EFFECT OF SALICYLIC ACID AND VARIETIES ON INCIDENCE OF APHID AND YIELD OF MUSTARD

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Salicylic Acid and Varieties on Incidence of Aphid and Yield 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 Entomology, embodies the result of a piece of *bonafide* research work carried out by **Fatima Tuz Zohora Mony**, Registration number: **08-02741** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2015
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ABSTRACT

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2014 to March, 2015 to find out effect of salicylic acid and varieties on incidence of aphid and yield of mustard. The experiment comprised of two factors; Factors A: Levels of salicylic acid (3 levels)- S_0: 0 mM SA (control), S_1: 0.2 mM SA,S_2: 0.4 mM SA and Factor B: Mustard varieties (5 levels)- V_1: BARI Sarisha-1, V_2: BARI Sarisha-13, V_3: BARI Sarisha-14, V_4: BARI Sarisha-15 and V_5: BARI Sarisha-16. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. For salicylic acid, at early flowering stage, the lowest number of aphid (2.87) was observed from S_2 and the highest number (3.12) from S_0. At mid flowering stage, the lowest number of aphid (3.17) was observed from S_2 and the highest number (3.52) from S_0. At late flowering stage, the lowest number of aphid (3.52) was observed from S_2 and the highest number (3.93) from S_0. At flowering stage, the lowest infested plant (5.27%) was found from S_2, while the highest (7.87%) from S_0. The highest seed yield (1.85 t/ha) was recorded from S_2, whereas the lowest (1.44 t/ha) from S_0. Due to different mustard varieties at early flowering stage, the lowest number of aphid (2.67) was recorded from V_5, whereas the highest number (3.34) from V_1. At mid flowering stage, the lowest number of aphid (3.06) was recorded from V_5, whereas the highest number (3.52) from V_1. At late flowering stage, the lowest number of aphid (3.46) was recorded from V_5, whereas the highest number (4.00) from V_1. At flowering stage, the lowest infested plant (4.91%) was recorded from V_5, whereas the highest (8.49%) from V_1. In case of interaction effect, at early flowering stage the lowest number of aphid (2.27) was observed from the treatment combination of S_2V_5 and the highest number (3.67) from S_0V_1. At mid flowering stage, the lowest number of aphid (2.70) was observed from the treatment combination of S_2V_5 and the highest number (3.77) from S_0V_1. At late flowering stage, the lowest number of aphid (3.00) was observed from the treatment combination of S_2V_5 and the highest number (4.47) from S_0V_1. At flowering stage, the lowest infested plant (2.71%) was recorded from the treatment combination of S_2V_5, while the highest (10.14) from S_0V_1. The highest seed yield (2.46 t/ha) was found from the treatment combination of S_2V_5, while the lowest (1.04 t/ha) from S_0V_1. It was revealed that 0.4 mM SA and BARI Sarisha-16 was superior for controlling mustard aphid and also for obtaining higher yield and yield contributing characters of mustard.

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CHAPTER I

INTRODUCTION

Mustard (*Brassica campestris*) belongs to the genus *Brassica* of the family Cruciferae, is mainly a self-pollinating crop, although on an average 7.5 to 30% out-crossing does occur under natural field conditions (Abraham, 1994; Rakow and Woods, 1987). *Brassica napus, B. campestris* and *B. juncea* are the three species of mustard those produce edible oil. It is one of the most important oil crops of the world after soybean and groundnut (FAO, 2012). It is not only a high energy food but also a carrier of fat soluble vitamins like A, D, E and K in the body. Mustard oil meets the one third of edible oil requirement of the country (Ahmed, 2008). It is used as condiment, salad, green manure, fodder crop, and its leaf and stem are used as vegetable in the various mustard growing countries.

In Bangladesh, the total production of mustard was 0.525 million metric ton from 0.483 million hectare of land (AIS, 2013). Bangladesh has been facing acute shortage of edible oil for the last several decades and for that it needs to import oil and oilseeds to meet up the deficit. Our internal production can meet only about 21% of our consumption and the rest 79% is needed to import (Begum *et al.*, 2012). A huge amount of foreign exchange involving over 160 million US$ is being spent every year for importing edible oils due to insufficient oil production in Bangladesh (Rahman, 2002). Mustard is the principal oil crop in Bangladesh and other than edible oil mustard oil also serves as an important raw material for industrial use such as in soaps, paints, varnishes, hair oils, lubricants, textile auxiliaries, pharmaceuticals etc. Its oil is also used by the villagers for hair dressing and body massage before bath. Dry mustard straw is also used as fuel. Moreover, mustard oil cake is used as a feed for cattle and fish and as a good manure. In Bangladesh the major mustard growing districts are Comilla, Tangail, Jessore, Faridpur, Pabna, Rajshahi, Dinajpur, Kushtia, Kishoregonj, Rangpur and Dhaka (BBS, 2011).

Although mustard is an important crop but the cultivation of mustard has to compete with other grain crops and thus it has been shifted to marginal lands of poor productivity. With increasing population, the demand of edible oil is increasing day by day and it is, therefore, highly accepted that the production of edible oil should be increased considerably to fulfill the demand. The area under mustard is declining due to late harvesting of high yielding T. *aman* rice and increased cultivation of *boro* rice and on an average we are loosing an area of 104,000 hectare and production of 68,000 tons of mustard and rapeseed in last ten years (Anon., 2006). Mustard seed contains about 40-45% oil and for that by increasing production of mustard we can meet the shortage of edible oil. The average per hectare yield of mustard in our country is alarmingly very poor compared to those of advanced countries like Germany, France, UK and Canada which produce 6,667 kg ha^{-1}, 5,070 kg ha^{-1}, 3,264 kg ha^{-1}, 3,076 kg ha^{-1}, respectively. At present the world average yield of mustard is 1,586 kg ha^{-1} (FAO, 2013).

