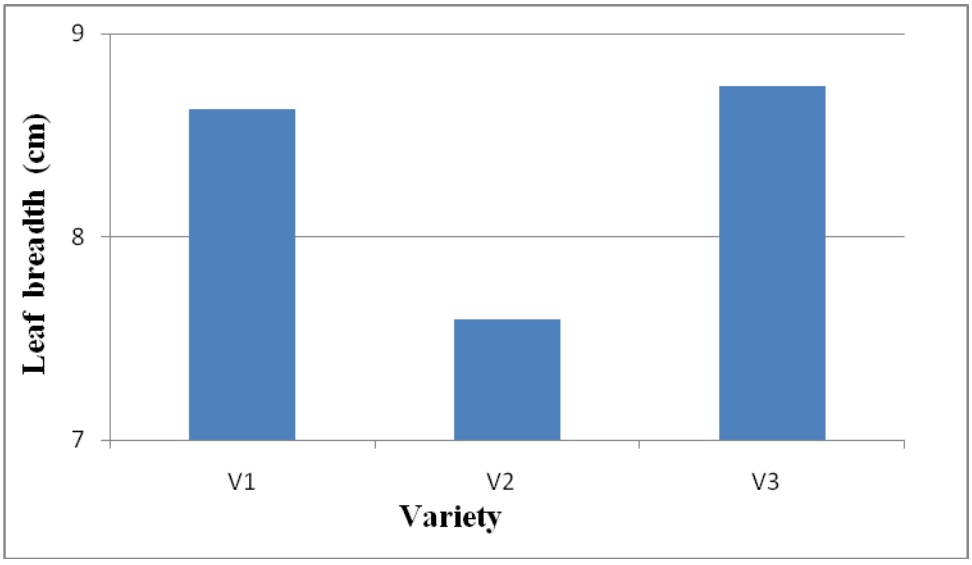
4.3 Leaf breadth:

Varieties showed a significant variation in leaf breadth (Fig.3). At 40 DAS, the maximum leaf breadth (8.74 cm) was recorded from V_3 (BARI mula-4) treatment, which was statistically identical to V_1 (BARI mula-1) treatment. On the other hand, minimum leaf breadth (7.59 cm) was recorded from V_2 (BARI mula-2) treatment.

Variation on leaf breadth differed significantly among different nutrients of radish (Fig.4). Maximum leaf breadth (8.85 cm) was recorded from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment, which was statistically identical to N_0 (NPKS (standard dose) + without bio-fertilizer) treatment. On the other hand, minimum leaf breadth (7.69 cm) was recorded from N_2 (50% CD+ 50% Vermicompost) treatment.

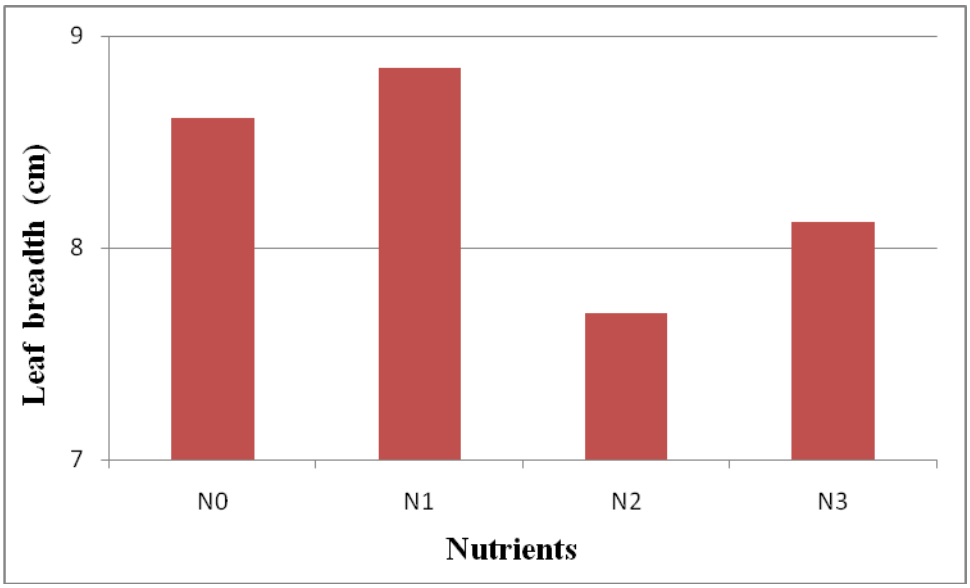
Combined effect of varieties and nutrients on leaf breadth per plant was found statistically significant (Table.4). At 40 DAS, the highest leaf breadth per plant (9.87 cm) was obtained from V_3N_1 (BARI mula-4 with Standard dose of NPKS + Bio-fertilizer) treatment combination and the lowest leaf breadth per plant (7.08 cm) was produced from V_2N_2

(BARI mula-2 with 50% CD+ 50% Vermicompost) treatment combination, which was statistically similar to V_2N_3 treatment combination.



(Where, V_1= BARI mula-1, V_2= BARI mula-2, V_3= BARI mula-4) at 5% LSD

Fig 3. Performance of variety on leaf breadth of radish



(Where, N_o= NPKS (standard dose) + without bio-fertilizer, N_1= NPKS (standard dose) + Bio-fertilizer, N_2=50% CD+ 50% Vermicompost , N_3= 50% CD + 50% Vermicompost + Bio- fertilizer) at 5% LSD

Fig 4. Effect of nutrients on leaf breadth of radish

4.4 Days required to 1st inflorescence initiation:

Days required to 1st inflorescence initiation were showed statistically significant variation due to different varieties (Table.1). The longest period (63.42 days) was required for 1st inflorescence initiation from V_2(BARI mula-2) treatment and the shortest period (48.50 days) was required for 1st inflorescence initiation from V_3(BARI mula-4) treatment.

Days required to 1st inflorescence initiation were showed statistically significant variation due to different nutrients (Table.1). The longest period (59.22 days) was required for 1st inflorescence initiation from N_3(50% CD + 50% Vermicompost + Bio-fertilizer) treatment and the shortest period (49.89 days) was required for 1st inflorescence initiation from N_0(NPKS (standard dose) + without bio-fertilizer) treatment.

Days required to 1st inflorescence initiation was showed statistically significant variation due to the combined effect of varieties and nutrients (Table.4). The longest period (66.33 days) was required for 1st inflorescence initiation from V_2N_3(BARI mula-2 with 50% CD + 50% Vermicompost + Bio-fertilizer) treatment combination, which was statistically similar to V_2N_2 treatment combination and the shortest period (42.33 days) was required for 1st inflorescence initiation fromV_3 N_1(BARI mula-4 with standard dose of NPKS + Bio-fertilizer) treatment combination.

Table 1. Performance of different variety and nutrients on number of leaves per plant, days to inflorescence initiation, days to inflorescence harvest and number of siliqua per inflorescence of radish

Treatments	Number of leaves/plant	Days to inflorescence initiation		Days to inflorescence harvest	Number of siliqua/ inflorescence
		1st	80%		
Different variety					
V_1	11.55 b	52.25 b	71.25 b	123.67 b	128.50 b
V_2	8.14 c	63.42 a	84.25 a	120.08 c	67.50 c
V_3	12.17 a	48.50 c	69.00 c	126.75 a	132.42 a
LSD(0.05)	0.4872	1.1168	1.1345	1.8744	2.8576
CV%	5.42	2.41	1.79	1.79	3.08
Nutrients					
N_0	10.70 b	52.44 c	73.67 c	124.44 b	119.56 b
N_1	11.83 a	49.89 d	71.89 d	127.56 a	125.67 a
N_2	9.60 c	57.33 b	75.78 b	118.11 c	93.11 d
N_3	10.34 b	59.22 a	78.00 a	123.89 b	99.56 c
LSD(0.05)	0.5626	1.2895	1.3100	2.1644	3.2996
CV%	5.42	2.41	1.79	1.79	3.08

4.5 Days required to 80% inflorescence initiation:

Days required to 80% inflorescence initiation were showed statistically significant variation due to different varieties (Table.1). The longest period (84.25 days) was required for 80% inflorescence initiation from V_2 (BARI mula-2) treatment and the shortest period (69.0 days) was required for 80% inflorescence initiation from V_3 (BARI mula-4) treatment.

