EFFECT OF SOURCE OF NITROGEN AND WEED CONTROL METHOD ON THE PERFORMANCE OF MUSTARD

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*This is to certify that the thesis entitled "EFFECT OF SOURCE OF NITROGEN AND WEED CONTROL METHOD ON THE PERFORMANCE OF MUSTARD" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment 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 **FARJANA AFROJ** Registration No. 14-06332, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that any help or sources of information as has been availed of during the course of this work has duly been acknowledged & style of the thesis have been approved and recommended for submission.

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EFFECT OF SOURCE OF NITROGEN AND WEED CONTROL METHOD ON THE PERFORMANCE OF MUSTARD

ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the rabi season from November 2014 to February 2015 to study the effect of source of nitrogen and weed control method on the performance of mustard cv. BARI Sarisha-14. The treatment consisted of four sources of nitrogen viz. N_0= no nitrogen (Control), N_1= Prilled urea, N_2= NPK mixed fertilizer and N_3= Urea super granule, and three different weeding methods viz. W_0 = No weeding, W_1= hand weeding and W_2= Herbicidal weeding. The experiment was laid out in a Split plot design with three replications. Results showed that a significant variation among the treatments in respect majority of the observed parameters. The tallest plant (56.16 cm) was recorded with prilled urea. The maximum number of branches per plant (5.17), number of siliquae per plant (26.34) and number of seeds per silliqua (29.06) were also produced by prilled urea. The highest seed yield (1139.00 kg ha^{-1}) was obtained from prilled urea. On the other hand, the tallest plant (55.49 cm) of mustard was produced with hand weeding. The maximum number of branches per plant (4.63), number of siliquae per plant (22.75) and number of seeds per silliqua (26.31) was obtained from hand weeding. The highest seed yield (1040.00 kg ha^{-1}) was also obtained from hand weeding. The interaction effect of nitrogen and weeding had significant effect on almost all parameter. The highest seed yield (1382.00 kg ha^{-1}) was obtained from prilled urea with hand weeding interaction treatment.

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LIST OF ACRONYMS AND ABBREVIATIONS

AEZ	=	Agro-Ecological Zone
Agric.	=	Agriculture
Agril.	=	Agricultural
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centi-meter
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
DMRT	=	Duncan Multiple Range Test
df	=	Degrees of freedom
et al.	=	And others
g	=	Gram (s)
HI	=	Harvest Index
Hr	=	Hour
i.e.	=	*id est* (L), that is
J.	=	Journal
Kg ha^{-1}	=	Kilogram per hectare
LAI	=	Leaf Area Index
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
Max	=	Maximum
Min	=	Minimum
mm	=	Millimeter
N	=	Nitrogen
NPK	=	Nitrogen, Phosphorus and Potassium
No.	=	Number
NS	=	Not significant
ppm	=	Parts per million
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
WUE	=	Water use efficiency
Wt	=	Weight
%	=	Percent
µg	=	Micro gram
^{0}C	=	Degree Celsius

CHAPTER 1

INTRODUCTION

CHAPTER I

INTRODUCTION

Mustard is an oil seed crop belongs to the genus *Brassica* of the family Brassicaceae. It is one of the most important oilseed crops throughout the world after soyabean and groundnut (FAO, 2004). It has a remarkable demand for edible oil in Bangladesh. It occupies first position of the list in respect of area and production among the oilseed crops grown in this country (BBS, 2004). Mustard covers about 70 % of the total production in Bangladesh. The area and production of mustard of our country was about 682000 acres and 262000 tons, respectively with an average yield of 0.94 t ha^{-1} during 2011-2012 (BBS, 2014). The present domestic edible oilseed production is 722 thousand tons, which meets only one third of national demand. Mustard seeds contain 40-45% oil and 20-25% protein (Mondal and Wahhab, 2001). Using local ghani average 33% oil may be extracted. Oil cake is a nutritious food item for cattle and fish. Oil cake is also used as a good organic fertilizer. Dry mustard plants may be used as fuel.

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). 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). The area and production of oilseeds are gradually declining due to (i) Low yield potential of oilseed varieties (ii) High infestation of diseases and pests, compared to other crops (iii) Instability of yield due to micro-climatic fluctuation (iv) Expansion of irrigation facilities and more profitable crops are available in place of in the cropping patterns. Most oilseeds crops respond positively with high management, yet they cannot compete with other high value crops. Usually, farmers do not allocate their good piece of land and also they do not follow proper management practices for oil crops.

So, their yields are low. This yield can be increased by using different agronomic management practices among them nitrogen and weed management are important agronomic traits.

Nitrogen has an important role in seed protein and physiological functions of the plant. It is an essential constituent of amino acids, amides, nucleotides and nucleoproteins and is essential to cell division, expansion and consequently plant growth. Crop plants can take up N as nitrate, ammonium ions and assimilate them into protein and nucleic acids. Nitrogen supports the plant with rapid growth, increasing seed and fruit production and enhancing quality of leaf and oil seed crops (Allen & Morgan, 2009).High yielding varieties of mustard are very responsive to fertilizers; particularly nitrogen is also responsive to nitrogenous fertilizer more under irrigated condition than under rain fed condition (Islam *et al.*, 1992). It encourages the flow of assimilates to flowers and developing siliqua and ultimately the seed. But the nitrogen reserve of Bangladesh soil is very low due to warm climate accompanied by centuries of cultivation in the same piece of land (Porteh and Islam, 1984). On the other hand, deficiency of nitrogen also hampers the production of mustard. Therefore, energy and high costs of fertilizer nutrients necessitate economizing their use. The recovery of applied nitrogen is low due to several loss processes operating in the field. Split application of fertilizer suggested for increasing nitrogen use efficiency is often not practical due to adverse soil water situations. Hence, the entire amount of nitrogen required to be applied in single broadcast application when the water regime is favorable. A single broadcast application however increases nitrogen loss.

Urea is the principal source of N, which is the essential element in determining the yield potential (Mae, 1997). The predominant form of nitrogen fertilizer is used in Bangladesh as prilled urea (PU). Traditionally mustard is cultivated with PU which is prone to loss in the field in various ways thus plants suffer from proper nutrition (Dinnes *et al.*, 2002). It is reported that about 40% of applied nitrogen as PU in the oxidized zone of soil is used by the plant and rest enters to loss process (De Datta and Buresh, 1989; Cassman *et al.*, 2002). As prilled urea is dynamic and reactive in nature, it losses represent not only an economic drain for farmers but also have negative impact on the environment since the reactive compounds of nitrogen decrease water quality and contribute to global climate change (Gallowya et al., 2003). Urea super granule (USG) and NPK mixed fertilizer are the other source of N which has been proved to improve nitrogen use efficiency. USG dissolves slowly in soil providing a steady supply of available nitrogen throughout the growing period of crop thus crop satisfied with its demand during its different stages of growth and produces greater yield. Deep placement of USG thus has greater benefit over surface split application with moderate to heavy textured soil, low permeability and percolation rate, and high cation exchange capacity (Mohanty *et al.*, 2007).

Choosing the correct dose, source and timing of N fertilizer application is therefore a important aspect of successful mustard crop production. The problem of type of applied fertilizers, rarely taken into consideration by researches and in practice, is even more ambiguous (Wiesler *et al.*, 1999). In spite of the well-recognized effects of the main N fertilizer components, i.e. N sources and/or some other nutrients as a secondary components on soil and plants, the third N factor, i.e. chemical composition of the applied N fertilizers, is seldom treated as an important factor in the mustard crop production system (Wiesler *et al.*, 1999).

Effective weed control in mustard throughout the entire growing season is especially important because weeds interfere with crop plants causing serious impacts either in the competition for light, water, nutrients and space or in the allelopathy. Weed competition not only decreases mustard crop yield, but also reduces its quality and market value. Mustard as a slowly growing crop is particularly exposed to severe competition from weeds. Weed suppression by shading only begins after the canopy of mustard leaves grown over the rows and early covered the field. Faster growth of weeds is disadvantageous for light and hence photosynthesis needed for mustard plants. Through this light deprivation less energy is available to crop plant for metabolic production and hence growth, yield and its quality of mustard plant will be reduced. In addition, weeds with branched, vigorous root systems inhibit the development of mustard plant through severe nutrition deprivation. According to the mentioned reasons, a linear decline was observed in seed yield of mustard with increasing in weed population and biomass.

Quarshi *et al.* (2002) reported that weed could be controlled by manual, cultural and chemical methods. The best way to control weeds is by keeping them out of the fields. The use of clean seed (certified seed), clean equipment are examples of good field sanitation techniques which involves practices that prevent weeds from entering or spreading through the fields. This will reduce the weed pressure and decrease the introduction of new and /or noxious weeds in the fields. Although weed management practices like hand weeding and herbicide application are effective in weed control but are uneconomical due to higher costs (Cheema *et al.*, 2003). Moreover, the chemical weed control method is hazardous for health and causes environmental pollution.

The experimental evidences on effect of source of nitrogen and weed control method on the performance of mustard are limited under Bangladesh condition. The present study was therefore, undertaken with the following objectives.

i. To select the suitable source of nitrogen in mustard,

ii. To select the suitable methods of weed control in mustard, and

iii. To observe the interaction effect of nitrogen source and weed control method in mustard.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Cruciferous *Brassica* is one of the common and most important oil crops of Bangladesh and as well as many country of the world. In Bangladesh the average productivity of mustard is low in comparison to the developed countries. The crop has received much attention by the researchers on various aspects of its production. Many studies have been carried in many countries of the world. The work so far done in Bangladesh is not adequate and conclusive. Nevertheless some of the important and informative works and research findings have been reviewed in this chapter under the flowing headings.

2.1 Effect of source of nitrogen on the growth and yield of mustard:

Samir *et al.* (2015) studied the effect of different rates of nitrogen fertilizer (0, 60, 120 and 180 kg N ha^{-1}) on crop growth, seed yield, yield components and seed quality of canola. Nitrogen was applied in three equal splits, 2 weeks, 4 weeks and 8 weeks after planting during each crop season. Statistical analysis of the obtained data presented that nitrogen at a rate of 180 kg N ha-1 dominated other N rates of 120, 60, 0 kg N ha-1 for plant growth, yield and quality parameters except seed oil content that were higher at 120 Kg N ha-1 level. An overall improvement of 59% in plant height, 112% in number of branches, 111% in number of fruits/plant, 87% in 1000 seed weights and 19% in crude protein content were documented for 180 Kg N ha^{-1}. On contrary a reduction of 5% in oil content was recorded by moving from 120 Kg N ha^{-1} to 180 Kg N ha^{-1}. Current results suggested that N at a rate of 180 Kg h^{-1} can be adopted as best level of nitrogen fertilizer for canola cultivation.

Two field experiments were conducted by Johnson *et al.* (2013) in Saskatchewan and Alberta, Canada, to determine effect of N fertilizer application on *Brassica carinata* plant density, seed and straw yield, N uptake in seed and straw, N use efficiency (NUE), N fertilizer use efficiency (NFUE) and seed quality. N rates applied were 0 to 160 kg N ha^{-1} and 0 to 200 kg N ha^{-1} in exps. 1 and 2, respectively. Plant density was not affected by increasing N rate at 5 site-years but declined with high rates of N application at 2 site-years. Seed yield responded to applied N in 6 of 7 site-years, with the non-responsive site having a high total N uptake at the 0 kg N ha^{-1} rate (high N value). There were no sites where seed yields were maximized with the N rates applied. Response trends of straw yield and N uptake were similar to that of seed yield at the corresponding site-years. NUE and NFUE generally declined as N rate increased. Protein concentration in seed generally increased and oil concentration in seed decreased with increasing N rates.

