FEASIBILITY OF REPLACING CHEMICAL FERTILIZER BY USING ORGANIC FERTILIZER IN MUSTARD

RAHIMA JERIN

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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By

RAHIMA JERIN
Registration No: 09-3708

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APPROVED BY

Prof. Dr. A.K.M. Ruhul Amin	**Prof. Dr. Parimal Kanti Biswas**
Supervisor	**Co-supervisor**

Prof. Dr. A.K.M. Ruhul Amin
Chairman
Examination Committee

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Dhaka-1207,

Memo No: SAU/ Agronomy

CERTIFICATE

This is to certify that the thesis entitled **"Feasibility Of Replacing Chemical Fertilizer By Using Organic Fertilizer In Mustard"** submitted to the faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in, **Agronomy** embodies the result of a piece of *bona fide* research work carried out by **Rahima Jerin**, Registration Number: **09-3708** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:

Dhaka, Bangladesh

Prof. Dr. A.K.M. Ruhul Amin
Department Of Agronomy
Sher-e-Bangla Agricultural University
Dhaka-1207,

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ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October, 2010 to March, 2011 to study the feasibility of replacing chemical fertilizer by using organic fertilizer in mustard. There are 10 treatments in this experiment comprised with organic manure and inorganic fertilizer and their treatments combinations including control viz., T_0 (control), T_1 (all chemical fertilizer at recommended dose), T_2 (Cowdung at rcommended dose), T_3 (compost at recommended dose), T_4 (½ Cowdung + ½ Compost), T_5 cowdung + compost), T_6 (Cowdung + ½ Chemical fertilizer), T_7 (Compost + ½ Chemical fertilizer), T_8 (Cowdug + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdug + ½ compost + ½ chemical fertilizer) on growth and yield performance of mustard var. BARI sarisha-15. The experiment was conducted following Randomized Complete Block Design (RCBD) single factor with 3 replications. Among the treatments, all chemical fertilizer at recommended dose (T_1) and organic cowdung and compost in combination with half chemical fertilizer (T_8) were superior than other individual or combination of organic and inorganic treatments considering the all morphological, yield and yield contributing characters of mustard. Treatment of half cowdung and half compost with half chemical fertilizer (T_9) also showed statistically similar result in respect of yield contributing characters as well as seed yield. So, it is possible to reduce the use of chemical fertilizers by combined use of organic and chemical fertilizer without significant yield loss of mustard.

CONTENTS

Chapter	Title	Page No
	Acknowledgements	**i**
	Abstract	**ii**
	Contents	**iii-vi**
	List of Tables	**vii**
	List of Figures	**viii**
	List of Appendices	**ix**
	Abbreviations	**x**
I	**INTRODUCTION**	**1-3**
II	**REVIEW OF LITERATURE**	**4-27**
	2.1. Effect of chemical fertilizer on growth and yield of mustard and other related crops	4
	2..2 Effect of organic fertilizer on growth and yield of mustard and other related crops	13
III	**MATERIALS AND METHODS**	**28-38**
	3.1 Description of the experimental site	28
	3.1.1 Location and time	28
	3.1.2 Soil	28
	3.1.3 Climate and weather	29
	3.2 Experimental materials	29
	3.2.1 Treatments	29

CONTENTS (Contd.)

Chapter	Title	Page No
	3.3 Experimental design and layout	30
	3.4 Land preparation	31
	3.5 Manures and fertilizers	31
	3.6 Seed treatments	32
	3.7 Seed sowing	32
	3.8 Intercultural operations	33
	3.8.1 Thinning out	33
	3.8.2 Weeding	33
	3.8.3 Irrigation and drainage	33
	3.8.4 Disease and pest management	33
	3.9 Harvesting and processing	34
	3.10 Data collection	34
	3.10.1 Growth parameters	34
	3.10.1.1 Plant height	34
	3.10.1.2 Number of branch plant^{-1}	34
	3.10.1.3 Dry weight of plant^{-1} (g)	35
	3.10.1.4 Crop Growth Rate (CGR)	35
	3.10.1.5 Relative Growth Rate (RGR)	36
	3.10.2 Yield Contributing Characters and Yield	36
	3.10.2.1 Number of plants m-^{2}	36

CONTENTS (Contd.)

Chapter	Title	Page No
	3.10.2 Yield Contributing Characters and Yield	36
	3.10.2.2 Number of siliqua plant^{-1}	36
	3.10.2.3 Number of seed siliqua^{-1}	36
	3.10.2.4 1000-grain weight (g)	37
	3.10.2.5 Seed yield kg ha^{-1}	37
	3.10.2.6 Stover yield kg ha^{-1}	37
	3.10.2.7 Biological yield (kg ha^{-1})	37
	3.10.2.8 Harvest index (%)	37
	3.11 Statistical analysis	38
IV	RESULTS AND DISCUSSION	**39-58**
	4.1 Effect of different doses of organic and inorganic fertilizer on growth characters	39
	4.1.1 Plant height	39
	4.1.2 Number of branches plant^{-1}	42
	4.1.3 Dry weight of plant (g)	45
	4.1.4 Crop growth rate (CGR)	48
	4.1.5 Relative growth rate (RGR)	48
	4.1.6 Number of plants m^{-2}	51

CONTENTS (Contd.)

Chapter	Title	Page No
	4.2 Effect of different doses of organic and inorganic fertilizer on yield and yield attributing characters	53
	4.2.1 Siliqua plant^{-1}	53
	4.2.2 Seeds siliqua^{-1}	53
	4.2.3 1000-seed yield (g)	54
	4.2.4 Stover yield (kg ha^{-1})	56
	4.2.5 Seed yield (kg ha^{-1})	56
	4.2.6 Biological yield (kg ha^{-1})	56
	4.2.7 Harvest index (%)	57
V	SUMMARY AND CONCLUSION	**59-61**
	REFERENCES	**62-78**
	APPENDICES	**79-83**

LIST OF TABLES

Table	Name of the Table	Page No.
1	Dose and method of application of organic and inorganic fertilizers in mustard field (BARI, 2006)	32
2	Effect of chemical and organic fertilizer on plant height (cm) at different days after sowing (DAS) of mustard	41
3	Effect of chemical and organic fertilizer on number of branches plant^{-1} at different days after sowing (DAS) of mustard	44
4	Effect of chemical and organic fertilizer on dry weight of plant (g) at different days after sowing (DAS) of mustard	47
5	Effect of chemical and organic fertilizer on number of siliqua plant^{-1}, number of seed siliqua^{-1} and 1000-seed yield of mustard at harvest	55
6	Effect of chemical and organic fertilizer on stover yield seed yield, biological yield and harvest index of mustard at harvest	58

LIST OF FIGURES

Figure	Name of the Figure	Page No
1	Effect of chemical and organic fertilizer and their different combinations on crop growth rate (CGR) of mustard.	49
2	Effect of chemical and organic fertilizer and their different combinations on relative growth rate (RGR) of mustard.	50
3	Effect of chemical and organic fertilizer and their different combinations on number of plants m^{-2} of mustard.	52

LIST OF APPENDICES

Appendix	Name of the Appendix	Page no
i	Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka	79
ii	Monthly record of air temperature, rainfall and relative humidity of the experimental site during the period from October 2010 to March 2011	80
iii	Lay out of the experiment	81
iv	Analysis of variance on plant height at different days after sowing as influenced by chemical and organic fertilizer and their different combination on mustard	82
v	Analysis of variance on number of branches plant^{-1} at different days after sowing as influenced by chemical and organic fertilizer and their different combination on mustard	82
vi	Analysis of variance on dry weight of plant at different days after sowing as influenced by chemical and organic fertilizer and their different combination on mustard	82
vii	Analysis of variance on CGR, RGR and number of plant m^{-2} as influenced by chemical and organic fertilizer and their different combination on mustard	82
viii	Analysis of variance on RGR and number of plant m^{-2} as influenced by chemical and organic fertilizer and their different combination on mustard	83
ix	Analysis of variance on number of siliqua plant^{-1}, number of seed siliqua^{-1} and 1000-seed yield as influenced by chemical and organic fertilizer and their different combination on mustard	83
x	Analysis of variance on stover yield, seed yield, biological yield and harvest index as influenced by chemical and organic fertilizer and their different combination on mustard	83

ABBREVIATIONS

%	: Percentage
µM	: Micro mol
^{0}C	: Degree Celcius
BAP	: 6-benzyl amino purine
BARI	: Bangladesh Agricultural Research Institute
BBS	: Bangladesh Bureau of Statistics
BRRI	: Rice Research Institute Bangladesh
RCBD	: Randomized Complete Block Design
cv.	: Cultivar
DMRT	: Duncans Multiple Range Test
dw	: Distilled water
e.g.	: Exempli gratia (by way of example)
et al	: And others
FAO	: Food and Agriculture Organization
Fig.	: Figure
g	: Gram
GA_3	: Gibberellic acid
HCL	: Hydrochlori acid
$HgCl_2$	: Mercuric Chloide
i.e.	: ed est (means That is)
IRRI	: International Rice research Institute
kn	: Kinetin
mgL^{-1}	: Milligram per litre
Na_2-EDTA	: Sodium salt of ferric ethylene diamine tetraacetate
NAA	: α-napthalene acetic acid
NaCl	: Sodium chloride
NaOH	: Sodium hydroxide
NNC	: National Nutritional Council
NSB	: National Seed Board
pH	: Negative logarithm of hydrogen ion
spp	: Species (plural number)
UV	: Ultra Violet
var.	: Variety
Viz.	: Namely

CHAPTER I
INTRODUCTION

Mustard *(Brassica juncea*) belongs to the family Cruciferae is important oil crop in Bangladesh. It is the main cultivable edible oil seed corp of Bangladesh. Mustard is the most important popular oil crop which is grown in rabi season in Bangladesh. Mustard covers the land area of 216800 hectares in Bangladesh and produces about 183500 metric tons of oil seeds (BBS, 2007). Bangladesh occupies the 5th place in respect of total oil seed production in the world and occupies the first position in respect of area and production among the oil crops grown in Bangladesh (BBS, 2010).

Domestic production of edible oil almost entirely comes from rapeseed and mustard occupying only about 2% area of total cropped area in Bangladesh (BBS, 2002). The annual oil seed production of 0.41 million tons of which the share of rapeseed-mustard is 0.21 million tons, which comes about 52% of the total edible oil seed production. Mustard covers about 61.2% of the total acreage under oil seed and 52.6% of the total oil seed production in Bangladesh (BBS, 2005). The yield of this crop in Bangladesh is much lower compared to other countries. The average yield of rapeseed-mustard in Bangladesh is very low (0.76 t ha^{-1}) that is less than 50% of the world average (FAO, 2004).

Bangladesh is deficit in edible oil, which costs valuable foreign currency for importing seeds and oil. Annually country is producing about 2.80 Lac m tons of edible oil as against the requirement of 9.80 Lac m tons thus import oil is regular phenomenon of this country (BBS, 2010). Every year Bangladesh imports 2085864 metric tons of edible oil to meet up the annul requirement of the country, which costs Tk.64430 million (BBS, 2007). Both the acreage and production of the crop have been decreasing since 1990 mainly due to ingression of cereal crops like-rice, maize, wheat etc. Delayed harvest of transplanted aman rice and wetness of soil are another reason which hinders mustard cultivation in rabi season (BARI, 2008). Chemical fertilizers have contributed significantly towards the pollution of water, air and soil. So the current trend is to explore the possibility of supplementing chemical fertilizers with organic ones which are ecofriendly and cost effective.

Although intensive use of inorganic fertilizers and pesticides has been an important tool in the drive for increased crop production. In fact more fertilizers consumption is a good indication of agricultural productivity but depletion of soil fertility is commonly observed in soils. Due to heavy use of chemical herbicides, pesticides and intensification of agricultural production during the past few decades has led to other harmful effects like nitrate in the ground water, contamination of fooding materials, eutrophication, stratospheric changes etc. High agricultural inputs are unlikely to be sustainable for very long unless the inputs are correctly judged in terms of both their quality and quantity. Organic Farming seems to be more appropriate as it considers the important aspects like sustainable natural resources and environment. It is a production system, which favors maximum use of organic materials like crop residues, FYM, compost, green manure, oil cakes, bio-fertilizers, bio-gas slurry etc. to improve soil health from the different experiment, microbial fertilizers like Rhizomic, Azotobacter, Blue green algae, Azolla etc. have increased the yield and also played important role for minimizing the harmful effect of pesticides and herbicides. Organic farming is a practical proposition for sustainable agriculture if adequate attention is paid to this issue. There is urgent need to involve more and more scientist to identify it.

Organic manures, valuable byproducts of farming and allied industries, contribute to plant growth through their favorable effects on physical, chemical and biological properties of the soil. Availability of soil P is also enhanced by addition of organic manures, presumably due to chelation of cations by organic acids and other decay products (Mohanty *et al.*, 2006). Organic manures like Farmyard manure (FYM) have a pronounced residual effect on the nutrient availability. Many of the benefits attributed to organic manures have been well documented. High costs of inorganic fertilizers are making it difficult to use them extensively in developing countries.

Inorganic fertilizers when applied along with FYM can result in a remarkable increase in the yield (Gosh *et al*., 2006). However, a major portion of the applied chemical nitrogen fertilizers is lost through the leaching, run off, emissions and volatilizations which cause economic losses and serious environmental problems (Singh *et al*., 2006; Abdin *et al*., 2006; Galloway *et al*., 2008; Singh *et al*., 2010). Organic fertilizer viz. farm yard manure (FYM), bio-fertilizers or other organic manure are used for eco-friendly organic farming, however they are unable to replace chemical fertilizers in terms of crop productivity that because of theyr used as combined for better production of any crop.

In view of the importance of this crop, attention has to be given to increase its production in order to meet the huge shortage of edible oil in the country. Very few research works have been conducted in our country regarding the effects of poultry manure, cowdung and biogas slurry on yield, quality and nutrient uptake by mustard. Keeping the above stated fact in view, the present study was undertaken in achieving the following objectives:

i. To observe the effect of organic and chemical fertilizer on the performance of mustard,

ii. To observe the effect of different combination of chemical and organic fertilizer on mustard,

iii. To select the best combination of chemical and organic fertilizer on higher yield of mustard and,

iv To find out the feasibility of replacing chemical fertilizer by using organic fertilizer.

CHAPTER II
REVIEW OF LITERATURE

Organic manure and inorganic/chemical fertilizer are the essential factor for sustaining soil fertility and crop productivity because they are the store house of plant. Organic manure and inorganic fertilizer act as a source of essential plant nutrient. Exprimental evidences in the use of cowdung, compost and nitrogen, phosphorus, potassium, sulphur and boron showed an intimate effect on the yield and yield attributes of mustard. Yield and yield contributing characters of mustard are considerably varied by different doses of cowdung, compost and NPKSB fertilizers and their combined application. Some literatures related to the "Effect of level of various organic manure and inorganic fertilizer on the yield and yield attributes of mustard" are reviewed under the following heading in this chapter.