Days required to 80% inflorescence initiation were showed statistically significant variation due to different nutrients (Table.1). The longest period (78.00 days) was required for 80% inflorescence initiation from N_3 (50% CD + 50% Vermicompost + Bio-fertilizer) treatment and the shortest period (71.89 days) was required for 80% inflorescence initiation from N_0(NPKS (standard dose) + without bio-fertilizer) treatment.

Days required to 80% inflorescence initiation was showed statistically significant variation due to the combined effect of varieties and nutrients. The longest period (86.67 days) was required for 80% inflorescence initiation from V_2N_3(BARI mula-2 with 50% CD + 50% Vermicompost + Bio-fertilizer) treatment combination, which was statistically identical to V_2N_2 treatment combination and the shortest period (64.67 days) was required for 80%

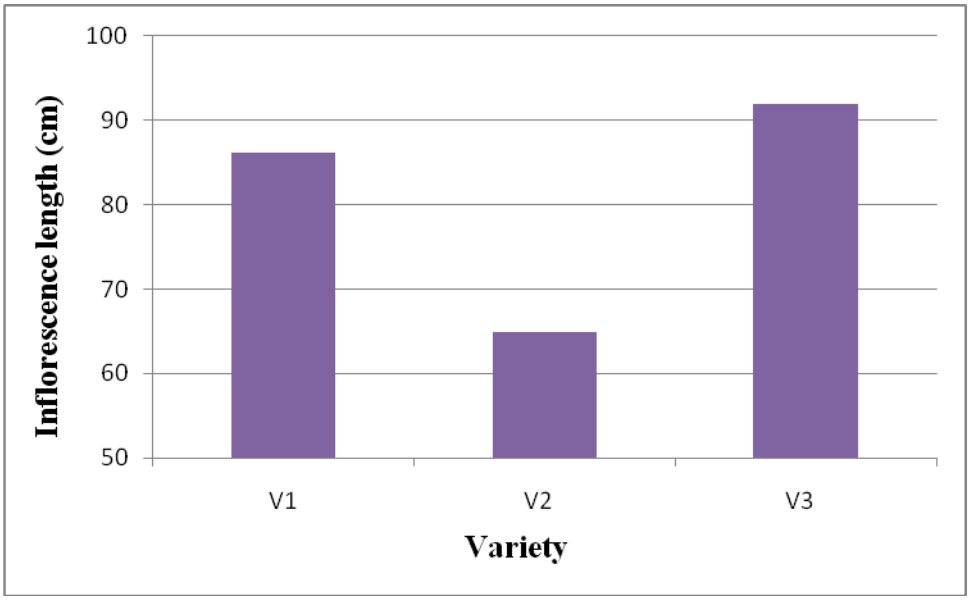
inflorescence initiation fromV_3 N_1(BARI mula-4 with standard dose of NPKS + Bio-fertilizer) treatment combination.

4.6 Inflorescence length:

Inflorescence length was significantly affected by the varieties (Fig.5). Maximum inflorescence length (91.92 cm) was found from V_3 (BARI mula-4) treatment and minimum inflorescence length (64.83 cm) was found from V_2 (BARI mula-2) treatment.

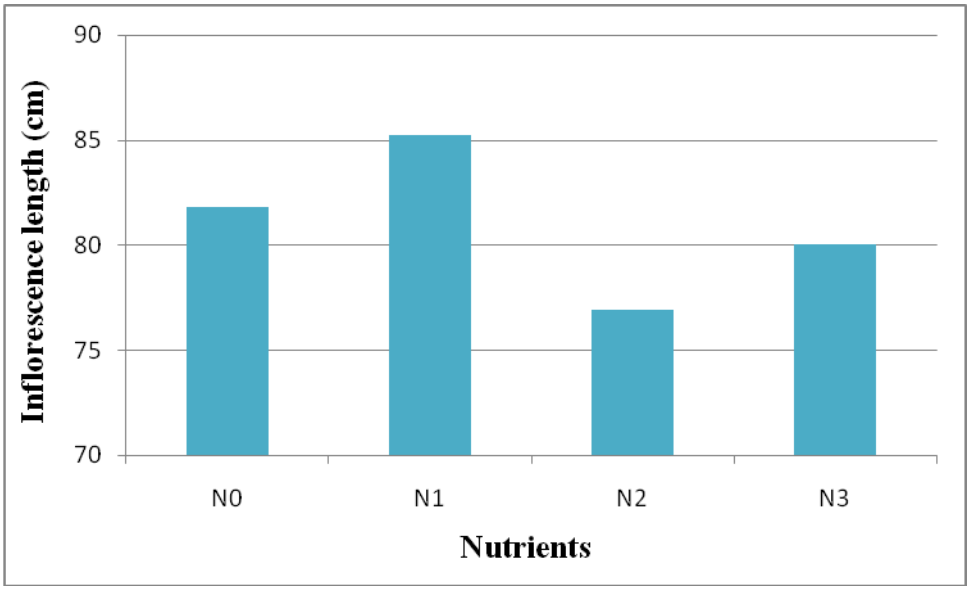
Inflorescence length of radish varied due to application of different nutrients (Fig.6). Maximum inflorescence length (85.22 cm) was found from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and minimum inflorescence length (76.89 cm) was found from N_2 (50% CD+ 50% Vermicompost) treatment.

Combined effect of varieties and nutrients on inflorescence length per plant of radish was found statistically significant (Table.5). At harvest, the highest inflorescence length per plant (98.0 cm) was obtained from V_3N_1 (BARI mula-4 with standard dose of NPKS + Bio-fertilizer) treatment combination and the lowest inflorescence length per plant (61.33 cm) was produced from V_2N_2 (BARI mula-2 with 50% CD+ 50% Vermicompost) treatment combination.