Nasim *et al.* (2012) conducted an experiment on sunflower (*Helianthus annus* L.) had emerged as an economically important crop in Pakistan due to its significant share in vegetable oil production. A two-year field study was conducted in 2008 and 2009. The objective was to determine the effect of different nitrogen (N) levels (N_1 = 0 kg ha^{-1}, N_2 = 60 kg ha–1, N_3 = 120 kg ha^{-1}, N_4 = 180 kg ha^{-1} and N_5 = 240 kg ha^{-1}) on three sunflower hybrids (Hysun-33, Hysun-38 and Poineer-64A93) in agro-climatic conditions of Gujranwala, a sub-humid region in the centre of the Punjab province of Pakistan. Results showed that Hysun-38 gave maximum TDM (15815 kg ha^{-1}) and maximum grain yield (3389 kg ha^{-1}), while minimum TDM (14640 kg ha^{-1}) and grain yield (3125 kg ha^{-1}) was observed in Hysun-33. Among different N rates evaluated, N_4 gave maximum TDM (17890 kg ha^{-1}) and grain yield (3809 kg ha^{-1}) compared to the other N rates. The maximum oil content (46.2%) was observed in Hysun-38 without application of N fertilizer (N_1), while the minimum oil content (40.6%) was observed from N_5 treatment.

Jabin *et al.* (2012) were conducted an experiment at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during Rabi season (October- February) 2009-2010 to study the influence of application method of prilled urea and urea supper granule on yield of mustard. The treatments comprised of T1= Prilled Urea (PU) broadcasted (conventional method), T2=PU given in the side furrows, T3= PU given between two rows, T4=PU and seed given in the same furrows, T5=Urea Super Granules (USG) placed at 5 cm depth as basal, T6=USG placed at 5 cm depth at 10 days after sowing (DAS), T7=USG placed at 5 cm depth at 20 DAS, T8=USG placed at 5 cm depth at 30 DAS, T9=USG placed at 10 cm depth as basal, T10=USG placed at 10 cm depth at 10 DAS, T11=USG placed at 10 cm depth at 20 DAS, T12=USG placed at 10 cm depth at 30 DAS, T13=USG placed at 15 cm depth as basal, T14=USG placed at 15 cm depth at 10 DAS, T15=USG placed at 15 cm depth at 20 DAS and T16=USG placed at 15 cm depth at 30 DAS. Results showed that USG placed at 5 cm depth at 20 DAS gave the highest branches plant-1 (6.86), siliquae plant-1 (58.60), seeds siliqua-1 (32.00), 1000 grain weight (3.56 g) which reflected in higher values of seed yield (3.59 t ha^{-1}), biological yield (6.78 t ha^{-1}) and harvest index (52.62%) compared to PU application. Use of USG had two fold advantages over conventional use of PU. It out yielded PU by 39.14% when this method required about 52.38% less urea than the amount of PU was used.

Keivanrad and Zandi (2014) investigated agronomical and qualitative features of Indian mustard in a semi-arid region from Iran. Field trials were designed in split plot arrangement based on a Randomized Complete Block Design with three replicates at the Agricultural Faculty of Takestan, Iran. In the study, plant height (cm), the number of seeds in the siliqua (seed $siliqua^{-1}$), the number of siliquae in the plant (siliquae $plant^{-1}$), seed yield (kg ha^{-1}), biological yield (kg ha^{-1}), thousand-seed weight (g), harvest index (%), oil content (%) and oil yield (kg ha^{-1}) were determined. The all growth and yield parameters of mustard plant were significantly affected by nitrogen fertilization. All the parameters, except for harvest index (HI), were drastically affected by used densities. The highest seed yield and oil yield (2961 and 1159 kg ha^{-1}, respectively) were obtained for the crop utilized with 200 kgN ha-1 in plots with 80 plants m^{-2}. The maximum oil content (43.97%) was recorded in the lowest plant density (80 plants m^{-2}) and nitrogen application level of 50 kg ha^{-1}. Results suggest that in semi-arid region of Takestan, researchers must direct their selection treatments to increase oil quality of Indian mustard.

Ozturk (2010) reported that the winter rapeseed (*Brassica napus* L.) had 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 pod^{-1}, 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.

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.

Kardgar *et al.* (2010) studied the effects of different levels of N fertilization and plant density on the yield of field mustard (*Brassica campestris*) cv. Goldrush, a study was carried out in Qazvin, Iran in 2009-2010 as a split-plot experiment based on a randomized complete block design with three replications. The main plot was pure N from urea source at four levels of 0, 50, 100 and 150 kg ha^{-1} and the sub-plot was plant density at four levels of 60, 80, 100 and 120 plants m^{-2}. Statistical analysis showed that different levels of plant density and N significantly affected the number of siliquae plant^{-1}, the number of seeds siliqua^{-1}, 1000-seed weight, seed yield, oil yield, biological yield and harvest index. The increase in N level increased all these traits at all treatments. Also, higher densities up to 100 plants m^{-2} led to higher values of all traits. The density of 120 plants m^{-2} resulted in the lowest value of all traits at all treatments. In total, the densities of 80 and 100 plants m^{-2} and the application of 100 kg N ha^{-1} were considerably superior and produced the highest seed yield (3491 kg ha^{-1}) and oil yield (1084 kg ha^{-1}). Furthermore, the highest seed oil content (37.97%) was obtained at the density of 100 plants ha^{-1} treated with 150 kg N ha^{-1}.

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.

Allen and Morgan (2009) investigated 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.

Singh and Singh (2006) conducted two field experiments for two crop cycles each for two years on an entities over *Citronella Java*. They found that the oil yields were 9% higher in USG than that of PU and N recovery of USG and PU were 31 and 21%, respectively.

Singh *et al.* (2004) reported that nitrogen application did not affect the oil content in mustard but oil yield and chlorophyll content were increased up to 90 kg N ha-1 over the control. Nitrogen application increased the seed yield of mustard. Nitrogen and sulfur content both in seed and straw and total N and S uptake enhanced due to application of 90 kg N ha^{-1} over its preceding rates. The increased nitrogen and sulfur content enhanced the total uptake of nitrogen and sulfur.

An experiment was conducted by Tripathi (2003) in Uttar Pradesh, India in 1994-95 and 1995-96 to investigate the effects of N levels (80, 120, 160 and 200 kg ha^{-1}) on the growth, yield and quality of Indian mustard cv. Varuna. Nitrogen was applied at 3 equal splits, at sowing, at first irrigation and at 60 days after sowing. Results showed that all the yield characters except number of branches increased with increasing N levels up to 160 kg N ha^{-1}, The number of branches $plant^{-1}$ increased up to 200 kg N ha^{-1}. Net returns were maximum (Rs. 19 901 ha^{-1}) at 160 kg N ha^{-1} because seed yield was also maximum at this N rate. The benefit cost ratio increased up to 160 kg N ha^{-1}, with a maximum of Rs. 209 earned per rupee investment.

Saikia *et al.* (2002) reported the response of Indian mustard cv. Pusa giant grown in New Delhi, India during rabi season of 1998-99. They found that the varieties response positively to the use of USG than prilled urea and neem coated urea.

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).

Suhartatik (1991) reported that point placement of urea super granule with lime significantly increased the leaf area index (LAI) of mungbean.

Sardana and Verma (1987) conducted an experiment in New Delhi, India in 1983-84 and reported that larger urea granule causes slow release of nitrogen and results significant increase in leaf are index (LAI) of mungbean.

2.2 Effect of weed control method on the growth and yield of mustard:

Ranjeet *et al.* (2014) was carried out an experiment during the winter (rabi) season of 2009–10 and 2010–11 at Chatha, Jammu, to assess the yield along with the monetary benefits in chickpea (*Cicer arietinum* L.) and Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] intercropping system with different weed-management practices. Significantly higher values of plant height of chickpea (63.36 cm) and Indian mustard (174.72 cm), dry-matter accumulation of chickpea (22.13 g $plant^{-1}$) and Indian mustard (117.22 g $plant^{-1}$) were recorded under sole stands of the each crop followed by chickpea + Indian mustard (replacement series) intercropping system. Both the sole crops gave higher yields than chickpea + Indian mustard, when grown in additive and replacement series in the respective order. The highest chickpea-equivalent yield (1.39 t ha^{-1}), land-equivalent ratio (1.65), net returns (₹ 24,415 ha^{-1}) and benefit: cost (1.63) ratio were obtained in chickpea + Indian mustard intercropping system in additive followed by replacement series. Weed management practices not only reduced the density and dry weight of weeds but also increased crop production potential of the intercropping system (productivity). Application of pendimethalin @ 1 kg ha^{-1} as pre-emergence recorded the maximum weed-control efficiency (85.16%), net returns (₹ 20,373 ha^{-1}) and benefit: cost ratio (1.71) followed by the application of fluchloralin @ 1kg ha^{-1}.

Tarundeep Kaur *et al.* (2013) carried out an experiment at Ludhiana, Punjab during 2009 and 2010 to study the effect of different weed control treatments on growth and yield of rapeseed. Eight herbicide treatments, *viz.* trifluralin at 0.48 kg and 0.60 kg ha^{-1} (pre-plant and pre-emergence), pendimethalin at 0.56 kg and 0.75 kg ha^{-1} (preemergence), pendimethalin at 0.75 kg ha^{-1} (pre-plant) and oxyfluorfen at 0.25 kg ha-1 (pre-emergence), two hand weeding (25 and 45 days after sowing) and unweeded control were kept. Two hand weeding, preplant application of trifluralin at

0.60 kg ha^{-1}, and pre-plant and pre-emergence application of pendimethalin at 0.70 kg ha^{-1} significantly decreased dry weight of associated weeds as compared to unweeded control. Weed control efficiency recorded similar trend as of dry matter of weeds. Accordingly, the increased with application of these weed control treatments.

Patel *et al.* (2013) was conducted an experiment at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat) to integrated weed management studies in mustard [*Brassica juncea* (L.) Czern and Coss. ex Coss. during rabi season of 2011-12. The experiment comprising 12 treatments viz., weedy check, interculturing+1 HW at 25 DAS, pendimethalin @ 0.5 and 0.75 kg ha^{-1} PE alone and along with HW at 25 DAS with each level, oxadiargyl @ 75 and 90 g ha^{-1} PE alone and along with HW at 25 DAS with each level, oxyfluorfen @ 100 g ha^{-1} as PE and weed free was conducted in a randomized block design with three replications. The results of the experiment indicated that higher values of plant growth characters viz., dry matter production $plant^{-1}$ (51.00 g) and yield attributing characters viz., number of siliquae $plant^{-1}$ (280.37), number of seeds $siliqua^{-1}$ (14.70) and test weight (4.25 g) were recorded under weed free treatment. Pendimethalin @ 0.5 kg ha^{-1} PE+1 HW at 25 DAS, oxadiargyl @ 75 g ha^{-1} PE+1 HW at 25 DAS and pendimethalin @ 0.5 kg ha^{-1} PE were found equally effective in respect to these characters which were significantly higher than rest of the treatments.

Sodangi *et al.* (2013) was carried out an experiment in the 2006 and 2007 rainy seasons at the Teaching and Research farm of Ibrahim Badamasi Babangida University, Lapai, Niger State to carry out an economic assessment of some weeding methods in the production of soybean ((L.) Merr.) at Lapai in the Southern Guinea savanna zone of Nigeria. Treatments consisted of three weeding methods (chemical, hoe, and no - weeding) in a randomized complete block design. Paraquat (N, N!-dimethyl-4,4!-bipyridinium dichloride) was used for the chemical weeding and the hoe-weeding was done two times (at 3 and 5 weeks after sowing (WAS) and three times (at 3, 5 and 7WAS). In 2006 and 2007 as well as the combined analysis, hoe weeding three times at 3, 5 and 7 WAS produced the highest grain yields, and, on the average, the highest net benefit and marginal rate of return. It is recommended that soybean farmers at Lapai should employ hoe-weeding at 3, 5 and 7DAS.