For increasing the production of mustard every effort is being paid by adopting modern agricultural practices such as use of high yielding varieties, optimum fertilizer application and assured irrigation in order to meet the growing demand of oils although up to date insect pest infestation is a serious problem. More than three dozen of pests are known to be associated with various phenological stages of mustard crops (Singh and Singh, 1983). Among them mustard aphid is the most serious and destructive pest and limiting factor for successfully cultivating of mustard in South Asia (Bakhetia, 1983; Zaman, 1990). The rate of reproduction varies from 5-9 young in a single day by a single female and the total numbers of young produced varies from 76-188 (Nair, 1986). Both the nymph and adult of the aphid suck sap from leaves, stems, inflorescences and pods, as a result the plant show stunted growth, withered flowers and malformed pods (Atwal and Dhaliwal, 1997; Begum 1995; Butane and Jotwani, 1984). The loss in grain weight due to these pests varies greatly within Brassicae; being 35.0-73.3% under different agro climatic regions with a mean loss of 54.2% (Reddy *et al*., 1990).

Salicylic acid ($C_7H_6O_3$) is an endogenous growth regulator of phenolic nature, which participates in the regulation of physiological processes in plant, such as stomatal closure, ion uptake, inhibition of ethylene biosynthesis, transpiration and stress tolerance (Shakirove *et al.*, 2003). Plant growth regulators (PGRs) are organic compounds, which play an essential role in many aspects of plant growth and development (Patil *et al.*, 1987; Dharmender *et al.*, 1996). PGRs can improve the physiological efficiency including photosynthetic ability and can enhance the effective partitioning of accumulates from source and sink in the field crops (Solaimani *et al.*, 2001). Salicylic acid plays a significant role in plant water relations (Barkosky and Einhelling, 1993), photosynthesis, growth and stomatal regulation under abiotic stress conditions and also created defense mechanism against insect pests (Khan *et al*., 2003; Arfan *et al*., 2007).

Variety plays an important role in producing high yield of mustard because different varieties perform differently for their genotypic characters, and aphid preferences of different mustard variety also vary from variety to variety. Improved variety is the first and foremost requirement for initiation and accelerated crop production program. There are some HYVs of mustard, which have been released by Sher-e-Bangla Agricultural University (SAU), Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA). The yield of mustard in Bangladesh has been increased obviously by using high yielding mustard varieties and improvement of management practices as well as application of plant growth regulators.

With conceiving the above scheme in mind, the present research work has been undertaken in order to fulfill the following objectives:

- To assess the infestation level of aphid in mustard due to the application of salicylic acid on different mustard varieties and their effects on the seed yield of mustard.
- To find out suitable levels of salicylic acid and variety on preference of aphid in mustard; and

CHAPTER II

REVIEW OF LITERATURE

Mustard is one of the important oil crop in Bangladesh and also in many countries of the world. There are many insect pests of mustard among them aphids is the most important one. Different variety have different preference of aphid and salicylic acid also plays a significant role in controlling mustard. But the research work in these aspects so far done in Bangladesh and elsewhere is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the preference of aphid on mustard so far been done at home and abroad have been reviewed in this chapter under the following headings:

2.1 Introduction of aphid

There are six species of aphids that damage crops. These species include *Rhopalosiphum padi, Schizaphis graminurn, Sitobion avenae, Metopoliphiurn dirhodum, R. Maidis* and *Diuraphis noxia.* Two of those species are commonly known as Russian Aphid (*Diuraphis noxia*) and Bird Cherry-Oat Aphid (*Rhopalosiphum padi*) which are considered notorious for their direct and indirect losses.

Aphid is known to be a sporadic insect causing significant yield losses by spreading out from its origin. The centre of origin for aphid is considered to be the central Asian mountains of Caucasus and Tian Shan. The species could now be found in South Africa, Western United States, Central and Southern Europe and Middle East. The economic impact of aphid includes direct and indirect losses that have been estimated to be $893 million in Western United States during 1987 to 1993 (Morrison and Peairs, 1998) whereas 37% yield losses in winter have been reported in Canadian Prairies. Direct losses have also been assessed as an increased input cost due to insecticides and indirect losses include reduced yield due to aphid infestation.

Climatic conditions and temperature in particular, play a significant role in population dynamics of the aphids. A warmer temperature can potentially accelerate the aphid's growth both in terms of number and size, yet, the extreme temperatures can possibly reduce the survival and spread of aphids. Aphid is known to be present in its three different morphological types: immature wingless females, mature wingless females and mature winged females. Winged mature females or adults spread the population and infection to the surrounding host plants whereas the wingless types or apterous cause damage by curling and sucking the young leaves. Heavily infested plants may typically look prostrated and/or stunted with yellow or whitish streaks on leaves. These streaks, basically, are formed due to the saliva injected by the aphid (Morrison and Peairs, 1998). The most obvious symptoms due to heavy infestations can cause reduced leaf area, loss in dry weight index, and poor cholorophyll concentration. Plant growth losses could be attributed mainly due to reduced photosynthetic activity to plants aphid infestation. The photochemical activities of the plants were reportedly inhibited by the aphid feeding from leaves and disruption in electron transport chain. Spikes can have bleached appearance with their awns tightly held in curled flag leaf. Yield losses can greatly vary due to infestation at different growth stages, duration of infestation and climatic conditions (wind patterns and temperature). A number of biotypes for aphid have been reported to be present throughout the cereal production areas of the world. These biotypes are classified due to significant genetic differences among them.

A number of strategies have been deployed to mitigate aphid infestation. Among these strategies, the host plant resistance has been the most effective and economic method to induce antixenosis, antibiosis and/or tolerance against aphid. Its host plant resistance is well known to be qualitative in nature, and about nine resistance genes have been documented so far. A number of alternate methods to control this pest has been suggested and practiced that include cultural, biological and chemical control methods. Cultural control strategies involving eradication of volunteer and alternate host plants are generally recommended. Another strategy

is grazing the volunteer plants which significantly reduce the aphid infestation (Walker and Peairs, 1998). Adjusting planting dates to de-synchronize the insect population dynamics and favourable environmental conditions of any particular area can also be helpful in controling aphid. The enhanced fertigation of infested field, and biological control of aphid is also possible with 29 different species of insects and 6 fungus species of the predator insects, 4 different species of wasps have become adopted to United States. Besides these cultural practices, chemical control method is also widely practiced with equivocal cost efficiency.