(Where, V_1= BARI mula-1, V_2= BARI mula-2, V_3= BARI mula-4) at 5% LSD

Fig. 5. Performance of variety on inflorescence length of radish



(Where, N_o= NPKS (standard dose) + without bio-fertilizer, N_1= NPKS (standard dose) + Bio-fertilizer, N_2=50% CD+ 50% Vermicompost , N_3= 50% CD + 50% Vermicompost + Bio- fertilizer) at 5% LSD

Fig. 6. Effect of nutrients on inflorescence length of radish

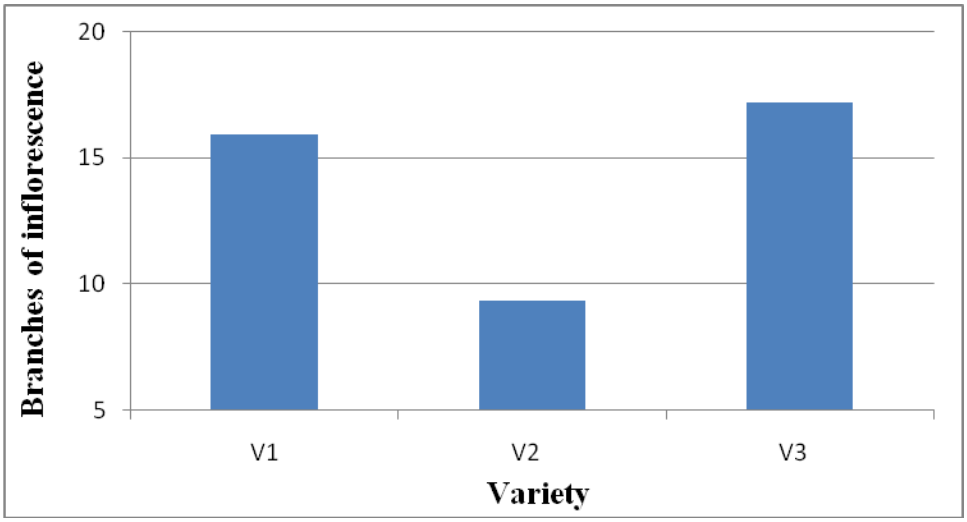
4.7 Number of branches per inflorescence:

Highly significant difference was observed among the varieties in respect of number of branches per inflorescence (Fig.7). Maximum number of branches per inflorescence (17.17) was observed from V_3 (BARI mula-4) treatment and minimum number of branches per inflorescence (9.33) was observed from V_2(BARI mula-2) treatment.

Number of branches per inflorescence varied apparently due to application different nutrients (Fig.8). Maximum number of branches per inflorescence 17.56 was observed from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and minimum number of branches per inflorescence 11.78 was observed from N_2(50% CD+ 50% Vermicompost) treatment.

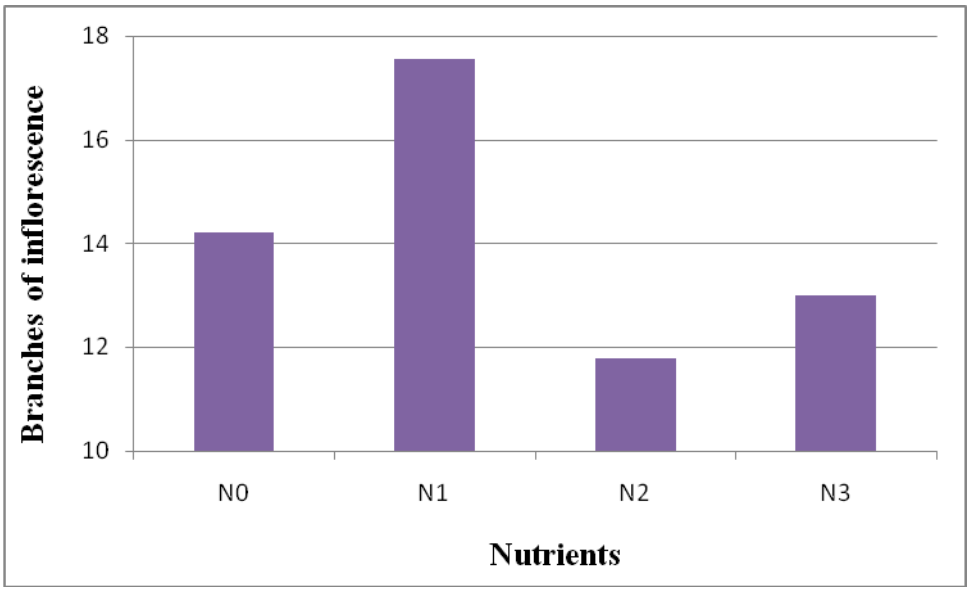
Combined effect of varieties and nutrients on number of branches per inflorescence was found statistically significant (Table.5). At harvest, the maximum number of branches per inflorescence (22.0) was obtained from V_3N_1 (BARI mula-4 with standard dose of NPKS + Bio-fertilizer) treatment combination and the minimum number of branches per inflorescence (7.33) was produced from V_2N_2 (BARI mula-2 with 50% CD+ 50%

Vermicompost) treatment combination, which was statistically similar to V_2N_3 treatment combination.



(Where, V_1= BARI mula-1, V_2= BARI mula-2, V_3= BARI mula-4) at 5% LSD

Fig. 7. Performance of variety on branches of inflorescence of radish



(Where, N_o= NPKS (standard dose) + without bio-fertilizer, N_1= NPKS (standard dose) + Bio-fertilizer, N_2=50% CD+ 50% Vermicompost , N_3= 50% CD + 50% Vermicompost + Bio- fertilizer) at 5% LSD

Fig.8. Effect of nutrients on branches of inflorescence of radish

4.8 Days required to harvest

Days required to inflorescence harvest were showed statistically significant variation due to the different varieties (Table.1). The longest (126.75 days) was required for harvest from V_3(BARI mula-4) treatment. On the other hand, the shortest (120.08 days) was required for harvest from V_2(BARI mula-2) treatment.

Days required to inflorescence harvest were showed statistically significant variation due to the different nutrients (Table.1). The longest period (127.56 days) was required for harvest from N_1(Standard dose of NPKS + Bio-fertilizer) treatment. On the other hand, the shortest period (118.11 days) was required for harvest from N_2(50% CD+ 50% Vermicompost) treatment.

Days required to inflorescence harvest was showed statistically significant variation due to the combined effect of varieties and nutrients (Table.5). The longest period (132.67 days) was required from V_3N_1(BARI mula-4 with standard dose of NPKS + Bio-fertilizer) treatment combination, which was statistically similar to V_3N_0 treatment combination and the shortest period (115.33 days) was required from V_2N_2 (BARI mula-2 with 50% CD+ 50% Vermicompost) treatment combination.

4.9 Number of siliqua per inflorescence

Highly significant difference was observed among the varieties in respect of number of siliqua per inflorescence (Table.1). Maximum number of siliqua per inflorescence (132.42) was observed from V_3 (BARI mula-4) treatment and minimum number of siliqua per inflorescence (67.50) was observed from V_2(BARI mula-2) treatment.

Number of siliqua per inflorescence varied apparently due to application different nutrients (Table.1). Maximum number of siliqua per inflorescence (125.67) was observed from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and minimum number of siliqua per inflorescence (93.11) was observed from N_2 (50% CD+ 50% Vermicompost) treatment.

Combined effect of varieties and nutrients on number of siliqua per inflorescence was found statistically significant (Table.5). At harvest, the maximum number of siliqua per per inflorescence (154.33) was obtained from V_3N_1 (BARI mula-4 with standard dose of

NPKS + Bio-fertilizer) treatment combination and the minimum number of siliqua per inflorescence (61.0) was produced from V_2N_2 (BARI mula-2 with 50% CD+ 50% Vermicompost) treatment combination, which was statistically similar to V_2N_3 treatment combination.

4.10 Siliqua length

Siliqua length was significantly influenced by varieties (Table.2). Result revealed that the maximum siliqua length (5.27 cm) was produced from V_3 (BARI mula-4) treatment and the minimum siliqua length (3.92 cm) was recorded from V_2(BARI mula-2) treatment.

Variation on siliqua length differed significantly among different nutrients of radish (Table.2). Maximum siliqua length (5.09 cm) was recorded from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment. On the other hand, minimum siliqua length (4.29 cm) was recorded from N_2 (50% CD+ 50% Vermicompost) treatment.

