EFFECTS OF POULTRY LITTER BASED COMPOST ON THE GROWTH AND YIELD OF MUSTARD

A Thesis

By

MD. ABU SYED
Student No. 1705210

MASTER OF SCIENCE
IN
CROP PHYSIOLOGY AND ECOLOGY

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
DINAJPUR-5200, BANGLADESH

DECEMBER 2018

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Submitted to the
Department of Crop Physiology and Ecology
Hajee Mohammad Danesh Science and Technology University, Dinajpur
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
IN
CROP PHYSIOLOGY AND ECOLOGY

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DECEMBER 2018

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

The Author express his deepest sense of gratefulness to the Almighty Allah who has enabled his to complete the present research work and to prepare this capacious thesis for the degree of Master of science (MS) in Crop Physiology and Ecology.

The Author expresses his heartiest respect, sincere appreciation and immense indebtedness to his respectable teacher research Supervisor Professor Dr. Abu Khayer Md. Muktadirul Bari Chowdhury, for his scholastic guidance during planning and execution of the research, valuable suggestions, continuous support and all hint of support and help throughout the period of research work and preparation of manuscript of the thesis.

The Author fells proud to express his hearted sense of respect gratefulness to his co-supervisor Professor Dr. Md. Maniruzzaman Bahadur for his valuable suggestions, sincere helps, scholar instructions and careful corrections of the manuscript of the thesis.

The Author recognize a profound thanks to Professor Dr. Md. Abu Hasan and Professor Dr. Sripati Sikder, Chairman, Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur for their important suggestions, all round help and kindly support for successful completion of the manuscript of the thesis.

The author also extend gratitude to all the friends, staffs of the Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and

Technology University, Dinajpur for their help assistance during the period the research.

The Author is very thankful gratitude to all friends existing colleagues as well wisher for their eagerness, direct and indirect helps during the period of research work.

At last, from the core of heart, the Author feels duty bound to acknowledge the blessing incentives of beloved parents Md. Nur Ali and Mrs. Shahina Begum and other family members for their blessing, inspirations, sacrifices moral supports and financial assistance, which encouraged paved the way for higher studies.

December 2018 *The Author*

ABSTRACT

To evaluate the poultry litter based composts efficacy on mustards production, a pot experiment was conducted at the Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during December 2017 to May 2018. The experiment was laid out in a two factorial Randomized complete block design RCBD) with three replications. Two mustard varieties, such as V_1=BINA Sarisha-4 and V_2=BARI Sarisha-15 and three dose of poultry based compost as well as one recommended fertilizer, such as T_1 = control (recommended dose) (Urea 2.5 g, TS 1.35 g, MoP 0.75 g, Gypsum 1.13 g per pot), T_2= 10 ton/ha, T_3 = 20 ton/ha, T_4 = 30 ton/ha were applied in soil during to study the effects. Different growth performance such as plant height, leaf number, leaf area, dry weight, branch number and yield and yield contributing characters were recorded during the experiment. Most of the morphological traits and yield and yield contributing characters were significantly influenced by different dose of compost in both the varieties. The highest plant height, leaf number, leaf area, branch number, seed yield, stover yield, day to maturity, length of siliqua, thousands seed weight and stover yield were obtained at T_3 (compost 20 ton/ha). But the longest length of siliqua and the highest number of seed in siliqua was recorded T_4 (compost 30 ton/ha). And the highest harvest index (%) was recorded from T_1 (control). All the yield and yield contributing characters found more in BINA Sarisha-4 compared to BARI Sarisha-15. It also observed that BINA Sarisha-4 took maximum day to first flowering and 50% flowering. And BARI Sarisha-15 took minimum days to first flowering and 50% flowering. The interaction between T_3 (compost 20 ton/ha) and V_1 (BINA Sarisha-4) gave the highest seed yield V_1T_3 (2.33 t ha^{-1}) and V_2 (BARI Sarisha-15) T_1 (control) combination gave the lowest yield (1.27 t ha^{-1}).

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LIST OF ABBREVIATIONS

AEZ = Agro-Ecological Zone

BARI = Bangladesh Agriculture Research Institute

et al. = And others

BINA = Bangladesh Institute of Nuclear Agriculture

RCBD = Randomized Complete block Design

CHAPTER I

INTRODUCTION

Mustard (*Brassica* spp.) and rapeseed are commonly known as mustard belongs to the family of cruciferae under the genus *Brassica*, which is one of the important and widely grown oilseed crop of winter season in Bangladesh. It is one of the important oil yielding crops of the world after soybean and groundnut (FAO, 2012). But it occupies the first position in respect of area and production among the oil crop grown in Bangladesh (DAE, 2015). Mustard seeds contain 40-45% oil and 20-25% protein, 8-10 % fibers, 6-10 % moisture, and 10-12 % extractable substances. Using local ghani average 33% oil may be extracted. Oil cake is a nutritious food item for cattle and fish. Oil cake is also used as a good organic fertilizer. Dry mustard plants may be used as fuel.

In Bangladesh the edible oil production is 3,76,000 metric tons of which rapeseed (Brassica spp.) covers 62% of the total annual oil (MOA, 2006). Worldwide the total annual production of rapeseed along with mustard is 63.04 million tons of seed from an area of 34.33 million hectares (FAO, 2013). Among the oil seed crops grown in Bangladesh, mustard tops the list in respect of both production and acreage (BBS 2015). The present area and production of mustard is 3.25 lac hectare and 3.59 lac metric ton, respectively. The average yield of mustard in Bangladesh is very low (1.1 t ha^{-1}) (BBS 2015) compared to other oilseed crops. Rapeseed-mustard represents an important source of cooking oil in Bangladesh and meets around one third of the edible oil requirement of the country (Ahmed, 2008). Our internal production can meet only about 21% of total demand and the

rest 79 % is met by the import (Begum *et al*. 2012). Due to insufficient production, a huge amount of foreign exchange involving over 160 million US Dollar is being spent every year for importing edible oils in Bangladesh (Rahman 2002).

Bangladesh is facing a huge deficit of edible oil. The per capita oil supply for the peoples of Bangladesh is only 4.5 kg per year (FAO 2003). Domestic production of edible oil almost entirely comes from mustards, groundnut and sesame. Mustard is grown in rabi season usually under rainfed and low input conditions. Mustard oil plays an important role as a fat substitute in our daily diet. This oil widely used as cooking and medicinal ingredients. Dry mustard plants may be used as fuel. Moreover, mustard oil cake is used as feed for cattle and fish and also as good manure. The competition of mustard to marginal lands causing poor productivity. In view- of population growth; the requirement of edible oil should be increasing day by day. It is therefore, highly expected that the production of edible oil should be increased considerably to fulfill the demand. There is a general consensus that increasing yield/unit area is the most reasonable way to increase total production. To increase mustard production, it is necessary to improve per hectare yield by cultivating modern varieties with improved management practices like balanced and efficient fertilizer application, irrigation, timely sowing and pest control, etc. Mustard is an important oil seed crop in Bangladesh. It accounts about 72% of total oilseed production in the country.

The area under rapeseed and mustard is 0.30 million hectares which is about 80 % of the total oilseed area (Anonymous 2003). But the area under mustard is

declining due to late harvesting of high yielding transplanted Aman rice and increased cultivation of Boro rice. Last ten years have witnessed gradual decline in an area of 104 thousand hectare and production 68 thousand tons of mustard and rapeseed (Anonymous 2006). The production of edible oil is being decreased, but the demand is increasing day by day with the increasing population. The present domestic edible oilseed production is 267 thousand tons which only one third of national demand (Anonymous 2006).

The present per capita oil consumption is only 10 g/day as compared to the total need of 22 g/day (Anonymous 2000). The shortage of edible oil in the country has become an acute problem. To fulfill this demand, Bangladesh has to import a large quantity of edible oil every year at the cost of huge amount of foreign exchange worth some Tk 1100 million (Anonymous 2006). Cultivation of low yielder local varieties with poor fertilizer management are the major causes for poor yield of mustard in the country (Alam and Rahman. 2006).

In Bangladesh, the average yield of mustard is very low 0.74 t/ha only as compared to about 2.77 t/ha in the European countries. The poor yield of mustard might be attributed to inefficient and inappropriate uses of production inputs like fertilizers, seeds and ignorance of improved technologies for crop production. High yield potential of a variety is the prerequisite for increasing the production of a crop. In the recent years, Bangladesh Agricultural Research Institute (BARI) has developed a number of high yielding varieties of mustard with yield potential up to 2.5 t/ha. The present national average yield of mustard is only 0.79 t/ha (Anonymous 2006)

In the northern part of Bangladesh especially in the greater Dinajpur District, recently, new cropping patterns introduced as Mustard-Boro-T. Aman rice under medium high land and mustard- Boro rice under medium low land. In those patterns, the farmers are using local variety of mustard with very poor fertilizer management and harvest very poor yield of mustard. Poultry litter based compost improve plant growth by enriching the soil. It improving the capacity to hold water and adding essential nutrients in mustard crops.

By introducing the high yield of varieties with better poultry litter based compost management packages the yield of mustard can be increased manifold. So, the experiment was under taken with the following objective:

- To study the effect of poultry litter based compost fertilizer on vegetative growth of mustard.
- To evaluate effect of compost on yield contributing characters and yield of mustard.
- To observe the growth and development of mustard with selected poultry litter based compost dose.

CHAPTER II

REVIEW OF LITERATURE

The productivity of any crop is a complex phenomenon which is governed by numerous endogenous and exogenous factors. It can be enhanced by adopting suitable agro-techniques *viz*., use of improved varieties, timely sowing, appropriate spacing, fertilizer management, proper irrigation scheduling and proper measures to minimize losses through weeds, insect-pests and diseases etc. Among various agronomical factors responsible for increasing productivity of any crop, fertilizer management play important role for harvesting potential production of mustard under different agro-climatic conditions.

An attempt has been made to review the available literatures concerning the present investigation are presented in this chapter. The work done, especially on these aspect of mustard is very meagre; hence similar work on other crops has also been included whenever felt necessary. A brief summary on research work done in the past by eminent scientists on related aspects has been highlighted and reviewed under the following broad headings.

2.1 Effect of organic manures (FYM, Vermicompost and Castor cake)

2.1.1 Plant growth characters

2.1.3 Yield and Yield attributes

2.1.3 Quality parameters

2.1.4. Nutrient content and uptake

2.2 Effect of bio-fertilizers (*Azotobacter* spp. and PSB spp.)

2.2.2 Plant growth characters

2.2.3 Yield and Yield attributes

2.2.3. Quality parameters

2.2.4. Nutrient content and uptake

2.3 Combined effect of organic manures and bio-fertilizers

2.1 Effect of organic manures (FYM, Vermicompost and Castor cake)

Soil organic matter is one of the important natural resource. The research recognized that crop production and soil fertility may be maintained or improved by organic matter through adding organic manures (Vaughan and malcon, 1985). It also plays a vital role in governing physical, chemical and biological properties of soil. FYM is the principle source of organic manures in country.

2.1.1 Plant growth characters

Kansotia *et al.* (2015) reported that application of vermicompost @ 6.0 t/ha to Indian mustard (*Brassica juncea* L.) has been recorded significantly increased the number of primary and secondary branches per plant.

It was revealed by Sood *et al.* (2015) that plant height, total dry matter, number of primary & secondary branches were significantly increased at 90 DAS due to application of FYM @ 10 t/ha with chemical fertilizer (Urea) to Indian mustard (*Brassica juncea* L.) compared to control

Lepcha *et al.* (2015) indicated that significantly increased plant height (148.60 cm), no. of primary branches per plant (10.92) and no. of secondary branches per plant (28.82) at 90 DAS were recorded under treatment 20% nitrogen through FYM + 20% nitrogen through vermicompost + 20% nitrogen through poultry manure + 20% nitrogen through neem cake + 20% nitrogen through inorganic to Indian mustard (*Brassica juncea* L.), followed by 50% nitrogen through vermicompost + 50% nitrogen through inorganic as compared to control.

Parihar *et al.* (2014) found that application of vermicompost @ 6.0 t/ha to Indian mustard (*Brassica juncea* L.) significantly enhanced the plant height as well as number of primary and secondary branches as compared to other treatments.

In an experiment, Raju *et al.* (2013) observed that highest dry matter production (3026 kg/ha) was obtained in under application of 50% RDN through inorganic fertilizer + 50% RDN through vermicompost to safflower (*Carthamus tinctorius* L.) as compared to control.

Yadav *et al.* (2013) observed that application of FYM @ 6.0 t/ha to Taramira (*Eruca sativa*) significantly enhanced plant height, total dry matter, number of primary and secondary branches followed by vermicompost @ 3.0 t/ha as compared to other treatments.