Life cycle

Most aphids reproduce sexually throughout most or all of the year with adult females giving birth to live offspring often as many as 12 per day without mating. Young aphids are called nymphs. They molt, shedding their skin about four times before becoming adults. There is no pupal stage. Some species produce sexual forms that mate and produce eggs in fall or winter, providing a more hardy stage to survive harsh weather and the absence of foliage on deciduous plants. In some cases, aphids lay these eggs on an alternative host, usually a perennial plant, for winter survival. When the weather is warm, many species of aphids can develop from newborn nymph to reproducing adult in seven to eight days. Because each adult aphid can produce up to 80 offspring in a matter of a week, aphid populations can increase with great speed (Flint, 1998).

Nature of damage

Low to moderate numbers of leaf-feeding aphids aren't usually damaging in gardens or on trees. However, large populations can turn leaves yellow and stunt shoots; aphids can also produce large quantities of a sticky exudates known as honeydew, which often turns black with the growth of a sooty mold fungus. Some aphid species inject a toxin into plants, which causes leaves to curl and further distorts growth. A few species cause gall formations (Cannon, 2008).

Squash, cucumber, pumpkin, melon, bean, potato, lettuce, beet, chard, and bok choy are crops that often have aphid-transmitted viruses associated with them.

The viruses mottle, yellow, or curl leaves and stunt plant growth. Although losses can be great, they are difficult to prevent by controlling aphids, because infection occurs even when aphid numbers are very low; it takes only a few minutes for the aphid to transmit the virus, while it takes a much longer time to kill the aphid with an insecticide.

2.2 Aphid population in *Brassica* species

Rana (2005) conducted a 2-year study on the preference and performance of *Lipaphis erysimi* on different *Brassica* species in the field and under greenhouse conditions revealed that rapeseed (*B. campestris* var. BSH-1, B. campestris var. YSPB-9) and mustard (*B. juncea* RH-30) were better hosts for this aphid than other *Brassica* species (*B. napus*, *B. nigra*, *Eruca sativa*, *B. carinata*). On the first group of plants, the rate of nymphal development, longevity and fecundity of this pest were significantly less than on the second group of plants. Development was significantly prolonged when the aphid was reared on second group of plants.

Experiment was conducted by Vekaria and Patel (2005) during rabi 1993-94 and 1994-95 revealed that the incidence of aphid commenced 6 weeks after sowing (WAS) i.e., the third week of December and reached the peak intensity (3.94 AI) at 14 WAS coinciding with the second week of February during 1993-94, however, during 1994-95 aphid incidence commenced late (8 WAS), i.e. during last week of December and reached the peak intensity (3.08 AI) 13 WAS coinciding with first week of February. The aphid population exceed fluctuated above economic threshold level (ETL) between 11 and 14 WAS coinciding with the third week of January to second week of February.

The incidence of mustard aphid (*Lipaphis erysimi*) in 8 *B. carinata* cultivars (C-3248-8, Peela Raya, Brown Raya, MMC-5, C-90-1063, UCD-593, C-90-1204 and C-90-1205) was studied by Rustamani *et al.* (2005) in Pakistan. The abundance of mustard aphid was evaluated when the plants were 2 weeks old; subsequent evaluation was conducted at weekly intervals. Aphid reproduction was also evaluated for 3 weeks. The aphid population, initially observed on the first week

of December (1.45 per plant, on average), peaked on the first week of February (198.75 per plant, on average) in all cultivars, then declined until the maturity of the crop. UCD-593 (25.41 per plant) and Peela Raya (24.78 per plant) showed the lowest aphid densities, whereas MMC-5 recorded the highest aphid density (85.93 per plant). Peela Raya and UCD-593 were resistant to the aphid; the other cultivars were susceptible. The number of progenies remained below 10 per cage in Peela Raya, UCD-593 and C-90-1204.

A field experiment was conducted by Verma *et al*. (2005) during the rabi seasons of 2001/02 and 2002/03 at Kanpur, Uttar Pradesh, India to screen 16 mustard cultivars (15 *B. juncea* and one *B. nigra*) for their resistance to the mustard aphid, *Lipaphis erysimi*. Aphid infestation index (AII, 0-5 scale) was calculated at full flowering and full pod formation stages. Banarsi Rai and Rohini were considered highly resistant to aphid infestation, with AII of 0.56-0.67 and 0.79-069 in 2001/02 and 2002/03, respectively. RK-819, Krishna, RK-9304, RGN-19, RK-9801, RK-90, Basanti, SBG-51, Urvashi and MLN-157 were moderately resistant, with AII of 2.1-2.95 in both years. Varuna, Vaibhav, Vardan and UPN-9 were susceptible, with AII of 3.8-3.3, 3.8-3.0, 3.4-3.0 and 3.3-3.0 in both years.

Devi *et al*. (2004) reported that a mosaic disease of leaf mustard (*Brassica juncea* var. rugosa) was found widespread in different locations of Manipur (up to 90.50%) and prevalent in the market samples from different sources (up to 89.58%). Disease incidence was low during October-November and high during February-March months. The causal virus was transmissible by sap (7.88%) and by three species of aphid (*Myzus persicae*, *Lipaphis erysimi* and *Brevicoryne brassicae*) but not through seeds.

Indian mustard seeds were sown on 8, 18 and 28 November, and 8 and 18 December in a field experiment conducted by Patel *et al*. (2004) in India during winter and reported that the critical period of mustard exposure to aphids was during the flowering stage of the crop. The aphid population increased in December.

Roy *et al*. (2004) conducted an experiment on aphid dynamics in mustard crop with reference to weather and phenological stages and reported that three *Brassica* cultivars, Agrani, Pusa Jaikisan and Varuna, were sown under 3 sowing dates, i.e. 1 October, 15 October and 1 November, in New Delhi, India, during the rabi seasons. The first crop season experienced relatively warmer temperature during seed filling and pod maturing stage compared to the second crop season. Early sowing resulted in early flowering, early pod development, longer seed filling period and maturity duration. Days taken to maturity were reduced with delayed sowing. Mustard aphid (*Lipaphis erysimi*) infestation started during either flowering or pod formation stage. Peak population of mustard aphid was mostly found during seed filling stage.