2.1 Effect of chemical fertilizer on growth and yield of mustard and other related crops

Anjum *et al*. (2012) reported that in the agricultural systems balancing fertilization, optimization of nutrient replenishment, minimization of nutrient losses to the environment and the concept of co-ordination in action among plant nutrients could be a significant strategy for improvement of growth and productivity of oleiferous brassica. Among important plant nutrients nitrogen (N) and sulphur (S) are known essential elements for growth, development and various physiological functions in plants. Oilseed brassica require higher amounts of S in addition to N for optimum growth and yield. Additionally, positive interaction between S and N has been reported to be beneficial for various aspects of oilseed brassica.

Dalal and Nandkar (2011) conducted field experiment on cotton black soil to investigate the effect of various levels of NPK on the plant height, number of branches and on the seed yield. NPK application from 20:10:10 kg ha^{-1} progressively and significantly enhanced the seed yield. The maximum seed yield was with the application of 50:40:25 kg NPK ha^{-1}, while the NPK application at the rate of 60:50:30 and 70:50:35 kg NPK ha^{-1}, receives decrease in yield. Similarly there were no enhancement in plant height, number of branches per plant and number of pod $plant^{-1}$ in higher doses.

Amanullah and Malhi (2011) conducted an experiment on S and K deficient clay loam soil to determine seed yield and yield components response of *Brassica* oilseed rape versus mustard to S (15, 30, and 45 kg S ha^{-1}) and K (30, 60, and 90 kg K ha^{-1}) fertilizers plus one control (no S and K applied). Seed yield and yield components increased significantly with K and S fertilization as compared to the zero-S/zero-K control. Both genotypes responded positively for seed yield and yield components to K and S fertilization, but the magnitude of response varied with levels of S and K, as well as combined K + S applications. It is concluded that a combination of 60 kg K + 30 kg S ha^{-1} would improve seed yield and yield components of rape and mustard in the study area and contribute significantly to increased production.

A field experiment was conducted in 2007-2008 on a sulfur (S) and potassium (K) deficient clay loam soil under irrigation to determine response of phenology and seed quality of Brassica oilseed rape versus mustard to S and K fertilizer application (Hasan and Sukhdev, 2011). Twenty treatments in a randomized complete block design were consisted of two oilseed genotypes [rape (*B. napus* canola) and mustard (*B. juncea* canola)], at three rates each of S (15, 30, and 45 kg S ha^{-1}) and K (30, 60, and 90 kg k ha^{-1}), plus control (no K and S applied). Days to flowering, pod formation, seed filling duration and maturity were enhanced with K and S fertilization compared to control plots. The species *B. napus* took more time to flowering, pod formation, seed filling duration and maturity compared to *B. juncea*. Both genotypes responded positively for seed quality (oil and protein content) to K and S fertilization, but the magnitude of response varied with level and combination of K and S fertilization. Delay in the phenological stages showed negative relationship with oil and protein content in seed of both genotypes. It is concluded that a combination of 60 kg K ha-1 + 30 kg S ha^{-1} would accelerate phenological development and improve seed quality of rape and mustard in the study area.

Ozturk (2010) reported that the winter rapeseed (*Brassica napus* L.) has potential to become an alternate oilseed crop both for edible oil production and energy agriculture (biofuel production) for Turkey. Three N sources, ammonium sulfate, ammonium nitrate and urea, were applied as hand broadcast on the soil surface at five doses (0, 50, 100, 150, and 200 kg N ha^{-1}). The traits investigated were plant height, number of branches and pods $plant^{-1}$, number of seed per pod, thousand seed weight, seed yield, oil and protein content. There were significantly effects on seed yield, oil and protein content, and other yield components due to N sources and rates. In general, ammonium sulfate and urea gave higher seed yield than ammonium nitrate. Mean values of both seasons indicated that 100 and 150 kg N ha^{-1} rate increased significantly yield and quality traits with regard to other N treatments.

Mir *et al*. (2010) conducted an experiment on mustard (*Brassica juncea* L.) to study the effect of different combinations of phosphorous and potassium applied as monocalcium superphosphate and muriate of potash respectively (each at the rate of 30, 60, 90 kg P_2O_5 and K_2O ha^{-1}) on yield and yield attributes of mustard. In addition, a uniform dose of urea at the rate of 80 kg N ha^{-1} was applied. At harvest, various yield characteristics including number of pods $plant^{-1}$ number of seed pod^{-1}, seed yield and oil yield were studied. The effect of phosphorus alone as well as in combination with potassium was significant. Treatments 60 kg P_2O_5 ha^{-1} and 60 kg P_2O_5 60 kg K_2O ha^{-1} proved optimum and the increase in seed yield was due to increase in pods $plant^{-1}$ and seeds pod^{-1}.

Le Dily *et al*. (2010) studied the effects of different N-application rates on the dynamics of N uptake, partitioning, and remobilization. The experiment was conducted on winter oilseed rape (*Brassica napus* L. cv. Capitol) under three levels of N input (0, 100, and 200 kg N ha^{-1}) from stem elongation to maturity using ^{15}N-labeling technique to distinguish between N uptake and N retranslocation in the plant. Nitrogen fertilization affected the time-course of N uptake and also the allocation of N taken up from flowering to maturity. Most pod N came from N remobilization, and leaves accounted for the largest source of remobilized N regardless the N-application rate. However, the contribution of leaves to the remobilized N pool increased with the N dose whereas the one of taproot decreased. Stems were the main sink for remobilized N from stem elongation to flowering. Leaves remained longer on N200 than on N0 and N100 plants, and N concentration in fallen leaves increased with the N treatment and in N100 plants along an axial gradient from the basal to the upper leaves. Overall, these results show that the timing of N supply is more crucial than the N amount to attain a high N efficiency.

El-Habbasha and Abd El-Salam (2010) conducted an experiment at the Agricultural Experimental Station of the National Research Center, Qalubeia Governorate, Egypt, during the two successive winter seasons 2005-2006 and 2006-2007. The experimental design aimed to study the response of some canola varieties (Topas and Pactol cvs.) to nitrogen fertilizer levels (20, 40 and 60 kg N/feddan, (feddan=4200 m2)) and zinc foliar application at two growth stages (rosette and bud stages), one zinc foliar application (rosette stage) or two zinc foliar applications (rosette and bud stages). They observed that there were no significant differences between both varieties in studied characters, except, plant height and seed yield/feddan. Pactol surpassed Topas in plant height, 1000-seed weight, seed yield/plant, seed yield/feddan and oil yield/feddan. Increasing nitrogen fertilizer level from 20 to 60 kg N/feddan significantly increased plant height, number of siliqua/plant, seed yield/plant, seed yield/feddan and oil yield/feddan. Most of studied characters were significantly increased by increasing number of zinc foliar application where, two zinc foliar application significantly increased plant height, number of siliqua/plant, seed yield/ plant, seed yield/feddan and oil yield/feddan. The interactions between different factors showed significant differences in the most studied characters.

Cheema *et al*. (2010) conducted an experiment on canola crop which is substituting the indigenous rape and mustard crops due to its high quality edible oil and to its ability to grow well on rain and canal irrigated areas. Nitrogen is one of the most important nutrients for growth and development. A two-years field study (Nov. 2001-April 2003) was carried out to determine optimum N level and stage of its application for canola crop under irrigated conditions of Faisalabad, Pakistan. Five N levels (0, 30, 60, 90 and 120 kg ha^{-1}) were maintained at different times i.e., full N at sowing, ½ N at sowing +½ N at branching, ½ N at sowing + ½ N at flowering and ½ N at branching + ½ N at flowering. The total dry matter (TDM), crop growth rate (CGR), leaf area duration (LAD), seed yield, oil yield and protein content were significantly affected by different nitrogen rates. The highest N level (120 kg ha^{-1}) produced maximum values for all these traits as compared to minimum in control during both years of study. Time of nitrogen application did not significantly affect TDM, CGR, protein and oil contents however, split application of nitrogen (½ at sowing + ½ at branching or flowering) produced significantly higher seed and oil yield than full nitrogen at sowing or its split application as ½ at branching + ½ at flowering.

Mcgrath and Zhao (2009) conducted an experiment to test the seed yield responses of winter oilseed rape (*Brassica napus* L., cvs Libravo or Falcon) to the addition of different rates of S fertilizer, at three N application rates, on a sandy loam. The yield benefits were obtained mainly from the application of the first 10 kg S ha^{-1} and further yield increases were unlikely above 40 kg S ha^{-1}. Increasing N application from 180 to 230 kg ha^{-1} decreased seed yield. In contrast, seed yield was not increased by S at zero or low (50 or 100 kg ha^{-1}) N rates. Application of S also increased seed oil content in 1993/94, when the degree of S deficiency was particularly severe. With an application of 230 kg N ha^{-1}, the crops took up 5–22 kg S ha^{-1} at maturity when no S was applied and 26–51 kg S ha^{-1} when 40 kg S ha^{-1} was applied. The utilization efficiency of the fertilizer S ranged from 50 to 73% in the three seasons.

Allen and Morgan (2009) investigate the effect of nitrogen on the growth of oilseed rape. The results of the second experiment, when 0, 105·5 and 211·0 kg N ha^{-1} were compared, presented and discussed. The application of nitrogen increased the yields of seed and oil, principally through increased production of seeds by a larger number of pods. However, the application of nitrogen had little effect on average pod weight or average seed weight. Crop growth rates were increased by the application of nitrogen and reached their highest levels during the period of pod development when the leaf areas had declined to very low levels. The order of effects of nitrogen ($N_2 > N_1 > N_0$) was similar for LAI, number of pods per plant and number of seeds per pod.

Starner *et al*. (1999) reported that the effects of N levels on canola oil yield were not significant but there was a trend towards increasing seed yield for N level up to 100 kg ha^{-1} N. Nitrogen applications usually decreases oil and increase protein contents of rapeseed (Daneshvar *et al*., 2008; Bybordi and Malakouti, 2002).

Mahan *et al*. (2008) studied to assess the effect of planting geometries to fertilizer combinations on growth and yield of mustard (*Brassica juncea*) var. 'varuna'. The results revealed that the increasing doses of fertilizers increased the growth, yield attributing and yield characters, the maximum seed and stover yield was recorded up to 100 : 45 : 25 kg of N_2O, P_2O_5 and K_2O. Regarding planting geometries the 50 × 15 cm showed the highest seed yield.

Joshi and Mali (2008) observed that the effect of nitrogen and sulphur on the yield and fatty acid composition of mustard (*Brassica juncea* L.). Significantly higher grain and oil yields were obtained with N and S application. Applications of nitrogen up to 60 kg ha^{-1} and sulphur up to 40 kg ha^{-1} favourably influenced the grain yield. Increasing levels of N decreased the oil content while application of sulphur improved the oil content. The contents of linoleic and linolenic acid were maximum (16.82 and 8.73%, respectively) with 60 kg N along with 40 kg S ha^{-1}. No use of fertilizers led to higher contents of undesirable fatty acids such as palmitic (hypercholesterimic) and erucic (do not have food value) acids.

Ibrahim *et al*. (2008) observed the the increment in applied nitrogen rates up to 213 kg $ha-^{1}$ in both seasons. Nitrogen rates x application times interaction affected rapeseed yield significantly during the first winter season. The highest seed yield of 2.5 t/ha was obtained by adding 213
kg N $ha-^{1}$ in two split doses at sowing and just before the third irrigation. The second yield value of 2.47 t/ha was produced under the same N rate when applied in two split doses before second and third irrigation. However, in the second season (1986/87), rapeseed plants did not exhibit significant responses to nitrogen rates x application times interaction.

Boelcke *et al*. (2008) observed that the effects of stand establishment and nitrogen fertilizer on yield and yield stability of winter oil-seed rape (*Brassica napus* L). Highest yield stability was achieved at early sowing when combined with lower plant densities. 200 kg N $ha-^{1}$ in one dose resulted in lowest yield performance and enhanced instability. Contrastingly, the 240 kg N/ha treatment advanced yield stability regardless of split regimes. Nevertheless, split application to 100 kg kg N $ha-^{1}$50 kg N $ha-^{1}$ + 50 kg N $ha-^{1}$ also guaranteed that high yield performance and optimum yield stability were reached simultaneously and, that the total nitrogen input could be limited to 200 kg N ha-^{1}.

Ahmad *et al*. (2008) reported that the growth and yield of rape-seed-mustard in relation to sulphur and nitrogen interaction. Three levels of sulphur (0, 40 and 60 kg ha^{-1}) in combination with three levels of nitrogen (60, 100 and 150 kg ha^{-1}) were tested as treatments, T_1, T_2, T_3, T_4, and T_5. Results indicated significant favourable effects of sulphur and nitrogen, when applied together, on yield components, seed and oil yield. Maximum response was observed with treatment T_3 (having S and N of 40 and 100 kg ha^{1}, respectively). Percentage oil content of seed was maximal at T_4 (having S and N of 60 and 100 kg ha^{1}) in both cultivars. The increase in N dose from 100 to 150 kg ha^{-1} without any change in applied S, i.e. 60 kg ha^{1} (T_5), decreased the percentage oil content. The seed and oil yield, however, were similar to T_3.

Nitrogen fertilizer is the most important element for crop growth and high yield with good quality where, it causes an increase in photosynthesis rate, metabolites synthesized, merstematic activity and translocated assimilates to the seed. Seed yield and yield attributes increased by increasing nitrogen levels (Mekki, 2003; Banga *et al.*, 2007 and El Kholy *et al.*, 2007).

Malhi *et al*. (2006) were conducted to determine yield, seed quality with the effect of S (0, 10, 20, 30, and 40 kg S ha^{-1}) to response of different *Brassica* (*B.*) oilseed. Seed yield was highest with Cutlass *juncea* mustard in a dry year (2003), but was highest with InVigor 2663 hybrid canola in years with above-average precipitation (2004 and 2005). Seed yield was usually maximized at the rate of 30 kg S ha^{-1} for all *B.* species/cultivars. Oil concentration in seed increased with S fertilization for all *B.* species/cultivars. There was a significant (albeit small) increase of protein concentration in seed due to S fertilization.

Hati *et al*. (2006) investigate to study the effects of combined use of inorganic fertilizer (NPK) and organic manure (farmyard manure) on soil physical properties, water-use efficiency, root growth and yield of soybean [*Glycine max* (L.) Merr.] in a soybean–mustard cropping system. Application of 10 Mg farmyard manure and recommended NPK (NPK + FYM) to soybean for three consecutive years improved the organic carbon content of the surface (0–15 cm) soil from an initial value of 4.4 g kg^{-1} to 6.2 g kg^{-1} and also increased seed yield and water-use efficiency by 103% and 76%, respectively, over the control. Root length density (RLD) up to the 30 cm depth was highest in the NPK + FYM plots and it was 31.9% and 70.5% more than NPK and control plots. The RLD showed a significant and negative correlation ($r = -0.88^{**}$) with the penetration resistance.

Aziz *et al.* (2006) observed that brassica cultivars varied significantly for the concentration of P in their shoots. All the cultivars when grown with MAP did not differ significantly for root P concentration while shoot P concentration was significantly greater in plants grown with MAP as compared to rock phosphate. Brassica cultivars significantly differed for their phosphorus use efficiency.