De and Sinha (2012) observed that application of 50% RDF + FYM @ 10 t/ha vermicompost @ 2.5 t/ha to soil significantly increased plant population and no. of primary & secondary branches per plant rapeseed (*Brassica compestris* L.) as compared to other treatments.

Chinnamuthu and Venkatakrishnan (2010) revealed that application of vermicompost @ 2.0 t/ha significantly enhanced plant height in smaller compared to that of FYM @ 5.0 t/ha (147.80 cm and140.80 cm, respectively).

In an experiment Byrareddy *et al.* (2008) showed that plant height, number of leaf per plant and total dry matter per plant of sunflower (*Helianthus annus* L.) were significantly higher due to application of FYM @ 8.0 t/ha + 75% as compared to other treatments.

Naik *et al.* (2007) revealed that application of vermicompost @ 2.0 t/ha to safflower (*Carthamus tinctorius* L.) supported plant height (75.4 cm), number of leaf (140.4), number of branches (28.8) and total dry matter production (114.4 g/plant) significantly at harvest as compared to other treatments.

Govindan and Thirumurugan (2005) found that application of vermicompost 2.0 t/ha to soybean (*Glycine max* L.) recorded significantly increased plant height (84.70 cm) and leaf area (cm^2) index (3.40) as compared to other treatments.

Badiyala and Kumar (2003) noticed that application of 100% RDF + FYM @ 5.0 t/ha to linseed (*Linum usitatissimum* L.) recorded significantly higher plant height and no. of branches per plant over control.

Thakuria *et al.* (2001) reported that 100% RDF + vermicompost @ 2.0 t/ha applied to linseed (*Linum usitatissimum* L.) recorded significantly increased the plant height, no. of branches per plant and dry matter production per plant as compared to other treatments.

Patel *et al.* (1996) observed that significantly increased leaf area (cm^2) index (LAI) and crop growth rate (CGR) under application of FYM @ 10 t/ha to Indian mustard (*Brassica juncea* L.) as compared to control.

2.1.2 Yield and Yield attributes

Kansotia *et al.* (2015) reported that application of vermicompost @ 6.0 t/ha to Indian mustard (*Brassica juncea* L.) recorded significantly increased no. of siliqua per plant, no. of seed per siliqua, seed yield and stover yield as compared to control.

Lepcha *et al.* (2015) revealed that significantly increased no. of siliqua per plant, no. of seed per siliqua, seed yield and stover yield were recorded under treatment 20% nitrogen through FYM + 20% nitrogen through vermicompost + 20% nitrogen through poultry manure + 20% nitrogen through neem cake + 20% nitrogen through inorganic to Indian mustard (*Brassica juncea* L.), followed by 50% nitrogen through vermicompost + 50% nitrogen through inorganic as compared to control.

Parihar *et al.* (2014) noticed that application of vermicompost @ 6.0 t/ha to Indian mustard (*Brassica juncea* L.) recorded significantly higher no. of siliqua per plant (182.1), no. of seed per siliqua (13.42), test wt. (4.83 g) and seed yield (18.65 q/ha) compared to other treatments.

Raju *et al.* (2013) indicated that highest seed yield (1239 kg/ha) of safflower (*Carthamus tinctorius* L.) was obtained under application of 50% RDN through inorganic fertilizer + 50% RDN through vermicompost as compared to control.

Singh *et al.* (2013) found that application of 75% RDF + FYM @ 5.0 t/ha produced significantly higher seed yield (2.09 t/ha) and stover yield (6.01 t/ha) of Indian mustard (*Brassica juncea* L.) as compared to other treatments.

Yadav *et al.* (2013) observed that application of FYM @ 6.0 t/ha to taramira (*Eruca sativa*) recorded significantly higher no. of siliqua per plant, no. of seed per siliqua, seed yield and stover yield, followed by vermicompost @ 3.0 t/ha as compared to other treatments.

Jat *et al.* (2013) noticed that increasing levels of FYM (0, 5.0 and 10 t/ha) improved the seed yield (11.4, 14.8 and 16.9 q/ha, respectively) and stover yield (28.4, 36.1 and 40.6 q/ha, respectively) of Indian mustard (*Brassica juncea* L.) as compared to other applications.

De and Sinha (2012) observed that application of 50% RDF + FYM @ 10 t/ha vermicompost @ 2.5 t/ha to rapeseed (*Brassica compestris* L.) recorded significantly higher no. of siliqua per plant (189.47), no. of seed per siliqua (7.19) and test wt. (3.84 g) as compared to other treatments.

Chinnamuthu and Venkatakrishnan (2010) revealed that application of vermicompost @ 2.0 t/ha to sunflower (*Helianthus annus* L.) recorded significantly higher seed yield and stalk yield compared to application of FYM @ 5.0 t/ha.

Aruna and Reddy (2008) noticed that application of vermicompost @ 10 t/ha to soybean (*Glycine max* L.) recorded significantly higher No. of pod per plant

(59.1), 100 seed wt. (15.80 g) and seed yield (1143 kg/ha) over the application of FYM @ 5.0 t/ha + 50% N kg/ha (29.70, 13.9 g and 782 kg/ha, respectively).

Meena *et al.* (2008) indicated that application of FYM @ 10 t/ha gave significantly higher seed yield and stover yield of Indian mustard (*Brassica juncea* L.) as compared to other applications.

Naik *et al.* (2007) reported that application of vermicompost @ 2.0 t/ha to safflower (*Carthamus tinctorius*) recorded significantly higher seed yield (13.8 q/ha) as compared to other treatments.

Reddy *et al.* (2003) revealed that application of FYM @ 10 t/ha recorded significantly higher seed yield of castor (1056 kg/ha) and mustard (2037 kg/ha) over application of RDF. Application of FYM, on an average increased the seed yield of castor (23%) and mustard (36%) compared to RDF.

Patel *et al.* (1996) observed that significantly increased seed and stover yield was recorded under application of FYM @ 10 t/ha to Indian mustard (*Brassica juncea* L.) as compared to other applications.

2.1.3 Quality parameters

Lepcha *et al.* (2015) noticed that significantly increased oil content (39.02 %) was recorded under treatment 20% nitrogen through FYM + 20% nitrogen through vermicompost + 20% nitrogen through poultry manure + 20% nitrogen through neem cake + 20% nitrogen through inorganic to Indian mustard (*Brassica juncea*

L.), followed by 50% nitrogen through vermicompost + 50% nitrogen through inorganic as compared to control.

Kansotia *et al.* (2015) reported that application of vermicompost @ 6.0 t/ha to Indian mustard (*Brassica juncea* L.) recorded significantly higher oil content (40.62 %) and protein (22.68 %) as compared to control.

Rasool *et al.* (2015) revealed that application of 100 % RDF + FYM @ 10 t/ha to sunflower (*Helianthus annus* L.) recorded higher oil yield (105.6 q/ha) as compared to other treatments.

Singh *et al.* (2013) found that maximum protein yield (429.2 kg/ha) and oil yield (869.1 kg/ha) of Indian mustard (*Brassica juncea* L.) was recorded under 75% RDF + FYM @ 5.0 t/ha as compared to other treatments.

Ali and Mahmoud (2012) reported that application of FYM @ 7.7 t/ha to safflower (*Carthamus tinctorius* L.) produced the highest oil yield (1292.58 kg/ha) as compared to other treatments.

De and Sinha (2012) indicated that application of 50% RDF + FYM @ 10 t/ha vermicompost @ 2.5 t/ha to rapeseed (*Brassica compestris* L.) recorded significantly higher oil content (44.99 %) and oil yield (606.04 kg/ha) as compared to other treatments.

Aruna and Reddy (2008) noticed that application of vermicompost @ 10 t/ha to soybean (*Glycine max* L.) recorded significantly higher protein content (41.80 %)

and oil content (24.30 %) over the application of FYM @ 5 t/ha + 50% N kg/ha (38.70 % and 23.1 %, respectively).

Shukla and Warsi (2005) observed that application of 100% RDF + vermicompost @ 2.0 t/ha with sulphur to Indian mustard (*Brassica juncea* L.) recorded significantly higher oil content (41.55%) and protein content (22.36%) as compared to other treatments.

2.1.4 Nutrient content and uptake

Kansotia *et al.* (2015) reported total nitrogen and phosphorus content as well as uptake recorded significantly highest in seed & stover of Indian mustard (*Brassica juncea* L.) under vermicompost @ 6.0 t/ha as compared to other treatments.

Raju *et al.* (2013) noticed that highest uptake of nitrogen (11.74, 40.37 and 63.36 kg/ha), phosphorus (4.39, 8.34 and 13.14 kg/ha) and potassium (4.68, 11.36 and 42.40 kg/ha) observed by safflower (*Carthamus tinctorius* L.) (at 30, 60 DAS and harvest, respectively) under application of 50% RDN through inorganic fertilizer + 50% RDN through vermicompost as compared to other treatments.

Jat *et al.* (2013) indicated that successive increasing levels of FYM (0, 5.0 and 10 t/ha) increased content and uptake of nitrogen, sulphur, zinc and iron in seed & stover of Indian mustard (*Brassica juncea* L.) as compared to other treatments.

Singh *et al.* (2013) revealed that significantly highest N, P & K uptake by Indian mustard (*Brassica juncea* L.) (68.7, 15.6 and 18.1 kg/ha, respectively) were recorded under 75 % NPK + FYM @ 5.0 t/ha and maximum available N, P_2O_5& K_2O (175, 12.0 and 155 kg/ha, respectively) was noticed under 100% NPK alone.

De and Sinha (2012) found that significantly increased N, P & K uptake by seed & stover of rapeseed (*Brassica compestris* L.) was recorded at harvest under treatment of 50% RDF + FYM @ 10 t/ha + vermicompost @ 2.5 t/ha over control.

Jat *et al.* (2012) revealed that nitrogen, sulphur, zinc and iron content in soil increased significantly with increasing level of FYM.

Arbad and Ismail (2011) reported that maximum total N, P & K uptake by safflower (*Carthamus tinctorius* L.) (80, 24.51 and 117 kg/ha, respectively) were recorded under application of 100% RDF + FYM @ 10 t/ha as compared to other treatments.

Kademani *et al.* (2003) observed that highest uptake of nitrogen, phosphorus and potassium by sunflower (*Helianthus annus* L.) were recorded under application of vermicompost @ 2.0 t/ha followed by application of FYM @ 5.0 t/ha.

2.2 Effect of bio-fertilizers (*Azotobacter* spp. and PSB spp.)

Bio-fertilizers are microbial inoculants of selective microorganisms like bacteria, algae, fungi, already existing in nature. Bio-fertilizers which are preparation of efficient nitrogen fixing, p solubilizing or cellulose decomposing microorganisms, when applied to seed or soil enhances availability of nutrients to plant providing an economically viable and ecological sound means to reducing external input of chemical fertilizers (Gupta and pandhar, 1996). They may help in improving soil fertility by way of accelerating biological nitrogen fixation from atmosphere, solubilization of the insoluble nutrients already present in soil, decomposing plant

residues, stimulating plant growth and production. The process is slow, consumes less energy and provides cheap nutrient to soil and plant without polluting the nature. Integration of bio-fertilizers with inorganics sustains the productivity by improving soil biological, chemical & physical properties; improve the nutrient use efficiency and reduces the use of costly inorganic fertilizers (Singh *et al*. 2009). Bio-fertilizers, more commonly known as "Microbial inoculants", help in improving the soil fertility. They include nitrogen fixing, phosphate solubilizing and growth promoting micro-organisms (Goel *et al*. 1999).

2.2.1 Plant growth characters

Solanki *et al.* (2015) reported that application of phosphorus 50 kg/ha + sulphur 50 kg/ha + seed inoculation with PSB to Indian mustard (*Brassica juncea* L.) recorded significantly increased no. of primary branches per plant and no. of secondary branches per plant over control.

Bera *et al.* (2014) found that inoculation of Azotobacter + PSB + VAM to sunflower (*Helianthus annus* L.) recorded significantly higher plant height (118.3 cm) and total dry matter per plant (23.88 g) at harvest as compared to control.

Meena *et al.* (2014) revealed that highest plant height at 90 DAS (158.03 cm),no. of primary branches per plant (12.50) and no. of secondary branches per plant (25.42) were recorded under application of 100 % NPK + seed inoculation with Azotobacter + PSB each 10 ml/kg seed of Indian mustard (*Brassica juncea* L.).

Mahboobeh and Jahanfar (2012) observed significantly increased plant height (114.3 cm) of canola (*Brassica napus* L.) due to 100% RDF + Azotobacter inoculation as compared to non-inoculation (108.1 cm).