Combined effect of varieties and nutrients on siliqua length was found statistically significant (Table.5). At harvest, the maximum siliqua length (5.83 cm) was obtained from V_3N_1 (BARI mula-4 with standard dose of NPKS + Bio-fertilizer) treatment combination and the minimum siliqua length (3.50 cm) was produced from V_2N_2 (BARI mula-2 with 50% CD + 50% Vermicompost) treatment combination.

Table 2. Performance of different variety and nutrients on siliqua length, seeds number/siliqua,1000 seed wt, seed yield /plot, seed yield/ha of radish

Treatment	Siliqua length (cm)	No. of seeds/siliqua	1000 seed wt (g)	Seed yield/plot (g)	Seed Yield /ha (t)
Different variety					
V_1	5.00 b	6.58 a	11.36 b	273.96 b	1.27 b
V_2	3.92 c	3.62 b	8.82 c	163.98 c	0.76 c
V_3	5.27 a	6.40 a	12.01 a	298.44 a	1.38 a
LSD(0.05)	0.203	0.297	0.288	8.677	0.040
CV%	5.07	6.34	3.18	4.18	4.18
Nutrients					
N_0	4.81 b	5.64 b	11.16 b	257.04 b	1.19 b
N_1	5.09 a	6.20 a	11.61 a	286.32 a	1.33 a
N_2	4.29 c	4.97 c	9.69 d	208.56 d	0.97 d
N_3	4.734 b	5.33 b	10.45 c	229.92 c	1.06 c
LSD(0.05)	0.234	0.343	0.333	10.01	0.046
CV%	5.07	6.34	3.18	4.18	4.18

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance,
Where, V_1= BARI mula-1, V_2= BARI mula-2, V_3= BARI mula-4
N_o= NPKS (standard dose) + without bio-fertilizer, N_1= NPKS (standard dose) + Bio-fertilizer,
N_2=50% CD+ 50% Vermicompost , N_3= 50% CD + 50% Vermicompost + Bio- fertilizer

4.11 Number of seeds per siliqua:

Number of seeds per siliqua was differed significantly among the varieties (Table.2). Maximum number of seeds per siliqua (6.58) was observed from V_1 (BARI mula-1) treatment, which was statistically identical to V_3 (BARI mula-4) treatment and minimum number of seeds per siliqua (6.40) was obtained from V_2 (BARI mula-2) treatment.

Significant variation was recorded on number seeds per siliqua for different nutrients (Table.2). Maximum number of seeds per siliqua (6.20) was observed from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and minimum number of seeds per siliqua (4.97) was obtained from N_2 (50% CD+ 50% Vermicompost) treatment.

Combined effect of varieties and nutrients on number of seeds per siliqua was found statistically significant (Table.6). At harvest, the maximum number of seeds per siliqua (7.27) was obtained from V_3N_1 (BARI mula-4 with standard dose of NPKS + Bio-fertilizer)

treatment combination which was similar to V_3N_1 and the minimum number of seeds per siliqua (3.27) was produced from V_2N_2 (BARI mula-2 with 50% CD+ 50% Vermicompost) treatment combination, which was statistically similar to V_2N_3 treatment combination.

4.12 1000 seed weight

A significant variation was observed on 1000 seed weight among the different varieties of radish (Table.2). Maximum 1000 seed weight (12.01 g) was obtained from V_3 (BARI mula-4) treatment and minimum 1000 seed weight (8.82 g) was recorded from V_2 (BARI mula-2) treatment.

Highly significant difference was observed among the nutrients in respect of 1000 seed weight (Table.2) . Maximum 1000 seed weight (11.61 g) was obtained from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and minimum 1000 seed weight (9.69 g) was recorded from N_2 (50% CD+ 50% Vermicompost) treatment.

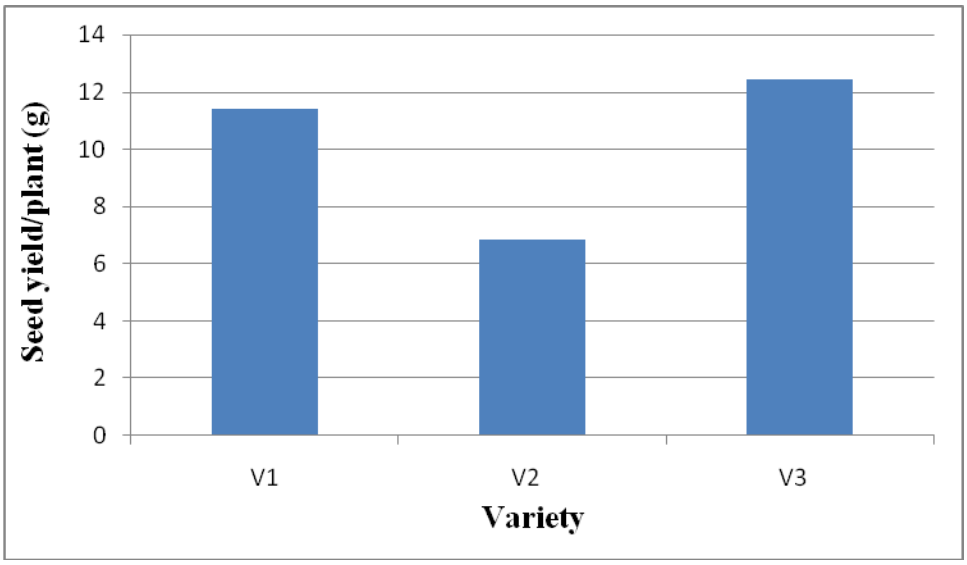
Combined effect of varieties and nutrients on 1000 seed weight was found statistically significant (Table.6). The maximum 1000 seed weight (13.19 g) was obtained from V_3N_1 (with Standard dose of NPKS + Bio-fertilizer) treatment combination and the minimum 1000 seed weight (7.98 g) was produced from V_2N_2 (with 50% CD+ 50% Vermicompost) treatment combination.

4.13 Seed yield per plant

Significant influenced was noted on seed weight per plant affected by varieties (Fig.9). The highest seed yield per plant (12.44 g) was obtained from V_3 (BARI mula-4) treatment and the lowest seed yield per plant (6.83 g) was recorded from V_2 (BARI mula-2) treatment.

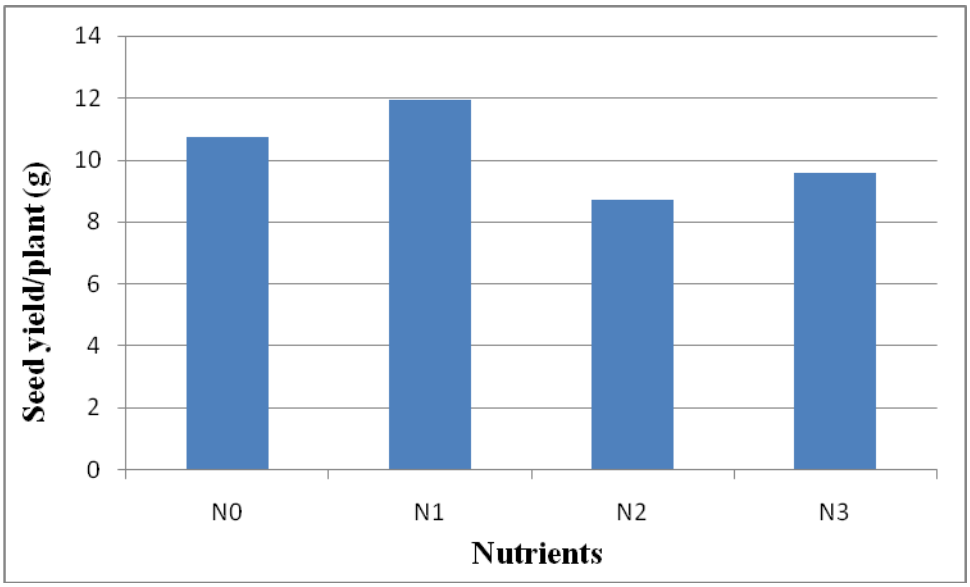
Significant variation was remarked on seed weight per plant as influenced by nutrients (Fig.10). The highest seed yield per plant (11.93 g) was obtained from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and the lowest seed yield per plant (8.69 g) was recorded from N_2 (50% CD+ 50% Vermicompost) treatment.