Rathke *et al*. (2005) conducted an experiment to determine the productivity of winter oilseed rape (*Brassica napus* L.) as affected by previous crop and nitrogen (N) fertilization. Fertilizer was applied to winter oilseed rape as either calcium ammonium nitrate (CAN) or cattle manure slurry. The N rates applied to winter oilseed rape corresponded to 0, 80, 160, and 240 kg N ha^{-1} . Highest values for all these traits were obtained at 240 kg ha^{-1} mineral N fertilization when the effects of the previous crop were small. Pooled maximum seed yields for the high fertilizer rate ranged from 4.79 to 4.90 t ha^{-1}. Under high N rates, the lowest oil contents (43.8–44.1%) were observed. In contrast, the highest oil concentrations were found for the unfertilised plots (46.8–47.7%). Crude protein contents of 21.6% and 17.7% were measured at high and low N rates, respectively. Compared to cereals, winter rapeseed requires a higher amount of nutrients, and available N frequently limits seed yield. Hocking *et al*. (1997) said that rapeseed requires about 25% more N than wheat.

Mankotia *et al.* (2003) conducted a field experiment to investigate the effect of N (40, 80, 120 and 160 kg $ha\text{-}^{1}$), phosphorus (40 and 80 kg $ha\text{-}^{1}$) and farmyard manure (0 and 5 t $ha\text{-}^{1}$) on nutrient uptake by *Brassica napus* var. oleifera and toria, grown as intercrop. Nitrogen and phosphorus contents in the *Brassica napus* increased with increasing levels of nitrogen and P fertilizer, respectively. N, P, K and S uptake by intercrops increased with increasing levels of nitrogen, phosphorus and FYM.

Altaf *et al*. (1999) investigatedto study its effect on growth and yield attributes of *Brassica juncea* (L.) Czern. and Coss. (V_1) and *Brassica campestris* L. (V_2). In the experiment, conducted in the field, kg S ha 40^{-1} as $CaSO_4$ (gypsum) was applied either in a single basal application (S_1) or in two (S_2) or three (S_3kg kg N ha-^{1}) split applications; and 100^{-1} as urea was applied either in two (N_2) or three (N_3) splits. Biomass accumulation, leaf-area index (LAI), leaf-area duration (LAD), crop growth rate (CGR) and photosynthesis in the leaves were determined at various phenological stages. Split application of S and N (S_2N_2 or S_3N_3) resulted in significant improvement in growth and yield of both the genotypes compared with the application of S in a single basal application and N in two splits (S_1N_2). Increases in biomass accumulation, LAI, LAD, CGR and photosynthetic rate due to application of S_3N_3 were 48.4, 81.3, 77.9, 101.1 and 28.6% respectively, over the results of S_1N_2. Seed yield, biological yield and harvest index improved by 41.3, 26.9 and 11.6% respectively, with this treatment.

Sieling and Christen (1997) reported that the effect of the cropping history on the seed yield of oil-seed rape is extremely scarce. In addition, eight nitrogen treatments were tested for their potential to reduce negative effects of the preceding crops. The number of seeds m-^{2} showed a similar pattern, whereas the thousand-seed weight partly compensated for the reduced seed number. It was highest if oil-seed rape was grown 2 years previously. The cultivars differed significantly in their yield potential. Express (3.79 t ha^{-1}) yielded 0.6 t ha^{-1} more than Falcon (3.18 t ha^{-1}). Increasing amounts of fertilizer-N (80–200 kg N ha^{-1}) increased the seed yield from 3.21 t ha^{-1} to 3.84 t ha^{-1}. Changes in the distribution pattern within one fertilizer amount had no effect on seed yield.

Abd-EI-Gawad *et al*. (1990) who reported that increasing levels of K application not only increased the seed yield but also increased the pod number $plant^{-1}$ and number of seeds pod^{-1}. Mahadkar *et al*. (1996) also reported that increasing the rate of K fertilizer increased the number of pods.

Bilsborow *et al*. (1993) investigated on the response of low glucosinolate, low erucic acid (double low) cultivars of oilseed rape to spring nitrogen application.Seed yield and protein content increased in response to increasing nitrogen application. In each season over 85% of the maximum recorded yield was obtained with an application of 150 kg N ha-^{1}. In the absence of spring nitrogen, seed yield varied considerably over the three seasons. Seed glucosinolate concentration was significantly increased withnitrogen applications between 0 and 150 kg N ha-^{1}. Increasing nitrogen beyond 150 kg N ha^{-1} hadlittle or no effect on seed glucosinolate concentration. The results are examined with reference to the varying effects of increasing nitrogen application rates on seed glucosinolate concentrations reported previously.

Singh *et al*. (1992) examined that the effect of three sub-surface drain spacings and three levels of phosphorus on the yield, chemical composition and uptake of nutrients by Indian mustard (*Brassica juncea*). The number of siliquae m^{-2} and seed yield decreased with increasing drain spacing. Application of phosphorus increased seed yield and yield attributes. The concentrations of nitrogen, phosphorus and potassium in the seed and stalks decreased and those of sodium, calcium and magnesium increased with increasing drain spacing, but application of phosphorus increased the concentration of these nutrients in the seed and stalks. Absence of phosphorus in the drain water effluent and the level of available phosphorus in the soil profile after crop harvest indicated very slow movement of phosphorus, most of which was retained in the top 30 cm of soil.

2.2 Effect of organic fertilizer on growth and yield of mustard and other related crops

Nath and Singh (2012) were observing that the vermiwash (VW), singly and in combination with different biopesticides (BPs), was used in an agricultural field to control aphid (*Lipaphis erysimi*) infestation and to increase the growth and yield of mustard (*Brassica campestris*). A significant reduction in the aphid population was observed on mustard plants after spraying VW obtained from different combinations of animal dung and agro-wastes with 95% neem (*Azadirachta indica*) oil and 86% custard apple (*Annona squamosa*) leaves. The combination of garlic (*Allium sativum*) extract with different VWs could control 97% of the aphid population. VW obtained from animal dung + gram bran with neem oil was also very effective against aphids. A VW spray with BP increased the productivity of the mustard crop up to 3.5 times more than the control. These results clearly demonstrate that the use of VW with plant products is more beneficial for organic farming. It also compensates for deficiencies in essential nutrients, certain plant growth hormones, enzymes and vitamins. VW, singly and in combination with plant products, provides effective control against aphids, which are injurious to mustard plants.

Sharma and Singh (2011) conducted an experinemt to study the effect of organic matrix based slow release fertilizers (SRFs) on plant growth, nitrate assimilation and seed yield of *Brassica juncea* L. cv. pusa bold. The agro-waste materials like cow dung, clay soil, neem leaves and rice bran were mixed together in 2:2:1:1 ratio and used as organic matrix for the immobilization of chemical fertilizer nutrients with commercial grade saresh (Acacia gum, 15% solution) as binder. Different fertilizer treatments were organic matrix based slow release fertilizers, SRF-I (542.0 kg N ha-^{1});SRF-II (736.5 kg N ha-^{1}) and chemical fertilizer combinations, boron (3 kg ha^{-1})+sulphur (15 kg ha-1)+nitrogen (80 kg ha-1) and boron (3 kg ha^{-1}) + sulphur (15 kg ha^{-1})+nitrogen (80 kg ha^{-1})+phosphorus(15 kg ha^{-1})+potassium (100 kg ha^{-1}). Organic matrix based SRF-II released ammonium up to 50-d in wet soil under laboratory conditions which showed maximum retention of the nutrients. A very significant increase in plant growth, nitrate assimilation and seed yield was recorded in organic matrix based SRF-II applied plants. The maximum percent increase in biomass production was observed with organic matrix based SRF-II (increase of 65.8% in root fresh weight, 38.0% in root dry weight, 45.9% in leaf fresh weight plant-1 and 27.5 % in leaf dry weight plant-1 in 60-d old plants). It also increased the acquisition and assimilation of nitrate from the plant's rhizosphere which was evident by 45.6% increase in nitrate, 27.5% in nitrite and 11.7% in nitrate reductase activity (NRA) in leaves of 45-d old plants over control. The organic matrix based SRF-II significantly increased the seed yield by 28% in Indian mustard. Cost analysis revealed that this formulation is cost effective as it is based on agro waste materials.

Lata and Veenapani (2011) examined the effect of water hyacinth manure in comparison to control on *Brassica juncea (Indian mustard)*. Soil mineral analysis test was carried out for soil sample types. Added organic matter, water hyacinth manure in various combinations into soil has been found to influence the performance of crop plants as a result of the increase in nutrient availability. The observations revealed positive response with 100% water hyacinth manure, 50% water hyacinth manure and water hyacinth manure combined with farm yard manure on the growth behaviour of seedlings as they were enhanced significantly compared with that of the seedlings grown in control. The growth of *Brassica juncea* was more pronounced with 50% water hyacinth manure and productivity with 100% water hyacinth manure treatment.

A field experiment was conducted by Patil *et al*. (2011) to study the effect of organic manures and rock phosphate on growth and yield of chickpea (*Cicer arietinum* L.) in vertisols of northern Karnataka. Interaction effect of compost 5 t along with rock phosphate 200 kg ha^{-1} recorded significantly higher grain yield (2130 kg ha^{-1}) and haulm yield (3300 kg ha^{-1}) over other treatment combinations except either of organic manures FYM 5 t or compost 5 t along with 150 to 200 kg rock phosphate per ha. Significantly higher B:C ratio (3.32) was recorded with rock phosphate @ 200 kg ha^{-1} over other lower levels. Similarly, combination of compost @ 5 t/ ha with 150 kg rock phosphate resulted in higher B:C ratio (3.37).

Aslam *et al*. (2010) investigating to evaluate the effect of organic and inorganic sources of phosphorous on the growth and yield of mungbean (*Vigna radiate* L.). FYM, poultry manure and chemical fertilizer were accumulated at various concentrations to formulate different treatments. Analysis of data revealed significant differences with respect to plant height, number of plants $m\text{-}^{2}$, leaf area (cm^{2}), root length (cm), number of pod bearing branches plant $-^{1}$, number of pods plant$-^{1}$, number of seeds pod$-^{1}$, pod size (cm), number of seeds plant $-^{1}$, 1000 seed weight (g), biological yield (kg ha^{-1}), seed yield (kg ha^{-1}), harvest index (%) and grain protein contents (%) indicating primacy of integration of the two sources in having improved mungbean productivity.

Amanullah *et al*. (2010) reported that the poultry manure is rich in organic manure since solid and liquid excreta are excreted together resulting in no urine loss. In deep litter manure, the litter absorbs moisture and helps keep the manure friable. They observed that the different types of poultry manure produced different yield and quality of crops.

Datta *et al*. (2009) conducted an experiment to evaluate the impact of combined dose of chemical fertilizer, biofertilizer in combination with compost for the yellow sarson (Brassica campestries cv. B9). Various morpho-physiological parameters viz., plant population, length of shoot and root, leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR), yield attributes viz., number of siliquae per plant, number of seeds siliquae-^{1}, 1000 seeds weight (test weight), seed yield, stover yield and physiological and biochemical parameters viz., pigment content, sugar, amino acid, protein, ascorbic acid content in physiologically active leaf were performed. The treatment T1 i.e., 40% less N fertilizer, 25% less P fertilizer, K fertilizer constant + 12 kg ha-1 biofertilizer (Azophos) and organic manure (compost) @ 5Mt ha-1, showed the maximum chlorophyll accumulation (10.231 mg g-1 freshweight), highest seed /siliquae (25.143), test weight of seeds (4.861g) and highest seed yield (10.661 tha-^{1}). A comparison between all the morphological, anatomical, physiological and biochemical parameters due to application of chemical fertilizer, bio-fertilizer and compost alone and in combination and their impact on soil microorganism, flora and fauna will throw sound environmental information.

Paten *et al*. (2008) observed the effect of FYM, nitrogen and source of fertilizer on growth and yield of mustard [*Brassica juncea* (L.) Czernj & Cosson]. The results showed significant variation in leaf area index (LAI), crop growth rate (CGR), dry matter production and seed yield. The direct effect of farmyard manure (FYM) was conspicuous in improving the growth of mustard. FYM application at 10 tonnes ha^{-1} significantly increased the LAI, CGR and dry matter accumulation per plant almost all the stages during first year study (1992–93) and in pooled analysis. Similarly, nitrogen application registered maximum LAI, CGR at 75 kg level and RGR and NAR at 50 kg level during both years. Sulphur carrying source (Ammonium sulphate plus single super phosphate) increased all stages growth characters.

Maximum dry matter accumulation per plant and seed yield were recorded with highest levels of FYM (20 t ha^{-1}), N (75 kg ha^{-1}) and source having S. Seed yield was strongly associated with LAI and dry matter accumulation per plant at all the stages.

Nitrogen, sulfur and boron fertilization has significantly enhanced growth and yield of *B. juncea* in the Indian soil (Nema *et al*., 2008). However, a major portion of the applied chemical nitrogen fertilizers is lost through the leaching, run off, emissions and volatilizations which cause economic losses and serious environmental problems (Singh *et al*., 2006; Abdin *et al*., 2006; Galloway *et al*., 2008; Singh *et al*., 2010). Farm yard manure (FYM) and bio-fertilizers are used for eco-friendly organic farming, however they are unable to replace chemical fertilizers in terms of crop productivity.

Ebrahimi *et al.* (2007) reported that rapeseed varieties had different significant effects on number of branches, but non significant effect on protein percentage. In addition, Yasari *et al.* (2008) reported that treatment canola with mineral and biofertilizer resulted in maximum seed yield coinciding with maximum number of pods/plant.

According to a field experiment conducted by Chand *et al*. (2006) it was found that integrated supply of plant nutrients through FYM (farmyard manure) and fertilizer NPK, along with Sesbania green manuring, played a significant role in sustaining soil fertility and crop productivity.

Widjajanto *et al.* (2003) reported the increased performance of *Brassica rapa* by the incorporation of water hyacinth into soil-crop systems. Gunnarssen & Petersen (2006) also highlighted that using composted water hyacinth material could serve as quality manure for improving soil fertility conditions and thus crop yields on the whole.

The significant difference in total aerobic bacteria, fungal and actinomycetes were observed in soil amended with green manure *viz*., *S. rostrata* and *Crotalaria juncea* and inorganic fertilizer such as urea super granules and sulphur application (Ramalingam and Kannaiyan, 2006).

Kler and Walia (2006) opined that organic farming treatment supplemented with FYM along with crop residue incorporation and green manuring was recorded higher growth components *viz*., dry matter accumulation, leaf area index, over chemical farming in wheat under maize-wheat cropping system.

Asghar *et al*. (2006) reported that the organic wastes could convert them into a value-added product that may be effective even when applied in small quantity compared with the traditional use of their huge quantities. Two field trials were conducted to evaluate the integrated use of recycled organic waste and chemical fertilizers for improving growth and yield of radish. Recycled organic waste (compost) was enriched with an auxin precursor L-tryptohan (@ 6 mg kg^{-1} compost) and this enriched compost was tested alone and in combination with recommended nitrogen fertilizer @ 50 and 75%. Enriched compost + 50% recommended nitrogen fertilizer produced significantly better results in almost all the parameters except number of leaves $plant^{-1}$ and root length. Other parameters like leaf area, root girth, total biomass $plant^{-1}$, and yield ha^{-1} were increased by 82, 68, 132.9 and 167.6%, respectively compared to control. Results revealed that enriched compost with 50% recommended nitrogen fertilizer gave almost same results as the 100% N fertilizer alone, thus saving half of the Nitrogen.