Sana Ullah Chaudhry *et al.* (2011) conducted an experiment at Adaptive Research Farm Gujranwala, Pakistan during rabi 2007-08 and 2008-09 to evaluate the effect of different herbicides on weed control and yield of canola. Four herbicides viz. Stomp 330 E (pendimethalin) (3.00 l ha^{-1}), Partner 75 WP (isoproturon) (2.00 kg ha^{-1}), Sencor 70 WP (metribuzin) (0.625 kg ha^{-1}) and Dual Gold 960 EC (S-metolachlor) (2.00 l/ha) were applied at seed bed preparation (SBP) and just after sowing (JAS) as pre-emergence while the Topik 15 WP (clodinafap-propargyl) (0.300 kg ha^{-1}) was applied as post emergence herbicide. Application of Stomp, Sencor, Partner and Dual Gold at SBP significantly reduced the narrow leaved weeds by 98.32, 97.19, 96.43 and 94.09% and ultimately reduced dry weight of weeds upto 34.78, 42.94, 44.32 and 38.27g m^{-2}, respectively. Dual Gold at SBP showed 96.71 percent reduction in broad leaved weeds, whereas Topik failed to control the broad leaved weeds. Maximum grain yield (2315 kg ha^{-1}) was obtained where Stomp was applied followed by Dual Gold (2230 kg ha^{-1}) and Partner (2183 kg ha^{-1}) at SBP. Spray of Sencor both at SBP and JAS showed negative effect on crop plants and decreased yield by 1285 and 1246 kg ha^{-1}, respectively as compared with control. The highest net return (Rs. 40820 ha^{-1}) was obtained by the application of Stomp followed by Dual Gold (Rs. 37465 ha^{-1}) and Partner (Rs. 35680 ha^{-1}) at SBP.

Simic *et al.* (2011) reported the level of weed infestation directly affects the intensity of competitive relationship between sunflower crops and weeds. This two-year study dealt with the observed effects of pre-emergence flurochloridone + s-metolachlor herbicides on the distribution of weeds in different stages of sunflower development. Simultaneously, in order to monitor the effects of weeds independence on herbicides application and the duration of competition, the sunflower plant height was measured. At the end of the life cycle, the yield and the oil content of the sunflower seeds were established. The total fresh weed biomass changed in dependence on the sunflower developmental stages and was always lower on the herbicide-treated area. This affected the sunflower plant height, yield and the oil content, which were higher, on the average, in the variants with herbicide applications (70.4 cm, 2959.7 kg ha^{-1} and 42.0%) than in the variants without herbicides application (57.4 cm, 2711.1 kg ha^{-1} and 40.1%).

Ehsan *et al.* (2010) investigated the effect of herbicides on oilseed rape yield and population and biomass of weeds a field experiment was conducted during the 2004 and 2005 at the Darab Agricultural College, east of Shiraz, Iran. Herbicide treatments Included combination of trifluralin with pronamide, haloxyfop-p methyl, propaquizafop, and isoxaben. Results showed that with increasing number and biomass of wild mustard (*Sinapis arvensis* L.), fumitory (*Fumaria sp.*) and wild oat (*Avena fatua* L.), per square meter, oilseed rape yield decreased significantly, in both 2004 and 2005. There were highly negative significant correlations between oilseed rape and wild mustard ($r=-0.73$, $p<0.01$), fumitory ($r=-0.86$, $p<0.01$) and wild oat ($r=-0.88$, $p<0.01$) biomass at 8 weeks after planting (WAP). There were significant path coefficient, direct effect, between wild mustard number at 8 WAP ($p=0.58$, $p<0.01$), fumitory number at 8 WAP ($p=-0.11$, $p<0.05$), fumitory biomass at 8 WAP ($p=-0.19$, $p<0.01$), wild oat biomass at 8 WAP ($p=-0.12$, $p<0.01$), wild oat number at 16 WAP ($p=-0.11$, $p<0.05$) with oilseed rape yield. The lowest oilseed rape yield observed at trifluralin at 1200 g ha^{-1} (2615 and 2609 kg ha^{-1}) and at 1400 g ha^{-1} (2565 and 2612 kg ha^{-1}) in 2004 and 2005, respectively.

Roshdy *et al.* (2008) carried out an experiment at the Agricultural Experimental Station of the National Research Center at Shalakan, Qalubeia Governorate Egypt during the two successive winter seasons 2005/2006 and 2006/2007 to study the effect of weed control treatments (unweeded, one-hand hoeing, two-hand hoeing and pendimethalin (stomp) at a rate of 1.7 L fed^{-1}. as pre-emergence) on weed control, yield and its components of three "canola" varieties (Serw-4, Serw-6 and Pactol). Serw-4 variety gave the lowest total fresh and dry weight of associated weeds m^{-2} at 45 and 60 days after planting compared to the other two varieties in both seasons. Two-hand hoeing at 21 and 35 days after planting decreased total fresh and dry weight of associated weeds and increased fresh and dry weight of canola plants at 45 and 60 days after planting. Also, it recorded an increasing in yield and its attributes in both seasons compared to other weed control treatments. Serw-4 cv., surpassed significantly in seed and biological yields (kg fed^{-1}.) as well as, number of seeds pod^{-1}, number of pods $plant^{-1}$, seeds $plant^{-1}$ (g) and oil (%) except 1000-seed weight compared to Serw-6 and Pactol varieties. The interaction between canola varieties and weed control treatments was significant. The most successful treatment applying was Serw-4 cv. with two-hand hoeing, followed by the same variety with pendimethalin (stomp) at a rate of 1.7 L fed^{-1} as pre-emergence of all studied characters in both seasons.

Bazzaz *et al*. (2003) conducted an experiment in two successive rabi seasons (1998-1999 and 1999-2000) to find out the effective herbicide for weed control in mustard. Performance of ronstar and Setoff were tested against on hand weeding at 25 days after sowing and unweeded control plots using three mustard varieties (Daulat, Dhali and Tori-7). Application of ronstar effectively reduced weed dry weight and give 10 and 30% higher grain yield of mustard compared to hand weeding and unweeded control plots, respectively. Setoff also reduced weed dry weight but at the same time it reduced plant stand and yield attributes of mustard that causes 60-75% yield reduction compared to unweeded control plot. This indicates that Set off in detrimental to weeds as well as mustard. Yield difference of the varieties was significant. Among the varieties, Daulat gave the highest grain yield. Interaction effect of varieties and weed control measures was significant.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during rabi season (November to February) of 2014-15 to find out the effect of source of nitrogen and weed control method on the performance of mustard.

3.1 Experimental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. It is located at $90^{0}22'$ E longitude and 23°4l′ N latitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28 (Appendix I).

3.2 Climatic condition

The experimental area under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during rabi season, October-March and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season, April-September. Detailed of the meteorological data of air temperature, relative humidity and rainfall during the period of the experiment was collected from the Bangladesh Meteorological Department (climate and weather division), Agargaon, Dhaka, presented in Appendix II.

3.3 Soil condition

The soil of the experimental area situated to the Modhupur Tract (UNDP, 1988) under the AEZ no. 28 and Tejgoan soil series (FAO, 1988). The soil was sandy loam in texture having pH 5.70. The physical and chemical characteristics of the soil have been presented in Appendix III.

3.4 Experimental Materials

3.4.1 Seed

A moderately salinity tolerant and high yielding variety of mustard, BARI Sarisha-14 developed by the Bangladesh Agricultural Research Institute (BARI); Joydebpur, Gazipur was used in the experiment as planting material. The seed was collected from the Bangladesh Agricultural Research Institute (BARI); Joydebpur, Gazipur.

Before sowing germination test was done in the laboratory and percentage of germination was over 95%.

3.4.2 Fertilizers

The recommended doses of Urea, TSP, MOP, Gypsum, $ZnSO_4$ and Boric acid were added to the soil of the experiment.

3.5 Methods

3.5.1 Treatments

Factor A: Sources of Nitrogen -4 (main plot)

N_0 = No nitrogen (control)

N_1= Prilled urea

N_2= NPK mixed fertilizer

N_3= Urea super granule

Factor B: Weed control method -3 (sub plot)

W_0 = No weeding

W_1= Hand weeding

W_2 = Herbicidal weeding

3.5.2 Design and layout

The experiment was laid out in a Split plot design with three replications. Experimental plot was first divided into three blocks. Each block was then divided into four main plots to accumulate source of the nitrogen at random. Each main plot was then divided into three subplots. Thus the total number of plots were 36. Layout of the experiment was done keeping inter block and inter plot spacing of 1m and 0.5m, respectively. The unit plot size was 3.0 m x 2.25 m. Layout of the experiment was done on 17 November, 2014 with interplot spacing of .50m and inter block spacing of 1m. The layout of the experiment is shown in Appendix IX.

3.5.3 Land preparation

The land was ploughed with a rotary plough and power tiller for four times. Ploughed soil was then brought into desirable fine tilth and leveled by laddering. The weeds were clean properly. The final ploughing and land preparation were done on 14

November, 2014. According to the layout of the experiment the entire experimental area was divided into blocks and subdivided into plots for the sowing of mustard seed. In addition, irrigation and drainage channels were prepared around the plot.

3.5.4 Fertilization

In this experiment fertilizers were used according to BARI which were urea, triple super phosphate (TSP =180 kg ha^{-1}), Muriate of potash (MOP =85 kg ha^{-1}), Gypsum (180 kg ha^{-1}), $ZnSO_4$ (5 kg ha^{-1}) and Boric acid (10 kg ha^{-1}) used as source of nitrogen, phosphorus, potassium, sulphur and boron, respectively. The amounts of fertilizer as per treatment required per plot were calculated. Except nitrogen total amount of all other fertilizers of each plot were applied and incorporated into soil during final land preparation. Nitrogen fertilizer was applied as per treatment. Half of prilled urea was applied during final land preparation and rest half was applied before flowering for prilled area treatment. While imposing USG treatment, USG was placed in alternate rows maintaining a distance of 15 cm in each row at a depth of 10 cm. Mixed fertilizer was applied at final land preparation and mixed thoroughly with the soil.

3.5.5 Sowing of seed

Sowing was done on 18 November, 2014 in rows 30 cm apart. Seeds were sown continuously in rows at a rate of 8 kg ha^{-1}. After sowing the seeds were covered with the soil and slightly pressed by hand.

3.5.6 Thinning

At 15 DAS first thinning was done on 03 December 2014. The final thinning was done after 25 days of sowing, on 13 December, 2014. The plant to plant distance was maintained as 10 cm.

3.5.7 Weeding

The description of weeding methods are given below:

I. No weeding: Weeds were allowed to grow in the plots from sowing to harvesting of crop. No weeding was done.

II. Hand weeding: Two hand weedings were done at 20 and 45 DAS, respectively.

III. Herbicidal weeding: Whip Super 9 EC was foliar sprayed @ 650 ml ha^{-1} at 20 DAS and 45 DAS as post emergence herbicide.

3.5.8 Irrigation and drainage

Irrigation was given four times during crop growing period. First post sowing and the rest at 10, 30 and 60 DAS. First one was light irrigation and last two was flood irrigation. The drainage system was well prepared and thus excess water drained easily.

3.5.9 Crop protection

The crop was infested with aphids (*Aphis spp*) at the time of siliqua filling. The insects were controlled successfully by spraying Hilthion 57 EC @ 1000 ml ha^{-1}. The insecticide was sprayed two times, the first on 15 January 2015; the second on 29 January 2015.