Premi *et al.* (2012) noticed significantly increased plant height (181.7 cm), no. of primary branches per plant (4.3) and no. of secondary branches per plant (8.1) of Indian mustard (*Brassica juncea* L.) due to phosphorus solubilizing bacteria (PSB) over non-inoculation with PSB.

Mohsen and Asad (2011) reported that application of 100% NPK + seed inoculant (Azospirillum & Azotobacter) significantly affected growth characters of sunflower (*Helianthus annuus* L.) like plant height (144.9 cm) and head diameter (25.29 cm) over control (135.3 cm and 19.56 cm, respectively).

Ekram *et al.* (2010) indicated that application of 50% RDN + bio-fertilizers (Azotobacter, Azospirillum, PSB and Trichoderma) recorded significantly increased plant height (71.4 cm), no. of leaf per plant (145.4), no. of branches per plant (30.8) and total dry matter production (122.4 g/plant) of Indian mustard (*Brassica juncea* L.) as compared to other treatments.

Yadav *et al.* (2010) noticed that significantly increased plant height, no. of primary branches per plant and no. of secondary branches per plant at 90 DAS were recorded under application of sulphur @ 40 kg/ha + inoculation with Azotobacter @ 200 g/10 kg of seed to Indian mustard (*Brassica juncea* L.).

Zehra and Ekin (2010) revealed that application of 100 kg/ha P_2O_5 + PSB as seed treatment 10ml/kg seed of sunflower (*Helianthus annus* L.) recorded significantly

higher plant height (168.1 cm), stem diameter (3.04 cm) and head diameter (27.1 cm) as compared to control (160.9 cm, 2.33 cm and 20.2 cm, respectively).

Patil *et al.* (2009) reported that (50:50:00 NPK kg/ha) + Azotobacter (as seed treatment) + PSB (as soil application) was recorded higher capitula per plant (16.37) of safflower (*Carthamus tinctorius* L.) as compared to control.

Yasari and Patwardhan (2007) found that 100% RDF + seed treated with Azotobacter and Azosprillum helped to increase the Leaf Area (cm^2) Index (5.06) and Crop Growth Rate (18.3 g/m^2/day) of Canola (*Brassica napus* L.) over the control.

Sudhakar and Rani (2003) observed that application of 50% nitrogen + seed inoculation Azotobacter @ 10 ml/kg seed to safflower (*Carthamus tinctorius* L.) recorded highest plant height (79 cm) and no. of branches per plant (17) at 90 DAS as compared to control (64 cm and 11, respectively).

2.2.2 Yield and Yield attributes

Lim (2016) conducted a field experiment to find out the yield responses to increasing rates of organic fertilizer for mustard. The optimum rate of poultry manure was 29.1 t/ha and the yield obtained was 17.9 t/ha. The optimum rate of poultry manure was 46.6 t/ha and the yield obtained was 21.2 t/ha.

Solanki *et al.* (2015) reported that application of phosphorus 50 kg/ha + sulphur 50 kg/ha + seed inoculation with PSB to Indian mustard (*Brassica juncea* L.)

significantly increased seed yield (19.75 q/ha) and stover yield (50.45 q/ha) as compared to other treatments.

Bera *et al.* (2014) observed that inoculation of Azotobacter + PSB + VAM to sunflower (*Helianthus annus* L.) recorded significantly increased 100 seed wt. (5.33g), diameter of thalamus (15.25 cm), seed yield (3225 kg/ha) and stalk yield (7544 kg/ha) over control (4.70 g, 11.20 cm, 1969 kg/ha and 5929 kg/ha, respectively).

Bodkhe *et al.* (2014) revealed that highest seed yield (1340 Kg/ha) of safflower (*Carthamus tinctorius* L.) was significantly improved with combinedapplication of 100%NPK with dual inoculation of biofertilizers (Azotobacter + PSB) as compared to single inoculation of bioinoculant either of Azotobacter or PSB as well as fertilizers alone.

Mahboobeh and Jahanfar (2012) indicated that significantly higher no. of siliqua per plant (76.3), no. of seed per siliqua (20.88), test wt. (2.7 g) and seed yield (2195 kg/ha) of canola (*Brassica napus* L.) under 100% RDF + Azotobacter inoculation as compared to non-inoculation (75.8, 19.88, 2.1 g and 2080 kg/ha, respectively).

Premi *et al.* (2012) noticed that significantly higher no. of siliqua per plant (192), no. of seed per siliqua (14.1), test wt. (5.7 g), seed yield (1696 kg/ha) and stover yield (4564 kg/ha) of Indian mustard (*Brassica juncea* L.) due to phosphorus solubilizing bacteria (PSB) over non-inoculation with PSB. The seed yield was increased by 5.5 % due to PSB inoculation.

Dhanasekar and Dhandapani (2012) found that bio-fertilizers (Azotobacter, Azospirillum, Phosphobacter and Rhizobacter) treated with seeds of hybrid sunflower (*Helianthus annuus* L.) showed increase yield 90% in TCSH-1 and 65% in SSH-48 hybrids over control.

Abas and Sidat (2011) revealed that application of 60 kg/ha N + inoculation with Azotobacter @10 ml/kg seed of safflower (*Carthamus tinctorius* L.) was recorded significantly higher seed yield (1257.7 kg/ha) over control (801.1 kg/ha).

Akbari *et al.* (2011) reported that significantly higher seed yield (2823.3 kg/ha) and stolk yield (9917.9 kg/ha) was obtained under application of 50 kg/ha nitrogen + Azotobacter + Azospirillum to sunflower (*Helianthus annus* L.).

Ekram *et al.* (2010) reported that application of 50% RDN + bio-fertilizers (Azotobacter, Azospirillum, PSB and Trichoderma) recorded significantly increased seed yield (1338.9 kg/ha) and stover yield (2840.2 kg/ha) of Indian mustard (*Brassica juncea* L.) as compared to other treatments.

Yadav *et al.* (2010) noticed that application of sulphur @ 40 kg/ha + inoculation with Azotobacter @ 200 g/10 kg seed of Indian mustard (*Brassica juncea* L.) recorded significantly higher no. of siliqua per plant (173.1), no. of seed per siliqua (11.22), test wt. (4.1 g) and seed yield (1933 kg/ha) as compared to other treatments.

Zehra and Ekin (2010) observed that application of 100 kg/ha P_2O_5 + PSB as seed treatment 10ml/kg seed of sunflower (*Helianthus annus* L.) recorded significantly

higher no. of filled seed per head (1045.6), 100 seed wt. (7.1 g) and seed yield (5.08 t/ha) over control (950.12, 70.3 g and 3.90 t/ha, respectively).

Patil *et al.* (2009) indicated that (50:50:00 NPK kg/ha) + Azotobacter (as seed treatment) + PSB (as soil application) recorded higher seed yield per plant (26.70 g), seed yield (14.09 q/ha) and harvest index (17.88 %) of safflower (*Carthamus tinctorius* L.).

Prasad and Akhuri (2009) noticed that application of 50% nitrogen + Azotobacter seed treatment @ 10 ml/kg seed of sunflower (*Helianthus annus* L.)recorded significantly higher seed yield (1646 kg/ha) as compared to control (785kg/ha).

Yasari and Patwardhan (2007) found that 100% RDF + seed treated with Azotobacter and Azosprillum helped to increase the yield of canola (*Brassica napus* L.) by 21.17% over the control, raised the no. of siliqua per plant 16.05 %, no. of branches per plant 11.78 % and test wt. 2.93 %.

Zamil *et al.* (2004) a pot experiment was carried out to find out the effects of different animal manure on yield, quality and nutrient uptake by mustard cv. Agrani. The experiment comprised of two levels of cage system poultry manure, deep litter system poultry manure, cow dung and bio-gas slurry viz. 10 and 20 ton ha-1, one control and one chemical fertilizer @ recommended dose. Cage system poultry manure @ 20 ton ha-1 significantly increased the seed and straw yield of mustard and cow dung showed lower performance. In straw and seed the highest uptake of N, P, K, Ca, Mg and S was obtained from cage system poultry manure

@ 20 ton ha^{-1}. The overall results suggest that cage system poultry manure @ 20 ton ha-1 gave best performance among the parameters studied.

Sudhakar and Rani (2003) observed that application of 50% nitrogen + seed inoculation Azotobacter @ 10 ml/kg seed to safflower (*Carthamus tinctorius* L.) recorded highest no. of capitula per plant (34), no. of seed per capitula (26) and seed yield (877 kg/ha) over control (23, 17 and 554 kg/ha, respectively).

2.2.3 Quality parameters

Bera *et al.* (2014) noticed that inoculation of Azotobacter + PSB + VAM to sunflower (*Helianthus annus* L.) recorded significantly increased oil content (48.4%) as compared to control (42.5%).

Meena *et al.* (2014) revealed that highest oil content (43.98%) and oil yield(1085 kg/ha) were recorded under application of 100 % NPK + seed inoculation with Azotobacter + PSB each 10 ml/kg seed of Indian mustard (*Brassica juncea* L.).

Mahboobeh and Jahanfar (2012) reported that significantly increased oil content and oil yield of canola (*Brassica napus* L.) obtained due to 100% RDF + Azotobacter inoculation as compared to other treatments.

Abas and Sidat (2011) found that application of nitrogen 60 kg/ha + inoculation with Azotobacter @ 10 ml/kg seed of safflower (*Carthamus tinctorius* L.) recorded significantly higher oil content (27.7 %) and protein content (16.6%) as compared to control (24.8% and 14.8%, respectively).

Akbari *et al.* (2011) observed that oil content (49.5%) and protein content (20.2%) obtained with application of 50 kg/ha nitrogen + Azotobacter + Azospirillum to sunflower (*Helianthus annus* L.).

Ekram *et al.* (2010) indicated that application of 50 % RDN + bio-fertilizers (Azotobacter, Azospirillum, PSB and Trichoderma) recorded significantly increased oil content (44.4 %) and protein content (25.5 %) of Indian mustard (*Brassica juncea* L.) as compared to other treatments.

Yadav *et al.* (2010) revealed that that application of sulphur @ 40 kg/ha + inoculation with Azotobacter @ 200 g/10 kg seed of Indian mustard (*Brassica juncea* L.) produced the highest oil content (42.34 %) as compared to control.

Zehra and Ekin (2010) observed that application of 100 kg/ha P_2O_5 + PSB as seed treatment 10 ml/kg seed of sunflower (*Helianthus annus* L.) recorded significantly higher oil yield (2.12 t/ha) as compared to control (1.38 t/ha).

Yasari and Patwardhan (2007) noticed that application of 100% RDF + seed treated with Azotobacter and Azosprillum of canola (*Brassica napus* L.) recorded higher oil content (45.13 %) as compared to control.

2.2.4 Nutrient content and uptake

Solanki *et al.* (2015) reported that application of phosphorus 50 kg/ha + sulphur 50 kg/ha + seed inoculation with PSB to Indian mustard (*Brassica juncea* L.) were showed total available nitrogen (254.56 kg/ha), phosphorus (37.43 kg/ha), potassium (338.34 kg/ha) and sulphur (15.49 kg/ha) in soil after harvest of crop.

Bodkhe *et al.* (2014) revealed that nutrient uptake nitrogen, phosphorus, potassium and sulphur by safflower (*Carthamus tinctorius* L.) were recorded significantly improved with combined application of 100%NPK with dual inoculation of bio-fertilizers (Azotobacter + PSB) as compared to single inoculation of bio-inoculant either of Azotobacter or PSB as well as fertilizers alone.

Premi *et al.* (2012) noticed that significantly increased total phosphorus uptake by Indian mustard (*Brassica juncea* L.) was obtained due to phosphorus solubilizing bacteria (PSB) inoculation. Total phosphorus uptake increased 13.2% over non-inoculation.

Lal and Singh (2010) indicated that highest N and P uptake by seed and stalk of sunflower (*Helianthus annuus* L.) were recorded under application of 100 NPK + seed inoculation with Azotobacter & PSB (each 10 ml/kg seed).

Yadav *et al.* (2010) noticed that the soil samples collected after harvest of Indian mustard (*Brassica juncea* L.) showed the slight decrease in pH and EC and increase in organic carbon, available nitrogen, phosphorus, potassium and sulphur were recorded by the application of sulphur @ 40 kg/ha + inoculation with Azotobacter @ 200 g/10 kg seed.

Sharma *et al.* (2009) observed that highest N, P & K uptake (83, 25.30 and 109 kg/ha, respectively) by safflower (*Carthamus tinctorius* L.) were recorded under 100% NPK + seed inoculation with Azotobacter & PSB over control.

Natanje *et al.* (2003) found that highest nitrogen & phosphorus contain in seed and stover as well as uptake by Indian mustard (*Brassica juncea* L.) was obtained under treatment seed inoculation with Azotobacter & PSB over control.