Application of recommended quantities of vermicompost to different field crops has been reported to reduce the requirement of chemical fertilizers without affecting the crop yield. Application of 100 per cent nitrogen as vermicompost registered the higher plant height and number of branches per plant of tomato and it was significantly superior over supplementation of 100 per cent N through urea and FYM (Kannan *et al*., 2006). Similar trend was found in plant height of basmati rice at maturity with the application of vermicompost and it was at par with treatment receiving azolla @ 1.5 t $ha\text{-}^{1}$. A progressive increase in plant height and leaf area index of soybean was observed with the conjunctive use of 75 per cent N through vermicompost and remaining 25 per cent N through chemical fertilizer and was found at par with 100 per cent N through vermicompost alone. The additive benefit realized from vermicompost application (Govindan and Thirumurugan, 2005) might be ascribed to its higher nutrient contents and their availability to crop.

Among the various organic manures, the compost produced by earthworms (vermicompost), is a rich source of macro and micronutrients. Curry and Byrne (1992) found that earthworm derived nitrogen could supply 30 per cent of the total crop requirement as it is a potential source of readily available nutrients for plant growth. It not only supplies a good amount of different nutrient elements but also contains beneficial microbes like nitrogen fixing bacteria, mycorrhizae and growth promoting substances (Barik *et al*., 2006) for betterment of crops.

Zamil *et al*. (2004) conducted an experiment at Bangladesh Agril. Univ., Mymensingh to find out the effects of different animal manure on yield, quality and nutrient uptake by mustard cv. Agrani. The experiment comprised two levels of cage system poultry manure, deep litter system poultry manure, cow dung and bio-gas slurry viz. 10 and 20 t ha^{-1}, one control and one chemical fertilizer @ recommended dose. Cage system poultry manure @ 20 t 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 t $ha^{-1.}$ Protein and oil content was also found higher in this treatment. Seed yield was found to be significantly and positively correlated with branch and effective pod per plant. Protein and oil contents of mustard seeds were increased with increasing level of animal manures though their effects were not significant. A positive and significant correlation was observed between protein and oil contents of mustard cv. Agrani. The overall results suggest that cage system poultry manure @ 20 t ha^{-1} gave best performance among the parameters studied.

The use of manure application enhances soil productivity, increases the soil organic carbon content, soil micro-organisms, improves soil crumb structure, the nutrient status of the soil and enhances crop yield. Organic manure is also very cheap and effective as a good source of nitrogen for sustainable crop production, but its availability remains an important issue due to its bulky nature, while inorganic fertilizer is no longer within the reach of poor-resource farmers due to its high cost (Rahman, 2004).

The studies conducted by Shyalaja and Swarajyalakshmi (2004) revealed that use of organic manures can improve the soil health and productivity with low costs. Significantly higher seed and straw yield was recorded in the treatment in which 1 ton poultry manure was applied along with 75% recommended dose of fertilizer. Increased levels of organic source significantly increased the yield. Thousand seed weight was significantly more where there was integrated use of organic and mineral sources of fertilizer. All the treatments, organic manures alone or in combination with mineral sources have no effect on the oil content of sunflower. Because oil content is genetic content and cannot be altered by agronomic practices.

The benefit of using either crop residues such as water hyacinth residues has been reported by Widjajanto *et al*., 2001 and 2003. The study of water hyacinth as biofertilizer revealed that the incorporation of water hyacinth into soil crop system increased the performance yield of the crop plant *Brassica juncea*. Water hyacinth manure (WHM) in all combinations was found to be more effective for the growth and yield of the test plant over the control.

But to achieve sustainability in high production systems, only the integrated use of organic and inorganic fertilizers can play a vital role (Gosh *et al*., 2004). They stated organic manures added in the soils in combination with inorganic or chemical fertilizers, supplement all nutrients to crop and increase the productivity of crops. Most distinguishable results for the direct and residual effects were obtained where FYM @ 5 t ha^{-1} was applied along with 75% NPK for soybean crops.

Bonde *et al*. (2004) observed that all the organic residues significantly lowered the bulk density over the control. Among different organic residues, FYM recorded greater value of availability of nitrogen, phosphorus and potassium in soil as compared to other treatments (wheat straw and pressmud compost treatments) including control, in cotton-soybean cropping system.

A long term (15 year) field experiment conducted at Dryland Farming Research Station, Bhilwara, Rajasthan revealed that the application of 100 per cent recommended N through FYM to maize in rainy season and 100 per cent N and P_2O_5 through fertilizer in the winter season to mustard recorded the maximum plant height and test weight in both the crop and mustard equivalent yield (Kumpawat, 2004).

Rautaray *et al*. (2003) conducted an experiment to study the direct effect of fly ash, organic wastes and chemical fertilizers on rice (*Oryza sativa*) and their residual effect on mustard (*Brassica napus var glauca*) grown in sequence. Yields of mustard were also higher under the residual effect of the former rather than the latter. However, this beneficial residual effect under integrated nutrient sources was inadequate for the mustard crop in the low fertility test soil. The yield increase was 10% when it was used in combination with only chemical fertilizers. The minimum yield advantage, 3%, occurred when fly ash was applied alone. The equivalent yield of the rice–mustard cropping sequence was equally influenced by either of the organic wastes. Cadmium and Ni content in rice grain and straw were less under the direct effect of fly ash. The residual effect on mustard was similar for Ni content in seed and stover; however, Cd content was increased. Beneficial residual soil chemical properties in terms of pH, organic carbon and available N, P and K were noted for integrated nutrient treatments involved fly ash, organic wastes and chemical fertilizers as compared to continuous use of only chemical fertilizers. Application of fly ash alone was effective in raising soil available P. Thus, integrated use of fly ash, organic wastes and chemical fertilizers was beneficial in improving crop yield, soil pH, organic carbon and available N, P and K in sandy loam acid lateritic soil.

The field experiment using organic manures in soybean, revealed that vermicompost equivalent to 100 per cent RDN and 75 per cent RDN were able to maintain yield level comparable to that of 100 per cent NPK through inorganic fertilizers. Whereas pressmud @ 100 per cent N and 75 per cent N and composted coir pith (100% N and 75% N) were not able to maintain yield level (Govindan and Thirumurugan, 2002). He also noticed that application of organic manures markedly improved soil available nitrogen status. Among them application of vermicompost equivalent to 100 per cent N, 75 % N and composted coirpith equivalent to 75 % RDN recorded higher soil available N status (110.3 kg ha-^{1}, 133 kg ha-^{1} and 101.0 kg ha-^{1} respectively after soybean) over 100 per cent inorganic NPK (92.4 kg ha-^{1}) treatment.

Rajkhowa *et al*. (2000) opined that the highest dry matter and seed yield of greengram in a pot culture experiment was recorded with the application of 75 % N as urea along with 5 t ha-^{1} vermicompost and it was at par with the application of N as vermicompost equivalent to RDN.

Parasuraman and Rajagopal (1998) at Coimbatore reported that, incorporation of coir waste @ 10 t ha-^{1} resulted in higher seed yield (1187 kg ha-^{1}) as compared to incorporation of FYM @ 12.5 t per ha (1108 kg ha-^{1}) and incorporation of coir waste @ 5 t per ha (998 kg ha-^{1}).

Application of vermicompost or FYM @ 10 t ha-^{1} as well as vermicompost @ 5 t ha-^{1} produced significantly higher dry matter per plant than no organic manure in sunflower hybrids (Devidayal and Agarwal, 1998). The significant increase in dry weight might be due to cumulative effects of improvement in all the growth parameters with the application of organic manures. Average increase in dry weight per plant was 7 to 9 per cent with 10 t per ha FYM and 10.5 per cent with 10 t ha-^{1} vermicompost over no organic manure.

According to Dayal and Agarwal, (1998) different nutrient sources (organic & inorganic) in varying combinations viz. 0 or 10 t farmyard manure ha-1, 5 or 10 t vermicompost ha-^{1} or 250 kg ha-^{1} of Fertonic (a bio-organic soil enricher) and 0, 40:20, 80:40 or 120:60 kg NP ha-^{1} were tested for the yield performance of sunflower. Seed yields were higher with the 2 higher rates of NP than with any of the organic fertilizers.

One of the incubation study made by Serra-Wittling *et al*. (1995), recorded carbn mineralization and dehydrogenase activity were significantly correlated. Addition of the oldest compost had no effect on the activity of C cycle enzymes, but the youngest compost increased the soil enzyme activity at the higher application rate.

Gidnavar *et al*. (1992), observed a favourable contribution of green manures like sunhemp, cowpea, blackgram, soybean and horsegram on organic carbon status of soil which inturn resulted in possible increase in moisture retention. However organic carbon content was highest in FYM treated soil.

Farm yard manure occupies an important position among bulky organic manures. The cattle excreta based FYM in India can potentially supply approximately 3.3 mt of N, P, and K per year (Gaur, 1984). It has been estimated that a tonne of FYM would supply 3.6 kg nitrogen + 1.9 kg phosphorus + ^{1}.8 kg potassium (Gaur, *et al*., 1992).

Farm yard manure occupies an important position among bulky organic manures. The cattle excreta based FYM in India can potentially supply approximately 3.3 million tones of N, P_2O_5 and K_2O per year (Gaur, 1984).

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Elsharawy *et al.* (2003) examined the effect of the compost of some plant residues i.e., rice straw and cotton stalks on some physical and chemical properties of the sandy soil. Application of cotton stalks or rice straw composts significantly improved the physical properties of the tested soil, i.e., bulk density, hydraulic conductivity and moisture contents namely field capacity, wilting point and available water. Concerning the effect of composts application on the availability of N, P and K in the cultivated soils, rice straw was better than cotton stalks.

According to HDRA (1999) compost derived from organic wastes, such as segregated household waste, green botanical waste and food processing waste are becoming available in increasing quantities. These supply a complex mixture of nutrients in organic and mineral forms and are also used as soil condition to maintain and improve soil structure.

Chittra and Janaki (1999) stated that application of composted coir pith improve the soil available K status and increased the uptake of potassium by grain and straw yield of rice. Application of 50 kg N with green leaf manure gave the highest grain and straw yield in both seasons, followed by composted coir pith.

BARC (1997) reported that organic matter content of a particular soil was an indicator of its productivity. It helped in binding the soil particles into aggregates thereby improving drainage and reducing erosion, reduce leaching loss of nutrients through enhanced action exchange activity, increased water holding capacity, supported the activities of micro organisms, increaseed the benefit from chemical fertilizers, and promote the production of beneficial plant hormones.

Verma (1995) concluded that the organic materials commonly used to improve soil conditions and fertility include crop residues, urban wastes, green manures, biogas spent slurry, microbial preparations, vermicomposts and biodynamic preparation.

Rai (1965) observed that compost when incorporated in the soil improved the physical structure of the soils. Sandy soils are compacted and clay soils become loose. The water holding and heat absorbing capacity of soils increase and thus compost improves the permeability of soils and makes the working of soils easier.

Cho *et al*. (1986) reported that organic matter could be considered as the life to the soil and was the store house of the plant nutrients. Organic matter is the principal sources of N and other nutrient elements increases the soil buffering capacity protect soil erosion and maintain healthy community of soil organisms.

In a 12 year study in typical clayey rice soil (Aeric Albaquept) of Bangladesh by Farid *et al.* (1998) showed that incorporation of compost or rice straw and subsequent decomposition increased and maintained OM level at 2.5% that was higher than that in traditionally managed rice soil (<2%).

Method of composting is one of the important factors to accumulate from the waste for organic manuring. FSES (1996) reported that composting by pit polythene method accumulated three times more compost over farmers conventional method. Quality compost also produced by this method gave better yield of crops and improved soil organic matter.

In a long term trial Mani *et al.* (1980) showed that the organic matter content of the soil increased from 1.45 to 2.61% with farmyard manure, from 1.46 to 2.70% with green leaf manure and from 1.45 to 2.58% with compost.

Aga *et al.* (2004) assessed the effect of compost on the growth and yield of rice. Plant growth characters such as plant height were highest with application of 15 t compost ha^{-1}. Grain yield increase significantly with the graded levels of compost application @ 10 t ha^{-1}, but the response decreased with the increase of compost from 10 t 15 t ha^{-1}.

Prasad *et al.* (2004) carried out an experiment on management of rice root Nematode, *Hirschmanniella oryzae*, in Hyderabad, Andhra Pradesh, India in relation to application of fresh leaves of *Azadirachta indica*, *Sesbania aculeata* or water hyacinth. Compost @ 60 kg ha^{-1} was found useful for managing this nematode and increasing grain yield.

Tejada and Gonzalez (2003) reported that influence of four doses of a compost originating from residues of crushed cotton gin on wheat in dry land conditions (Guadalquivir Valley, Andalusia, Spain) has been studied. The results showed that this compost was of a great agricultural interest product because of its organic matter content. The application of this by product to the soil resulted in an increase in soil microbial activity, structural stability and soil porosity. Mineralization of organic matter produced a higher concentration of NO_3-N in soil, an increase on the yield parameters and grain yield in both seasons.

Tamaki *et al.* (2002) examined the correlation between growth and yield of rice and duration of organic farming (compost mixed with straw) in comparison with conventional farming. In organic farming plant height of rice was shorter and shoot number hill $^{-1}$ was lesser than in conventional farming, but both of these values increase as the duration of organic farming increased. The maximum tiller number was smaller and panicle number was also smaller in organic farming. However, both the panicle number and panicle length increased as the duration of organic farming increased. The grain-straw ratio was higher in organic farming than in conventional farming. These results suggest that the growth and yield of rice increased with continuous organic farming and the yield increased with increase in number of panicle hill^{-1} and number of grain panicle^{-1}.

Rani and Srivastsva (1997) reported that vermicompost was tested in pot experiment for its ability to replace a proportion of the urea fertilizer applied to rice. Compared with N fertilizer alone, supplying one-third or one-quarter of N as vermicompost increased plant height, grain yield and yield components of rice.

Fan and Yu (1990) showed that by continuous application of farmyard manure, river sludge, green manures and wheat straw increased the soil organic matter content by 52%, 32.2%, 15.1% and 15%, respectively and increased total wheat production by 40.4, 11.1, 13.1 and 2.7%, respectively.

Bangar *et al.* (1989) reported that compost of paddy straw can be enriched using urea and Mussooric rock phosphate for N and P enrichment, respectively. In plot trial during two years, wheat grain and straw yields increased significantly.

From the above discussion it is observed that both the organic and the inorganic fertilizers exerted significant effects on grain yield of Mustard. Many researchers opined that use of compost from different sources alone can mitigate the requirements of crop damaged as done by chemical fertilizers. But it is better to use both organic and inorganic fertilizer for crop production because combination of organic and inorganic fertilizer generates positive response to both the crop yield and soil properties.

CHAPTER III

MATERIALS AND METHODS

The details of the materials and methods of this research work have been described in this chapter.

3.1 Description of the experimental site

3.1.1 Location and time

The present research work was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October, 2010 to March, 2011. The experimental area was located at 23.74^0 N latitude and 90.35^0 E longitude with an elevation of 8.2 m from the sea level (Khan, 1997).

3.1.2 Soil

The soil of the experimental area was to the general soil type series of shallow red brown terrace soils under Tejgaon series. Upper level soils were clay loam in texture, olive-gray through common fine to medium distinct dark yellowish brown mottles under the Agro-ecological Zone (AEZ- 28) and belonged to the Madhupur Tract (UNDP, 1988; FAO, 1988). The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done from Soil Resources Development Institute (SRDI), Dhaka. The experimental plot was also high land, fertile, well drained and having p^H 5.8. The physicochemical property and nutrient status of soil of the experimental plots are given in Appendix 1A and 1B.