Significant variation was remarked as influenced by different varieties and nutrients combinations (Table.6). It was found that the highest seed yield per plant (14.31 g) was observed from the V_3N_1 treatment combination and the lowest seed yield per plant (5.67 g) was found from the V_2N_2 treatment combination.



(Where, V_1= BARI mula-1, V_2= BARI mula-2, V_3= BARI mula-4)

Fig. 9. Performance of variety on seed yield/plant of radish



(Where, N_o= NPKS (standard dose) + without bio-fertilizer, N_1= NPKS (standard dose) + Bio-fertilizer, N_2=50% CD+ 50% Vermicompost , N_3= 50% CD + 50% Vermicompost + Bio- fertilizer)

Fig.10. Effect of nutrients on seed yield/plant of radish

4.14 Seed yield per plot

Remarkable variation was identified on seed weight per plot due to the effect of varieties (Table.2). The highest seed yield per plot (298.44 g) was obtained from V_3 (BARI mula-4) treatment and the lowest seed yield per plot (163.98 g) was recorded from V_2 (BARI mula-2) treatment.

Remarkable variation was recorded on seed weight per plot due to the effect of nutrients (Table.2) . The highest seed yield per plot (286.32 g) was obtained from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and the lowest seed yield per plot 208.56 g was recorded from N_2 (50% CD+ 50% Vermicompost) treatment.

Remarkable variation was identified on seed weight per plot due to the effect of different varieties and nutrients combinations (Table.6). It was found that the highest seed yield per plot (343.44 g) was observed from the V_3N_1 (BARI mula-4with Standard dose of NPKS + Bio-fertilizer)treatment combination and the lowest seed yield per plot (136.08 g) was found from the V_2N_2 treatment combination.

4.15 Seed yield per hectare

Significant variation was remarked on seed weight per hectare as influenced by varieties (Table.2). The highest seed yield per hectare (1.38 t) was obtained from V_3 (BARI mula-4) treatment and the lowest seed yield per hectare (0.75 t) was recorded from V_2 (BARI mula-2) treatment.

Remarkable variation was recorded on seed weight per hectare due to the effect of nutrients (Table.2). The highest seed yield per hectare (1.33 t) was obtained from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and the lowest seed yield per hectare (0.97 t) was recorded from N_2 (50% CD+ 50% Vermicompost) treatment.

The recorded data on seed weight per hectare was significant with the application of different varieties and nutrients combinations (Table.6). The highest seed weight per hectare (1.59 t) was observed from the V_3N_1 treatment combination and the lowest seed yield per hectare (0.63 t) was found from the V_2N_2 treatment combination.

4.16 Germination (%)

The germination percentage was differed significantly among the varieties (Table. 3). The range of germination percentage was 89.61 to 98.08 %. The highest germination percentage (98.08 %) was observed in V_3 (BARI mula-4) treatment, which was statistically identical to V_1 (96.66 %). The variety V_2 (BARI mula-2) was inferior to V_1 (BARI mula-1) and V_3 (BARI mula-4) whose germination percentage was (89.61 %).

Seeds of radish obtained from different nutrients treatment showed non-significant influence on germination percentage (Table. 3). However, results indicated that the highest seed germination (95.77 %) was recorded from the N_0 (controlled) treatment whereas the lowest seed germination (94.87 %) was recorded from the N_2 (50% CD+ 50% Vermicompost) treatment.

Significant variation was recorded on germination percentage affected by combined effect of different varieties and nutrients (Table.7). The highest germination percentage (98.84 %) was observed in V_3N_2 treatment combination, which was statistically identical to V_1N_0, V_1N_1, V_1N_2, V_1N_3, V_3N_0, V_3N_1 and V_3N_3. The lowest germination percentage (88.52%) was obtained from V_2N_0 treatment combination.

Table 3. Performance of different variety and nutrients on germination (%), germination energy (%), germination capacity (%), speed of germination (%) of radish seed.

Treatment	Germination (%)	Germination energy(%)	Germination capacity(%)	Speed of Germination (%)
Different variety				
V_1	96.66 a	75.69 a	96.66 a	78.38 ab
V_2	89.61 b	71.26 b	89.61 b	76.88 b
V_3	98.08 a	76.60 a	98.08 a	79.62 a
LSD(0.05)	2.5491	1.7088	2.5491	2.3269
CV%	3.18	2.71	3.18	3.51
Nutrients				
N_0	93.77	75.04	93.77	79.78
N_1	95.15	74.46	95.15	77.94
N_2	95.35	74.21	95.35	77.20
N_3	94.87	74.37	94.87	78.26
LSD(0.05)	2.9434^{NS}	1.9732^{NS}	2.9434^{NS}	2.6868^{NS}
CV%	3.18	2.71	3.18	3.51

4.17 Germination energy (%)

There was significant variation in germination energy among the three radish varieties (Table .3). The maximum germination energy (76.60%) was observed in V_3 (BARI mula-4) treatment, which was statistically identical to V_1 (75.69%) treatment and minimum (71.26%) was in V_2 (BARI mula-2) treatment.

Non-significant variation was observed on germination energy affected by nutrients (Table. 3).

Significant variation was recorded on germination energy affected by combined effect of different varieties and nutrients (Table.7).The highest germination energy (77.16%) was observed in V_3N_2 treatment combination, which was statistically identical to V_1 N_0, V_1N_3, V_3N_0, V_3N_1, V_3N_3 and similar toV_1N_1, V_1N_2,. The lowest germination capacity (70.22%) was obtained from V_2N_3 treatment combination.

4.18 Germination capacity (%)

The germination percentage was differed significantly among the varieties (Table. 3). The range of germination capacity was 89.61 to 98.08 %. The highest germination capacity (98.08 %) was observed in V_3 (BARI mula-4) treatment, which was statistically identical to V_1 (96.66 %). The variety V_2 (BARI mula-2) was inferior to V_1 (BARI mula-1) and V_3 (BARI mula-4)whose germination capacity was (89.61 %).

Non-significant variation was observed on germination energy affected by nutrients (Table. 3).

Combined effect of different varieties and nutrients were significantly influenced by germination capacity (Table.7). The highest germination capacity (98.84 %) was observed in V_3N_2 treatment combination, which was statistically identical to V_1 N_0, V_1N_1, V_1N_2, V_1N_3, V_3N_0, V_3N_1 and V_3N_3. The lowest germination capacity (88.52%) was obtained from V_2N_0 treatment combination.

4.19 Speed of germination (%)

There was significant variation in speed of germination among the radish varieties (Table.3). The maximum speed of germination (79.62%) was observed in V_3 (BARI mula-4) treatment, which was statistically similar to V_1 (78.38 %) treatment and minimum (76.88 %) was in V_2 (BARI mula-2) treatment.