2.3 Combined effect of organic manures and bio-fertilizers

Khadtare *et al.* (2016) observed that significantly increased no. of capitula per plant (29.5), test wt. (547 g), seed yield (1094 kg/ha), and biological yield (3985 with Azotobacter as compared to control (17.3, 4.14 g, 776 kg/ha and 3038 kg/ha, respectively).

Jebarathnam and Sumalatha (2014) observed that significantly higher plant height at harvest, stem diameter at 70 DAS, head diameter at harvest, seed yield and stalk yield of sunflower (*Helianthus annus* L.) were recorded under application of 100% RDF + vermicompost @ 2.5 t/ha + seed inoculation with Azotobacter & PSB over control.

Singh *et al*. (2014) noticed that effect of three levels of FYM (0, 2.5 & 5.0 t/ha) with two bio-fertilizers (Azotobactor and Azospirillum) @ 4.0 Kg/ha each and three levels of N (0, 40 & 80 kg/ha) on Indian mustard (*Brassica juncia* L.), cv. RH. The yield attributes and seed as well as stover yield increased significantly with the application of FYM (5.0 t/ha) over control. Seed inoculation with either of the bacteria significantly increased the no. of branches per plant, no. of siliqua per plant, no. of seed per siliqua, seed and stover yield. Integrated use of bio-fertilizers, FYM with 40 Kg of nitrogen gave seed yield equal to the 80 kg N/ha

alone. Maximum seed yield was obtained in the use of higher doses of N fertilizer in conjunctions with bio-fertilizers (Azotobactor and Azospirillum) and FYM.

Rundala *et al*. (2013) revealed that different fertility levels had significant effect on all the growth parameters (Plant height and dry matter accumulation per plant), yield attributes (no. of branches per plant, no. of siliqua per plant, no. of seeds per siliqua and test wt.), yield (seed and stover) of Indian mustard. The maximum values of these parameters were recorded under application of 75% RDF through FYM + 25% through fertilizers being at par with 50% RDF through FYM + 50% through fertilizers except stover yield which was at par with 100% RDF through FYM significantly superior to rest of the treatments. Results further indicated that dual inoculation with Azotobacter + PSB significantly increased plant height, dry matter accumulation per plant, no. of branches per plant, no. of siliqua per plant, no. of seeds per siliqua, test wt., seed and stover yield over control.

Tripathi *et al*. (2011) reported that an application of 100 % RDF + FYM @ 2 t/ha + S @ 40 kg/ha + $ZnSO_4$ @ 25 kg/ha + B @ 1 kg/ha with seed inoculation Azotobacter @ 10 ml/kg seed were resulted in maximum plant height, dry matter accumulation, total branches per plant, no. of siliqua per plant, no. of seeds per siliqua, test wt. and seed yield of Indian mustard. Nutrient concentration in terms of N, P, K, S, Zn and B content in seed and stover were significantly higher at 100% recommended dose of fertilizers and increased significantly at both the fertility levels with each successive addition of FYM, S, Zn, B and Azotobacter.

Mishra *et al.* (2010) noticed that significantly higher oil content, protein content, nitrogen , phosphorus and potassium content and uptake by Indian mustard (*Brassica juncea* L.) were recorded under application of 100 % RDF + FYM @ 5.0 t/ha + seed inoculation with Azotobacter as compared to rest of treatments.

Haque (2010) reported that Seed yield per plant was increased by 5.34% when mustard plants were fertilized with 50% NPK along with 50% BioF/compost over the recommended dose of NPK fertilizer application. In contrast, only 7.3 and 6.62% decreased seed yields per plant were observed when mustard plants fertilized with BioF/compost and 75% BioF/compost along with 25% NPK fertilizer over the recommended dose of NPK fertilizer, respectively. Thus, there is a scope of using *Trichoderma-enrich* biofertilizer for higher yield, reduced cultivation cost and environmental pollution.

Datta *et al.* (2009) revealed that significantly increased plant growth, yield and quality characters like plant population (172 /m^2 at 90 DAS), crop growth rate (1.37 g/ m^2/day at 70 DAS), leaf area (cm^2) index (1.70 at 70 DAS), no. of seed per siliqua (25.14), test wt. (4.86 g) and seed yield (10.60 t/ha) were recorded under application of 75% RDF + FYM @ 5.0 t/ha + seed inoculation with Azotobacter @ 10 ml/kg seed of Yellow sarson (*Brassica campestries*) as compared to other treatments.

Kadu and Ismail (2008) reported that highest uptake of nitrogen (59.44 kg/ha), phosphorus (20.52 kg/ha) and potassium (85.62 kg/ha) by safflower with application of full NPK (60-40-00 kg/ha) + vermicompost @ 5.0 t/ha + seed

inoculation (Azotobacter & PSB) as compared to NPK or organics alone on vertisol at Parbhani.

Sharma and Jain (2008) found that the seed yield (22.96 q/ha) was significantly higher with integrated use of 50% NPK through fertilizers + FYM @ 5.0 t/ha + PSB @ 200g/kg seed followed by 50% NPK + FYM @ 5.0 t/ha seed yield (22.65 q/ha) of Indian mustard (*Brassica juncea* L.) as compared to inorganic fertilizers alone or in combination with bio-fertilizers. The highest gross and net returns were also obtained with the application of 50% NPK through fertilizers + FYM @ 5.0 t/ha + PSB @ 200g/kg seed.

Basak N. C. *et al. (*2006) to evaluate different nutrient management packages for the Mustard- Boro rice- T. Aman rice cropping system. An integrated nutrient management package (IPNS) where cowdung @ 10 t/ha was applied along with chemical fertilizers for high yield goal level and the cropping pattern based fertilizer recommendation for MYG on AEZ basis (FRG'97) included. The results showed that the IPNS treatment gave better yield performance of mustard, Boro and T. Aman rice followed by soil test based fertilizer dose for high yield goal (ED2). The IPNS treatment also gave the highest gross return (Tk. 118960/ha) and gross margin (Tk. 105556/ha) while the highest MBCR (5.73) was obtained with FRG'97.

Singh and Singh (2006) studied the response of Indian mustard (*Brassicajuncea* L.) to FYM @ (2.5 and 5.0 t/ha) + inorganic N @ (0, 40 and 80 kg/ha) in combination with bio-fertilizers (*Azotobacter chroococcum* and *Azospirillum*).

They found that no. of branches per plant, no. of siliqua per plant, no. of seeds per siliqua, test wt., oil content, seed yield and stover yield significantly increased with the application of FYM @ 5.0 t/ha + *Azotobacter chroococcum* @ 10 ml/kg seed + *Azospirillum* spp. @ 10 ml/kg seed over the control.

Choudhary *et al.* (2006) observed that highest plant height (158cm), no. of primary branches per plant (6.45), no. of secondary branches per plant (13.47), no. of siliqua per plant (151.97), no. of seed per siliqua (14.53), test wt. (5.44 g), seed yield (24.54 q/ha) and stover yield (49.24) of Indian mustard (*Brassica juncea* L.) were recorded under application of 100 % RDF + FYM @ 5.0 t/ha + seed inoculation with Azotobacter & PSB each 10 ml/kg seed.

Nandhagopal *et al*. (2003) application of 100% N + 100% P as enriched FYM in conjunction with Azospirillum and PSB inoculation produced highest seed yield, stalk yield and oil content. This treatment combination registered the highest values for most of the growth and yield attributes. The data revealed that application of recommended levels of N (75 kg/ha) and P (90 kg/ha) in combination with bio-fertilizers (*Azospirillum* and PSB) produced the highest seed yield (2211 kg/ha) and stalk yield (3554 kg/ha) of sunflower hybrid (MSFH-17).

CHAPTER III

MATERIALS AND METHODS

The pot experiment was conducted to study the effect of different doses of compost and fertilizers yield of BINA Sarisha-4 and BARI Sarisha-15. The experiment was conducted at research field and laboratory in the Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of December, 2017 to May, 2018. Details of the methodology of the experiment followed during the research period are presented in this chapter.

3.1 Experimental site and soil

The experimental site was located at 25° 38” and 88°41” E longitude and at the elevation of 34.5 m in above the sea level .The experimental field was medium high land, sandy loam textured soil belonging to agro ecological zone 1 (AEZ 1) named old Himalayan piedmont. Plain (FAQ and UNDP 1988). The soil was sandy loam and fertility status of the soil is presented

3.2 Climate and Weather

The experimental area was under subtropical climate characterized by winter the month of December, 2017 to May, 2018. The mean of meteorological parameter, like precipitation, relative humidity, air temperature, day length and sunshine hours of the experimental site during the crop growing period.

3.3 Experimental design and layout

The experiment was laid out in a two factors randomized complete block design (RCBD) with three replications. The experiment pot were divided into three blocks where each block represent a replication. Each block then divided into eight pot.

3.4 Treatments of the experiment

The experiment comprised of two sets of factors such as

Factor A: Two Verities

V_1 = BINA Sarisha-4

V_2 = BARI Sarisha-15

Factor B: levels of fertilization

T_1 : Control (Recommended dose) (Urea 2.5 g, TSP 1.35 g, MoP 0.75 g, Gypsum 1.13 g per pot)

T_2 : Compost (10 ton/ha) poultry litter based compost

T_3 : Compost (20 ton/ha) poultry litter based compost

T_4 : Compost (30 ton/ha) poultry litter based compost

3.5 Experimental material

The two recommended high yielding varieties of mustard of BARI Sarisha-15 and BINA Sarisha-4 were used in experiment. BARI Sarisha-15 variety were

developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and BINA Sarisha-4 were developed by Bangladesh Institute of Nuclear Agriculture *(*BINA), Mymensingh.

BARI Sarisha-15: This variety is under the group of *B. campestris*. Plant height is about 90-100 cm. Leaf of this variety light yellow and smooth. Its secondary branches is low. The color of its flowers is white. Seed color is yellow with a 42-43% oil content. The duration in the field is between 80 and 85 days. The yield of varies was reported from 1.55 to 1.65 t/ha which is a 20-25% higher yield than Tori-7.

3.6 Soil sample collection and Pot preparation

Soil was collected from the arable land of Crop physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University, Dinajpur from a depth of l5 cm. The collected soil was sundried for a week and weeds were removed. Fifteen kilogram soil was taken into each pot. Thus the pots were ready for planting.

3.7 Setting of pots for the experiment

The pots were placed in the selected space of Research Field of Crop physiology and Ecology HSTU, Dinajpur in 4 rows and 6 columns. The row to row and column to column distance was maintained properly. Pot size is diameter 1feet and depth 1feet.

3.8 Manuring and fertilization

The entire quantity of poultry litter based compost was applied just after opening the land and . Treatments were T_1= control (Urea 2.5 g, TSP 1.35 g, MOP 0.75 g, Gypsum 1.13 g per pot), T_2 = 10 ton/ha of compost , T_3 = 20 ton/ha of compost, T_4 =, 30 ton/ha of compost.

3.9 Chemical Compositions of Poultry litter based Compost

N-1.6%, P-1.21%, K-0.35% (Kobra, 2016 and Alam, 2017).

3.10 Sowing of seed

The seeds were sown in pot as per treatment on 11 December 2017 by hand uniformly as par as practicable @ of 7 kg ha^{-1}. After sowing the seeds were covered with soil by hand. The spacing between line to line was 20 cm and plant to plant was 5 cm. Five plants was selected each pot.

3.11 Intercultural Operations

Intercultural operations were done to ensure normal growth of the crop. The following intercultural operations were done.

3.12 Irrigation

Necessary irrigations were provided to the pots when required during the growing period of mustard crop. About ten to twelve irrigation were done.

3.13 Weeding

The pots were infested with some common weeds, which were removed by uprooting them from the field when needed during the period of the cropping season. Weeding were done about three time in mustard plant pots experiment.

3.14 Insect and Pest Control

Plants were infested with Aphid which were successfully controlled by proper observation.

3.15 Plant Protection Measures

Crop was protected from birds, rats and rain water during the cropping season period by a plastic shade and visual portion observation. To control the birds visual pro was done properly, especially during morning and afternoon.

3.16 Harvesting and processing

The crop was harvested pot wise at maturity when 90% siliqua were matured. Following sample collect, harvesting was done. The harvested plants were tied into bundles and carried to the threshing floor. The plants were sun dried by spreading the bundles on the threshing floor. The seeds were separated from the stover by hand. Per pot yields of seed and straw were recorded after drying the plants in the sun followed by threshing and cleaning.

3.17 Sampling and data collection

Five plants from each pot were selected random and tagged for the data collection. Data on growth were collected from sowing to maturity and yield and yield contributing data were collected after harvest. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and stover yield per pot were recorded after cleaning and drying plants in the sun. Data were collected on the following parameters.