3.1.3 Climate and weather

The experimental area is situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of April to September (Kharif Season) and scanty rainfall during the rest period of the year (Biswas, 1987). The detailed meteorological data in respect of air temperature, relative humidity, total rainfall and soil temperature recorded by the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka during the period of study have been presented in Appendix II.

3.2 Experimental materials

3.2.1 Treatments

A. Variety

Mustard cultivar BARI sarisha-15 was used as experimental materials for the study which was released from Bangladesh Agricultural Research Institute (BARI). The seed of the variety of this experiment was collected from BARI, Joydebpur, Gazipur. The characteristics of this variety were shown below:

1. Plant height : 90-100 cm
2. Branches : Primary branches 68, but secondary branches absence
3. Siliqua plant^{-1} : 70-80
4. Seed siliqua^{-1} : 20-22
5. 1000 grain weight: 3.25-3.50 g
6. Yield : 1550-1650 kg ha^{-1}

B. Treatments

The experiment comprised the following ten treatments including control

T_0: Control (without fertilizer)

T_1: All chemical fertilizer (recommended dose)

T_2: Cowdung (Recommended dose)

T_3: Compost (Recommended dose)

T_4: ½ Compost + ½ Cowdung

T_5: Cowdung + Compost

T_6: Cowdung + ½ Chemical fertilizer

T_7: Compost + ½ Chemical fertilizer

T_8: Cowdung + Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

The recommended followed in this experiment was a per BARI ,2006 as mention in table 1.

3.3 Experimental design and layout

The experiment consisted of BARI sarisha- 15 and was laid out in Randomized Complete Block Design (RCBD) with 3 replications. There were 30 unit plots altogether in the experiment. The size of each unit plot was 4m × 2.5m. Row to row and plot to plot distances were 1.0 m and 0 .75 cm, respectively. The treatments were assigned in plot at random. Details layout of the experimental plot has beean presented in Appendix III.

3.4 Land preparation

Power tiller was used to open the experimental field first time. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed with the help of power tiller to obtain good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of this crop. Laddering was done in order to break the clods into small pieces followed by each ploughing. All the weeds and stubble were removed from the experimental field. The plots were spaded one day before planting and the whole amount of fertilizers were incorporated thoroughly before planting according to fertilizer recommendation of BARI, (2006). At final land preparation Furadan 5G was applied in the field @ 8 kg ha^{-1} to protect young plants from the attack of mole cricket, ants, and cutworms.

3.5 Manures and fertilizers

The calculated entire amount of all manures and fertilizers were applied during final plot preparation according to the design and treatment. The applied manures were mixed properly with the soil in the plot using a spade. The dose and time of application of organic and inorganic fertilizers are shown in below:

Table1 Dose and method of application of organic and inorganic fertilizers in mustard field (BARI,2006)

Manure and fertilizers	Dose (ha^{-1})	Application (%)	
		Basal	1st installment
Urea	220 kg	66.66	33.33
TSP	180 kg	100	-
MP	85 kg	100	-
Gypsum	150 kg	100	-
Zinc oxide	5 kg	100	-
Boric acid	6 kg	100	-
Cowdung/ Compost	8 ton	100	-

3.6 Seed treatment

Before sowing seeds were treated with Provex -200@0.25% to prevent seeds from the attack of soil borne disease. Furadan @1.2 kg ha^{-1} was also used as per treatment against wireworm and mole cricket.

3.7 Seed sowing

Seeds were sown on 6th November, 2010. The row to row and plant to plant distances were 30 cm and 6 cm, respectively. Seeds were placed at about 3 to 4 cm depth from the soil surface. Few seedlings were grown in the border of the plots.

3.8 Intercultural operations

3.8.1 Thinning out

Emergence of seedling was completed within 7 days after sowing. Over crowded seedlings were thinned out two times. First thinning was done at 24-11-2010 to remove unhealthy and lineless seedlings. The second thinning was done at 4-12-2010.

3.8.2 Irrigation and drainage

Three irrigations were applied in the field at 10, 25, and 45 days after sowing(DAS). Proper drainage system was also developed for draining out excess water.

3.8.3 Weeding

Weddings were done to keep the plots free from weeds which ultimately ensured better growth and development of mustard seedlings. First weeding was done at 15 DAS, second & third weeding was done at 30 & 50 days after sowing to keep the soil loose and aerated.

3.8.4 Disease and pest management

The experimental crop was not infected with any disease and no fungicide was used. Hairy caterpillars attacked the young plants and accumulated on the lower surface of leaves where they usually sucked juice of green leaves. Borers also attacked the plots. They attacked at the early growing stages of seedlings. To control these pests, the infected leaves were removed from the stem and destroyed together with the insects by hand picking. Besides, pyriphos and triel- 20 ml were also applied to control these insects. The insecticide was sprayed whenever it needed.

3. 9 Harvesting and processing

The crop was harvested manually depending upon the maturity from each plot starting from 6th February, 2011. For collecting yield data plants of central 3m^2 areas was harvested in plot. During harvest, random selected 10 plants of each plot were cut at the ground level with sickle and bundled and tagged carefully for recording necessary some morphological and yield contributing parameters data. The harvested plants of 3m^2 area of each treatment were brought to the cleaned threshing floor and siliqua and seed were separated from plants by hand and allowed them for drying well under bright sunlight. Finally, seeds or grain yield was taken on individual plot basis at moisture content of 12% and converted into t ha^{-1}.

3.10 Data Collection

3.10.1 Growth parameters

3.10.1.1 Plant height (cm)

Plant height was measured in centimeter by a meter scale at 15, 30, 45, 60, 75 DAS (Days after sowing) and at harvest period. Data were recorded as the average of randomly selected 10 plants from the inner rows of each plot. Plant height from the ground surface to the top of the main shoot and the mean height were expressed in cm.

3.10.1.2 Branches plant^{-1}(no.)

Number of branches plant^{-1} data was also recorded at 45, 60, 75 DAS and at harvest where all the primary and secondary branches were considered in each plant.

3.10.1.3 Dry weight plant^{-1} (g)

The plant dry matter weight was measured by oven dry method. Ten plants randomly collected from each plot were uprooted and were gently washed to remove sand and dust particles adhered to the plants. Then the water adhered to the plants were soaked with paper towel. After then the samples were kept in an oven at 70^{o}C for 72 hours to attain constant weight. When the plant samples were attained at constant weight, the dry weights was recorded at 20, 40, 60, 80 DAS and at harvest.

3.10.1.4 Crop Growth Rate (CGR)

The crop growth rate values at different growth stages were calculated using the following formula-

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1} \; gm^{-2} day^{-1}$$

Where,

W_1= Total dry matter production at previous sampling dateW_2= Total dry matter production at current sampling date

T_1= Date of previous sampling

T_2= Date of current sampling

GA= Ground area (m^2)

3.10.1.5 Relative Growth Rate (RGR)

The relative growth rate (RGR) values at different growth stages were calculated using the following formula-

$$RGR = \frac{Log_e W_2 - Log_e W_1}{T_2 - T_1} \ gg^{-1}day^{-1}$$

Where,

W_1= Total dry matter production at previous sampling date

W_2= Total dry matter production at current sampling date

T_1= Date of previous sampling

T_2= Date of current sampling

Log_e= Natural logarithm

3.10.2 Yield Contributing Characters and Yield

3.10.2.1 Number of plants m^{-2}

Number of plants was counted from the central $3m^2$ area of each plot and then calculated the plants m^{-2}.

3.10.2.2 Number of siliqua $plant^{-1}$

Number of siliqua was counted from randomly selected ten plants after harvest and averaged them to have number of siliqua $plant^{-1}$.

3.10.2.3 Number of seeds $siliqua^{-1}$

Total number of seed was counted from the selected 20 siliqua and averaged them to have number of seeds $siliqua^{-1}$.

3.10.2.4 Weight of 1000 seeds

One thousand seeds were randomly counted and selected from the stock seed and weighed in gram by digital electric balance. It was expressed as 1000-seed weight in gram (g).

3.10.2.5 Seed yield (kg ha^{-1})

Seeds obtained from each unit plot were sun-dried and weighed carefully. The dry weight of seeds of central 3m^2 areas used to record seeds yield plot^{-1} and converted this into kg ha^{-1}.

3.10.2.6 Stover yield (kg ha^{-1})

Straw obtained from each unit plot was sun-dried and weighed carefully. The dry weight of straw of central 3m^2 area was used to record the final straw yield plot^{-1} which was finally converted to kg ha^{-1}.

3.10.2.7 Biological yield (kg ha^{-1})

Grain and straw yields were altogether regarded as biological yield. The biological yield was calculated with the following formula-

Biological yield (kg ha^{-1}) = Seed yield + Stover yield.

3.10.2.8 Harvest index (%)

Harvest index is the ratio of economic yield to biological yield and was calculated with the following formula-

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.11 Statistical analysis

The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program (Russel, 1986). The mean values for all the parameters were calculated and the analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test at 5 % levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The results of the experiment are presented and describe in this chapter under the different growth, yield contributing characters and yield of

mustard with some tables and figures as follows:

4.1 Effect of different doses of organic and inorganic fertilizer on growth characters

4.1.1 Plant height

The enlargement of plant showed significant variation (P<0.01) due to the effect of different doses of chemical and organic fertilizer at 15 days interval starting from 15 days after sowing (DAS) up to 75 DAS and at harvest (Appendix IV). The results of the analyzed plant height data was present in Table 2.

Initial stage of data recording (15 DAS), the tallest plant (13.46 cm) was observed in T_1 (All chemical fertilizer at Recommended dose) which was closely (13.38 cm) followed by T_8 (Cowdug + Compost + ½ Chemical fertilizer). The shortest plant (10.34 cm) was recorded in T_0 (Control) which was very close (10.77 cm) to T_4 (½ Cowdung + ½ Compost) (Table 2).

At 30 DAS, treatments T_1 (All chemical fertilizer at Recommended dose) produced the longest plant (42.42 cm) which was statistically similar to T_8 (Cowdug + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdug + ½ Compost + ½ Chemical fertilizer). The shortest plant (31.82 cm) was found in control treatment (T_0). Other treatments showed intermediate result in respect of plant height.

The tallest plant (90.93 cm) was recorded in T_1 (All chemical fertilizer at recommended dose) which was statistically similar to T_8 (Cowdug + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdug + ½ Compost + ½ Chemical fertilizer) 90.91 and 90.41 cm, respectively at 45 DAS. This result was closely followed by T_4, T_5, T_6 and T_7, (84.52, 85.29, 87.25 and 86.55 cm respectively). The shortest plant (74.17 cm) was also recorded in control treatment (T_0).

At 60 DAS the treatment T_1 (all chemical fertilizer at recommended dose) produced the tallest plant (114.80 cm) which was closely followed by T_8 (Cowdug + compost + ½ chemical fertilizer) and T_9 (½ Cowdug + ½ compost + ½ chemical fertilizer) (114.40 and 113.0 cm, respectively). Among the treatments, control treatment also showed the shortest plant (81.33 cm) at 60 DAS.

At 75 DAS, the tallest plant (108.80 cm) was recorded in T_1 (all chemical fertilizer at recommended dose) which was statistically similar to T_8 (Cowdug + compost + ½ chemical fertilizer) and T_9 (½ Cowdug + ½ compost + ½ chemical fertilizer) (108.40 and 106.20 cm, respectively). On the other hand, control treatment gave the shortest plant (84.42 cm).

At harvest stage, T_1 (all chemical fertilizer at recommended dose) they gave the longest plant (108.30 cm) which was closely (105.10 cm) followed by T_8 (Cowdug + compost + ½ chemical fertilizer) and the shortest plant (80.34 cm) was recorded in control treatment.

Table 2. Effect of chemical and organic fertilizer on plant height (cm) at different days after sowing (DAS) of mustard

Treatments	Plant height (cm)					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
T_0	10.34 d	31.82 d	74.17 c	81.33 f	84.42 d	80.34 f
T_1	13.46 a	42.42 a	90.93 a	114.8 a	108.8 a	108.3 a
T_2	11.22 cd	32.75 d	82.07 b	97.03 e	91.02 c	89.36 e
T_3	11.40 bd	32.56 d	81.78 b	98.26 e	92.26 c	90.83 e
T_4	10.77 d	34.01 d	84.52 ab	100.9 de	93.86 bc	92.22 e
T_5	11.47 ad	34.95 cd	85.29 ab	98.47 e	94.66 bc	93.33 de
T_6	11.57 ad	38.49 bc	87.25 ab	108.6 bc	98.80 b	99.07 bd
T_7	11.33 cd	37.89 bc	86.55 ab	106.1 cd	97.09 bc	98.58 cd
T_8	13.38 ab	40.62 ab	90.91 a	114.4 ab	108.4 a	105.1 ab
T_9	12.85 ac	41.26 ab	90.41 a	113.0 ab	106.2 a	103.9 ac
s/x	**0.6159**	**1.217**	**2.143**	**1.898**	**1.979**	**1.980**
CV (%)	**9.05**	**5.75**	**4.35**	**3.18**	**3.51**	**3.57**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.05 level of probability

Note:

T_0= Control
T_1= All chemical fertilizer (Recommended dose)
T_2= Cowdung (Recommended dose)
T_3= Compost (Recommended dose)
T_4= ½ Cowdung + ½ compost
T_5= Cowdung + compost
T_6= Cowdung + ½ chemical fertilizer
T_7= Compost + ½ chemical fertilizer
T_8=Cowdug + compost + ½ chemical fertilizer
T_9= ½ Cowdug + ½ compost + ½ chemical fertilizer

4.1.2 Number of branches plant^{-1}

Number of branch plant^{-1} showed significant variation at 0.05% level of probability due to the effect of different organic and inorganic fertilizer at different days after sowing whose analysis of variance data has been present in appendix V. Number of branches plant^{-1} data was recorded four times at 45, 60, 75 DAS and at harvest period and it was presented in Table 3.

The maximum number of branches plant^{-1} (6.457) was observed in T_1 (All chemical fertilizer at Recommended dose) which was followed by T_8 (Cowdug + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdug + ½ Compost + ½ Chemical fertilizer) (6.26 and 6.03, respectively) at 45 DAS. In contrast, the minimum number of branches plant^{-1} (2.73) was recorded in control treatment at the same days.

At 60 DAS, the maximum number of branches plant^{-1} (7.140) was found in T_1 (all chemical fertilizer at recommended dose) which was statistically similar to T_8 (7.057) and T_9 (7.003). The second maximum number of branches plant^{-1} 5.397 and 5.800 was recorded in T_6 and T_7 respectively. The minimum number of branches plant^{-1} (3.340) was also recorded in control treatment.

Among the treatments, the maximum number of branches plant^{-1} (7.94) was recorded in T_1 (All chemical fertilizer at recommended dose) which was statistically similar to T_8, $T_{9,}$ T_6 and T_7 (7.77, 7.53, 6.75 and 6.60 respectively) at 75 days after sowing. The minimum number of branches plant^{-1} (4.073) was observed in control treatment.