Non significant variation was observed on speed of germination affected by nutrients (Table. 3)

Significant variation was recorded on speed of germination affected by combined effect of different varieties and nutrients (Table.7).The highest speed of germination (81.93%) was observed in V_3N_0 treatment combination, which was statistically similar to V_1N_0, V_1N_1,V_1N_3, V_2N_3, V_3N_1, V_3N_2 and V_3N_3 and similar toV_1N_1, V_1N_2. The lowest speed of germination (76.05%) was obtained from V_2N_2 treatment combination.

Table 4. Combined effect of different variety and nutrients on number of leaves/plant, leaf length and breadth, days to inflorescence initiation of radish

Treatment combinations	Number of leaves/plant (40DAS)	Leaf length (cm) (40DAS)	Breadth of leaf (cm) (40DAS)	Days to inflorescence initiation	
				1st	80%
V_1N_0	11.93 bc	32.57 c	9.04 b	49.67 g	69.33 ef
V_1N_1	12.29 b	37.05 b	8.60 bc	47.00 h	69.67 ef
V_1N_2	10.72 d	26.27 ef	8.17 cd	55.33 de	71.33 de
V_1N_3	11.27 cd	30.45 cd	8.71 bc	57.00 d	74.67 c
V_2N_0	8.18 f	28.77 de	7.69 de	62.67 b	83.33 b
V_2N_1	9.45 e	28.53 de	8.09 cd	60.33 c	81.33 b
V_2N_2	7.03 g	24.84 fg	7.08 e	64.33 ab	85.67 a
V_2N_3	7.90 fg	22.83 g	7.52 de	66.33 a	86.67 a
V_3N_0	12 .00 bc	37.053 b	9.09 b	45.00 h	68.33 f
V_3N_1	13.73 a	39.913 a	9.87 a	42.33 i	64.67 g
V_3N_2	11.07 cd	31.99 c	7.87 d	52.33 f	70.33 ef
V_3N_3	11.87 bc	35.76 b	8.14 cd	54.33 ef	72.67 cd
LSD(0.05)	0.9744	2.5745	0.7283	2.2336	2.2689
CV%	5.42	4.87	5.17	2.41	1.79

Table 5. Combined effect of different variety and nutrients on inflorescence length, branches of inflorescence, days to harvest, number of siliqua/inflorescence, siliqua length of radish

Treatment combinations	Inflorescence length (cm)	Branches of inflorescence	Days to harvest	Number of siliqua/inflo.	Siliqua length (cm)
V_1N_0	86.00 de	18.33 b	120.67 de	144.67 b	5.21 b
V_1N_1	90.00 c	19.33 b	127.00 bc	148.00 b	5.38 b
V_1N_2	83.00 e	13.33 cd	118.67 ef	105.33 d	4.69 c
V_1N_3	85.67 e	12.67 de	128.33 b	116.00 c	4.73 c
V_2N_0	65.33 f	10.00 fg	122.00 de	67.67 f	3.96 d
V_2N_1	67.67 f	11.33 ef	123.00 d	74.67 e	4.06 d
V_2N_2	61.33 g	7.33 h	115.33 f	61.00 g	3.50 e
V_2N_3	65.00 f	8.67 gh	120.00 de	66.67 fg	4.17 d
V_3N_0	94.00 b	14.33 cd	130.67 ab	146.33 b	5.267 b
V_3N_1	98.00 a	22.00 a	132.67 a	154.33 a	5.83 a
V_3N_2	86.33 de	14.67 c	120.33 de	113.00 c	4.67 c
V_3N_3	89.33 cd	17.67 b	123.33 cd	116.00 c	5.31 b
LSD(0.05)	3.4207	1.9310	3.7489	5.7151	0.4065
CV %	2.49	8.07	1.79	3.08	5.07

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance,

Where, V_1= BARI mula-1, V_2= BARI mula-2, V_3= BARI mula-4 N_o= NPKS (standard dose) + without bio-fertilizer, N_1= NPKS (standard dose) + Bio-fertilizer, N_2=50% CD+ 50% Vermicompost , N_3= 50% CD + 50% Vermicompost + Bio- fertilizer

Table 6. Combined effect of different variety and nutrients on seeds number /siliqua, 1000 seed wt, seed yield/plant, seed yield/plot and seed yield /ha of radish

Treatment combinations	Seeds number/siliqua	1000 seed wt (g)	Seed yield/plant (g)	Seed yield/plot (g)	Seed Yield /ha (t)
V_1N_0	6.43 bcd	12.10 b	11.79 c	282.96 c	1.31 c
V_1N_1	7.30 a	12.10 b	13.14 b	315.36 b	1.46 b
V_1N_2	5.93 de	10.14 d	9.78 e	234.72 e	1.09 e
V_1N_3	6.67 b	11.11 c	10.95 d	262.80 d	1.22 d
V_2N_0	3.90 f	8.98 ef	6.84 g	164.16 g	0.76 g
V_2N_1	4.03 f	9.54 e	8.34 f	200.16 f	0.93 f
V_2N_2	3.27 g	7.98 g	5.67 h	136.08 h	0.63 h
V_2N_3	3.30 g	8.76 f	6.48 g	155.52 g	0.72 g
V_3N_0	6.6b c	12.40 b	13.50 b	324.00 b	1.50 b
V_3N_1	7.27 a	13.19 a	14.31 a	343.44 a	1.59 a
V_3N_2	5.70 e	10.94 c	10.62 d	254.88 d	1.18 d
V_3N_3	6.02 cde	11.50 c	11.31 cd	271.44 cd	1.26 cd
LSD(0.05)	0.5940	0.5776	0.7231	17.354	0.0803
CV %	6.34	3.18	4.18	4.18	4.18

Table 7. Combined effect of different variety and nutrients on germination capacity (%), speed of germination (%), germination (%), germination energy (%) of radish seed

Treatment combinations	Germination (%)	Germination energy (%)	Germination capacity (%)	Speed of germination (%)
V_1N_0	96.13 a	76.68 a	96.13 a	79.86 ab
V_1N_1	97.37 a	75.49 ab	97.37 a	77.58 ab
V_1N_2	97.03 a	74.65 abc	97.03 a	76.98 b
V_1N_3	96.10 a	75.92 a	96.10 a	79.10 ab
V_2N_0	88.52 b	72.29 bcd	88.52 b	77.54 ab
V_2N_1	89.65 b	71.74 cd	89.65 b	76.21 b
V_2N_2	90.18 b	70.80 d	90.18 b	76.05 b
V_2N_3	90.10 b	70.22 d	90.10 b	77.74 ab
V_3N_0	96.67 a	76.14 a	96.67 a	81.93 a
V_3N_1	98.42 a	76.15 a	98.42 a	80.04 ab
V_3N_2	98.84 a	77.16 a	98.84 a	78.57 ab
V_3N_3	98.39 a	76.96 a	98.39 a	77.94 ab
LSD(0.05)	5.0982	3.4176	5.0982	4.6537
CV %	3.18	2.71	3.18	3.51

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance,

Where, V_1= BARI mula-1, V_2= BARI mula-2, V_3= BARI mula-4 N_o= NPKS (standard dose) + without bio-fertilizer, N_1= NPKS (standard dose) + Bio-fertilizer, N_2=50% CD+ 50% Vermicompost , N_3= 50% CD + 50% Vermicompost + Bio- fertilizer

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the "Central Farm" in Sher-e-Bangla Agricultural University, Dhaka during November, 2019 to April, 2020 to investigate on the effect of bio-fertilizer mixed nutrient sources on growth, seed yield and quality of radish varieties. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Madhupur Tract", AEZ-28.The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. This experiment was conducted with two factors: Factor-A (Varieties)- (i) V_1- BARI mula-1 (ii) V_2- BARI mula-2 (iii) V_3- BARI mula-4; Factor-B: (Nutrients in absence or presence of bio-fertilizer) – (i) N_0- NPKS (standard dose) + without bio-fertilizer (ii) N_1- NPKS (standard dose) + Bio-fertilizer (iii) N_2- 50% CD+ 50% Vermicompost (iv) N_3- 50% CD + 50% Vermicompost + Bio-fertilizer. There are 12 treatment combinations such as V_1N_0, V_1N_1, V_1N_2, V_1N_3, V_2N_0, V_2N_1, V_2N_2, V_2N_3, V_3N_0, V_3N_1, V_3N_2 and V_3N_3. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield contributing characters and yield were recorded to find out the suitable variety and optimum nutrients for the potential growth and seed yield of radish.