3.18 Phenological parameters

Following phenological parameters were recorded-

i) Days to first flowering: Days to when first flowering start.

ii) Days to 50% flowering: Days when 50% plants completed flowering.

iii) Maturity stage: The number of days from sowing to maturity was determined by visually when whole plant becomes yellowish brown.

3.19 Morphological parameters

a) Leaf number

1. Five plants were tagged for data collection.

2. From these tagged plant data on number of leaf /plant was counted with an interval of 15 days, starting from 30 days and continued upto 60 days viz.

b) Plant height (cm)

The plants height was taken at 15, 30, 45, 60 and 75 days after sowing were measured from the base of the plant to the tip of the main stem and mean value of the plants height were recorded.

c) Branch number

Branch number was counted at 65 days from five plants. Those plants were tagged for data collection.

d) Leaf area (cm^2)

Leaf area per plant was measured by a digital leaf area meter (Model: Cl 202, USA). For data collection 5th leaf from the top of plant was selected. Data were

collected at 15 days interval. Average leaf area plant^{-1} was calculated and presented.

3.20 Yield and yield contributing characters

a) Number of siliqua plant^{-1}

Siliqua of five randomly selected plants of each pot were counted and then the average number of siliqua for each plant was determined.

b) Length of siliqua plant^{-1}

Length of siliqua was recorded from the base to the apex of each siliqua from randomly selected 5 siliqua from each pot and then means value was calculated.

c) Number of seeds in siliqua plant^{-1}

After shedding of the siliqua the numbers of seeds from each siliqua and finally mean value was recorded.

d) 1000 seed weight

One thousand clean sun-dried seeds were counted from the seed stock obtained from the sample plants and weight by electronic balance and expressed in gram (g).

e) Seed yield (t ha^{-1})

Total mustard plants were collected from pre-selected area of each pot. The plants were cut, threshed and dried. The dried seeds were weighed. Then the weighed

seed yield was converted to t ha^{-1}. Mustard is considered to be dry at 12 percent seed moisture.

g) Stover yield (t ha^{-1})

After threshing the seed, the straw of pot plants were properly sundried from hour and the values were expressed per unit basis.

H) Harvest index

Harvest index (HI) denotes the ratio of economic yield to biological yield (express in percentage) and was calculated with the following formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (t ha}^{-1})}{\text{Biological yield (t ha}^{-1})} \times 100$$

3.21 Statistical analysis

The collected data were analyzed using the computer package program MSTAT and the significance of the mean differences was adjudged by the "Duncan's Multiple Range Test" (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Phenological Parameters

4.1.1 Plant height at 15 DAS

The effects of poultry litter based composts on plant height at different days after sowing (DAS) were statistically significant (Table 1). The highest value was observed in BINA Sarisha-4 (11.52 cm) and the lowest value was observed in BARI Sarisha-15 (11.11 cm). Plant height was significantly influenced by the different doses of poultry litter composts. The highest value observed in T_3 (12.3 cm) treatment and the lowest in T_1 (10.33 cm) treatment. Sood *et al.* (2015), Lepcha *et al.* (2015), *Parihar et al.* (2014) and Yadav *et al.* (2013) also found similar results in mustard .

The plant height was significantly influenced by the combined effect of variety at dose of compost. The highest value was observed in V_1T_3 (12.74 cm) which was followed by V_2T_4 (12.23 cm) and the lowest value was in V_2T_4 (10.03 cm) treatment combination. Parihar *et al*. (2014) and Yadav *et al*. (2013) also found similar results in mustard.

4.1.2 Plant height at 30 DAS

The effects of poultry litter based composts on plant height at different days after sowing (DAS) were statistically significant (Table 1). The highest value was observed in BINA Sarisha-4 (34.81 cm) and the lowest value was observed in

BARI Sarisha-15 (33.92 cm). Plant height was significantly influenced by the different does of poultry litter composts. The highest value observed in T_3 (36.97 cm) treatment and the lowest in T_1 (32.98 cm) treatment. Parihar *et al*. (2014) and Yadav *et al*. (2013) also found similar results in mustard plant.

The combined effect of variety and compost was significantly influenced the plant height. The highest value was observed in V_1T_3 (37.78 cm) which was followed by V_2T_3 (36.15 cm) and the lowest value was in V_2T_1 (32.08 cm) treatment combination. Parihar *et al*. (2014) and Yadav *et al*. (2013) also found similar results.

4.1.3 Plant height at 45 DAS

The effects of poultry litter based composts on plant height at different days after sowing (DAS) were statistically significant (Table 1). The highest value was observed in BINA Sarisha-4 (61.34 cm) and the lowest value was observed in BARI Sarisha-15 (55.64 cm). Plant height was significantly influenced by the different does of poultry litter composts. The highest value observed in T_3 (61.15 cm) treatment and the lowest in T_1 (54.08 cm) treatment. Parihar *et al*. (2014) and Yadav *et al*. (2013) also found similar results in mustard plant.

The combined effect of variety and compost was significantly influenced the plant height. The value was observed in V_1T_3 (64.11 cm) which was followed by V_1T_4 (63.26 cm) and the lowest value was in V_2T_1 (50.49 cm) treatment combination. Parihar *et al*. (2014) and Yadav *et al*. (2013) also found similar results in mustard plant.

Table 1: Effect of poultry litter based compost on the plant height of mustard varieties

Variety	Plant height (cm) at 15 DAS	Plant height (cm) at 30 DAS	Plant height (cm) at 45 DAS	Plant height (cm) at 60 DAS	Plant height (cm) at 75 DAS
BINA Sarisha-4 (V1)	11.52 a	34.81 a	61.34 a	86.63 a	98.98 a
BARI Sarisha -15 (V2)	11.11 b	33.92 b	55.64 b	83.98 b	93.86 b
Significance level	*	*	*	**	*
Dose of poultry based compost					
T_1	10.33 d	32.38 c	54.80 d	80.12 d	90.31 d
T_2	10.69 c	33.03 d	57.08 c	83.46 c	93.76 c
T_3	12.3 a	36.97 a	61.15 a	88.84 a	100.83 a
T_4	11.98 b	35.10 b	60.94 b	88.80 b	100.77 b
Significance level	*	*	*	*	**
Interaction effect of varieties to dose of compost					
V_1T_1	10.63 f	32.66 g	57.59 f	80.94 g	92.94 f
V_1T_2	11.01 e	33.32 e	60.00 c	84.32 e	96.18 e
V_1T_3	12.74 a	37.78 a	64.51 a	91.54 a	104.47 a
V_1T_4	11.72 d	35.50 c	63.26 b	89.71 b	102.32 b
V_2T_1	10.03 h	32.08 h	50.99 h	79.29 h	87.69 h
V_2T_2	10.35 g	32.74 f	54.16 g	82.6 f	91.34 g
V_2T_3	11.86 c	36.15 b	57.80 e	86.14 d	97.19 d
V_2T_4	12.23 b	34.70 d	58.62 d	87.88 c	99.22 c
Significance level	*	*	**	*	*
CV(%)	8.76	8.98	7.67	11.33	9.96

T_1 : Control (Recommended dose) (Urea 2.5 g, TSP 1.35 g, MoP 0.75 g, Gypsum 1.13 g per pot)

T_2 : Compost (10 ton/ha) poultry litter based compost

T_3 : Compost (20 ton/ha) poultry litter based compost

T_4 : Compost (30 ton/ha) poultry litter based compost

*= 5% level of significance, **= 1% level of significance.

4.1.4 Plant height at 60 DAS

The effects of poultry litter based composts on plant height at different days after sowing (DAS) were statistically significant (Table 1). The highest plant height was observed in BINA Sarisha-4 (86.63 cm) and the lowest value was observed in BARI Sarisha-15 (83.98 cm). Plant height was significantly influenced by the different does of poultry litter composts. The highest plant highest was observed in T_3 (88.84 cm) treatment and the lowest one was in T_1 (80.12 cm) treatment. Parihar *et al*. (2014) and Yadav *et al*. (2013) also found similar results in mustard plant.

The combined effect of variety and compost was significantly influenced the plant height. The value was observed in V_1T_3 (91.54 cm) which was followed by V_1T_4 (89.71 cm) and the lowest value was in V_2T_1 (79.29 cm) treatment combination. Parihar *et al*. (2014) and Yadav *et al*. (2013) also found similar results in mustard plant.

4.1.5 Plant height at 75 DAS

The effects of poultry litter based composts on plant height at different days after sowing (DAS) were statistically significant (Table 1). The highest height was observed in BINA Sarisha-4 (98.98 cm) and the lowest one was observed in BARI Sarisha-15 (93.86 cm). Plant height was significantly influenced by the different does of poultry litter composts. The highest height was observed in T_3 (100.83 cm) treatment and the lowest one in T_1 (90.31 cm) treatment. Parihar *et al*. (2014) and Yadav *et al.* (2013) also found similar results in mustard plant.

The combined effect of variety and compost was significantly influenced the plant height. The highest value was observed in V_1T_3 (104.47) which was followed by V_1T_4 (102.32) and the lowest one was in V_2T_1 (87.69). Parihar *et al*. (2014) and Yadav *et al*. (2013) also found similar results in mustard plant.

4.1.6 Number of leaf at 15 DAS

Poultry litter based composts supported the number of leaf after different days of sowing (DAS) which were statistically significant (Table 2). The highest leaf number per plant was observed in BINA Sarisha-4 (5.78) and the lowest leaf number per plant was observed in BARI Sarisha-15 (5.28). Number of leaf per plant was significantly influenced by compost application. The highest value observed in T_3 (6.05) treatment and the lowest in T_1 (5.16) treatment. Byrareddy *et al.* (2008) and Naik *et al.* (2007) also found similar results in mustard plant.

Number of leaf per plant was significantly influenced by the interaction effect of variety and dose of compost. The highest number of leaf was observed in V_1T_3 (6.33) treatment combination and the lowest one was in V_2T_1 (5.11). Byrareddy *et al*. (2008) and Naik *et al.* (2007) also found similar results in mustard plant.

4.1.7 Number of leaf at 30 DAS

The effects of poultry litter based composts on number of leaf at different days after sowing (DAS) were statistically significant (Table 2). The highest leaf number per plant was observed in BINA Sarisha- 4 (10.78) and the lowest leaf number per plant was observed in BARI Sarisha-15 (10.13). Number of leaf per plant was significantly influenced by compost application. The highest value

observed in T_3 (11.66) treatment and the lowest in T_1 (9.22) treatment. Byrareddy *et al.* (2008) and Naiket *et al*. (2007) also found similar results in mustard.

Number of leaf per plant was significantly influenced by the interaction effect of variety and compost. The highest value was observed in V_1T_3 (11.78) treatment combination and the lowest value in V_2T_1 (8.99) treatment combination. Byrareddy *et al*. (2008) and Naik *et al*. (2007) also found similar results in mustard.

4.1.8 Number of leaf at 45 DAS

The effects of poultry litter based composts on number of leaf at different days after sowing (DAS) were statistically significant (Table 2). The highest leaf number per plant was observed in BINA Sarisha-4 (18.91) and the lowest leaf number per plant was observed in BARI Sarisha-15 (16.97).Number of leaf per plant was significantly influenced by poultry litter based compost application. The highest leaf number was observed in T_4 (19.67) treatment and the lowest in T_1 (15.38) treatment. Byrareddy *et al*. (2008) and Naik *et al*. (2007) also found similar results in mustard.

Number of leaf per plant was significantly influenced by the interaction effect of variety and compost. The highest value was observed in V_1T_3 (21.10) treatment combination and the lowest value in V_2T_1 (14.33) treatment combination. Byrareddy *et al*. (2008) and Naik *et al*. (2007) also found similar results in mustard.