At harvest, the maximum number of branches plant^{-1} (8.070) was recorded in T_1 (all chemical fertilizer at recommended dose) which was statistically similar to T_8 and T_9 (7.820 and 7.433, respectively). The next highest branches plant^{-1} 6.74 and 6.70 was found in T_7 (compost + ½ chemical fertilizer) and T_6 (Cowdung +½ Chemical fertilizer) treatments. The minimum number of branches plant^{-1} (4.31) was observed in control treatment.

Table 3. Effect of chemical and organic fertilizer on number of branches plant^{-1} at different days after sowing (DAS) of mustard

Treatments	Number of branches plant^{-1} (cm)			
	45 DAS	**60 DAS**	**75 DAS**	**At harvest**
T_0	2.73 e	3.34 d	4.07 c	4.31 e
T_1	6.46 a	7.14 a	7.94 a	8.07 a
T_2	3.61 de	3.97 cd	4.94 bc	5.27d
T_3	3.23 de	4.16 cd	5.10 bc	5.42 d
T_4	3.86 de	4.35 cd	5.17 bc	5.36 d
T_5	4.09 cd	4.96 bc	5.63 bc	5.73 cd
T_6	5.23 ac	5.39 b	6.74 ab	6.69 b
T_7	5.10 bc	5.80 b	6.60 ab	6.74 b
T_8	6.26 ab	7.05 a	7.77 a	7.82 a
T_9	6.03 ab	7.00 a	7.53 a	7.43 a
CV (%)	**14.72**	**10.55**	**15.34**	**8.17**
s/x	**0.3958**	**0.3240**	**0.5450**	**0.2915**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.05 level of probability

Note:
T_0= Control
T_1= All chemical fertilizer (Recommended dose)
T_2= Cowdung (Recommended dose)
T_3= Compost (Recommended dose)
T_4= ½ Cowdung + ½ compost
T_5= Cowdung + compost
T_6= Cowdung + ½ chemical fertilizer
T_7= Compost + ½ chemical fertilizer
T_8=Cowdug + compost + ½ chemical fertilizer
T_9= ½ Cowdug + ½ compost + ½ chemical fertilizer

4.1.3 Dry weight plant^{-1} (g)

Significant variation was found in dry weight plant^{-1} due to the effect of different organic and inorganic fertilizer at different days after sowing and the analysis of variance has been shown in appendix VI. Dry weight of plant data was recorded at 20 days interval starting from 20 DAS up to 80 DAS and the results presented in Table 4.

At 20 DAS, the highest dry weight of plant (0.1780 g) was taken from the treatment T_1 (all chemical fertilizer as a recommended dose) which was closely followed by T_3 (Cowdung + Compost + ½ Chemical fertilizer), T_4 (½ Cowdung + ½ Compost), T_5 (Cowdung + Compost), T_6 (Cowdung + ½ Chemical fertilizer), T_7 (Compost + ½ Chemical fertilizer), T_8 (Cowdung + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdung + ½ Compost + ½ Chemical fertilizer) (0.1630, 0.1600, 0.1670, 0.1703, 0.1680, 0.1740 and 0.1673 g, respectively). Significantly, the lowest weight plant^{-1} (0.1330 g) was found in control treatment (Table 4).

At 40 DAS, the highest dry weight of plant (1.600 g) was recorded in T_1 (all chemical fertilizer as a recommended dose) which was statistically identical to T_8 (Cowdung + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdung + ½ Compost + ½ Chemical fertilizer) (1.510 and 1.462 g, respectively). Statisticaly, the second highest weight plant^{-1} (1.51 g) was found in T_8 (Cowdung + ½ Chemical fertilizer) which was statistically similar to T_9 (½Compost +½ Cowdung + ½ chemical fertilizer) and the lowest weight of plant (0.75 g) was found in control treatment.

Among the different organic and inorganic fertilizer and their combinations, treatments, T_1 (all chemical fertilizer as a recommended dose) gave the highest dry weight of plant (6.120 g) to compare other treatments at 60 DAS which was statistically similar with T_8 (Cowdung + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdung + ½ Compost + ½ Chemical fertilizer) (5.710 and 5.370 g, respectively). The lowest dry weight of plant (2.900 g) was found in T_2 (cowdung at recommended dose) which was statistically similar with T_0 (control) treatment.

At 80 DAS, the highest dry weight of plant (10.65 g) was recorded in T_1 (all chemical fertilizer as a recommended dose) which was statistically similar to T_6 (Cowdung + ½ Chemical fertilizer), T_7 (Compost + ½ Chemical fertilizer), T_8 (Cowdung + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdung + ½ Compost + ½ Chemical fertilizer) (9.083, 10.33, 10.51 and 10.33 g, respectively). The lowest dry weight of plant (5.163 g) was found in T_0 (control) and it was statistically similar to T_2 (cowdung as recommended dose), T_3 (compost as recommended dose), T_4 (½ Cowdung + ½ Compost) and T_5 (Cowdung + Compost) (6.043, 6.000, 6.213 and 6.960 g, respectively) (Table 4).

Table 4. Effect of chemical and organic fertilizer on dry weight of plant at different days after sowing (DAS) of mustard

Treatments	Dry weight of plant^{-1} (g)				
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**At harvest**
T_0	0.13 c	0.75 d	3.18 ef	5.16 b	8.20 e
T_1	0.18 a	1.60 a	6.12 a	10.65 a	21.68 a
T_2	0.16 b	0.99 cd	2.90 f	6.04 b	10.29 de
T_3	0.16 ab	0.88 cd	3.94 de	6.00 b	12.84 cd
T_4	0.16 ab	1.11 bc	4.21 cd	6.21 b	14.84 bd
T_5	0.17 ab	1.10 bc	3.85 de	6.96 b	16.89 ac
T_6	0.18 ab	1.32 ab	4.87 bc	9.08 a	18.84 ab
T_7	0.17 ab	1.29 ab	4.34 cd	10.33 a	17.77 ab
T_8	0.17 ab	1.51 a	5.71 ab	10.51 a	20.14 a
T_9	0.17 ab	1.46 a	5.37 ab	10.33 a	20.18 a
s/x	**0.005774**	**0.09309**	**0.2739**	**0.7134**	**1.485**
CV (%)	**7.60**	**13.51**	**10.67**	**15.20**	**15.91**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.05 level of probability

Note:
T_0= Control
T_1= All chemical fertilizer (Recommended dose)
T_2= Cowdung (Recommended dose)
T_3= Compost (Recommended dose)
T_4= ½ Cowdung + ½ compost
T_5= Cowdung + compost
T_6= Cowdung + ½ chemical fertilizer
T_7= Compost + ½ chemical fertilizer
T_8=Cowdug + compost + ½ chemical fertilizer
T_9= ½ Cowdug + ½ compost + ½ chemical fertilizer

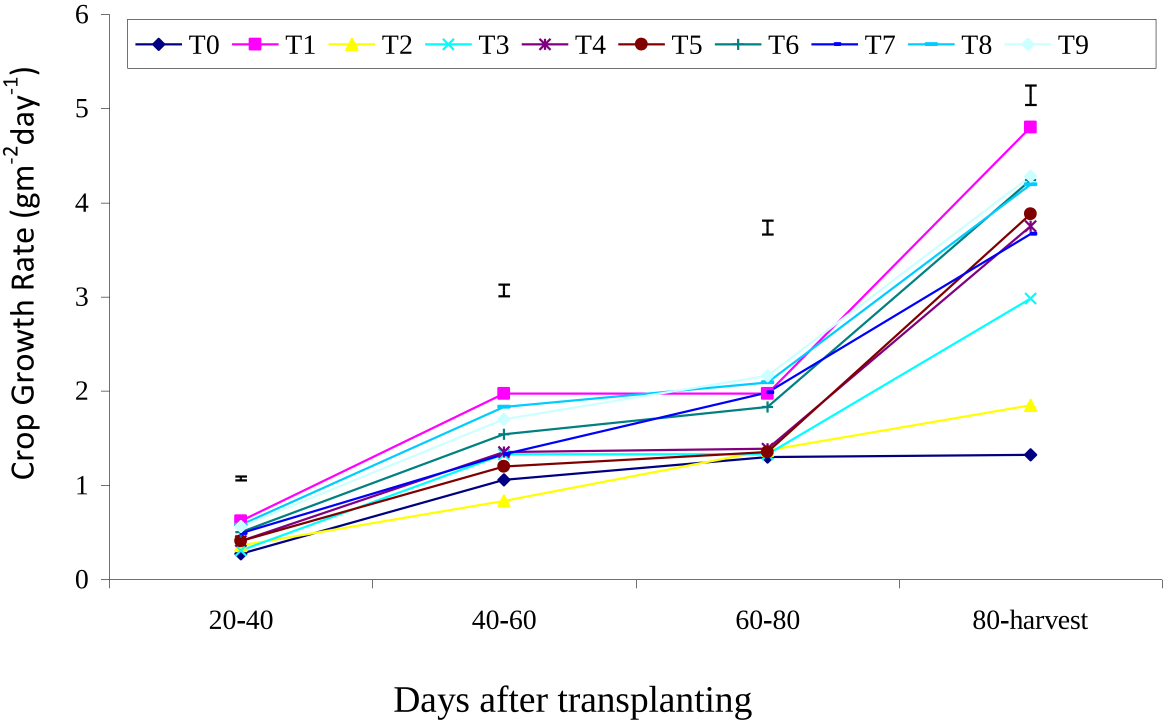
The highest dry weight of plant (21.68 g) was also recorded in T_1 (all chemical fertilizer as a recommended dose) which was statistically similar to T_8 (cowdug + compost + ½ chemical fertilizer) and T_9 (½ cowdug + ½ compost + ½ chemical fertilizer) (20.14 and 20.18 g, respectively) at the harvest stage of data recording. The lowest dry weight of plant (8.20 g) was found in T_0 (control) (Table 4).

4.1.4 Crop growth rate (CGR)

Highly significant differences were observed due to the effect of different organic and inorganic fertilizer at different days after sowing in respect of crop growth rate (CGR) (Fig. I and Appendix VII). In general the figure shows an increasing trend with the increase of growth stages in respect of CGR. The highest CGR was found in last CGR count dates for all treatments.

At 20 to 40 DAS, the highest CGR (0.623 $gm^{-2}day^{-1}$**)** was taken from the treatment (all chemical fertilizer as a recommended dose) which was closely followed by T_8 (Cowdung + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdung + ½ Composet +½ Chemical fertilizer) (0.58 and 0.56 $gm^{-2}day^{-1}$, respectively). Significantly, the lowest crop growth rate (0.27 $gm^{-2}day^{-1}$) was found in control treatment.

At 40-60 DAS, treatment T_1 (All chemical fertilizer as recommended dose) produced the maximum crop growth rate (1.97 $gm^{-2}day^{-1}$) which was statistically identical to T_8 (Cowdung + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdung + ½ Composet +½ Chemical fertilizer) (1.83 and 1.70 $gm^{-2}day^{-1}$, respectively). In contrast, the lowest crop growth rate (0.83 $gm^{-2}day^{-1}$**)** was found in T_2 (Cowdung as recommended dose) which was similar to control treatment.



T_0= Control, T_1= All chemical fertilizer (Recommended dose), T_2= Cowdung (Recommended dose), T_3= Compost (Recommended dose), T_4= ½ Cowdung + ½ compost, T_5= Cowdung + compost, T_6= Cowdung + ½ chemical fertilizer, T_7= Compost + ½ chemical fertilizer, T_8=Cowdug + compost + ½ chemical fertilizer, T_9= ½ Cowdug + ½ compost + ½ chemical fertilizer

Fig. 1: Effect of chemical and organic fertilizer and their different combinations on Crop Growth Rate (CGR) of mustard (S/x=0.018,0.11,0.10,0.11).

Among the treatments, T_9 (½ Cowdug + ½Compost + ½ Chemical fertilizer) gave the highest CGR (2.16 $gm^{-2}day^{-1}$) than other treatments at 60-80 days after sowing (DAS) which was statistically similar to T_8 (Cowdung + Compost + ½ Chemical fertilizer), T_7 (Compost + ½ Chemical fertilizer) and T_1 (all chemical fertilizer as recommended dose) (2.09, 1.99 and 1.97 $gm^{-2}day^{-1}$, respectively) at similar DAS.

At 80 DAS to harvest period, the highest CGR (4.80 $gm^{-2}day^{-1}$) was recorded in T_1 (all chemical fertilizer as recommended dose) which was closely followed by T_9 (½ Cowdug + ½Compost + ½ Chemical fertilizer), T_6 (Cowdug + ½ Chemical fertilizer) and T_8 (Cowdug + Compost + ½ Chemical fertilizer) (4.28, 4.24 and 4.19 $gm^{-2}day^{-1}$, respectively). Then lowest CGR (1.32 $gm^{-2}day^{-1}$) was found in T_0 (control) treatment (Fig. 1).

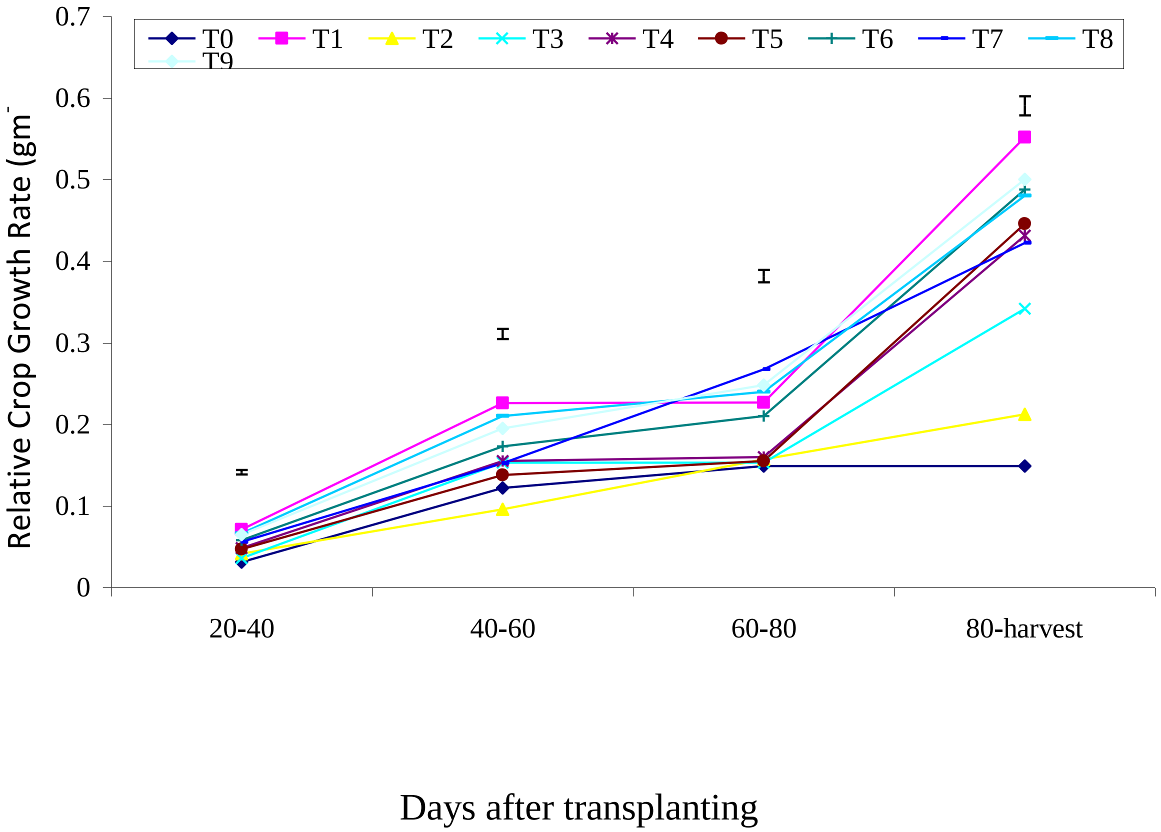
4.1.5 Relative growth rate (RGR)

Relative growth rate (RGR) showed significant variation due to the effect of different organic and inorganic fertilizer at different days after sowing (Fig.2 and appendix VIII). The maximum relative growth rate (0.07 $gm^{-2}day^{-1}$) was found in the treatment T_1 (all chemical fertilizer as a recommended dose) and it was statistically similar to T_8 (cowdug + compost + ½ chemical fertilizer) and T_9 (½ cowdug + ½ compost + ½ chemical fertilizer) (0.66 and 0.65 $gm^{-2}day^{-1}$, respectively) at 20 to 40 days after sowing. However, the lowest relative growth rate (0.31 $gm^{-2}day^{-1}$) was recorded in control treatment at the similar days after sowing (Fig. 2).