An experiment was conducted by Reza *et al*. (2004a) in Nadia, West Bengal, India, during the rabi season to investigate the effect of some abiotic factors on the population fluctuation of mustard aphid, *L. erysimi*. The population built up of mustard aphid was initiated in the 51st standard week during the end of December with initial intensity of 22.67/plant. The population increased up to 3rd standard week in January at the peak of 318.61. At the time of peak infestation, the maximum and minimum temperature was 27.37 and 14.62^0C, respectively. The maximum and minimum relative humidity was 95.28 and 62.28%, respectively. In the 4th and 5th standard weeks, a rainfall of 7.40 and 13.10 mm, respectively, decreased down the aphid population from 274.33 to 186.33/plant. None of the ecological parameters alone was responsible for rapid multiplication of the aphid.

Thirteen new strains of *B. juncea*, developed through intraspecific hybridization, were grown during rabi, at Pura, Jammu, India, and evaluated by Gupta and Bijral (2004) for their resistance to mustard aphid (*Lipaphis erysimi*). RSPR-69 recorded the highest seed yield of 16.33 q/ha, followed by RSPRO-13 (13.133 q/ha). However, RSPRO-13 recorded the lowest plant infestation and aphid population both at the flower initiation and full bloom stages.

A laboratory study was conducted by Mishra and Kanwat (2003) with 5 promising *Brassica* genotypes, i.e. *B. juncea* cultivars Varuna and Kranti, *B. campestris* cv. BSH-1, *B. napus* cv. R-15 and *B. carinata* cv. HC-2, indicated that mustard aphid, *L. erysimi*, passed through 4 nymphal instars. The total nymphal period varied from 8.19 (Kranti) to 9.65 (BSH-1) days. The pre-reproductive, reproductive and post-reproductive periods ranged from 1.25 (HC-2) to 1.53 (Kranti), 14.33 (Varuna) to 17.20 (R-15) and 2.40 (Varuna) to 2.64 (BSH-1) days, respectively. The adult longevity varied from 13.53 (Varuna) to 16.77 (R-15) days. The daily fecundity varied from 4.93 (Varuna) to 6.02 (R-15) nymphs per female per day.

An investigation was carried out by Keot *et al*. (2002) in Assam, India, to know the insect pest associated with the brassica vegetables and their seasonal incidence. As many as ten insect pests under four orders and six families were recorded infesting the brassica vegetables right from the seedling stage to the harvest of the crop. Four insects, cabbage butterfly (*Pieris canidia*), mustard aphid (*Lipaphis erysimi*), mustard sawfly (*Athalia lugens proxima*) and mustard flea beetle (*Phyllotreta cruciferae*) were found as major pests. Cutworm (*Agrotis ipsilon*), flea beetle (*Monolepta signata*), cabbage semilooper (*Plusia orichalcea* [*Thysanoplusia orichalcea*]), leaf eating caterpillar (*Spodoptera litura*) were found as minor pests.

2.3 Yield attributes and yields of mustard due to salicylic acid and variety

2.3.1 Effect of salicylic acid on mustard

2.3.1.1 Plant height

Field studies were conducted by Sharma *et al*. (2013) on an assembly of 25 Indian mustard genotypes to test the efficacy of salicylic acid (SA) on yield attributes, seed filling and seed yield and further to visualize the extent of genotypic variations in mitigating the yield losses with SA due to terminal heat stress under late sown conditions and revealed that foliar application of SA improved growth parameters.

2.3.1.2 Number of siliquae plant^{-1}

Field studies were conducted by Sharma *et al*. (2013) on an assembly of 25 Indian mustard genotypes to test the efficacy of salicylic acid (SA) on yield attributes, seed filling and seed yield and further to visualize the extent of genotypic variations in mitigating the yield losses with SA due to terminal heat stress under late sown conditions and revealed that foliar application of SA improved yield attributes particularly number of siliqua on main shoot.

2.3.1.3 Thousand seed weight

Field studies were conducted by Sharma *et al*. (2013) on an assembly of 25 Indian mustard genotypes to test the efficacy of salicylic acid (SA) on yield attributes, seed filling and seed yield and further to visualize the extent of genotypic variations in mitigating the yield losses with SA due to terminal heat stress under late sown conditions and revealed that foliar application of SA improved yield attributes and SA spray increased 1000 seed weight in NRCDR-2, Varuna and RH-10 than the other genotypes.

2.3.1.4 Grain yield

A field experiment was conducted by Muhal and Solanki (2015) at Udaipur to evaluate the effect of seeding dates and salicylic acid (SA) application on growth attributes, phenology and agro-meteorological indices of *Brassica* species and recorded that 100 ppm SA foliar spray registered significantly higher seed yield basis compared to water spray.

Field studies were conducted by Sharma *et al*. (2013) on an assembly of 25 Indian mustard genotypes to test the efficacy of salicylic acid (SA) on yield attributes, seed filling and seed yield and further to visualize the extent of genotypic variations in mitigating the yield losses with SA due to terminal heat stress under late sown conditions and revealed that RB-10 and NPJ-93 followed by CS-1900-2 registered higher seed yield with SA during the two years of study.

2.3.2 Effect of different varieties on mustard

2.3.2.1 Plant height

Hakim *et al*. (2014) evaluated two varieties (Early Mustard and S-9) were against six Zn levels and reported that S-9 ranked 1st with 216.50 cm plant height, while variety Early Mustard resulted in 186.56 cm plant height.

Mamun *et al*. (2014) evaluated the effect of variety and different plant densities on growth and yield of rapeseed mustard under rainfed conditions at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Four varieties (BARI Sarisha-13, BARI Sarisha-15, BARI Sarisha-16 and SAU Sarisha-3) and four plant densities were applied during the course of study and reported that BARI Sarisha-13 performed well in terms of plant height.

Laxminarayana and Pooranchand (2000) conducted an experiment during the rabi seasons at Madhira to determine the most suitable mustard (*Brassica juncea*) cultivar and found no significant variations in plant height among the cultivars.