3.5.10 General observation of the experimental field

The field was investigated frequently in order to reduce losses with weeds competition and insects and diseases infection.

3.5.10 Harvesting and threshing

Previous randomly selected ten plants, those were considered for the growth analysis was collected from each plot to analyse the yield and yield contributing characters. Rest of the crops was harvested when 80% of the siliquae in terminal raceme turned golden yellow in colour. After collecting sample plants, harvesting was started on February 16 and completed on February 19, 2015. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

3.5.11 Drying and weighing

The seed and stover thus collected were dried in the sun for couple of days. Dried seed and stover of each plot was weighed and subsequently converted into yield kg ha^{-1}.

3.6 Data collection

Ten (10) plants from each plot were selected as random and were tagged for the data collection. Some data were collected from sowing to harvesting with 10 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and stover yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

1. Plant height (cm)
2. No. of branches plant^{-1}
3. Total dry matter (g)
4. No of plants m^{-2}
5. No. of siliquae plant^{-1}
6. No. seeds silliqua^{-1}
7. Thousand seed weight (g)
8. Seed yield (kg ha^{-1})
9. Stover yield (kg ha^{-1})
10. Biological yield (kg ha^{-1})
11. Harvest index (%)
12. Weed density

3.6.1 Plant height (cm)

Plant height was measured four times such as 20, 45, 65 DAS and at harvest. The height of the plant was determined by measuring scale considering the distance from the soil surface to the tip of the randomly ten selected plants and mean value was calculated for each treatment.

3.6.2 Number of branches plant^{-1}

The number of branches plant^{-1} was counted four times such as 20, 45 DAS and 65 DAS and at harvest of mustard plants. Mean value of data were calculated and recorded.

3.6.3 Total dry matter (TDM)

The total dry matter was calculated from the three randomly selected plants from each plot from summation of leaves, stem, and inflorescence. Dry weight plant^{-1} was counted four times such as 20, 45, 65 DAS and at harvest of mustard plants. Mean value of data were calculated and recorded.

3.6.4 Number of plants m^{-2}

Number of plants was counted from randomly selected 1 m^2 area after harvest.

3.6.5 Number of siliquae plant^{-1}

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

3.6.6 Number of seeds siliqua^{-1}

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

3.6.7 Weight of 1000-seed (g)

One thousand cleaned dried seeds were counted randomly from each plot and weighed by using a digital electric balance at the stage when grain retained 10% moisture and the mean weight were expressed in gram.

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

After threshing, cleaning and drying, total seed from harvested area were recorded and was converted to kg ha^{-1}.

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

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

3.6.10 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.

3.6.11 Harvest index (%)

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

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

3.6.12 Weed density

The data on weed infestation as well as density were collected from each unit plot at 30 DAS, 50 DAS, 70 DAS and at harvest. A plant quadrate of 0.5 m^2 was placed randomly at three different spots of the plot. The infesting species of weeds within each quadrate were identified and their number was counted species wise. The average number of three areas samples was then multiplied by 2 to obtain the weed density m^{-2}.

3.7. Data analysis

The collected data were statistically analyzed by using the ANOVA technique. 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 4

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The results obtained with nitrogen and weeding and their combination are presented and discussed in this chapter. Data about growth, yield contributing characters and yield of mustard have been presented in both Tables and Figures.

4.1 Infested weed species in the experimental field

It is a general observation that conditions favorable for growing mustard are also favorable for exuberant growth of numerous kinds of weeds that compete with crop plants. This competition of weeds tends to increase when the weed density increases and interfere with the crop growth and development resulting poor yield. Ten weed species were found major to infest the experimental crop. Local name, common name, scientific name, family and morphological type of the weed species have been presented in Table 1.

The most important weeds of the experimental plot were *Cynodon dactylon, Cyperus rotundus, Eleusine indica, Alternanthera philoxeroide* and *Brassica kaber* respectively. Among the major ten species one was aquatic, three were grasses, one was sedges, five were broad leaved.

Table 1. Weed species found in the experimental plots in mustard

SL No.	Local name	Common name	Scientific name	Family	Types
1	Durba	Bermuda grass	*Cynodon dactylon*	Poaceae	Grass
2	Malancha	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae	Aquatic
3	Mutha	Nutgrass	*Cyperus rotundus*	Cyperaceae	Sedge
4	Keshuti	White eclipta	*Eclipta prostrata*	Asteraceae	Broadleaf
5	Chapra	Indian goosegrass	*Eleusine indica*	Poaceae	Grass
6	Bathua	Lambs quarter	*Chenopdium album*	Chenopodiaceae	Broad leaf
7	Bonsarisha	Wild mustard	*Brassica kaber*	Brassicaceae	Broad leaf
8	Boro Anguli	Scrab grass	*Digitaria sanguinalis*	poaceae	Grass
9	Arich	Tora weed	*Cassia tora*	Fabaceae	Broad leaf
10	Helencha	Harkuch	*Enhydra fluctuans*	Asteraceae	Broad leaf

4.2 Weed density

There observed significant variation on weed density due to nitrogen at different days after sowing (Table 2). The highest weed population (96.89, 83.56, 97.22 and 113.70 at 20, 45, 65 DAS and at harvest, respectively) was recorded from NPK mixed fertilizer (N_2), prilled urea (N_1) and no nitrogen (N_0) and lowest weed population (48.56, 56.33, 63.89 and 64.22 at 20, 45, 65 DAS and at harvest, respectively) was recorded from urea super granule (N_3). Significant variation was observed on weed density throughout the growing period for different weeding treatments at different days after sowing (Table 3). The highest weed population (86.92, 79.08, 116.2 and 129.9 at 20, 45, 65 DAS and at harvest, respectively) was observed in hand weeding

(W_1) and without weeding (W_0). The lowest number of weed (52, 59.75, 42.67, 49.08 at 20, 45, 65 DAS and at harvest, respectively) was observed in without weeding (W_0) and herbicidal weeding (W_2).

The effect of nitrogen and weeding interaction on number of total weeds was statistically significant (Table 4). The maximum total number of weeds (157.30, 118.30, 143.00, 186.00 at 20, 45, 65 DAS and at harvest, respectively) was found from N_2W_0 (NPK mixed fertilizer and no weeding) and minimum number of weeds (35.33, 41.33, 36.00, 41.00 at 20, 45, 65 DAS and at harvest, respectively) from urea super granule and herbicidal weed control application (N_3W_2).

Table 2. Effect of nitrogen on the number of weed m^{-2} at different days after sowing

Treatments	Number of weeds m^{-2}			
	20DAS	45 DAS	65DAS	At harvest
N_0	52.56 b	66.00 bc	89.78 ab	113.70 a
N_1	87.44 a	78.11 ab	97.22 a	105.80 a
N_2	96.89 a	83.56 a	75.89 bc	86.89 b
N_3	48.56 b	56.33 c	63.89 c	64.22 c
LSD(0.05)	34.49	13.40	18.69	17.66
CV (%)	77.28	65.83	54.57	73.04

N_0 = no nitrogen, N_1 = prilled urea, N_2 = NPK mixed fertilizer, N_3 = urea super granule

Table 3. Effect of weeding on number of weed m^{-2} at different days after sowing

Treatments	Number of weeds m^{-2}			
	20DAS	45 DAS	65DAS	At harvest
W_0	52 b	79.08 a	116.2 a	129.9 a
W_1	86.92 a	74.17 a	86.25 b	98.92 b
W_2	75.17 ab	59.75 b	42.67 c	49.08 c
LSD(0.05)	30.67	12.55	28.8	16.87
CV (%)	63.89	51.59	42.04	45.49

W_0 = no weeding, W_1 = hand weeding, W_2 = herbicidal weeding,

Table 4. Interaction effect of nitrogen and weeding on the number of weed m^{-2} of mustard field

Interaction (N source × weeding method)	Number of weeds m^{-2}			
	20DAS	45 DAS	65DAS	At harvest
N_0W_0	50.33 cd	49.33 d	103.30 a-c	105.30 bc
N_0W_1	64.00 cd	48.33 d	84.67 b-d	105.00 a-c
N_0W_2	43.33 cd	100.30 ab	41.67 d	50.00 c
N_1W_0	64.67 cd	104.30 ab	117.70 ab	136.70 ab
N_1W_1	72.67 c	75.67 b-d	120.70 ab	123.30 a-c
N_1W_2	125.00 b	54.33 d	53.33 cd	57.33 bc
N_2W_0	157.30 a	118.30 a	143.00 a	186.00 a
N_2W_1	57.67 cd	89.33 a-c	88.33 a-d	107.30 a-c
N_2W_2	75.67 c	43.00 d	39.67 d	48.00 c
N_3W_0	56.67 cd	73.33 b-d	100.70 a-c	91.67 bc
N_3W_1	53.67 cd	54.33 cd	51.33 cd	60.00 bc
N_3W_2	35.33 d	41.33 d	36.00 d	41.00 c
LSD(0.05)	28.90	31.96	50.97	72.94
CV (%)	63.89	51.59	42.04	45.49

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

N_0 = no nitrogen, N_1= prilled urea, N_2= NPK mixed fertilizer, N_3= urea super granule, W_0 = no weeding, W_1= hand weeding, W_2 = herbicidal weeding,

4.3 Plant height

Different nitrogen source influenced the height of mustard plant at different days after sowing except 20 days after sowing (Table 5). The tallest plant (6.96, 48.96, 55.45, 56.16 cm at 20, 45, 65 DAS and at harvest, respectively) was recorded from N_1 (Prilled urea) treated plot. In contrast, the shortest plant (36.13, 46.64, 47.66 cm at 45, 65 DAS and at harvest, respectively) was recorded from N_0 (control) plot. The result corroborates with the findings of Sarker (1994) and Siag *et al.* (1993) who observed maximum plant height in the nitrogen application treatment during branching and siliquae development stages.

There was significant difference among the weeding in respect of plant height at 65 DAS and at harvest (Table 6). The tallest plant (54.13 and 55.49 cm at 65 DAS and at harvest, respectively) was produced from W_1 (Hand weeding) and shortest plant (46.59 and 47.23 cm at 65 DAS and at harvest, respectively) was found in W_0 (no weeding). The results were in agreement with the findings of Khan and Tarique (2011) who found that the tallest plant was observed in completely weed free condition throughout the crop growth period with chemical weed control methods and next in two hand weeding treatment whereas lowest value was observed in no weeding treatment.

Table 5. Effect of nitrogen on the plant height of mustard at different days after sowing

Treatments	Plant height (cm)			
	20DAS	45 DAS	65DAS	At harvest
N_0	5.27	36.13 b	46.64 b	47.66 b
N_1	6.96	48.96 a	55.45 a	56.16 a
N_2	5.41	37.51 b	48.19 ab	49.09 ab
N_3	5.92	40.25 b	52.93 ab	53.95 ab
LSD(0.05)	NS	7.79	8.12	7.35
CV (%)	15.31	13.22	6.15	5.47

N_0 = no nitrogen, N_1= prilled urea, N_2= NPK mixed fertilizer, N_3= urea super granule,

Table 6. Effect of weeding method on the plant height of mustard at different days after sowing

Treatments	Plant height (cm)			
	20DAS	45 DAS	65DAS	At harvest
W_0	5.295	39.07	46.59 b	47.23 b
W_1	6.355	42.91	54.13 a	55.49 a
W_2	6.019	40.16	51.69 a	52.42 a
LSD(0.05)	NS	NS	5.009	3.746
CV (%)	15.36	15.81	5.47	5.55

W_0 = no weeding, W_1= hand weeding, W_2 = herbicidal weeding,

The combined effect of nitrogen and weeding had significant effect on plant height of mustard (Fig. 1). The figure indicated that irrespective of interactions plant height of mustard showed an increasing trend with the advances of crop ages. The increase was found from 20 DAS to 45 DAS after that the rate of increase was showed upto 65 DAS. After 65 DAS the rate of increase of plant height was much lower. However, the tallest plant (7.72, 50.55, 58.16 and 59.36 cm at 20, 45, 65 DAS and at harvest, respectively) was found in N_1W_1 (prilled urea with hand weeding) treatment combination, whereas the shortest plant (4.91, 34.46, 41.97, 43.08 cm at 20, 45, 65 DAS and at harvest, respectively) was observed in N_0W_0 (no nitrogen with no weeding) treatment combination.