Different yield contributing characters and yield were significantly influenced due to varied different varieties of radish. There were significant difference in the number of leaves, leaf length and breadth per plant among the different varieties of radish (Table.1). At 40 DAS, the maximum number of leaves (12.17), leaf length per plant (36.18 cm), leaf breadth (8.74 cm), were found from V_3 (BARI mula-4) treatment and the minimum number of leaves per plant (8.14), leaf length (26.24 cm) and leaf breadth (7.59 cm) were obtained from V_2 (BARI mula-2) treatment. Days required to 1st and 80% florescence initiation were showed statistically significant variation due to different varieties (Table.1). The longest period (63.42 days) and(84.25 days) were required for 1st and 80% inflorescence initiation from V_2(BARI mula-2) treatment and the shortest period (48.50 days) and (69.0 days) were required for 1st and 80% inflorescence initiation from V_3(BARI mula-4) treatment. Inflorescence length, number of branches per inflorescence, days required to inflorescence harvest, number of siliqua per inflorescence, siliqua length and number of seeds per siliqua

were significantly affected by the varieties. Maximum inflorescence length (91.92 cm), number of branches per inflorescence (17.17), (126.75 days) for harvest, number of siliqua per inflorescence (132.42), siliqua length (5.27 cm) and number of seeds per siliqua (6.58) were found from V_3 (BARI mula-4) treatment and minimum inflorescence length (64.83 cm), number of branches per inflorescence (9.33), (120.08 days) for harvest, number of siliqua per inflorescence (67.50), siliqua length (3.92 cm) and number of seeds per siliqua (3.62) were found from V_2 (BARI mula-2) treatment. A significant variation was observed on 1000 seed weight, seed weight per plant and plot among the different varieties of radish (Table.2). Maximum 1000 seed weight (12.01 g), seed yield per plant (12.44 g), seed yield per plot (298.44 g) and seed yield per hectare (1.38 t) was obtained from V_3(BARI mula-4) treatment and minimum 1000 seed weight (8.82 g), seed yield per plant (6.83 g), seed yield per plot (163.98 g) and seed yield per hectare (0.75 t) were recorded from V_2 (BARI mula-2) treatment.

Different yield contributing characters and yield were significantly influenced due to varied nutrients.A significant variation was found incase of number of leaves per plant, leaf length and breadth per plant due to the effect of nutrients (Table.1). At 40 DAS, the maximum number of leaves (11.83), leaf length per plant (35.16 cm) and leaf breadth (8.85 cm) were produced from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and the minimum number of leaves per plant (9.60), leaf length (27.70 cm) and leaf breadth (7.69 cm) were obtained from N_2 (50% CD+ 50% Vermicompost) treatment. Days required to 1st and 80% inflorescence initiation were showed statistically significant variation due to different nutrients (Table.1). The longest period (59.22 days) and (78.0 days) were required for 1st and 80% inflorescence initiation from N_3(50% CD + 50% Vermicompost + Bio-fertilizer) treatment and the shortest period (52.44 days) and (73.67 days) were required for 1st and 80% inflorescence initiation from N_0(NPKS (standard dose) + without bio-fertilizer) treatment. Inflorescence length, number of branches per inflorescence and days required to inflorescence harvest of radish varied due to application of different nutrients (Fig.6). Maximum inflorescence length (85.22 cm), number of branches per inflorescence (17.56) and (127.56 days) for harvest were found from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and minimum inflorescence length (76.89 cm), number of branches

per inflorescence (11.78) and (118.11 days) for harvest were found from N_2 (50% CD+ 50% Vermicompost) treatment (Table.1) .

Number of siliqua per inflorescence, siliqua length, number of seeds per siliqua and 1000 seed weight varied apparently due to application different nutrients (Table.1). Maximum number of siliqua per inflorescence (125.67), siliqua length (5.09 cm) number of seeds per siliqua (6.20) and 1000 seed weight (11.61 g) were observed from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and minimum number of siliqua per inflorescence (93.11), siliqua length (4.29 cm) number of seeds per siliqua (4.97) and 1000 seed weight (9.69 g) was observed from N_2 (50% CD+ 50% Vermicompost) treatment. Significant variation was remarked on seed weight per plant, plot and hectare as influenced by nutrients (Fig.10). The highest seed yield per plant (11.93 g), per plot (286.32 g) and per hectare (1.33 t) were obtained from N_1 (Standard dose of NPKS + Bio-fertilizer) treatment and the lowest seed yield per plant (8.69 g), per plot (208.56 g) and per hectare (0.97 t) were recorded from N_2 (50% CD+ 50% Vermicompost) treatment.

Combined effect of varieties and nutrients on number of leaves, leaf length and breadth per plant , days required to 1st and 80% inflorescence initiation, inflorescence length per plant and number of branches per inflorescence were found statistically significant (Table.4 and 5).The maximum number of leaves per plant (13.73) at 40 DAS, leaf length(39.91 cm) and breadth per plant (9.87 cm) at 40 DAS, days required to 1st (66.33 days) and 80% (86.67 days) inflorescence initiation, inflorescence length per plant (98.0 cm) and number of branches per inflorescence (22.0) were produced from V_3N_1 (BARI mula-4 with standard dose of NPKS + Bio-fertilizer) treatment combination and the minimum number of leaves per plant (7.03) at 40 DAS, leaf length (22.83 cm) and breadth per plant (7.08 cm) at 40 DAS, days required to 1st (42.33 days) and 80%(64.67 days) inflorescence initiation, inflorescence length per plant (61.33 cm) and number of branches per inflorescence (7.33) was produced from V_2N_2 (BARI mula-2 with 50% CD+ 50% Vermicompost) treatment combination, which was statistically similar to V_2N_3 treatment combination. Combined effect of varieties and nutrients on number of siliqua per inflorescence, siliqua length, number of seeds per siliqua, 1000 seed weight, seed yield per plant, plot and hectare were found statistically significant (Table.5 and 6). At harvest, the maximum number of siliqua per per inflorescence (154.33), siliqua length (5.83 cm), number of seeds per siliqua (7.30),

1000 seed weight (13.19 g), seed yield per plant (14.31 g), seed yield per plot (343.44 g) and seed weight per hectare (1.59 t) was obtained from V_3N_1 (BARI mula-4 with standard dose of NPKS + Bio-fertilizer) treatment combination and the minimum number of siliqua per inflorescence (61.0) siliqua length (3.50 cm), number of seeds per siliqua (3.27), 1000 seed weight (7.98 g), seed yield per plant (5.67 g), seed yield per plot (136.08 g) and seed weight per hectare (0.63 t) was produced from V_2N_2 (BARI mula-2 with 50% CD+ 50% Vermicompost) treatment combination, which was statistically similar to V_2N_3 treatment combination.