Table 2: Effect of poultry based compost on the number in leaf of mustard

Variety	Number of leaf at 15 DAS	Number of leaf at 30 DAS	Number of leaf at 45 DAS	Number of leaf at 60 DAS
BINA Sarisha-4 (V1)	5.78 a	10.78 a	18.91 a	23.91 a
BARI Sarisha -15 (V2)	5.28 b	10.13 b	16.97 b	23.07 b
Significance level	*	**	*	*
Dose of poultry based compost				
T_1	5.16 d	9.22 d	15.38 d	20.10 d
T_2	5.38 c	10.27 c	17.38 c	23.16 c
T_3	6.05 a	11.66 a	19.33 b	25.71 a
T_4	5.50 b	10.67 b	19.67 a	24.99 b
Significance level	**	*	*	*
Interaction effect of varieties to dose of compost				
V_1T_1	5.22 e	9.44 g	16.44 g	20.78 g
V_1T_2	5.67 d	10.67 d	17.89 d	23.11 f
V_1T_3	6.33 a	11.78 a	21.10 a	26.33 a
V_1T_4	5.89 b	11.21 c	20.21 b	25.44 b
V_2T_1	5.11 f	8.99 h	14.33 h	19.44 h
V_2T_2	5.11 f	9.89 f	16.89 f	23.22 e
V_2T_3	5.78 c	11.56 b	17.56 e	25.10 c
V_2T_4	5.11 f	10.11 e	19.10 c	24.55 d
Significance level	*	*	*	*
CV (%)	6.87	8.65	7.75	9.34

T_1 : Control (Recommended dose) (Urea 2.5 g, TSP 1.35 g, MoP 0.75 g, Gypsum 1.13 g per pot)

T_2 : Compost (10 ton/ha) poultry litter based compost

T_3 : Compost (20 ton/ha) poultry litter based compost

T_4 : Compost (30 ton/ha) poultry litter based compost

*= 5% level of significance, **= 1% level of significance.

4.1.9 Number of leaf at 60 DAS

The effects of poultry litter based composts on number of leaf at different days after sowing (DAS) were statistically significant (Table 2). The highest one was in BINA Sarisha-4 (23.91) and the lowest leaf number per plant was observed in BARI Sarisha-15 (23.07). Number of leaf per plant was significantly influenced by the dose of compost. The highest number of leaf was observed in T_3 (25.71) treatment and the lowest one was in T_1 (20.10) treatment. Byrareddy *et al*. (2008) and Naik *et al*. (2007) also found similar results in mustard.

Number of leaf per plant was significantly influenced by the interaction effect of variety and compost. The highest value was observed in V_1T_3 (26.33) treatment combination and the lowest value was in V_2T_1 (19.44) treatment combination. Byrareddy *et al*. (2008) and Naik *et al*. (2007) also found similar results in mustard.

4.1.10 Leaf area at 15 DAS

Like other morphological character leaf area per plant was significantly influenced poultry litter based composts after different days sowing (Table 3). The highest leaf area (cm^2) per plant was observed in BINA Sarisha - 4 (2.63) and the lowest one (cm^2) per plant was observed in BARI Sarisha-15 (2.69).

Leaf area (cm^2) per plant was significantly influenced by the interaction effect of variety and compost. The highest area was observed in V_1T_3 (2.73) treatment combination and the lowest one was in V_1T_1 (2.58). Similar results were found by Govindan and Thirumurugan (2005) in mustard area.

4.1.11 Leaf area at 30 DAS

The effects of poultry litter based composts on leaf area (cm^2) after 30 days of sowing (DAS) were statistically significant (Table 3). The highest leaf area (cm^2) per plant was observed in BINA Sarisha- 4 (18.29) and the lowest leaf area (cm^2) per plant was observed in BARI Sarisha-15 (17.87). Leaf area (cm^2) per plant was significantly influenced by compost application. The highest value observed in T_3 (19.28) treatment and the lowest in T_1 (16.87) treatment. Similar results was found by Govindan and Thirumurugan (2005). Leaf area (cm^2) per plant was significantly influenced by the interaction effect of variety and dose of compost. The highest value was observed in V_1T_3 (20.14) treatment combination and the lowest value in V_1T_1 (17.01) treatment combination. Similar results was found by Govindan and Thirumurugan (2005) in mustard plant.

4.1.12 Leaf area at 45 DAS

The effects of poultry litter based composts on leaf area (cm^2) at different days after sowing (DAS) were statistically significant (Table 3). The highest leaf area (cm^2) per plant was observed in BINA Sarisha - 4 (49.67) and the lowest leaf area (cm^2) per plant was observed in BARI Sarisha-15 (48.58). Leaf area (cm^2) per plant was significantly influenced by compost application. The highest value observed in T_3 (51.90) treatment and the lowest in T_1 (45.97) treatment. Similar results was found by Govindan and Thirumurugan (2005). Leaf area (cm^2) per plant was significantly influenced by the interaction effect of variety and dose of compost. The highest leaf area was observed in V_1T_3 (54.74) treatment combination and the lowest one was in V_2T_1 (45.31). Similar results were found by Govindan and Thirumurugan (2005).

Table 3: Effect of poultry litter based compost on the leaf area of mustard varieties.

Variety	Leaf area(cm^2) at 15 DAS	Leaf area(cm^2)at 30 DAS	Leaf area(cm^2) at 45 DAS	Leaf area(cm^2) at 60 DAS
BINA Sarisha-4(V1)	2.63 a	18.29 a	49.67 a	12.10 a
BARI Sarisha -15(V2)	2.59 b	17.87 b	48.58 b	11.14 b
Significance level	*	*	*	*
Dose of poultry based compost				
T_1	2.52 d	16.87 d	45.97 d	10.97 d
T_2	2.58 c	17.29 c	47.10 c	11.24 c
T_3	2.66 b	19.28 a	51.90 a	12.17 a
T_4	2.68 a	18.89 b	51.50 b	12.11 b
Significance level	*	*	*	*
Interaction effect of varieties to dose of compost				
V_1T_1	2.58 e	17.01 f	46.61 f	11.25 e
V_1T_2	2.59 d	17.51 d	47.87 e	11.47 d
V_1T_3	2.73 a	20.14 a	54.74 a	13.32 a
V_1T_4	2.62 c	18.49 c	49.41 c	12.38 b
V_2T_1	2.49 h	16.71 g	45.31 h	10.69 h
V_2T_2	2.56 f	17.06 e	46.33 g	11.01 g
V_2T_3	2.59 d	18.41 d	49.06 d	11.02 f
V_2T_4	2.72 b	19.27 b	53.6 b	11.84 c
Significance level	*	*	**	*
CV(%)	11.23	6.43	7.54	7.67

T_1 : Control (Recommended dose) (Urea 2.5 g, TSP 1.35 g, MoP 0.75 g, Gypsum 1.13 g per pot)

T_2 : Compost (10 ton/ha) poultry litter based compost

T_3 : Compost (20 ton/ha) poultry litter based compost

T_4 : Compost (30 ton/ha) poultry litter based compost

*= 5% level of significance, **= 1% level of significance.

4.1.13 Leaf area at 60 DAS

The effects of poultry litter based composts on leaf area (cm^2) at different days after sowing (DAS) were statistically significant (Table 3). The highest leaf area (cm^2) per plant was observed in BINA Sarisha-4 (12.10) and the lowest leaf area (cm^2) per plant was observed in BARI Sarisha-15 (11.14). Leaf area (cm^2) per plant was significantly influenced by dose of compost. The highest value observed in T_3 (12.17) treatment and the lowest was in T_1 (10.97) treatment. Similar results as found by Govindan and Thirumurugan (2005) in mustard plant.

Leaf area (cm^2) per plant was significantly enhanced by the interaction effect of variety and dose of compost. The highest leaf area was observed in V_1T_3 (13.32) treatment combination and the lowest in V_2T_1 (10.69). Similar results were found by Govindan and Thirumurugan (2005) in mustard plant.

4.1.14 Number of branches at 60 DAS

Number of branches per plant at 60 DAS varied significantly due to influenced of variety (Table 4). The highest number of branches per plant was observed in BINA Sarisha-4 (4.83) and the lowest was observed in BARI Sarisha-15 (4.44). Similarly number of branches per plant was significantly varied by dose of compost applied. The highest value observed in T_3 (5.44) treatment and the lowest in T_1 (3.60) treatment. Badiyala and Kumar (2003), De and Sinha (2012) and Yadav *et al.* (2013) also found the similar results.

Number of branches per plant was also significantly influenced by the interaction effect of variety and dose of compost. The highest value was observed in V_1T_3 (5.78) treatment combination and the lowest value in V_1T_1 (3.78). Badiyala and Kumar (2003), De and Sinha (2012) and Yadav *et al*. (2013) also found the similar results in mustard plant.

Table 4: Effect of compost on the branches and dry weight (g) of mustard varieties at different DAS

Variety	Branches at 65DAS	Dry weight(g) at 15 DAS	Dry weight(g) at 30 DAS	Dry weight(g) at 45 DAS	Dry weight(g)at 60 DAS
BINA Sarisha-4(V1)	4.83 a	.34 a	.89 a	5.02 a	7.39 a
BARI Sarisha-15(V2)	4.44 b	.33 b	.84 b	4.47 b	6.79 b
Significance level	*	*	*	*	*
Dose of poultry based compost					
T_1	3.60 d	.30 d	.73 d	3.74 d	6.09 d
T_2	4.44 c	.31 c	.82 c	4.32 c	6.63 c
T_3	5.44 a	.38 a	.98 a	5.38 b	7.99 a
T_4	5.05 b	.37 b	.93 b	5.54 a	7.64 b
Significance level	**	*	*	*	*
Interaction effect of varieties to dose of compost					
V_1T_1	3.78 g	.30 e	.70 h	4.08 h	6.48 f
V_1T_2	4.44 e	.31 d	.83 e	4.47 e	7.22 e
V_1T_3	5.78 a	.40 a	1.10 a	5.96 a	8.51 a
V_1T_4	5.33 b	.36 c	.90 c	5.58 b	7.36 d
V_2T_1	3.44 f	.29 f	.76 g	3.41 g	5.70 h
V_2T_2	4.44 e	.30 e	.82 f	4.16 f	6.01 g
V_2T_3	5.10 c	.36 c	.86 d	4.82 d	7.48 c
V_2T_4	4.78 d	.38 b	.97 b	5.48 c	7.92 b
Significance level	*	*	*	*	*
CV(%)	6.67	6.78	7.28	6.78	6.89

T_1 : Control (Recommended dose) (Urea 2.5 g, TSP 1.35 g, MoP 0.75 g, Gypsum 1.13 g per pot)T_2 : Compost (10 ton/ha) poultry litter based compost

T_3 : Compost (20 ton/ha) poultry litter based compost

T_4 : Compost (30 ton/ha) poultry litter based compost

*= 5% level of significance, **= 1% level of significance.

4.1.15 Dry weight at 15 DAS

The effects of poultry litter based composts on dry weight (g) at different days after sowing (DAS) were statistically significant (Table 4). The highest dry weight (g) per plant was observed in BINA Sarisha-4 (0.34 g) and the lowest dry weight (g) per plant was observed in BARI Sarisha-15 (0.33 g). Dry weight (g) per plant was significantly influenced by the dose of compost application. The highest value observed in T_3 (0.38 g) treatment and the lowest in T_1 (0.30 g) treatment. Naik *et al*. (2007) also found similar results in mustard plant.

Dry weight (g) per plant was also significantly influenced by the interaction effect of variety and dose of compost. The highest value was observed in V_1T_3 (0.40 g) treatment combination and the lowest value inV_2T_1 (0.29 g). Naik *et al*. (2007) also found similar results in mustard plant in mustard plant.

4.1.16 Dry weight at 30 DAS

The effects of poultry litter based composts on dry weight (g) at different days after sowing (DAS) were statistically significant (Table 4). The highest dry weight (g) per plant was observed in BINA Sarisha-4 (0.89) and the lowest dry weight (g) per plant was observed in BARI Sarisha-15 (0.84). Dry weight (g) per plant was significantly influenced by compost application. The highest value observed in T_3 (0.98 g) treatment and the lowest in T_1 (0.30 g) treatment. Naik *et al*. (2007) also found similar results in mustard plant.

Dry weight (g) per plant was significantly influenced by the interaction effect of variety and dose of compost. The highest value was observed in V_1T_3 (1.10 g)

treatment combination and the lowest value in V_1T_1 (0.70 g). Naik *et al*. (2007) also found similar results in mustard plant.

4.1.17 Dry weight at 45 DAS

The effects of poultry litter based composts on dry weight (g) at different days after sowing (DAS) were statistically significant (Table 4). The highest dry weight (g) per plant was observed in BINA Sarisha-4 (5.02 g) and the lowest dry weight (g) per plant was observed in BARI Sarisha-15 (4.47 g). Dry weight (g) per plant was significantly influenced by compost application. The highest value observed in T_4 (5.54 g) treatment and the lowest in T_1 (3.74) treatment. Naik *et al*. (2007) also found similar results in mustard plant.

Dry weight (g) per plant was significantly influenced by the interaction effect of variety and compost. The highest value was observed in V_1T_3 (5.96 g) treatment combination and the lowest value in V_1T_1 (4.08 g) treatment combination. Naik *et al*. (2007) also found similar results in mustard plant.