4.4 Total dry matter plant $^{-1}$

Nitrogen exerted a significant influence on the total dry matter plant^{-1} at 65 DAS and at harvest. The highest total dry matter plant^{-1} (3.36 g and 4.22 g at 65 DAS and at harvest, respectively) was recorded in N_1 treatment, (Table 7). The lowest total dry matter plant^{-1} (1.54 and 1.90 g at 65 DAS and at harvest, respectively) was recorded in no nitrogen (control) treatment.

There was not significantly variation in total dry matter plant^{-1} due to weeding at 20, 45 and 65 DAS and only significant at harvest. The maximum total dry matter plant^{-1} (0.086, 1.178, 2.658, 3.55g at 20, 45, 65 DAS and at harvest, respectively) was obtained from W_1 treatment and the minimum (0.035, 0.815, 2.357, 2.93 g at 20, 45, 65 DAS and at harvest, respectively) from W_0 (control) (Table 8).

Interaction of nitrogen and weeding had a significant effect on total dry matter plant^{-1} at 45, 65 DAS and at harvest (Fig. 2). It can be inferred from the result that dry matter per plant showed an increasing trend with the advances of days after sowing and continued upto at harvest irrespective of interaction except N_0W_2 and N_3W_0. The figure also indicated that the dry matter increment rate was much higher from 45 DAS to 65 DAS than early and later stages. However, the highest total dry matter plant^{-1} (0.16, 1.43, 3.58, 4.63 g at 20, 45, 65 DAS and at harvest, respectively) was obtained from N_1W_1 treatment while the lowest (0.01, 0.50, 1.40, 1.75 g at 20, 45, 65 DAS and at harvest, respectively) from N_0W_0 treatment (Fig. 2).

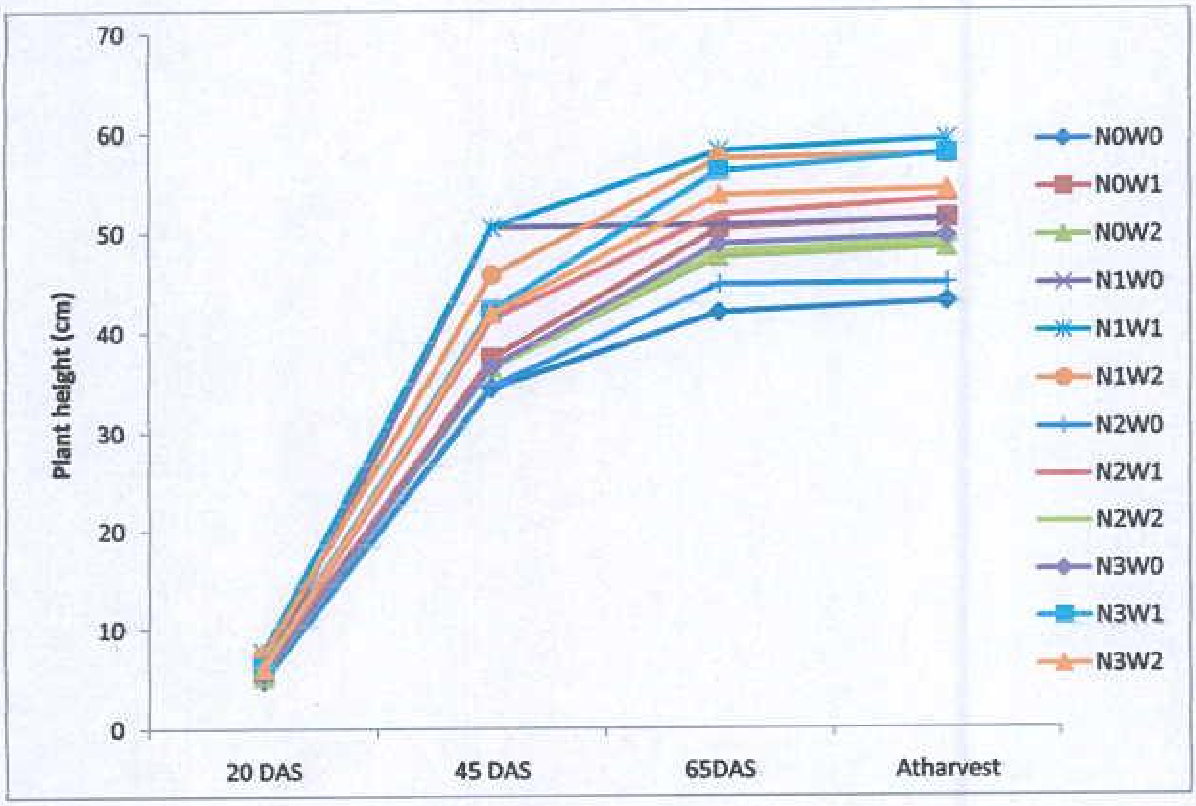

Fig.1 Interaction effect of nitrogen and weeding on the plant height of mustard at different days after sowing ($LSD_{(0.05)}$= NS, NS, 4.97 at 20, 45, 65 DAS and at harvest, respectively).

N_0 = no nitrogen, N_1= prilled urea , N_2= NPK mixed fertilizer, N_3= urea super granule, W_0 = no weeding, W_1= hand weeding, W_2 = herbicidal weeding,

Table 7. Effect of nitrogen on the total dry matter of mustard at different days after sowing

Treatments	Total dry matter (g $plant^{-1}$)			
	20DAS	45 DAS	65DAS	At harvest
N_0	0.03	0.63	1.54 c	1.90 c
N_1	0.10	1.32	3.36 a	4.22 a
N_2	0.04	0.83	2.33 b	3.34 b
N_3	0.06	1.19	2.86 ab	3.66 ab
LSD(0.05)	NS	NS	0.61	0.58
CV (%)	121.91	28.14	9.38	6.74

N_0 = no nitrogen, N_1= prilled urea, N_2= NPK mixed fertilizer, N_3= urea super granule,

Table 8. Effect of weeding on the total dry matter of mustard at different days after sowing

Treatments	Total dry matter (g $plant^{-1}$)			
	20DAS	45 DAS	65DAS	At harvest
W_0	0.035	0.815	2.357	2.93 b
W_1	0.086	1.178	2.658	3.55 a
W_2	0.052	0.9925	2.553	3.366 ab
LSD(0.05)	NS	NS	NS	0.44
CV (%)	121.91	24.20	4.69	7.08

W_0= no weeding, W_1= hand weeding, W_2= herbicidal weeding,

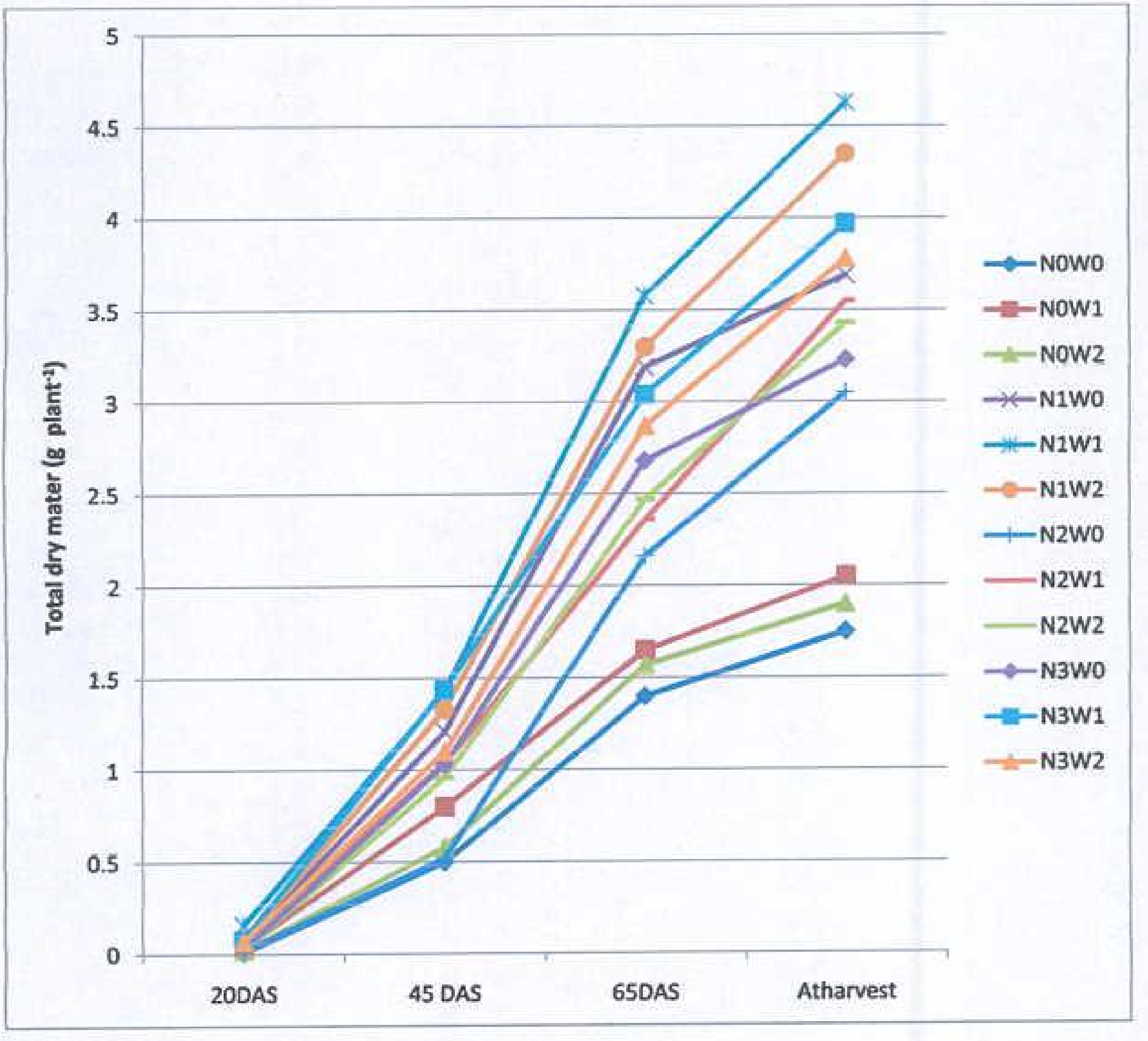

Fig. 2 Interaction effect of nitrogen and weeding on the total dry matter of mustard at different days after sowing (LSD $_{(0.05)}$= 0.12, 0.42, 0.20, 3.78 at 20, 45, 65 DAS and at harvest, respectively)

N_0 = no nitrogen, N_1= prilled urea, N_2= NPK mixed fertilizer, N_3= urea super granule, W_0 = no weeding, W_1= hand weeding, W_2 = herbicidal weeding,

4.5 Number of branches plant^{-1}

Nitrogen source was significantly influenced on number of branches plant^{-1} (Table 9). The maximum Number of branches plant^{-1} (5.17) was produced by N_1, which was statistically similar with N_2 and N_3 and without nitrogen (N_0) treatment was produced the lowest Number of branches plant^{-1} (3.12).