Ahmed *et al.* (1999) stated that the tallest plant (102.56 cm) was recorded in the variety Daulat. No significant difference was observed in plant height of Dhali and Nap-8509. Jahan and Zakaria (1997) reported that Dhali was the tallest plant (142.5 cm) which was at par with Sonali (139.5) and Japrai (138.6 cm). The shortest plant was observed in Tori-7 (90.97 cm) which was significantly shorter than other varieties. The exotic varieties were of intermediate types of plants.

Hussain *et al.* (1996) observed the highest plant height in Narendra (175 cm) which was identical with AGA-95-21 (166 cm) and Hyola-51 (165 cm). The shortest variety was Tori-7.

Mondal *et al.* (1992) found that variety had significant effect on plant height. They found the highest plant height (134.4 cm) in the variety J-5004, which was identical with SS-75 and significantly taller than JS-72 and Tori-7.

Ali *et al.* (1986**)** observed significant variation in plant height in different varieties of mustard and rape.

2.3.2.2 Number of siliqua plant^{-1}

Mamun *et al*. (2014) evaluated the effect of variety and different plant densities on growth and yield of rapeseed mustard under rainfed conditions at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Four varieties (BARI Sarisha-13, BARI Sarisha-15, BARI Sarisha-16 and SAU Sarisha-3) and four plant densities were applied during the course of study and reported that BARI Sarisha-13 performed well in terms of siliqua plant^{-1} (126.90).

Hakim *et al*. (2014) evaluated two varieties (Early Mustard and S-9) were against six Zn levels and reported that S-9 ranked 1st with 581.11 pods plant^{-1}, while variety Early Mustard resulted 484.67 pods plant^{-1}.

Pooran *et al.* (2000) found the highest number of siliqua plant^{-1} (180) in GM-1. Jahan and Zakaria (1997) reported that in case of number of siliqua plant^{-1}, the highest number was recorded in BLN-900 (130-9) which was identical to Dhali (126.3). Tori-7 had the lowest (46.3) number of siliqua plane.

Hussain *et al.* (1996) observed the highest number of siliqua plant^{-1} (187.3) in BLN-900 and the lowest (150.4) in Semu 249/84.

Mondal *et al.* (1992) obtained maximum number of siliquas plant^{-1} (136) in the variety J-5004, which was identical with the variety Tori-7. The lowest number of siliqua plant^{-1} (45-9) was found in the variety SS-75.

2.3.2.3 Siliqua length

Hussain *et al*. (2008) conducted an experiment to show the effect of boron application on yield and yield attributes of different mustard varieties. The experiment involved five boron levels and three mustard varieties viz. BARI sharisha-8, BARI sharisha-9 and BARI sharisha-11. BARI sharisha-11 and BARI sharisha-8 performed better in terms of siliqua length.

BARI (1999) reported that varieties had significant variation in of siliqua length. The highest siliqua length was found in Daulat and lowest in Dhali.

Hussain *et al.* (1996) observed the longest siliqua (8.07 cm) in BLN-900 and the shortest (4.83 cm) in Hyola-401.

2.3.2.4 1000 seed weight

Mamun *et al*. (2014) evaluated the effect of variety and different plant densities on growth and yield of rapeseed mustard under rainfed conditions at Sher-e Bangla Agricultural University, Dhaka, Bangladesh. Four varieties (BARI Sarisha-13, BARI Sarisha-15, BARI Sarisha-16 and SAU Sarisha-3) and four plant densities were applied during the course of study and reported that BARI Sarisha-13 performed well in terms of 1000 seed weight (4.00) considering the other variety.

Mondal and Wahab (2001) observed that thousand seed weight ranged 2.5- 2.65 g in improved Tori-7 *(B. campestris)* and 1.5-7.8 g in *Rai (B. juncea).* BARI (2001) concluded that there was significant variation in 1000-seed weight of mustard found in different varieties and highest weigh of 1000-seed was found in Jamalpur-1 variety and lowest in BARI Sarisha-10.

Karim *et al.* (2000) stated that varieties showed significant influence in weight of thousand seeds. They found higher weight of 1000-seed in J-3023 (3.43 g) J-3018 (3.42 g) and J-4008 (3.50 g).

Hussain *et al.* (1998) observed significant variation in case of 1000-seed weight as influenced by different varieties. They found Hyda-401 had the highest 1000-seed weight (3.4 g) and the lowest 1000-seed weight was recorded in Tori-7 (2.1 g) among the mustard variety. Jahan and Zakaria (1997) found variation in 1000-seed weight and the highest weight was in the variety BCN-900 (3.37 g) and the lowest in Tori-7 (2.27 g).

2.3.2.5 Seed and stover yield

Hakim *et al*. (2014) evaluated two varieties (Early Mustard and S-9) were against six Zn levels and reported that S-9 ranked 1st with 1960.30 seed yield kg ha^{-1}, while variety Early Mustard resulted 1677.90 seed yield kg ha^{-1}.

Mamun *et al*. (2014) evaluated the effect of four varieties (BARI Sarisha-13, BARI Sarisha-15, BARI Sarisha-16 and SAU Sarisha-3) and four plant densities were applied during the course of study and reported that maximum seed yield (1.60 t ha^{-1}) was recorded for BARI Sarisha-13.

Afroz *et al*. (2011) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh with two varieties viz. BARI Sarisha-9 and BARI Sarisha-6; three sowing date and three seed rates and higher seed yield was obtained by the variety BARI Sarisha-9.

Rahman (2002) stated that yield variation existed among varieties and the highest seed yield was observed in BARI Sarisha-7, BARI Sarisha-8 and BARI Sarisha11 (2.00-2.50 t ha^{-1}) and lowest yield in variety Tori-7 (0.95-1.10 t ha^{-1}).

BARI (2001) showed that seed yield and other yield contributing characters significantly varied among the varieties.