4.1.18 Dry weight at 60 DAS

The effects of poultry litter based composts on dry weight (g) at different days after sowing (DAS) were statistically significant (Table 4). The highest dry weight (g) per plant was observed in BINA Sarisha-4 (7.39 g) and the lowest dry weight (g) per plant was observed in BARI Sarisha-15 (6.79 g). Dry weight (g) per plant was significantly influenced by dose of compost application. The highest value observed in T_3 (7.99 g) treatment and the lowest in T_1 (6.09 g) treatment. Naik *et al*. (2007) also found similar results in mustard plant.

Dry weight (g) per plant was significantly influenced by the interaction effect of variety and dose of compost. The highest value was observed in V_1T_3 (8.51 g) treatment combination and the lowest value in V_2T_1 (5.70 g). Naik *et al*. (2007) also found similar results in mustard plant.

4.1.19 Day to first flowering

Days to first flowering was significantly influenced for variety (Table 5). The highest days was observed in BINA Sharisha-4 (30.63) and the lowest days was observed in BARI Sharisha-4 (29.43). Days to first flowering was significantly influenced by compost doses. The highest days was observed in T_1 (31.89) treatment and the lowest in T_3 (28.44) treatment. The interaction effect of variety and compost was significantly influenced the days to first flowering days. The combined effect of V_2T_1 took highest days to first flowering in (32.10), followed by V_1T_1 (31.66) and V_2T_2 (31.21) treatment combination and the lowest in V_1T_3 (27.78) treatment combination.

4.1.20 Days to 50% flowering

Days to 50% flowering was significantly influenced by variety (Table 5). The highest days were observed in BINA Sarisha-4 (41.80) and the lowest days were observed in BARI Sarisha-15 (41.07). Days to50% flowering was significantly influenced by compost doses. The highest days was observed in T_1 (43.78) treatment and the lowest in T_3 (39.27) treatment.

Table 5: Effect of compost on the day to first flowering and day to 50% flowering in mustard varieties.

Variety	Day to first flowering	Day to 50% flowering
BINA Sarisha-4 (V1)	30.63 a	41.80 a
BARI Sarisha-15 (V2)	29.43 b	41.07 b
Significance level	*	*
Dose of poultry based compost		
T_1	31.89 a	43.78 a
T_2	30.49 b	42.21 b
T_3	28.44 d	39.27 d
T_4	29.32 c	40.49 c
Significance level	*	*
Interaction effect of varieties to dose of compost		
V_1T_1	31.66 b	43.55 b
V_1T_2	29.78 e	42.10 d
V_1T_3	27.78 h	38.44 h
V_1T_4	28.55 g	40.21 f
V_2T_1	32.10 a	43.99 a
V_2T_2	31.21 c	42.33 c
V_2T_3	29.10 f	40.10 g
V_2T_4	30.10 d	40.78 e
Significance level	*	*
CV(%)	11.65	7.78

T_1 : Control (Recommended dose) (Urea 2.5 g, TSP 1.35 g, MoP 0.75 g, Gypsum 1.13 g per pot)

T_2 : Compost (10 ton/ha) poultry litter based compost

T_3 : Compost (20 ton/ha) poultry litter based compost

T_4 : Compost (30 ton/ha) poultry litter based compost

*= 5% level of significance, **= 1% level of significance.

The interaction effect of variety and dose of compost was significantly influenced the days to 50% flowering. The highest days of day to 50% flowering in V_2T_1 (43.99) and followed by other treatments like V_1T_1 (43.55) and V_2T_2 (42.33) treatment combination and the lowest days was in V_1T_3 (38.44) treatment.

4.1.21 Number of siliqua per plant

Number of siliqua per plant was varied due to effect of variety and highest dose of poultry litter based composed in mustard production (Table 6). The highest number of siliqua per plant was observed in BINA Sarisha-4 (75.91) and the lowest was observed in BARI Sarisha-15 (71.31). Number of siliqua per plant was significantly influenced by compost application. The highest value observed in T_3 (77.67) treatment and the lowest in T_1 (68.94) treatment. Kansotia *et al.* (2015), Lepcha *et al.* (2015) and Parihar *et al.* (2014) also found similar results in mustard plant.

Number of siliqua per plant was significantly influenced by the interaction effect of variety and compost. The highest value was observed in V_1T_3 (82.89) treatment combination and the lowest value in V_2T_1 (67.10) treatment combination. Kansotia *et al*. (2015), Lepcha *et al*. (2015) and Parihar *et al.* (2014) also observed similar results in mustard plant.

4.1.22 Length of siliqua (cm)

Length of siliqua (cm) was evaluated for poultry litter based composed in mustard production (Table 6). The highest length of siliqua per plant was observed in BINA Sarisha-4 (5.70) and the lowest value was observed in BARI Sarisha-15

(4.60). Number of siliqua per plant was significantly influenced by compost application. The highest value observed in T_4 (5.28) treatment and the lowest in T_1 (4.97) treatment.

Length of siliqua per plant was significantly influenced by the interaction effect of variety and compost. The highest value was observed in V_1T_3 (5.83) treatment combination and the lowest value in V_2T_1 (4.36) treatment combination.

4.1.23 Number of seeds in siliqua per plant

Number of seeds in siliqua per plant was evaluated for poultry litter based composed in mustard production (Table 6). The highest number of seeds in siliqua per plant was observed in BINA Sarisha-4 (27.52) and the lowest value was observed in BARI Sarisha-15 (24.58). Number of seeds in siliqua per plant was significantly influenced by compost application. The highest value observed in T_4 (26.82) treatment followed by T_3 (26.56) and the lowest value in T_1 (25.16) treatment. Kansotia *et al*. (2015), Lepcha *et al*. (2015) and Parihar *et al.* (2014) also found similar results in mustard plant.

Number of seeds in siliqua per plant was significantly influenced by the interaction effect of variety and compost. The highest value was observed in V_1T_3 (28.55) treatment combination and the lowest value in V_2T_1 (24.10) treatment combination. Kansotia *et al*. (2015), Lepcha *et al*. (2015) and Parihar *et al.* (2014) also stated similar results in mustard plant.

Table 6: Effect of poultry litter based compost on the number and length of siliqua and number of seed per plant of mustard varieties at final harvest

Variety	Number of siliqua per plant	Siliqua length (cm)	Number of seed in siliqua per plant
BINA Sarisha-4 (V1)	75.91 a	5.70 a	27.52 a
BARI Sarisha -15 (V2)	71.38 b	4.60 b	24.58 b
Significance level	*	*	*
Dose of poultry based compost			
T_1	68.94 d	4.97 d	25.16 d
T_2	71.99 c	5.10 c	25.66 c
T_3	77.67 a	5.22 b	26.56 b
T_4	75.99 b	5.28 a	26.82 a
Significance level	*	*	*
Interaction effect of varieties to dose of compost			
V_1T_1	70.78 g	5.57 d	26.21 d
V_1T_2	73.10 d	5.64 e	26.89 c
V_1T_3	82.89 a	5.83 a	28.55 a
V_1T_4	76.89 b	5.75 c	28.44 b
V_2T_1	67.10 h	4.36 h	24.10 h
V_2T_2	70.89 f	4.57 g	24.44 g
V_2T_3	72.44 e	4.62 f	24.56 f
V_2T_4	75.10 c	4.82 b	25.21 e
Significance level	*	*	*
CV(%)	6.45	7.22	8.57

T_1 : Control (Recommended dose) (Urea 2.5 g, TSP 1.35 g, MoP 0.75 g, Gypsum 1.13 g per pot)

T_2 : Compost (10 ton/ha) poultry litter based compost

T_3 : Compost (20 ton/ha) poultry litter based compost

T_4 : Compost (30 ton/ha) poultry litter based compost

*= 5% level of significance, **= 1% level of significance.

4.2 Yield and Yield Attributes

4.2.1 Seed yield per plant (g)

Seed yield per plant (g) was varied due to application of poultry litter based compost in soil for mustard production (Table 7). The highest value was observed in BINA Sarisha-4 (3.19 g) and the lowest value was observed in BARI Sarisha-15 (2.12 g). Seed yield per plant was significantly influenced by compost application. The highest value was observed in T_3 (2.85 g) treatment and the lowest value was found in T_1 (2.40g) treatment.

Interaction effect of variety and compost was significantly influenced the seed yield per plant. The highest value was observed in V_1T_3 (3.5 g) treatment combination and the lowest value in V_2T_1 (1.91) treatment combination.

4.2.2 Seed Yield per pot (g)

Seed yield per pot (g) was evaluated for poultry litter based composed in mustard production (Table 7). The highest value was observed in BINA Sarisha-4 (15.95 g) and the lowest value was observed in BARI Sarisha-15(10.64 g). Seed yield per pot was significantly influenced by compost application. The highest value was observed in T_3 (14.28g) treatment which was followed by T_4 (13.97 g) and the lowest was found in T_1 (12.02g) treatment. De and Sinha (2012) and Patil *et al.* (2009) also found the similar results in mustard plant.

Interaction effect of variety and compost was significantly influenced the seed yield per pot. The highest value was observed in V_1T_3 (17.5 g) treatment

combination and the lowest value in V_2T_1 (9.55g) treatment combination. De and Sinha (2012) and Patil *et al*. (2009) also found the similar results in mustard plant.

4.2.3 Stover yield per pot (g)

Stover yield per pot was evaluated for poultry litter based composed in mustard production (Table 7). The highest value was observed in BINA Sarisha-4 (49.5 g) and the lowest value was observed in BARI Sarisha-15 (39.33 g). Stover yield per pot was significantly influenced by compost application. The highest value was observed in T_3 (50.16 g) treatment which was followed by T_4 (48 g) and the lowest was found in T_1 (35.83g) treatment. De and Sinha (2012) and Patil *et al*. (2009) also found the similar results in mustard crop.

Interaction effect of variety and dose of compost was significantly influenced the stover yield per pot. The highest value was observed in V_1T_3 (58.00 g) treatment combination and the lowest value in V_2T_1 (31.33 g) treatment combination. De and Sinha (2012) and Patil *et al*. (2009) also found the similar results in mustard crop.

4.2.4 Day to maturity

Day to maturity was evaluated for poultry litter based composed in mustard production (Table 7). The highest value was observed in BINA Sarisha-4 (90.58) and the lowest value was observed in BARI Sarisha-15 (88.80). Day to maturity was significantly influenced by poultry litter based compost application. The highest value was observed in T_1 (90.67) treatment which was followed by T_2 (89.94) and the lowest one was found in T_4 (88.94) treatment.

Table 7: Effect of poultry litter based compost on maturity duration seed yield and stover yield of mustard varieties at final harvest

Variety	Seed yield per plant	Seed yield per pot (g)	Stover yield per pot(g)	Day to maturity
BINA Sarisha-4 (V1)	3.19 a	15.95 a	49.5 a	90.58 a
BARI Sarisha -15 (V2)	2.12 b	10.64 b	39.33 b	88.80 b
Significance level	*	*	*	*
Dose of poultry based compost				
T_1	2.40 d	12.02 d	35.83 d	90.67 a
T_2	2.58 c	12.9 c	43.66 c	89.94 b
T_3	2.85 a	14.28 a	50.16 a	89.21 c
T_4	2.79 b	13.97 b	48.00 b	88.94 d
Significance level	**	*	*	*
Interaction effect of varieties to dose of compost				
V_1T_1	2.9 d	14.5 d	40.33 f	90.21 d
V_1T_2	3.11 c	15.55 c	47.66 c	88.89 f
V_1T_3	3.5 a	17.5 a	58.00 a	87.67 h
V_1T_4	3.25 b	16.25 b	52.00 b	88.84 g
V_2T_1	1.91 h	9.55 h	31.33 h	91.10 a
V_2T_2	2.05 g	10.25 g	39.66 g	90.99 b
V_2T_3	2.21 f	11.07 f	42.33 e	90.78 c
V_2T_4	2.34 e	11.7 e	44.00 d	89.44 e
Significance level	*	*	**	*
CV(%)	7.89	6.76	6.45	5.76

T_1 : Control (Recommended dose) (Urea 2.5 g, TSP 1.35 g, MoP 0.75 g, Gypsum 1.13 g per pot)

T_2 : Compost (10 ton/ha) poultry litter based compost

T_3 : Compost (20 ton/ha) poultry litter based compost

T_4 : Compost (30 ton/ha) poultry litter based compost

*= 5% level of significance, **= 1% level of significance.

Interaction effect of variety and dose of compost was significantly influenced the day to maturity. The highest value was observed in V_2T_1 (91.10) treatment combination and the lowest value in V_1T_3 (87.67) treatment combination.

4.2.5 Thousand seed weight (g)

Thousand seed weight (g) was evaluated for poultry litter based composed in mustard production (Table 8). The highest thousand seed weight was observed in BINA Sarisha-4 (3.56) and the lowest value was observed in BARI Sarisha-15 (3.25). Thousand seed weight was significantly influenced by compost application. The highest value observed in T_3 (3.49) treatment followed by T_4 (3.49) and the lowest value in T_1 (3.22) treatment.