Number of branches plant^{-1} was not significantly influenced by weeding (Table 10). With the hand weeding (W_1) had the maximum number of branches plant^{-1} (4.63). However, the minimum number of branches plant^{-1} (4.03) was obtained from the without weeding (W_0).

A significant variation in the number of branches plant^{-1} was found between the nitrogen and weeding interaction (Table 11). The maximum number of branches plant^{-1} (5.73) was found in combined use of prilled urea and hand weeding treatment (N_1W_1), whereas the lowest number of branches plant^{-1} (2.93) was found in no nitrogen and without weeding (N_0W_0) treatment, which was statistically similar with N_0W_1 and N_0W_2.

Table 9. Effect of nitrogen on the plants m^{-2} and yield contributing character of mustard

Treatments	Plants m^{-2} (No.)	Branches plant^{-1} (No.)	Siliquae plant^{-1} (No.)	Seeds siliqua^{-1} (No.)	1000-Seed weight (g)
N_0	48.45 b	3.12 b	12.81 c	21.01 b	2.52 c
N_1	67.17 a	5.17 a	26.34 a	29.06 a	2.98 a
N_2	60.28 a	4.38 a	21.80 b	22.52 b	2.59 bc
N_3	64.39 a	4.62 a	24.44 ab	27.44 a	2.91 ab
LSD (0.05)	8.55	0.85	3.55	3.93	0.39
CV (%)	5.47	7.53	6.39	6.05	12.69

N_0 = no nitrogen, N_1= prilled urea, N_2= NPK mixed fertilizer, N_3= urea super granule,

Table 10. Effect of weeding on the plants m^{-2} and yield contributing character of mustard

Treatments	Plants m^{-2} (No.)	Branches $plant^{-1}$ (No.)	Siliquae $plant^{-1}$ (No.)	Seeds $siliqua^{-1}$ (No.)	1000-Seed weight (g)
W_0	56.17 b	4.03	19.16 b	24.07 b	2.56 c
W_1	63.46 a	4.63	22.75 a	26.31 a	2.90 a
W_2	60.58 ab	4.31	22.14 ab	24.64 ab	2.79 a
LSD(0.05)	6.689	NS	3.471	1.956	0.222
CV(%)	0.67	9.45	7.28	7.38	15.03

W_0 = no weeding, W_1 = hand weeding, W_2 = herbicidal weeding,

Table 11. Interaction effect of nitrogen and weeding on the plants m^{-2} and yield contributing character of mustard

Interaction (N source × weeding)	Plants m^{-2} (No.)	Branches $plant^{-1}$ (No.)	Siliquae $plant^{-1}$ (No.)	Seeds $siliqua^{-1}$ (No.)	1000-Seed weight (g)
N_0W_0	46.33 f	2.93 c	12.07 f	19.90 f	2.37 c
N_0W_1	50.50 ef	3.46 d	13.30 f	22.97 cd	2.67 a-c
N_0W_2	48.50 f	2.98 d	13.06 f	20.15 d	2.53 bc
N_1W_0	63.50 b-d	4.66 bc	24.33 b-d	27.06 ab	2.76 a-c
N_1W_1	71.50 a	5.73 a	27.87 a	30.23 a	3.15 a
N_1W_2	66.50 ab	5.11 ab	26.83 ab	29.87 a	3.03 a
N_2W_0	56.17 de	4.23 c	17.87 e	22.50 cd	2.43 c
N_2W_1	63.17 b-d	4.40 bc	24.13 bd	24.11 bc	2.72 a-c
N_2W_2	61.50 b-d	4.51 bc	23.40 cd	20.95 cd	2.63 a-c
N_3W_0	58.67 ab	4.30 c	22.36 d	26.82 ab	2.68 a-c
N_3W_1	68.67 ab	4.93 bc	25.69 a-c	27.93 a	3.07 a
N_3W_2	65.83 a-c	4.64 bc	25.26 a-d	27.57 a	2.98 ab
LSD (0.05)	6.97	0.71	2.69	3.20	0.46
CV (%)	0.67	9.45	7.28	7.38	15.03

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

N_0 = no nitrogen, N_1= prilled urea, N_2= NPK mixed fertilizer, N_3= urea super granule, W_0 = no weeding, W_1= hand weeding, W_2 = herbicidal weeding,

4.6 Number of siliquae plant^{-1}

Number of siliquae plant^{-1} is one of the most important yield contributing characters in mustard. The nitrogen source showed significant variation in the number of siliquae plant^{-1} (Table 9). The maximum number of siliquae plant^{-1} (26.34) was produced by N_1 treatment and N_0 produced the minimum number of siliquae plant^{-1} (12.81). The results were partially supported by Clarke and Simpson (1978) and fully supported by Sharma and Kumar (1989) in that nitrogen increased siliquae plant^{-1}.

There was a significant difference among the weeding in the number of siliquae plant^{-1} (Table 10). The maximum number of siliquae plant^{-1} (22.75) was produced in W_1 treatment. The minimum number of siliquae plant^{-1} (19.16) was produced in W_0 treatment.

A significant variation was found in the treatment combinations of nitrogen and weeding on number of siliquae plant^{-1} (Table 11). The maximum number of siliquae plant^{-1} (27.87) was found in N_1W_1, whereas the minimum number of siliquae plant^{-1} (12.07) was found in N_0W_0 treatment combination, which was statistically similar with N_0W_1 and N_0W_2.

4.7 Number of seeds silliqua^{-1}

Nitrogen source showed significant variation in the number of seeds silliqua^{-1} (Table 9). The maximum number of seeds silliqua^{-1} (29.06) was produced by N_1, whereas N_0 produced the minimum number of seeds silliqua^{-1} (21.01). The present results confirmed the findings of Deekshitula and Subbaiah (1997). Sarandon *et al.* (1993) stated that the application of N-fertilizer yielded the higher number of seeds siliqua^{-1} in mustard.

There was a significant difference among the weeding methods in the number of seeds silliqua^{-1} (Table 10). The maximum number of seeds silliqua^{-1} (26.31) was produced in W_1 treatment. The minimum number of seeds silliqua^{-1} (24.07) was produced in W_0 condition.

Number of seeds silliqua^{-1} exerted a significant variation among the treatment combinations of nitrogen and weeding (Table 11). The maximum number of seeds silliqua^{-1} (30.23) was found in N_1W_1 treatment combination, which was statistically similar with N_1W_2, N_3W_1 and N_3W_2. The minimum number of seed silliqua^{-1} (19.90) was found in N_0W_0 treatment, which was statistically similar with N_0W_2.

4.8 Number of plants m^{-2}

Nitrogen source significantly influenced the number of plants m^{-2} in mustard (Table 9). The maximum number of plants m^{-2} (67.17) was produced by N_1, which was statistically similar with N_2 and N_3, and without nitrogen (N_0) treatment was produced the lowest number of plants m^{-2} (48.45).

Number of plants m^{-2} influenced significantly by weeding in mustard (Table 10). With the hand weeding (W_1) had the highest number of plants m^{-2} (63.46). However, the lowest number of plants m^{-2} (56.17) was obtained from the without weeding (W_0).

A significant variation in the number of plants m^{-2} was found between the interaction of nitrogen and weeding (Table 11). The maximum number of plants m^{-2} (71.50) was found in combined use of prilled urea and hand weeding treatment (N_1W_1), whereas the lowest number of plants m^{-2} (46.33) was found in no nitrogen and without weeding (N_0W_0) treatment, which was statistically similar with N_0W_2.

4.9 Thousand Seed weight (g)

Thousand seed weight significantly influenced by the source of nitrogen (Table 9). The maximum weight of thousand seed (2.98 g) was produced by N_1 and the lowest thousand seed weight (2.52 g) was obtained from N_0 treatment. The result was supported by Sarker and Hassan (1988), Sharma and Kumar (1989) and Sarker *et al.* (2000).

The weight of thousand seed was significantly influenced by weeding treatments (Table 10). The highest thousand seed weight (2.90 g) was obtained from W_1 treatment, which was statistically similar with W_2. The lowest thousand seed weight (2.56 g) was obtained from W_0 treatment.

Thousand seed weight was significantly affected by the interaction of nitrogen source and weeding method (Table 11). The highest thousand seed weight (3.15 g) was found in N_1W_1 treatment combination, which was statistically similar with N_3W_1, N_3W_2, N_1W_2, N_1W_0, N_2W_2 and N_3W_0. The lowest thousand seed weight (2.37g) was found in N_0W_0 treatment, which was statistically similar with N_2W_0 and N_0W_2.

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

The seed yield of mustard per plot was converted into per hectare, and has been expressed in kg (Table 12). The different source nitrogen exerted significant effect on the seed yield ha^{-1}. The maximum seed yield ha^{-1} (1139.00 kg) was obtained from N_1 (prilled urea) treatment, whereas the minimum seed yield ha^{-1} (421.50 kg ha^{-1}) was obtained from N_0 (no nitrogen).

The total seed yield of mustard varied significantly due to the application of different method of weeding (Table 13). The highest seed yield (1040.00 kg ha^{-1}) was obtained from W_1 (hand weeding) while W_0 gave the lowest (581.10 kg ha^{-1}) yield.

The combined effect of nitrogen source and weeding method was significant on seed yield (Table 14). The highest seed yield (1382.00 kg ha^{-1}) was obtained from N_1W_1 (prilled urea with hand weeding) treatment combination. The lowest seed yield (291.10 kg ha^{-1}) was obtained from N_0W_0 (no nitrogen and no weeding) treatment.

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

The stover yield of mustard per plot was converted into per hectare and has been expressed in kg (Table 12). The different doses of nitrogen had effect on the stover yield. The maximum stover yield (647.50 kg ha^{-1}) was obtained from N_2 treatment, whereas the minimum stover yield (459.70 kg ha^{-1}) was obtained from N_0. It was interesting that nitrogen applied treatment helped to produce tallest plant, more number of branches $plant^{-1}$ and number of siliquae $plant^{-1}$ which ultimately increased stover yield. Patel *et al.* (1991), Sarker *et al.* (2000), and Sarker et al. (2001) reported similar views in respect of stover yield that nitrogen increased stover yield.

The total stover yield of mustard varied significantly due to different weeding methods (Table 13). The highest yield of stover (609.20 kg ha^{-1}) was obtained from W_1 (hand weeding), while W_0 gave the lowest (484.40 kg ha^{-1}) yield.