BARI (2000) reported that in case of poor management Isd-local gave the highest straw yield (3779 kg ha^{-1}) and lowest yield (1295 kg ha^{-1}) was found from Nap-248. In case of medium management, highest weight (6223.3 kg ha^{-1}) was recorded from the same variety and lowest (3702.3 kg ha^{-1}) from PT-303 under high management practices. The highest straw yield, 6400 kg was obtained from the variety Rai-5 and lowest 4413.3 kg ha^{-1} was obtained from variety Tori-7.

Pooran *et al.* (2000) studied 6 cultivars of mustard and observed that among the mustard cultivars, GM-1 gave the highest seed yield (1050 kg ha^{-1}), followed by Kranti and Pusa Bold (790 and 760 kg ha^{-1}, respectively) and Varuna and Sita produced comparable yields (680 and 610 kg ha^{-1}, respectively).

Jahan and Zakaria (1997) stated that yield variation is present in different varieties. They found highest yield in the exotic variety BLN-400 (2013 kg ha^{-1}) and the lowest seed yield was in AGA-95-21 (819 kg ha^{-1}).

Bukhtiar *et al.* (1992) showed that *Brassica carinata* yielded best (1578 kg ha^{-1}) followed by RL18 (1092 kg ha^{-1}) and DGL (828 kg ha^{-1}). The poorest yield (683 kg ha^{-1}) was given by Taranira *(Eruca sativa).*

Chakraborty *et al.* (1991) stated that seed yields are different from species to species. Chaudhury *et al.* (1988) in an experiment on irrigation with four cultivars of *B. juncea* obtained the highest yield from cv. RH-7513 without irrigation and from cv. Varuna with irrigation.

As per the above cited reviews, it may be concluded that application of salicylic acid and variety are the important factors for attaining optimum growth as well as highest yield of mustard. The literature revealed that the effects of salicylic acid and variety have not been studied well and have no definite conclusion for the preference of aphid in mustard plant grown under different agro climatic conditions of Bangladesh.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out the effect of salicylic acid and varieties on incidence of aphid and yield of mustard. The materials and methods those were used for conducting the experiment have been presented in this chapter. It includes a short description of the location of experimental site, soil and climatic condition of the experimental area, materials used for the experiment, design of the experiment, data collection and data analysis procedure.

3.1 Description of the experimental site

3.1.1 Experimental period

The field experiment was conducted during the period from November, 2014 to March, 2015.

3.1.2 Location of site

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74^/$N latitude and $88^0 35^/$E longitude with an elevation of 8.2 meter from sea level.

3.1.3 Climatic condition

The climate of experimental site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix I. During the experimental period the maximum temperature (27.1^0C) was recorded from February, 2015 and the minimum temperature (12.4^0C) from January, 2015, highest relative humidity (78%) was observed from November, 2014, whereas the lowest relative humidity (67%) and highest rainfall (30 mm) was recorded in February, 2015.

3.1.4 Characteristics of soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28) and the general soil type is Shallow Red Brown Terrace soil. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of silty clay with pH and organic matter 6.1 and 1.13, respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay, which have been presented in Appendix II.

3.2 Experimental details

3.2.1 Treatment of the experiment

The experiment comprised of two factors.

Factors A: Levels of salicylic acid (3 levels)

i) S_0: 0 mM SA (control)

ii) S_1: 0.2 mM SA

iii) S_2: 0.4 mM SA

Factor B: Mustard varieties (5 mustard varieties)

i) V_1: BARI Sarisha-1

ii) V_2: BARI Sarisha-13

iii) V_3: BARI Sarisha-14

iv) V_4: BARI Sarisha-15

v) V_5: BARI Sarisha-16

There were in total 15 (3×5) treatment combinations such as S_0V_1, S_0V_2, S_0V_3, S_0V_4, S_0V_5, S_1V_1, S_1V_2, S_1V_3, S_1V_4, S_1V_5, S_2V_1, S_2V_2, S_2V_3, S_2V_4 and S_2V_5.

3.2.2 Experimental design and layout

The two factor experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experiment area was divided into three equal blocks. Each block contained 15 plots where 15 treatments combination were allotted at random. There were 45 unit plot altogether in the experiment. The size of each plot was 2.0 m × 1.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively. The layout of the experiment is shown in Figure 1.