From the above findings, it can be concluded:

- For obtaining maximum seed yield of radish, BARI mula-4 (V_3) was observed the best among the other radish variety.
- For nutrients, $N_{300}P_{120}K_{140}$ Kg/ha + Bio-fertilizer (N_1) was identified to be superior for plant growth and yield parameters than others.
- Considering yield contributing characters, combined effect of V_3N_1 was found to provide the best results of radish seeds.

However, the experiment was, conducted in one season only and hence the results should be considered as a tentative. It is imperative that similar experiment should be carried out with more variables to reconfirm the recommendation of radish.

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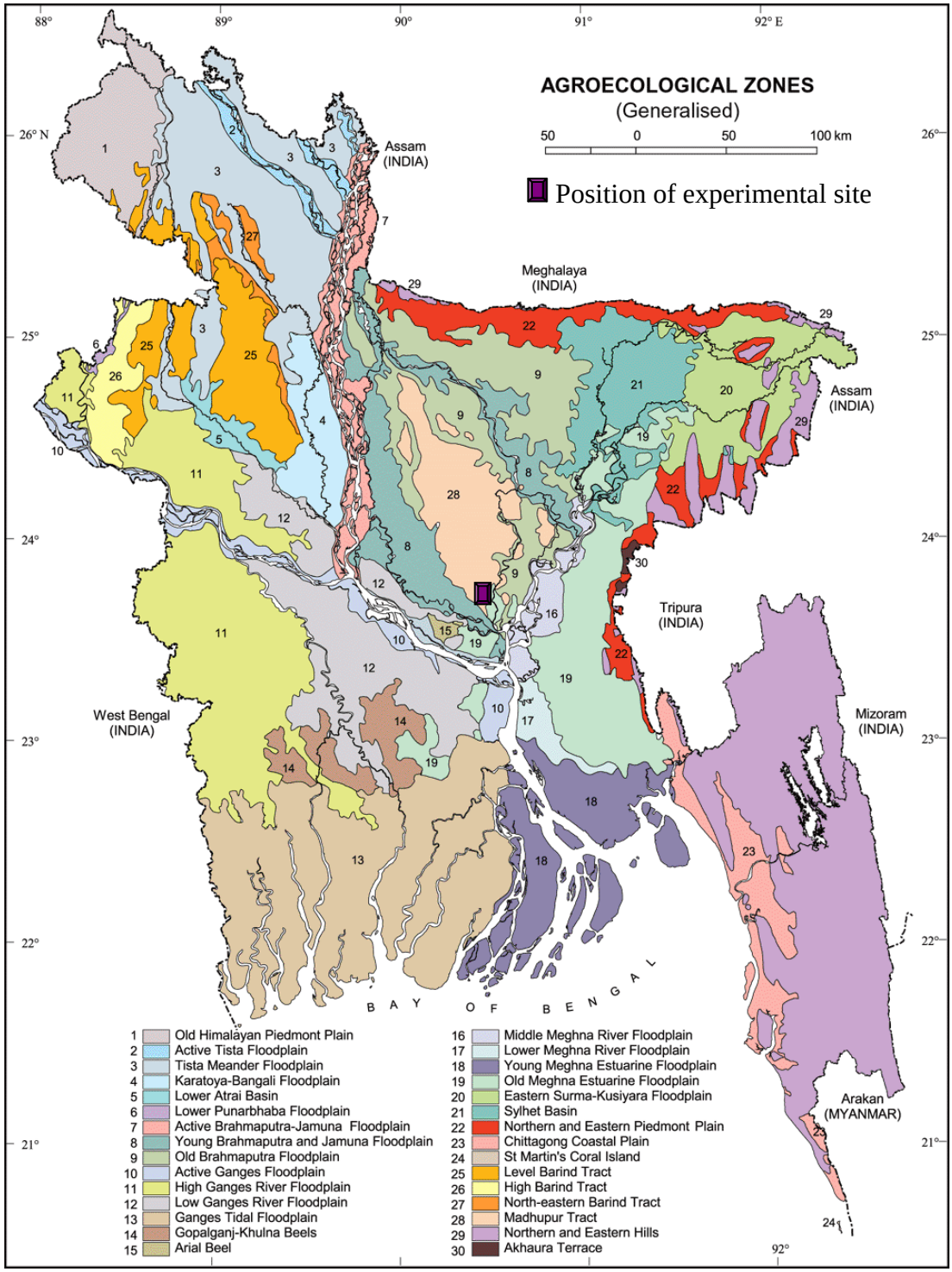
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Weather data, 2019, Dhaka

Month	Average RH (%)	Average Temperature (°C)		Total Rainfall (mm)	Average Sunshine hours
		Min.	Max.		
June	82	25.5	32.4	637	4.7
July	84	25.7	31.4	742	3.3
August	81	26.4	32.5	514	4.9
September	81	26.4	32.0	188	3.0
October	79	23.8	31.4	331	5.2
November	78	19.9	29.0	122	5.7
December	70	15.0	25.8	0	5.5

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207.

Appendix III. Physiochemical properties of the initial soil

Characteristics	Value
Partical size analysis.	
% Sand	26
% Silt	45
% Clay	29
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

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

Plate 1. Mature root in the experiment field

Plate 2. Flowering stage of radish

Plate 3. Seed formation stage

Plate 4. Harvested pod (sample)

Plate 5. Sample pod and seeds

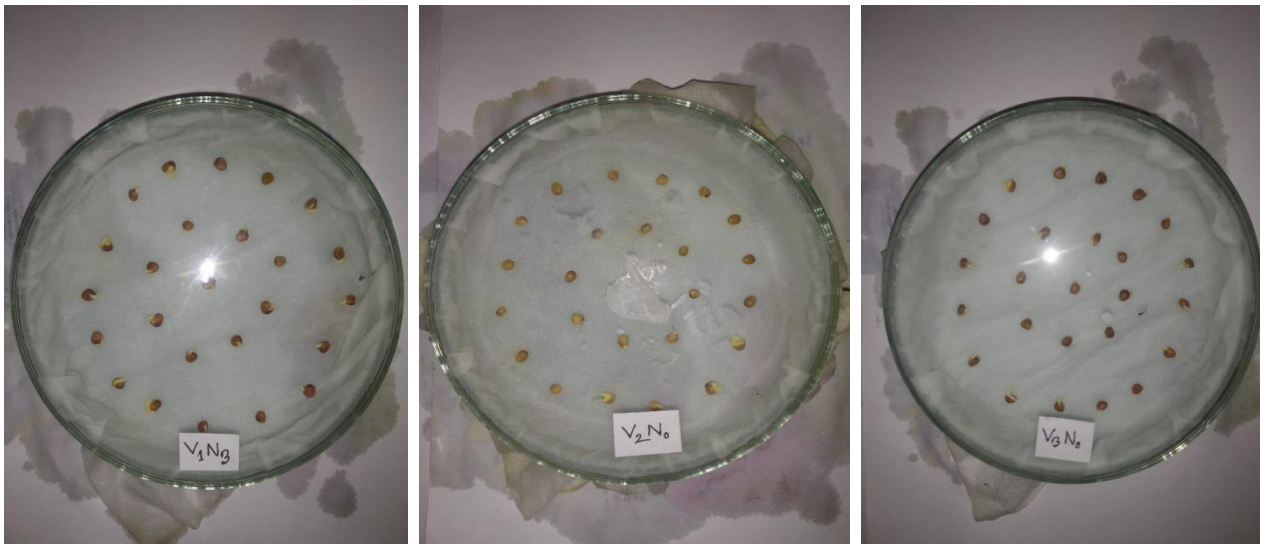


Plate 6. Germination test