Table 12. Effect of nitrogen on the yield and harvest index of mustard

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
N_0	421.50 d	459.70 b	881.10 c	47.27 b
N_1	1139.00 a	533.70 ab	1672.00 a	67.56 a
N_2	804.50 c	647.50 a	1452.00 b	55.73 ab
N_3	1024.00 c	514.40 ab	1538.00 b	66.01 a
LSD (0.05)	92.22	165.50	87.24	16.26
CV (%)	4.18	30.42	10.68	13.76

N_0 = no nitrogen, N_1= prilled urea, N_2= NPK mixed fertilizer, N_3= urea super granule,

Table 13. Effect of weeding on the yield and harvest index of mustard

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
W_0	581.10 b	484.40 c	1065.00 c	53.36 b
W_1	1040.00 a	609.20 a	1649.00 a	61.59 ab
W_2	920.30 a	522.80 b	1443.00 b	62.48 a
LSD(0.05)	311.9	23.85	104.70	8.988
CV (%)	4.29	20.50	8.08	9.46

W_0 = no weeding, W_1= hand weeding, W_2 = herbicidal weeding

Table 14. Interaction effect of nitrogen and weeding on the yield and harvest index of mustard

Interaction (N source × weeding method)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
N_0W_0	291.10 i	416.30 e	707.50 h	40.39 e
N_0W_1	516.70 gh	531.70 b-d	1048.00 f	49.63 de
N_0W_2	456.50 h	431.00 e	887.50 g	51.78 d
N_1W_0	763.40 ef	438.20 e	1202.00 e	63.55 a-c
N_1W_1	1382.00 a	592.80 b	1975.00 a	70.06 a
N_1W_2	1271.00 b	570.00 bc	1841.00 b	69.08 ab
N_2W_0	563.10 g	590.80 b	1154.00 e	50.44 de
N_2W_1	1027.00 d	735.00 a	1762.00 b	58.40 cd
N_2W_2	823.70 e	616.70 b	1440.00 d	58.34 b-d
N_3W_0	706.70 f	492.20 c-e	1199.00 e	59.06 b-d
N_3W_1	1234.00 b	577.30 bc	1812.00 b	68.27 a-c
N_3W_2	1131.00 c	473.70 de	1604.00 c	70.71 a
LSD(0.05)	62.99	81.25	87.28	9.68
CV (%)	4.29	20.50	8.08	9.46

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

N_0 = no nitrogen, N_1= prilled urea , N_2= NPK mixed fertilizer, N_3= urea super granule, W_0 = no weeding, W_1= hand weeding, W_2 = herbicidal weeding,

The combined effect of nitrogen and weeding was significant on yield of stover per hectare (Table 14). The highest yield of stover (735.00 kg ha^{-1}) was obtained from N_2W_1 treatment combination. The lowest yield of seed (416.30 kg ha^{-1}) was obtained from N_0W_0 treatment, which was statistically similar with N_0W_2, N_1W_0, N_3W_0 and N_3W_2 .

4.12 Biological yield (kg ha-1)

The different source of nitrogen had significant effect on the biological yield of mustard. The maximum biological yield (1672.00 kg ha^{-1}) was obtained from N_1

(prilled urea), treatment, whereas the minimum biological yield (881.10 kg ha^{-1}) was obtained from N_0 (no nitrogen) (Table 12).

The biological yield of mustard varied significantly due to the weeding method (Table 13). The highest biological yield (1649.00 kg ha^{-1}) was obtained from W_1 while W_0 gave the lowest (1065.00 kg ha^{-1}) yield.

The combined effect of nitrogen and weeding was significant on biological yield (Table 14). The highest biological yield (1975.00 kg ha^{-1}) was obtained from N_1W_1 treatment combination. The lowest biological yield (707.50 kg ha^{-1}) was obtained from N_0W_0 treatment.

4.13 Harvest index (%)

The different nitrogen source had significant effect on the harvest index of mustard. The maximum harvest index (67.56%) was obtained from N_1 (prilled urea), which was statistically similar with N_3 treatment. The minimum harvest index (47.27%) was obtained from N_0 treatment (Table 12).

The harvest index varied significantly due to the application of different weeding (Table 13). The highest harvest index (62.48%) was obtained from W_2 while W_0 gave the lowest (53.36%) harvest index.

The combined effect of nitrogen and weeding was significant on harvest index of mustard (Table 14). The highest harvest index (70.71 %) was obtained from N_3W_2 treatment combination, which was statistically similar with N_1W_1, N_1W_0 and N_3W_1 . The lowest harvest index (40.39%) was obtained from N_0W_0 treatment, which was statistically similar with N_0W_1.

CHAPTER 5

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the rabi season from November 2014 to February 2015 to find out the effect of source of nitrogen and weed control method on the performance of mustard. In this experiment, the treatment consisted of four sources of nitrogen viz. N_0 = no nitrogen (Control), N_1= Prilled urea, N_2= NPK mixed fertilizer, N_3= Urea super granule and three different weeding methods viz. W_0 = No weeding, W_1= hand weeding and W_2= Herbicidal weeding. The experiment was laid out in a split plot design with three replications. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed that a significant variation among the treatments in respect majority of the observed parameters.

There was significant difference among the nitrogen source in respect of all parameters. The tallest plant (6.96, 48.96, 55.45, 56.16 cm at 20, 45, 65 DAS and at harvest, respectively) was recorded in N_1 (prilled urea). The highest total dry matter plant^{-1}(0.10, 1.32, 3.36, 4.22 g at 20, 45, 65 DAS and at harvest, respectively) was recorded in N_1 treatment. The maximum number of branches per plant (5.17) was produced by N_1. The maximum number of siliquae per plant (26.34), and number of seeds per silliqua (29.06), number of plants per square meter (67.17) were produced by N_1. The maximum thousand seed weight (2.98 g) was produced by N_1. The maximum seed yield (1139.00 kg ha^{-1}) was obtained from N_1 (prilled urea) treatment, whereas the minimum seed yield (421.50 kg ha^{-1}) was obtained from N_0 (no nitrogen). The maximum stover yield (647.50 kg ha^{-1}) was obtained from N_2, treatment. The maximum biological yield (1672.00 kg ha^{-1}) was obtained from N_1 (prilled urea) treatment. The maximum harvest index (67.56%) was obtained with N_1 (prilled urea).

The tallest plant (6.36, 42.91, 54.13, 55.49 cm at 20, 45, 65 DAS and at harvest, respectively) was produced with W_1 (Hand weeding). There was significant variation in total dry matter per plant due to weeding at 20, 45 and 65 DAS and only significant was at harvest. The maximum total dry matter per plant (0.086, 1.178, 2.658, 3.55g at 20, 45, 65 DAS and at harvest, respectively) was obtained from W_1 treatment. The hand weeding (W_1) had the highest number of branches per plant (4.631). The maximum number of siliquae per plant (22.75), number of seeds silliqua^{-1} (26.31), and number of plants per square meter (63.46) was obtained from W_1 treatment. The highest thousand seed weight (2.90 g) was obtained from W_1 treatment. The highest seed yield (1040.00 kg ha^{-1}) was obtained from W_1 (hand weeding) while W_0 gave the lowest (581.10 kg ha^{-1}) yield. The highest stover yield (609.2 kg ha^{-1}) was obtained from W_1 (hand weeding). The highest biological yield (1649.oo kg ha^{-1}) was obtained from W_1. The highest harvest index (62.48%) was obtained from W_2.

The combinations of nitrogen and weeding had significant effect on almost all parameters. The tallest plant (7.72, 50.55, 58.16, 59.36 cm at 20, 45, 65 DAS and at harvest, respectively) was found in N_1W_1 (prilled urea with hand weeding) treatment combination. The highest total dry matter per plant (0.16, 1.43, 3.58, 4.63 g at 20, 45, 65 DAS and at harvest, respectively) was obtained from N_1W_1 treatment. The maximum number of branches per plant (5.73) was found in combined use of prilled urea and hand weeding treatment (N_1W_1). The maximum number of siliquae per plant (27.87), number of seeds per silliqua (30.23), number of plants per square (71.50) was found in combined use of prilled urea and hand weeding treatment (N_1W_1). The highest thousand seed weight (3.15 g) was found in N_1W_1 treatment combination. The highest seed yield (1382.00 kg ha^{-1}) was obtained from N_1W_1 (prilled urea with hand weeding) treatment combination. The lowest seed yield per hectare (291.10 kg) was obtained from N_0W_0 (no nitrogen and no weeding) treatment. The highest stover yield (735.00 kg ha^{-1}) was obtained from N_2W_1 treatment combination. The highest biological yield (1975.00 kg ha^{-1}) was obtained from N_1W_1 treatment combination. The highest harvest index (70.71 %) was obtained from N_3W_2 treatment combination, which was statistically similar with N_1W_1.

Considering the above results, it may be summarized that growth, seed yield and yield contributing parameters of mustard were influenced the source of nitrogen and methods of weeding. Therefore, the present experimental results suggest that the combined use of prilled urea with hand weeding would be beneficial to increase the seed yield of mustard variety BARI Sarisha- 14 under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. The results are required to substantiate further with different varieties of mustard.
3. It needs to conduct more experiments with nitrogen and weeding whether can regulate the growth, yield and seed quality of mustard variety BARI Sarisha-14.

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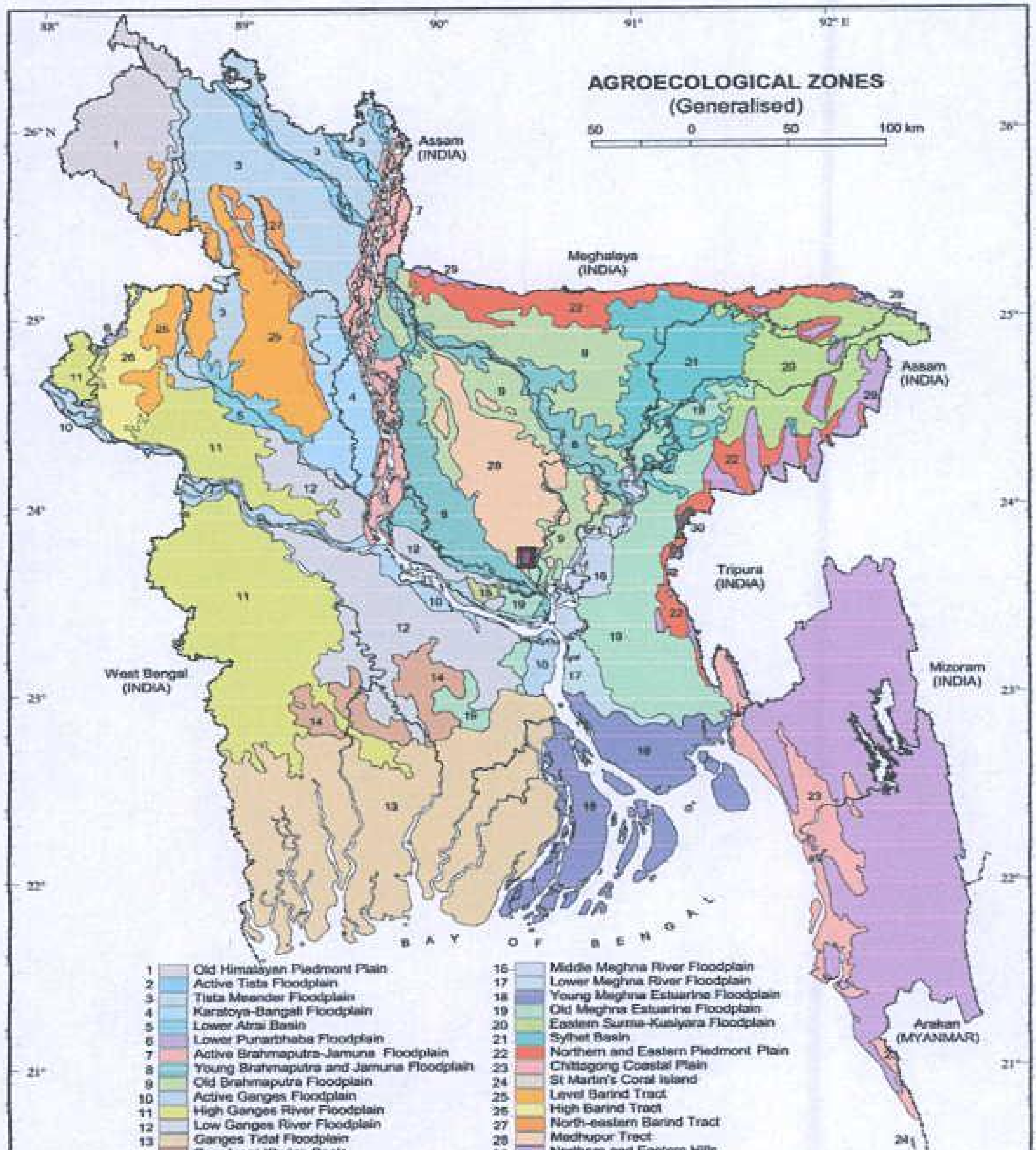
APPENDICES