3.3 Growing of crops

3.3.1 Seed collection

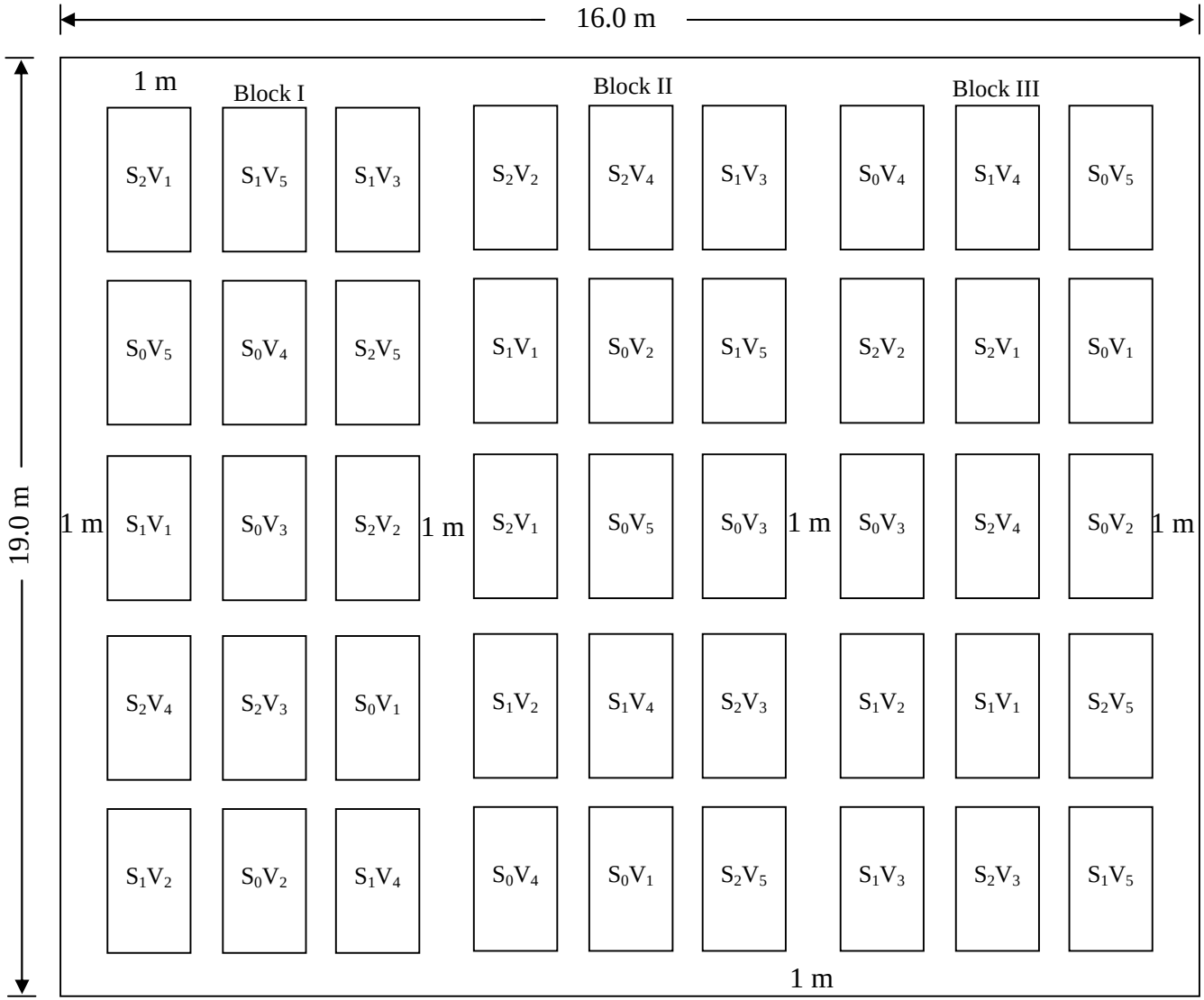
BARI Sarisha-1, BARI Sarisha-13, BARI Sarisha-14, BARI Sarisha-15 and BARI Sarisha-16, were used as plating materials in this experiment. All of the high yielding varieties of mustard developed by Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. The seeds were collected from the BARI, Joydebpur, Gazipur.

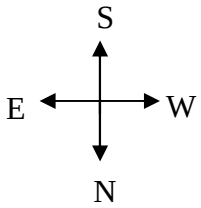
3.3.2 Land preparation

The experimental plot was opened on 14 November, 2014, with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed for three times followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil. Finally land was prepared on 26 November, 2014.

3.3.3 Application of manure and fertilizers

The total amount of urea, triple super phosphate, muriate of potash and borax at the rate of 230, 140, 50 and 10 kg ha^{-1}, respectively were applied at the time of final land preparation except urea. Urea was applied in three equal splits. First dose of urea fertilizer was applied at the time of final land preparation, second and third dose of urea fertilizer were applied at 20 and 45 days after sowing (DAS) respectively.





Plot size = 2.0 m × 1.0 m

Plot spacing = 0.5 m

Between replication= 1.0 m

Factors A: Levels of salicylic acid (3 levels)

i) S_0: 0 mM SA (control)

ii) S_1: 0.2 mM SA

iii) S_2: 0.4 mM SA

Factor B: Mustard varieties (5 mustard varieties)

i) V_1: BARI Sarisha-1

ii) V_2: BARI Sarisha-13

iii) V_3: BARI Sarisha-14

iv) V_4: BARI Sarisha-15

v) V_5: BARI Sarisha-16

Figure 1. Layout of the experimental plot

3.3.4 Seed sowing

The seeds of mustard were sown on 26 November, 2014 in rows in the furrows having a depth of 2-3 cm.

3.3.5 Intercultural operations

3.3.5.1 Thinning

Seeds started of germination four Days After Sowing (DAS). Thinning was done two times; first thinning was done at 8 DAS and second was done at 15 DAS to maintain optimum plant population in each plot as per the treatment of plant density.

3.3.5.2 Irrigation and weeding

Irrigation was provided for three times after seed sowing, 20 days before flowering and 50 days after sowing for pod development for all experimental plots equally. The crop field was weeded before providing irrigation.

3.4 Crop sampling and data collection

Five plants from each treatment and each replication were randomly selected and marked with sample card for data collection.

3.5 Monitoring and data collection

The mustard plants of different treatments were closely examined at regular intervals commencing from sowing to harvest. The following data were collected during the course of the study-

- Number of aphid at flowering and fruiting stages
- Number of healthy plants at flowering and fruiting stages
- Number of infested plants at flowering and fruiting stages
- Plant height at harvest
- Number of siliqua per plant
- Length of siliqua

- Weight of 1000 seeds
- Seed yield per hectare
- Stover yield hectare

3.5.1 Counting of aphid

The mustard plants were closely examined at regular intervals at flowering and fruiting stage. Aphid from 10 plants were recorded at early, mid and late flowering and fruiting stage and converted per plant. The insect population was collected by a needle brush in a Petri dish.

3.5.2 Determination of plant infestation

All the healthy and infested plants were counted from 1 m^2 selected area from middle place of each plot and examined. The collected data were divided into flowering and fruiting stage. The healthy and infested plants were counted and the percent plant damage was calculated using the following formula:

$$\text{Plant infestation (\%)} = \frac{\text{Number of infested plants}}{\text{Total number of plants}} \times 100$$

3.6 Harvest and post harvest operations

Harvesting was done when 90% of the siliqua became brown in color which was estimated by eye observation**.** The matured pods were collected by hand picking from each plot.

3.7 Procedure of data collection

3.7.1 Plant height

The plant height was measured at harvest with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

Photo 1. Healthy flowers and fruits of mustard.

Photo 2. Infested flowers and fruits of mustard.

3.7.2 Number of siliqua plant^{-1}

Numbers of total siliqua of selected plants from each plot were counted and the mean numbers were expressed as plant^{-1} basis. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.7.3 Length of siliqua

Length of siliqua was taken from randomly selected ten siliqua and the mean length was expressed on siliqua^{-1} basis.