Thousand seed weight was also significantly influenced by the interaction effect of variety and dose of compost. The highest value was observed in V_1T_3 (3.66) treatment combination and the lowest value in V_2T_1 (2.99) treatment combination.

4.2.6 Yield (tha^{-1})

Yield (tha^{-1}) was evaluated for poultry litter based composed in mustard production (Table 8). The highest value was observed in BINA Sarisha-4 (2.12 tha^{-1}) and the lowest value was observed in BARI Sarisha-15 (1.41 ton). Yield (tha^{-1}) was significantly influenced by compost application. The highest value was observed in T_3 (1.90 ton) treatment which was followed by T_4 (1.86 ton) and the lowest was found in T_1 (1.64 ton) treatment. De and Sinha (2012) and Patil *et al.* (2009) also found the similar results in mustard plant.

Interaction effect of variety and dose of compost was significantly influenced the yield (tha^{-1}). The highest yield (tha^{-1}) was observed in V_1T_3 (2.33 ton) treatment combination and the lowest value in V_2T_1 (1.27 ton) treatment combination. De and Sinha (2012) and Patil *et al*. (2009) also found the similar results in mustard plant.

4.2.7 Stover Yield (tha^{-1})

Stover yield (tha^{-1}) was evaluated for poultry litter based composed in mustard production (Table 8). The highest value was observed in BINA Sarisha-4 (6.69 ton) and the lowest value was observed in BARI Sarisha-15 (5.24 ton). Stover yield (tha^{-1}) was significantly influenced by compost application. The highest value was observed in T_3 (6.68 ton) treatment which was followed by T_4 (6.40 ton) and the lowest was found in T_1 (4.77 ton) treatment. De and Sinha (2012) and Patil *et al*. (2009) also found the similar results in mustard plant.

Interaction effect of variety and dose of compost was significantly influenced the stover yield (tha^{-1}). The stover yield (tha^{-1}) highest value was observed in V_1T_3 (7.33 ton) treatment combination and the lowest value in V_2T_1 (4.17 ton) treatment combination. De and Sinha (2012) and Patil *et al*. (2009) also found the similar results in mustard plant.

Table 8: Effect of poultry litter based compost on the thousands of seed weight, yield (tha^{-1}), stover yield (tha^{-1}) and harvest index (%) of mustard varieties at final harvest

Variety	Thousands of Seed Weight(g)	Yield (tha^{-1})	Stover Yield (tha^{-1})	Harvest Index (%)
BINA Sarisha-4 (V1)	3.56 a	2.12 a	6.59 a	32.46 a
BARI Sarisha -15 (V2)	3.25 b	1.41 b	5.24 b	27.27 b
Significance level	*	*	*	*
Dose of poultry based compost				
T_1	3.22 c	1.60 d	4.77 d	33.14 a
T_2	3.41 b	1.71 c	5.82 c	29.23 b
T_3	3.49 a	1.90 a	6.68 a	28.19 d
T_4	3.49 a	1.86 b	6.40 b	28.92 c
Significance level	**	*	*	*
Interaction effect of varieties to dose of compost				
V_1T_1	3.45 d	1.93 d	5.37 f	35.80 a
V_1T_2	3.51 c	2.07 c	6.35 c	32.59 b
V_1T_3	3.66 a	2.33 a	7.73 a	30.17 e
V_1T_4	3.60 b	2.16 b	6.93 b	31.28 c
V_2T_1	2.99 h	1.27 h	4.17 h	30.48 d
V_2T_2	3.32 g	1.36 g	5.28 g	25.86 h
V_2T_3	3.33 f	1.47 f	5.64 e	26.21 g
V_2T_4	3.38 e	1.55 e	5.86 d	26.55 f
Significance level	*	*	*	*
CV(%)	6.78	6.98	5.68	9.19

T_1 : Control (Recommended dose) (Urea 2.5 g, TSP 1.35 g, MoP 0.75 g, Gypsum 1.13 g per pot)

T_2 : Compost (10 ton/ha) poultry litter based compost

T_3 : Compost (20 ton/ha) poultry litter based compost

T_4 : Compost (30 ton/ha) poultry litter based compost

*= 5% level of significance, **= 1% level of significance.

4.2.8 Harvest Index (%)

Harvest index (%) was calculated and found that it varied due to application of poultry litter based compost in soil for the production of mustard (Table 8). The highest HI was observed in BINA Sarisha-4 (32.46%) and the lowest one was observed in BARI Sarisha-15(27.27%). Harvest index was varied significantly due to application of different doses of compost. The highest HI was observed in T_1 (33.14%) where the compost was added in soil treatment and the lowest value was found in T_3 (28.19%) treatment where only fertilized was applied.

Interaction effect of varieties to dose of poultry litter based compost was significantly influenced the harvest index. The harvest index highest value was observed in V_1T_1 (35.80%) treatment combination and the lowest one in V_2T_2 (25.86%) treatment combination.

CHAPTER V

SUMMARY AND CONCLUSION

A pot experiment was carried out at the research field of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during December 2017 to May 2018 to evaluate the poultry litter based composts efficacy on mustard cultivation. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. Factor A included four (4) fertilization levels i.e. T_1 = Control (recommended dose), T_2= Compost 10 ton/ha, T_3 = Compost 20 ton/ha, T_4 = Compost 30 ton/ha and Factor B included two mustard varieties i.e. V_1= BINA Sarisha-4 and V_2= BARI Sarisha-15. Various phenological parameters such as days to first flowering, days to 50% flowering and days to maturity were observed. Different morphological characters such as plant height (cm), leaf number, leaf area (cm^2), dry weight (g), number of branches $plant^{-1}$, seed yield per plant (g), seed yield per pot (g), stover yield per pot (g), day to maturity, number of siliqua $plant^{-1}$, length of siliqua $plant^{-1}$ (cm), thousands of seed weight(g), yield (t ha^{-1}), stover yield (t ha^{-1}) and harvest index were recorded. The experiment result showed that most of the morphological traits, yield and yield contributing characters were significantly influenced by different fertilization and varieties. All the data were statistically analyzed by MSTAT-C.

Result indicated that the tallest plants (11.52, 34.81, 61.34, 86.63 and 98.63 cm at 15 DAS, 30DAS, 45DAS, 60DAS and yield stages respectively) were found in

Compost (20 ton/ha) poultry litter based compost which was significantly different from all other treatments and the shortest plants (10.33, 32.38, 54.80, 80.12 and 90.31 cm at 15 DAS, 30 DAS, 45 DAS, 60 DAS and yield stages respectively) were found in control (recommended dose).

Plant height was significantly affected by interaction between dose of poultry based compost and varieties. Result indicated that the highest height (12.74, 37.78, 64.51, 91.54 and 104.47 at 15 DAS, 30 DAS, 45 DAS, 60 DAS and yield stages respectively) recorded from V_1T_3.

At the vegetative stage the number of leaf (6.05, 11.66, 19.33 and 25.71 at 15 DAS, 30DAS, 45DAS and 60DAS) were found in Compost (20 ton/ha) poultry litter based compost which was significantly different from all other treatments and the lowest number of leaf (5.16, 9.22, 15.38 and 20.10 at 15 DAS, 30DAS, 45DAS and 60DAS were found in Compost (20 ton/ha) poultry litter based compost.

Leaf area was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest number of leaf area (2.73, 20.14, 54.74 and 13.32 at 15 DAS, 30 DAS, 45 DAS and 60 DAS respectively) recorded from V_1T_3.

Number of branch was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest number of branch (5.78 at 65 DAS) recorded from V_1T_3.

Dry weight (g) was significantly affected by interaction between dose of poultry litter based compost that the highest dry weight (g) (0.40, 1.10, 5.96 and 8.51 at 15 DAS, 30 DAS, 45 DAS and 60 DAS, respectively) recorded from V1T3.

Day to first flowering was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest day to first flowering (32.10 DAS) recorded from V_2T_1.

Day to 50% flowering was significantly affected by interaction between dose of poultry based compost and varieties. Result indicated that the highest day to 50% flowering (43.99 DAS) recorded from V_2T_1 and the lowest was found in V_1T_3 (38.44 DAS).

At the final harvest result indicated that number siliqua per plant was significantly affected by interaction between dose of poultry litter based compost and varieties.The highest number siliqua per plant (82.89) recorded from V_1T_3 and the lowest was found in V_1T_3 (67.10).

At the final harvest length of siliqua (cm) was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest length of siliqua (cm) (5.83) recorded from V_1T_3 and the lowest was found in V_2T_1 (4.36).

Number of seed in siliqua per plant was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest number of seed in siliqua per plant (28.55) recorded from V_1T_3 and the lowest was found in V_2T_1 (24.10).

At the final harvest seed yield per plant (g) was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest seed yield per plant (g) (3.50) recorded from V_1T_3 and the lowest was found in V_2T_1 (1.91).

Seed yield per pot (g) was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest seed yield per pot (g) (17.50) recorded from V_1T_3 and the lowest was found in V_2T_1 (9.55).

Stover yield per pot (g) was significantly affected by interaction between dose of poultry letter based compost and varieties. Result indicated that the highest stover yield per pot (g) (58.00) recorded from V_1T_3 and the lowest was found in V_2T_1 (31.33).

Day to maturity was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest day to maturity (91.10) recorded from V_2T_1 and the lowest was found in V_1T_3 (87.67).

Thousands of seed weight (g) was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest thousands of seed weight (g) (3.66) recorded from V_1T_3 and the lowest was found in V_2T_1 (2.99).

Result indicated that the yield (t/ha) (1.90 t/ha) were found in compost (20 t/ha) which was significantly different from all other treatments and the lowest yield (t/ha) (1.60 t/ha) were found in control (recommended dose). Yield (t/ha) was

significantly affected by varieties between BINA Sarisha-4 and BARI Sarisha-15. Result indicated that the highest yield (t/ha) (2.12 t/ha) were found in BINA Sarisha-4 and the lowest was found BARI Sarisha-15 (1.41 t/ha).Yield (t/ha) was significantly affected by interaction between fertilization and varieties. Result indicated that the highest yield (t/ha) (2.33 t/ha) recorded from V_1T_3 and the lowest was found in V_2T_1 (1.27).

Stover yield (t/ha) was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest stover yield (t/ha) (7.33 t/ha) recorded from V_1T_3 and the lowest was found in V_2T_1 (4.17).

Harvest index (%) was significantly affected by interaction between dose of poultry litter based compost and varieties. Result indicated that the highest harvest index (%) (35.80 %) recorded from V_1T_1 and the lowest was found in V_2T_2 (25.86 %).

According to the present study it could be suggested that the mustard might be grown under T_3 fertilization (compost 20 t/ha) poultry litter based compost in order to get the optimum yield. However, these findings need to be further investigated and evaluated on different agro-ecological zone before final recommendation for the farmers.

CHAPTER VI

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APPENDICES

Appendix I. Characteristics of soil of the experimental site

General characters	**Description**	
Location	Crop Physiology and Ecology, HSTU, Dinajpur	
AEZ	Old Himalayan Piedmont Plain (AEZ-1)	
General Soil type	Non-Calcareous Brown Floodplain Soil	
Parent material	Piedmont alluvium	
Soil series	Ranishankail	
Drainage	Moderately well drained	
Flood level	Above flood level	
Topography	High land	
Physical characteristics	**Value**	
Bulk density (g cm-3)	0.86-1.07	
Particle size (%)		
Sand (2-0.02mm)	60.0	
Silt (0.02-0.002mm)	27.0	
Clay (< 0.002mm)	13.0	
Textural class	Sandy loam	
Chemical characteristics	**Content**	**Interpretation**
pH	5.40-5.50	Moderately acidic
Organic carbon (%)	0.69	Low
Organic matter (%)	1.19	Low
CEC (meq/100g soil)	5.60	Low
Total N (%)	0.07	Very low
Available P (ppm)	16.75	Medium
Exchangeable K (meq/100g soil)	0.17	Medium low

Source: Analysis of initial soil samples was done in SRDI, Dinajpur, Bangladesh

Appendix II: Weather data for growing season of mustard, December-May, 2018.

Month	Relative humidity (%)	Temperature		Total rainfall (mm)
		Minimum (^{o}C)	Maximum (^{o}C)	
December	85.00	13.30	27.80	0.00
January	89.00	9.00	20.90	0.00
February	78.00	13.20	28.50	0.00
March	69.00	17.30	34.10	1.00
April	66.00	20.70	34.10	4.00
May	78.23	23.00	35.10	7.10

Source: Wheat Research Centre, Dinajpur.