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly average air temperature, relative humidity and total rainfall of the experimental site during 2014-2015

Month	Air temperature (°C)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
November	26.98	14.88	71.15	00
December	25.78	14.21	68.30	00
January	25.00	13.46	69.53	00
February	29.50	18.49	50.31	00
March	33.80	20.28	44.95	00

Source: Bangladesh Meteorological Department (climate and weather division), Agargaon, Dhaka

Appendix III. Chemical properties of the soil of experiment field before seed sowing

CHARACTERISTICS	VALUE
Ph	5.70
Organic matter (%)	2.35
Total N (%)	0.12
K (me/100 g soil)	0.17
P (Mg/g soil)	8.90
S (Mg/g soil)	30.55
B (Mg/g soil)	0.62
Fe (Mg/g soil)	310.40
Zn (Mg/g soil)	4.82

Source: Soil Resource Development Institute (SRDI), Krishi Khamar Sharak, Dhaka

Appendix IV. Analysis of variance of the data on number of weeds m^{-2} of mustard as influenced by nitrogen and weeding method

Source	Degrees of freedom	Mean square			
		Number of weeds m^{-2}			
		20 DAS	45 DAS	65DAS	At harvest
Replication	2	3131.861	1646.083	48.028	1029.528
Factor A (nitrogen)	3	5352.25*	1344.963*	1971.583*	4366.102*
Error	6	3041.194	2184.935	1987.472	4578.157
Factor B (wedding method)	2	3787.861*	1211.583*	16393.53*	19956.78*
AB	6	2876.194*	2812.769*	867.194*	1623.074*
Error	16	2078.736	1341.972	1179.361	1776

* = Significant at 5% level of probability

Appendix V. Analysis of variance of the data on plant height of mustard as influenced by nitrogen and weeding method

Source	Degrees of freedom	Mean square			
		Plant height (cm)			
		20 DAS	45 DAS	65DAS	At harvest
Replication	2	0.418	37.314	24.994	19.417
Factor A (nitrogen)	3	5.301^{NS}	298.279*	150.67*	144.083*
Error	6	0.813	28.976	9.773	8.009
Factor B (wedding method)	2	3.522^{NS}	47.036^{NS}	177.89*	209.291*
AB	6	0.368	16.169	2.033	1.137
Error	16	0.818*	41.446*	7.713*	8.249*

NS-non significant

* = Significant at 5% level of probability

Appendix VI. Analysis of variance of the data on total dry matter of mustard as influenced by nitrogen and weeding method

Source	Degrees of freedom	Mean square			
		Total dry matter			
		20 DAS	45 DAS	65 DAS	At harvest
Replication	2	0.001	0.001	0.067	0.09
Factor A (nitrogen)	3	0.01^{NS}	0.911^{NS}	5.45*	8.819*
Error	6	0.005	0.079	0.056	0.049
Factor B (wedding method)	2	0.008^{NS}	0.394^{NS}	0.28^{NS}	1.217*
AB	6	0.001	0.036	0.021	0.066
Error	16	0.005*	0.058*	0.014*	0.054*

NS-non significant
* = Significant at 5% level of probability

Appendix VII. Analysis of variance of the data on yield contributing character of mustard as influenced by nitrogen and weeding method

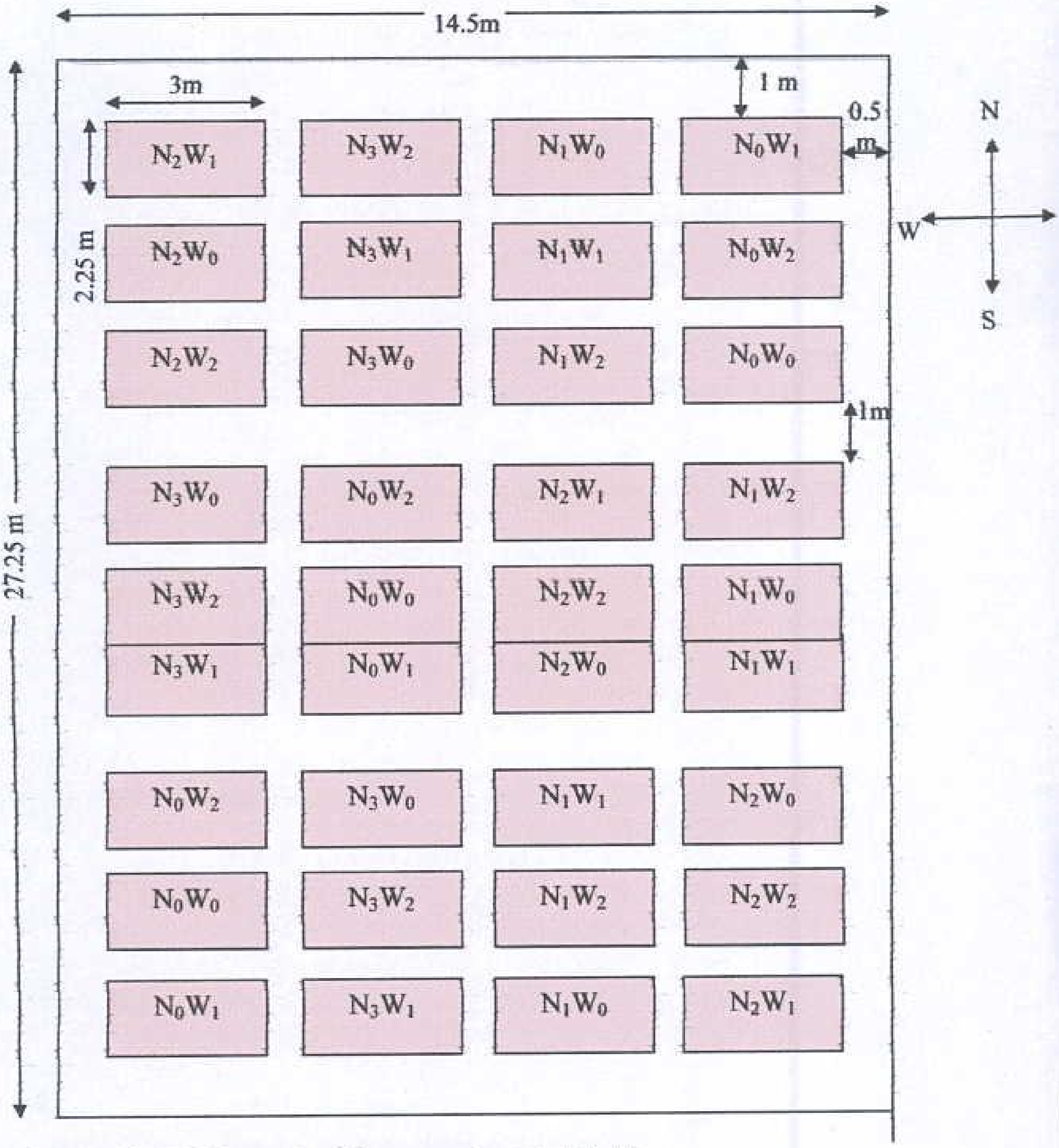
Source	Degrees of freedom	Mean square				
		Branches plant $^{-1}$	Siliquae plant $^{-1}$	Seeds siliqua^{-1}	Plants m $^{-2}$	1000-seed weight
Replication	2	0.498	7.071	11.202	152.591	0.786
Factor A (nitrogen)	3	6.725*	322.767*	133.504*	612.553*	0.464*
Error	6	0.106	1.861	2.291	10.831	0.122
Factor B (wedding method)	2	1.085*	44.281*	16.294*	161.911*	0.365*
AB	6	0.133	3.976	3.31	6.625	0.004
Error	16	0.167*	2.421*	3.407*	16.226*	0.171*

* = Significant at 5% level of probability

Appendix VIII. Analysis of variance of the data on yield and harvest index of mustard as influenced by nitrogen and weeding method

Source	Degrees of freedom	Mean square			
		Seed yield	stover yield	Biological yield	Harvest index
Replication	2	4013.898	14531.36	26967.93	29.219
Factor A (nitrogen)	3	897551.7*	56100.08*	1093131*	812.262*
Error	6	1259.444	26861.81	21906.82	66.246
Factor B (wedding method)	2	679758.4*	49046.09*	1051382*	303.323*
AB	6	27881*	3529.701*	38888.49*	6.546*
Error	16	1324.373	12203.37	12542.93	31.276

* = Significant at 5% level of probability



Appendix IX: Layout of the experimental field.

PLATES

PLATES

Plate 1: Field view of the experimental plot after germination stage

Plate 2: Field view of the experimental plot before flowering stage

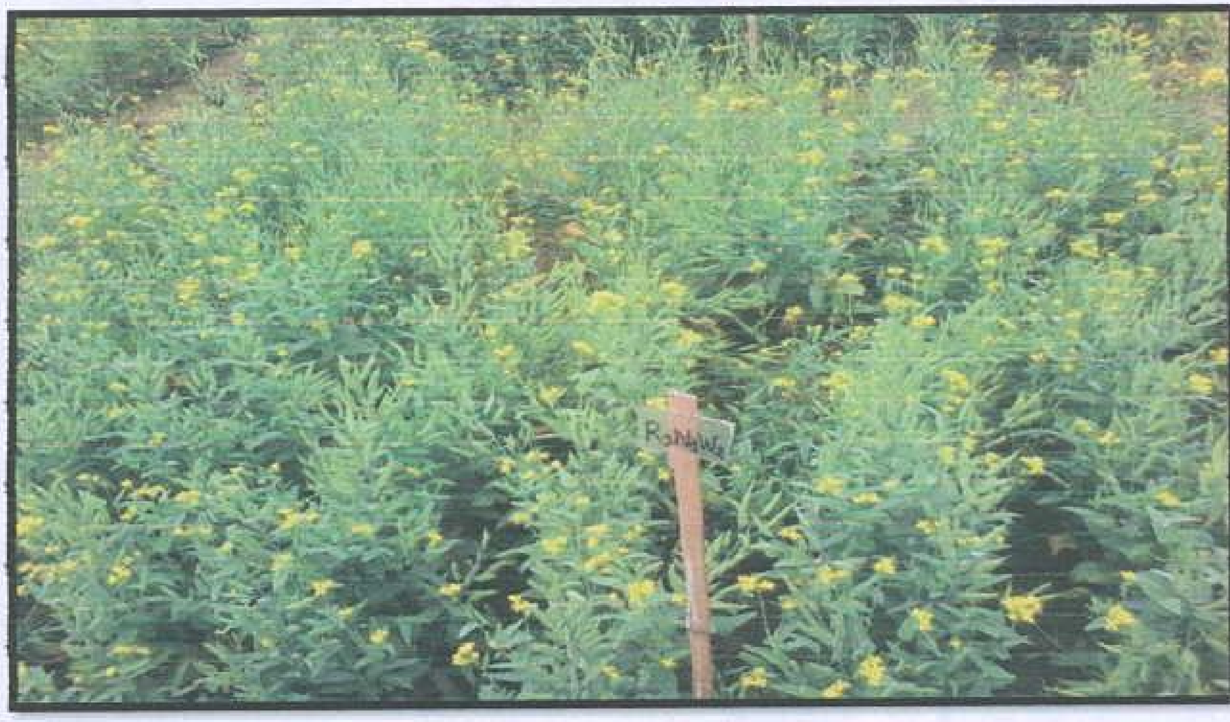


Plate 3: Field view of the experimental plot at flowering stage

Plate 4: Field view of the experimental plot at maturity stage