At 40-60 DAS, treatment T_1 (all chemical fertilizer as recommended dose) also showed the highest relative growth rate (0.226 $gm^{-2}day^{-1}$) which was followed by to T_8 (cowdug + compost + ½ chemical fertilizer). On the other hand, the lowest relative growth rate (0.096 $gm^{-2}day^{-1}$) was found in T_2 (cowdung as recommended dose).

Among the rest treatments, the highest relative growth rate (0.267 $gm^{-2}day^{-1}$) was found in T_7 (Compost + ½ chemical fertilizer) which was closely followed by T_9 (½ Cowdug + ½ compost + ½ chemical fertilizer) where the relative growth rate was 0.248 $gm^{-2}day^{-1}$ and it was statistically similar to T_8 (Cowdug + compost + ½ chemical fertilizer) (0.240 $gm^{-2}day^{-1}$, respectively) at 60 to 80 DAS.

At the final stage of data recording (80 to harvest), the highest RGR (0.552 gm^{-2} day^{-1}) was recorded in T_1 (all chemical fertilizer as a recommended dose). The second highest RGR (0.50 gm^{-2} day^{-1}) was observed in T_9 (½ Cowdug + ½ compost + ½ chemical fertilizer) which was statistically similar to T_6 (cowdung + ½ chemical fertilizer), T_8 (cowdug + compost + ½ chemical fertilizer), T_5 (cowdung + compost), T_4 (½ cowdung + ½ compost) and T_7 (Compost + ½ chemical fertilizer) (0.488, 4.80, 0.446, 0.431 and 0.422 gm^{-2} day^{-1}, respectively). On the other hand, the lowest RGR (0.149 $gm^{-2}day^{-1}$) was found in T_0 (control) treatment (Fig. 2).



T_0= Control, T_1= All chemical fertilizer (Recommended dose), T_2= Cowdung (Recommended dose), T_3= Compost (Recommended dose), T_4= ½ Cowdung + ½ compost, T_5= Cowdung + compost, T_6= Cowdung + ½ chemical fertilizer, T_7= Compost + ½ chemical fertilizer, T_8=Cowdug + compost + ½ chemical fertilizer, T_9= ½ Cowdug + ½ compost + ½ chemical fertilizer

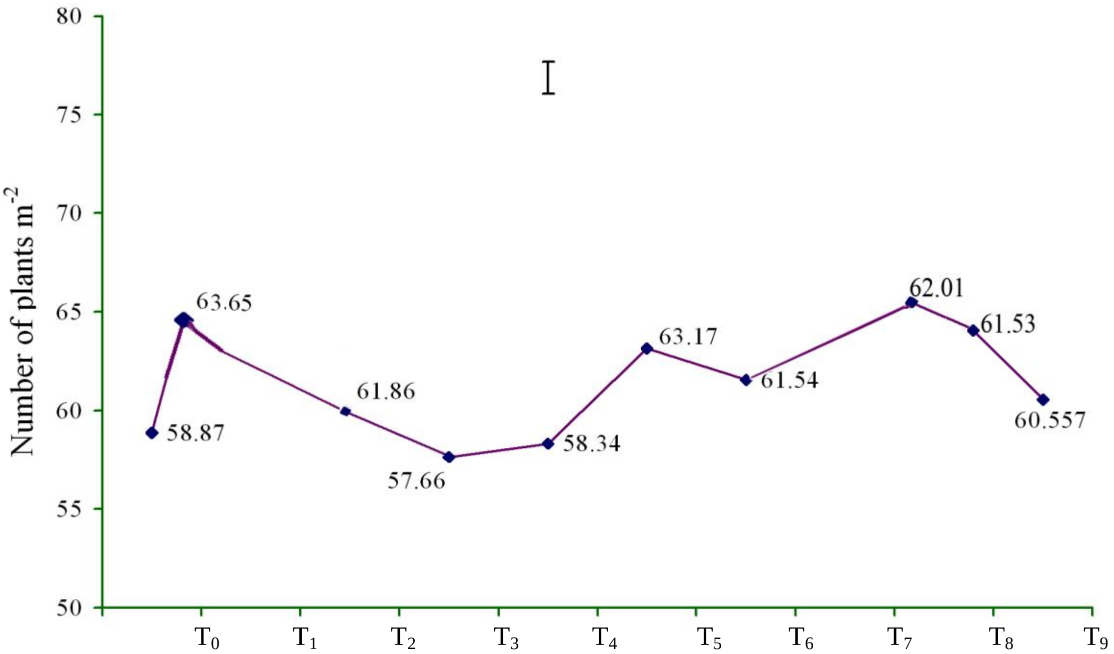
Fig. 2. Effect of chemical and organic fertilizer and their different combinations on Relative Crop growth rate (RGR) of mustard (S/x=0.018,0.0.05,0.018,0.025,).

4.1.6 Number of plants m^{-2}

Number of plants m^{-2} showed significant difference due to the effect of different organic and inorganic fertilizer at harvest (Fig.3 and appendix VIII).

The maximum number of plants m^{-2} (63.65) was found from the treatment T_1 (all chemical fertilizer as recommended dose) which was closely followed by T_7 (Compost + ½ Chemical fertilizer), T_8 (Cowdung + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdung + ½ Compost + ½ Chemical fertilizer) (62.01, 61.53 and 60.56, respectively). The minimum number of plants m-^{2} (57.66) was found in T_3 (compost as recommended dose) which was similar to T_0 (control) and T_4 (½ Cowdung + ½Composed) treatment.

s/x=1.170



Chemical and organic fertilizers treatments

Note:

T_0= Control

T_1= All chemical fertilizer (Recommended dose)

T_2= Cowdung (Recommended dose)

T_3= Compost (Recommended dose)

T_4= ½ Cowdung + ½ compost

T_5= Cowdung + compost

T_6= Cowdung + ½ chemical fertilizer

T_7= Compost + ½ chemical fertilizer

T_8=Cowdug + compost + ½ chemical fertilizer

T_9= ½ Cowdug + ½ compost + ½ chemical fertilizer

Fig. 3. Effect of chemical and organic fertilizer and their different combinations on number of plants m^{-2} of mustard(s/x=1.70)

4.2 Effect of different doses of organic and inorganic fertilizer on yield and yield attributing characters

4.2.1 Siliqua plant^{-1}

Individual or combination effect of different organic and inorganic fertilizer on number of siliqua plant^{-1} showed significant variation (Table 5 and appendix IX).

The maximum number of siliqua plant^{-1} (65.76) was recorded in T_1 (all chemical fertilizer at recommended dose) which was statistically similar to T_8 (Cowdug + Compost + ½ Chemical fertilizer), T_9 (½ Cowdug + ½ Compost + ½ Chemical fertilizer), T_6 (cowdung + ½ chemical fertilizer) and T_7 (Compost + ½ chemical fertilizer) 65.60, 64.84, 60.57 and 60.13, respectively). Whereas the minimum number of siliqua plant^{-1} (46.61) was noted in T_0 (control) which was followed by T_0, T_2, T_3, and T_4 treatments (46.41, 50.23, 52.26 and 53.06 respectively).

4.2.2 Seeds siliqua^{-1}

Different inorganic and organic fertilizer and their combinations effect on number of seeds siliqua^{-1} showed significant difference (Table 5 and Appendix IX). Treatment T_1 showed its superiority in producing highest number of seeds siliqua^{-1} (19.21) which was statistically at per with T_9 (18.95), T_8 (19.18), T_6 (17.34) and T_7 (17.12) respectively. The control treatment T_0 showed the lowest number of seeds siliqua^{-1} (13.23) which was statistically similar to $T_{2,}$ $T_{3,}$ T_4 and T_5 treatment (14.32, 14.78, 15.13 and 15.45 respectively).

4.2.3 1000-seed yield (g)

Weight of 1000-seed exerted non significant difference due to the effect of different inorganic and organic fertilizer and their combinations (Table 5 and appendix IX). Numerically the highest 1000-seed yield (3.45 g) was recorded in T_1 all chemical fertilizer applied which was followed by T_8 (Cowdug + Compost + ½ Chemical fertilizer) and T_9 (½ Cowdug + ½ Compost + ½ Chemical fertilizer) (3.42 and 3.41 g, respectively). The lowest value was found in the control treatment (2.73 g).

Table 5. Effect of chemical and organic fertilizer on yield attributes of mustard

Treatments	Siliqua plant^{-1} (no.)	Seed siliqua^{-1} (no.)	1000-seed yield (g)
T_0	46.41 d	13.23 c	2.73
T_1	65.76 a	19.21 a	3.45
T_2	50.23 cd	14.32 bc	3.05
T_3	52.26 cd	14.78 bc	3.24
T_4	53.06 cd	15.13 bc	3.09
T_5	55.08 bc	15.45 bc	3.18
T_6	60.57 ab	17.34 ab	3.23
T_7	60.13 ab	17.12 ab	3.22
T_8	65.60 a	19.18 a	3.42
T_9	64.84 a	18.95 a	3.40
s/x	**2.220**	**0.9232**	**0.2702**
CV (%)	**6.70**	**9.71**	**14.62**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.05 level of probability

Note:
T_0= Control
T_1= All chemical fertilizer (Recommended dose)
T_2= Cowdung (Recommended dose)
T_3= Compost (Recommended dose)
T_4= ½ Cowdung + ½ compost
T_5= Cowdung + compost
T_6= Cowdung + ½ chemical fertilizer
T_7= Compost + ½ chemical fertilizer
T_8=Cowdug + compost + ½ chemical fertilizer
T_9= ½ Cowdug + ½ compost + ½ chemical fertilizer

4.2.4 Seed yield (kg ha^{-1})

A significant variation was found on seed yield due to different inorganic and organic fertilizer and their combinations (Table 6 and appendix X). In general, application of fertilizer at different combination significantly enhanced seed yield over control. The highest seed yield (1654.0 kg ha^{-1}) was found in T_1 which was statically similar to T_8 (1619.0 kg ha^{-1}), T_9 (1599 kg ha^{-1}) T_6 (1513.0 kg ha^{-1}) and T_7 (1501.0 kg ha^{-1}). On the other hand, the lowest seed yield (746.0 kg ha^{-1}) was recorded in control treatment (Table 6).

4.2.5 Stover yield (kg ha^{-1})

Effect of different inorganic and organic fertilizer and their combinations effect on stover yield showed significant variation (Table 6 and appendix X). Significantly the highest stover yield was found in T_1 treatment (6697 kg ha^{-1}), the second highest stover was found in T_6 (5023.0 kg ha^{-1}), T_7 (4881.0 kg ha^{-1}) and T_8 (4383.0 kg ha^{-1}) and they are statistically similar. It is interesting that

Treatment $T_{2,}$ T_3 $T_{4,}$ T_5 and T_9 gave statistically similar and lowest stover yield as observed in T_0 (control).

4.2.6 Biological yield (kg ha^{-1})

Significant difference was observed on biological yield due to the effect of different inorganic and organic fertilizer and their combination treatments (Table 6 and appendix X). The highest biological yield (8351.0 kg ha^{-1}) was found in T_1 and the lowest biological yield was recorded in T_3 (3704.0 kg ha^{-1}), T_0 (3843 kg ha^{-1}), which was statically similar to T_4 (3775.0 kg ha^{-1}) T_2 (4211.0 kg ha^{-1}) and T_5 (4484.0 kg ha^{-1}). On the other hand, the second highest biological (6536.0 and 6322.0 kg ha^{-}

^{1}) was recorded from the treatment T_6 and T_7 (Table 6).

4.2.7 Harvest index (%)

Different inorganic and organic fertilizer and their combination effect on harvest index showed significant variation (Table 6 and appendix X). Harvest index completely responsible on seed yield and stover yield of any crop. Harvest index ranged from 19.83 to 32.47%, where the highest harvest index was recorded in T_9 and the lowest harvest index was observed in T_1 (19.83%). Among the treatments, harvest index was perform rating of the another treatment were T_4 (1.43%)>T_3 (28.41%)>T_5 (27.72%)>T_8 (27.16%)>T_2 (25.52%)>T_6 (23.27%)>T_7 (22.92%)>T_0 (20.11%).

Table 6. Effect of chemical and organic fertilizer on yield and harvest index of mustard

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	HarvestIndex (%)
T_0	746.0 d	3097.0 c	3843.0 de	20.11 d
T_1	1654.0 a	6697.0 a	8351.0 a	19.83 d
T_2	1055.0 c	3156.0 c	4211.0 de	25.52 bd
T_3	1056.0 c	2648.0 c	3704.0 e	28.41 ac
T_4	1173.0 c	2602.0 c	3775.0 e	31.43 ab
T_5	1240.0 bc	3244.0 c	4484.0 de	27.72 ac
T_6	1513.0 ab	5023.0 b	6536.0 b	23.27 cd
T_7	1501.0 ab	4881.0 b	6322.0 b	22.92 cd
T_8	1619.0 a	4383.0 b	6002.0 bc	27.16 ac
T_9	1599.0 a	3389.0 c	4988.0 cd	32.47 a
s/x	**91.84**	**314.90**	**361.0**	**1.821**
CV (%)	**12.09**	**13.94**	**11.98**	**12.19**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.05 level of probability

Note:
T_0= Control
T_1= All chemical fertilizer (Recommended dose)
T_2= Cowdung (Recommended dose)
T_3= Compost (Recommended dose)
T_4= ½ Cowdung + ½ compost
T_5= Cowdung + compost
T_6= Cowdung + ½ chemical fertilizer
T_7= Compost + ½ chemical fertilizer
T_8=Cowdug + compost + ½ chemical fertilizer
T_9= ½ Cowdug + ½ compost + ½ chemical fertilizer

CHAPTER V

SUMMARY AND CONCLUSION

The present research work was conducted at the exprimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October, 2010 to March, 2011 to study the feasibility of replacing chemical fertilizer by using organic fertilizer in mustard. The experiment comprised 10 different organic and inorganic fertilizer and their combination treatments viz., T_0 (control), T_1 (all chemical fertilizer as recommended dose), T_2 (Cowdung as rcommended dose), T_3 (compost as recommended dose), T_4 (½ Cowdung + ½ Compost), T_5 (Cowdung + Compost), T_6 (Cowdung + ½ Chemical fertilizer), T_7 (Compost + ½ chemical fertilizer), T_8 (Cowdung + Compost + ½ chemical fertilizer) and T_9 (½ Cowdung + ½ Compost + ½ Chemical fertilizer) on growth and yield performance of mustard var. BARI sarisha-15. The experiment was laid out in Randomized Complete Block Design (RCBD) single factor with three replications.

Among the applied treatments T_1 (all chemical fertilizer as recommended dose) produced the superior growth and T_0 (control) gave the lowest performance at every stage of data recording. However, the tallest plant (114.80 cm) was recorded in T_1 (all chemical fertilizer at recommended dose) at 60 days after sowing and the shortest plant (10.34 cm) was observed in T_0 (control) at initial stage of data recording (15 DAS). Treatment T_1 (all chemical fertilizer as recommended dose) also produced the maximum number of branches plant^{-1} (8.07) at harvest and the minimum number of branches plant^{-1} (2.73) was observed in T_0 (control) at 45 DAS. Dry weight of plant was the highest (21.68 g) in T_1 and the lowest (0.750 g) in control treatment at harvest period and 40 DAS, respectively. CGR and RGR were also perform the best in T_1 (4.80 and

0.55, respectively) and the lowest CGR and RGR (0.27 and 0.03, respectively) was recorded in control treatment at 80 to harvest and 25-45 days after sowing, respectively. The maximum number of plant m^{-2} (77.66) was recorded in T_1 and the minimum (57.66) was found in T_3 (compost as recommended dose) at harvest period.

The maximum number of siliqua $plant^{-1}$ and seeds $siliqua^{-1}$ (5.76 and 19.21, respectively) was recorded in T_1 (all chemical fertilizer at recommended dose) and the minimum (46.41 and 13.23, respectively) was observed in control treatment. The highest 1000-seed yield (3.45 g) was also recorded in T_1 (all chemical fertilizer at recommended dose) and the lowest (2.73 g) was found in control treatment. Among the treatments, T_1 (all chemical fertilizer at recommended dose) also produced the highest stover and seed yield (6697.0 and 16540 kg ha^{-1}) and the lowest (2602.0 and 1055.0 kg ha^{-1}) was found in T_4 and T_2, respectively.

Significant difference was also observed on biological yield and harvest index where, the highest biological yield (8351.0 kg ha^{-1}) was found in T_1 and the lowest biological yield (3704.0 kg ha^{-1}) was recorded in T_3. On the other hand, harvest index ranged from 19.83 to 32.47% where the highest harvest index was recorded in T_9 and the lowest harvest index was observed in T_1.

Conclusion

From the above results, it may be concluded that all chemical fertilizer at recommended dose showed the better performance on morphological and yield contributing characters of mustard but organic cowdung and compost in combination with half chemical fertilizer produced similar result with all chemical fertilizer applied treatment T_1 and also half cowdung and half compost with half chemical fertilizer showed statistically similar performance. So, considering the above observation cowdung and compost with the combination of half chemical fertilizer or half cowdung and half compost with half chemical fertilizer may be possible to use as replacing chemical fertilizer which will reduce production cost without significant yield reduction.

Recommendation

Considering the above observation of the present experiment, further studies in the following areas may be suggested.

1. Further study may be needed to ensure the growth and yield performance of mustard in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.
2. More inorganic and organic fertilizer may be needed to include for future study as sole or different combination to confirm in replacing chemical fertilizer doses.

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APPENDICES

Appendix I: Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological and chemical characteristics of the experimental field

Lab No.	Sample No	pH effect	Organic matter (%)	Total N (%)	K mM 100 g^{-1} soil	P	Gond	Br	Tama	Loh	Dos
						µg g^{-1} soil					
14058	T_0	5.3	1.21	0.061	0.11	19.3	3.38	0.11	2.4	266	2.3
		MA	Low	OL	Low	P	OL	OL	OH	OH	OH
14059	T_1	4.9	0.94	0.047	0.19	29.0	24.46	2.20	2.4	294	17.2
		LA	OL	OL	Medium	OH	P	OH	OH	OH	OH
14060	T_2	5.6	1.28	0.064	0.15	23.6	7.46	0.17	2.4	318	5.3
		LA	Low	OL	Low	High	OL	Low	OH	OH	OH
14061	T_3	6.0	0.94	0.047	0.11	19.4	3.95	0.04	2.6	336	4.2
		LA	OL	OL	Low	P	OL	OL	OH	OH	OH
14062	T_4	5.8	0.54	0.027	0.12	20.3	7.33	0.15	2.6	326	4.6
		MA	OL	OL	Low	P	OL	OL	OH	OH	OH
14063	T_5	5.4	1.55	0.078	0.13	21.1	5.50	0.12	2.61	290	4.0
		MA	Low	OL	Low	High	OL	OL	OH	OH	OH
14064	T_6	5.0	1.08	0.054	0.24	40.6	17.56	2.02	2.6	286	8.4
		MA	Low	OL	Medium	OH	Medium	OH	OH	OH	OH
14065	T_7	5.4	0.61	0.031	0.14	24.5	6.81	0.52	2.6	280	14.9
		MA	OL	OL	Low	High	OL	P	OH	OH	OH
14066	T_8	5.4	1.48	0.074	0.13	23.5	13.39	1.73	2.42	292	6.5
		MA	Low	OL	Low	High	Low	OH	OH	OH	OH
14067	T_9	5.3	1.21	0.061	0.15	22.9	12.22	5.90	2.6	282	7.2
		MA	Low	OL	Low	High	Low	OH	OH	OH	OH
14068	Soil	5.3	0.87	0.044	0.19	27.7	24.06	0.22	2.0	1.82	4.6
		MA	OL	OL	Medium	OH	P	Low	OH	OH	OH

MA= More acidity, LA= Less acidity, OL= Over low, L= Low, P= Perfect, OH= Over high

B. Physical properties of the initial soil

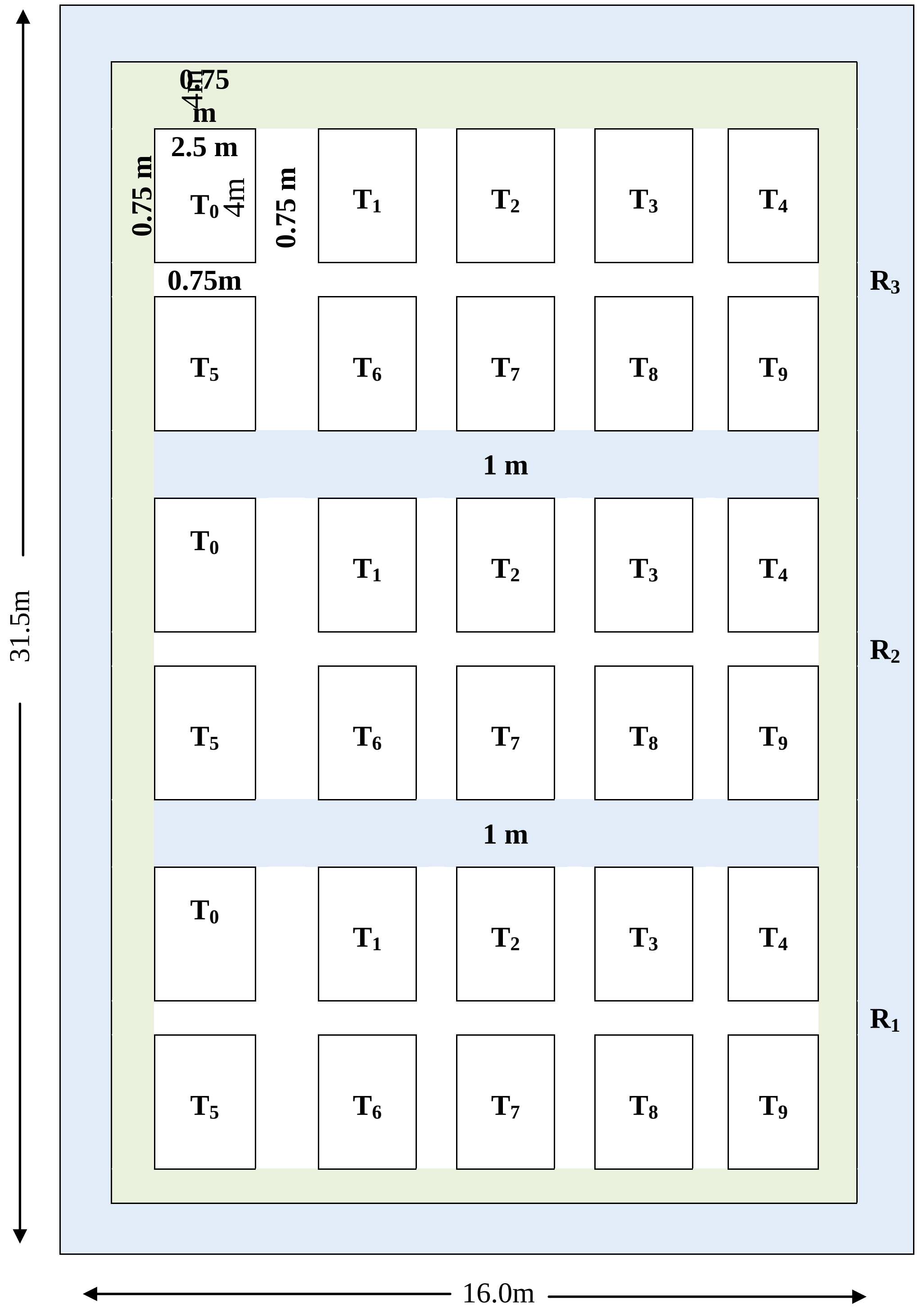
Soil sample no.	Soil ** sample	Sand	Silt	Clay
T_0	Silt loam	25.60	53.91	20.49
T_1	Silt loam	26.60	54.00	19.40
T_2	Silt loam	25.67	53.86	20.47
T_3	Silt loam	26.37	54.22	19.41
T_4	Silt loam	26.40	55.12	18.48
T_5	Silt loam	25.96	53.49	20.55
T_6	Silt loam	26.00	54.00	20.00
T_7	Silt loam	26.40	54.17	19.43
T_8	Silt loam	26.38	55.00	18.62
T_9	Silt loam	25.49	54.11	20.40
Soil	Silt loam	25.65	53.84	20.51

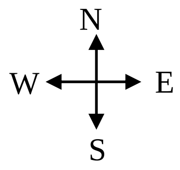
Appendix II: Monthly average air temperature, rainfall and relative humidity of the experimental site during the period from October 2010 to March 2011

Month	Air temperature (^0C)		Relative humidity (%)	Total Rainfall (mm)
	Maximum	Minimum		
October, 2010	26.11	18.05	77	19
November, 2010	25.82	16.04	78	00
December, 2010	22.40	13.50	74	00
January, 2011	24.50	12.40	68	00
February, 2011	27.10	16.70	67	30
March, 2011	31.40	19.60	54	11

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka- 1207

Appendix III: Lay out of the experiment





Plot size: 4.0m x 2.5m
Plot spacing: .75m
Between replication: 1.0m

Treatment:
T_0: Control (with fertilizers)
T_1: All chemical Fertilizers as recommended dose
T_2: Cowdung as recommended dose
T_3: Compost as recommended dose
T_4: ½ Cowdung + ½ compost
T_5: Cowdung+Compost
T_6: Cowdung+ ½ Chemical fertilizer
T_7: Compost+ ½ Chemical fertilizer
T_8: Cowdung+compost+chemical fertilizer
T_9: ½ cowdung+ ½ compost+ ½ chemical fertilizer

Appendix IV: Analysis of variance on plant height at different days after sowing as influenced by chemical and organic fertilizer and their different combination on mustard

Source of variation	Degrees of freedom	Mean square of plant height (cm)					
		15 DAE	30 DAE	45 DAE	60 DAE	75 DAE	At harvest
Replication	2	3.053	10.172	36.719	22.936	4.264	0.537
Treatments	9	3.481*	46.766**	80.621**	321.434**	195.486**	216.827**
Error	18	1.138	4.443	13.771	10.812	11.751	11.766

Appendix V: Analysis of variance on number of branches plant^{-1} at different days after sowing as influenced by chemical and organic fertilizer and their different combination on mustard

Source of variation	Degrees of freedom	Mean square of number of branches plant^{-1}			
		45 DAE	60 DAE	75 DAE	At harvest
Replication	2	2.625	0.838	7.842	0.298
Treatments	9	5.330**	5.681**	5.203**	4.209**
Error	18	0.159	0.001	0.303	0.323

Appendix VI: Analysis of variance on dry weight of plant at different days after sowing as influenced by chemical and organic fertilizer and their different combination on mustard

Source of variation	Degrees of freedom	Mean square of dry weight of plant (g)				
		20 DAE	40 DAE	60 DAE	80 DAE	At harvest
Replication	2	0.001	0.069	0.462	1.538	0.773
Treatments	9	0.000*	0.239**	3.368**	15.123**	61.131**
Error	18	0.000	0.026	0.225	1.527	6.614

Appendix VII: Analysis of variance on CGR as influenced by chemical and organic fertilizer and their different combination on mustard

Source of variation	Degrees of freedom	Mean square of CGR (gm^{-2}day^{-1})			
		20-40	40-60	60-80	80-harvest
Replication	2	0.013	0.193	0.007	0.096
Treatments	9	0.042**	0.370**	0.385**	3.768**
Error	18	0.000	0.041	0.032	0.039

**= Significant at 0.01 level of probability; *= Significant at 0.05 level of probability

Appendix VIII: Analysis of variance on RGR and number of plant m^{-2} as influenced by chemical and organic fertilizer and their different combination on mustard

Source of variation	Degrees of freedom	Mean square of RGR ($gm^{-2}day^{-1}$)				Number of plant m^{-2}
		20-40	40-60	60-80	80-harvest	
Replication	2	0.000	0.000	0.001	0.007	158.216
Treatments	9	0.001**	0.005**	0.006**	0.051**	110.777**
Error	18	0.000	0.000	0.000	0.002	4.106

Appendix IX: Analysis of variance on number of siliqua $plant^{-1}$, number of seed $siliqua^{-1}$ and 1000-seed yield as influenced by chemical and organic fertilizer and their different combination on mustard

Source of variation	Degrees of freedom	Mean square of		
		No. of siliqua $plant^{-1}$	Number of seed $siliqua^{-1}$	1000-seed yield (g)
Replication	2	48.022	4.180	0.093
Treatments	9	144.256**	14.338**	0.139ns
Error	18	14.790	2.557	0.219

Appendix X: Analysis of variance on stover yield, seed yield, biological yield and harvest index as influenced by chemical and organic fertilizer and their different combination on mustard

Source of variation	Degrees of freedom	Mean square of			
		Stover yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Replication	2	3538000.233	223368.513	5404546.300	8.719
Treatments	9	5139171.944**	282293.237**	7086257.278**	57.093**
Error	18	297474.900	25301.998	391324.078	9.951

**= Significant at 0.01 level of probability; *= Significant at 0.05 level of probability and ns= non significant