3.7.4 Weight of 1000 seeds

One thousand cleaned, dried seeds of mustard were counted from each harvest sample and weighed by using a digital electronic balance and weight was expressed in gram (g).

3.7.5 Seed yield

The seeds collected from 1 square meter of each plot were sun dried properly. The weight of seeds was taken and converted into yield in t/ha.

3.7.6 Stover yield

The stover collected from 1 square meter of each plot was sun dried properly. The weight of stover was taken and converted into yield in t/ha.

3.8 Statistical analyses

The data obtained for different parameters were statistically analyzed to find out the effect of salicylic acid and variety on preference of aphid in mustard. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the ‘F’ (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of salicylic acid and varieties on incidence of aphid and yield of mustard. Data were recorded on aphid infestation at flowering and fruiting stage, plant infestation at flowering and fruiting stage, yield contributing characters and yield of mustard. The analysis of variance (ANOVA) of the data is given in Appendix III-VII. The results have been presented and possible interpretations are given under the following headings:

4.1 Abundance of aphid

4.1.1 At early flowering stage

Different levels of salicylic acid showed statistically significant differences in terms of number of aphid per plant at early flowering stage (Figure 2). The lowest number of aphid (2.87) was observed from S_2 (0.4 mM SA) which was statistically similar (2.93) to S_1 (0.2 mM SA) and the highest number of aphid (3.12) was found from S_0 (0 mM SA i.e. control condition).

Number of aphid per plant at early flowering stage varied significantly due to different mustard variety (Figure 3). The lowest number of aphid (2.67) was recorded from V_5 (BARI Sarisha-16) which was statistically similar (2.70) to V_2 (BARI Sarisha-13) and closely followed (2.96) by V_3 (BARI Sarisha-14), whereas the highest number of aphid (3.34) was observed from V_1 (BARI Sarisha-1) which was statistically similar (3.19) to V_4 (BARI Sarisha-15).

Statistically significant variation was recorded due to the interaction effect of different levels of salicylic acid and mustard variety in terms of number of aphid per plant at early flowering stage (Table 1). The lowest number of aphid (2.27) was observed from the treatment combination of S_2V_5 (0.4 mM SA and BARI Sarisha-16) and the highest number of aphid (3.67) from the treatment combination of S_0V_1 (0 mM SA i.e. control condition and BARI Sarisha-1).

Table 1. Interaction effect of salicylic acid and variety on number of aphid at flowering stage of mustard

Treatment	Number of aphid at flowering stage of		
	Early	**Mid**	**Late**
S_0V_1	3.67 a	3.77 a	4.47 a
S_0V_2	3.17 bcd	3.63 abc	4.37 a
S_0V_3	2.97 cd	3.67 ab	4.00 abc
S_0V_4	2.93 d	3.20 b-e	3.07 e
S_0V_5	2.87 d	3.33 a-e	3.77 bcd
S_1V_1	2.90 d	3.53 a-d	3.83 bcd
S_1V_2	2.70 d	3.10 d-f	3.37 de
S_1V_3	2.97cd	3.17 b-f	3.40 de
S_1V_4	3.20 a-d	3.30 a-e	3.70 bcd
S_1V_5	2.87 d	3.13 c-f	3.60 cd
S_2V_1	3.47 ab	3.27 b-e	3.70 bcd
S_2V_2	2.23 e	3.00 ef	3.07 e
S_2V_3	2.93 d	3.30 a-e	3.67 bcd
S_2V_4	3.43 abc	3.60 a-d	4.17 ab
S_2V_5	2.27 e	2.70 f	3.00 e
$LSD_{(0.05)}$	**0.433**	**0.430**	**0.458**
Significance level	**0.01**	**0.05**	**0.01**
CV(%)	**8.71**	**7.73**	**7.47**

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

S_0: 0 mM SA (control)
S_1: 0.2 mM SA
S_2: 0.4 mM SA

V_1: BARI Sarisha-1
V_2: BARI Sarisha-13
V_3: BARI Sarisha-14
V_4: BARI Sarisha-15
V_5: BARI Sarisha-16

4.1.2 At mid flowering stage

Different levels of salicylic acid showed statistically significant differences in terms of number of aphid per plant at mid flowering stage (Figure 2). The lowest number of aphid (3.17) was observed from S_2 which was statistically similar (3.25) to S_1 and the highest number of aphid (3.52) was found from S_0.

Number of aphid per plant at mid flowering stage varied significantly due to different mustard variety (Figure 3). The lowest number of aphid (3.06) was recorded from V_5 which was statistically similar (3.24) to V_2, whereas the highest number of aphid (3.52) was observed from V_1 which was statistically similar (3.37 and 3.38) to V_4 and V_3, respectively.

Statistically significant variation was recorded due to the interaction effect of different levels of salicylic acid and mustard variety in terms of number of aphid per plant at mid flowering stage (Table 1). The lowest number of aphid (2.70) was observed from the treatment combination of S_2V_5 and the highest number of aphid (3.77) was recorded from the treatment combination of S_0V_1.

4.1.3 At late flowering stage

Different levels of salicylic acid showed statistically significant differences in terms of number of aphid per plant at late flowering stage (Figure 2). The lowest number of aphid (3.52) was observed from S_2 which was statistically similar (3.58) to S_1 and the highest number of aphid (3.93) was found from S_0.

Number of aphid per plant at late flowering stage varied significantly due to different mustard variety (Figure 3). The lowest number of aphid (3.46) was recorded from V_5 which was statistically similar with other variety expect V_1, whereas the highest number of aphid (4.00) was observed from V_1.

Statistically significant variation was recorded due to the interaction effect of different levels of salicylic acid and mustard variety in terms of number of aphid per plant at late flowering stage (Table 1). The lowest number of aphid (3.00) was observed from the treatment combination of S_2V_5 and the highest number of aphid (4.47) was recorded from the treatment combination of S_0V_1.

4.1.4 At early fruiting stage

Different levels of salicylic acid showed statistically significant differences in terms of number of aphid per plant at early fruiting stage (Figure 4). The lowest number of aphid (4.05) was observed from S_2 which was statistically similar (4.20) to S_1 and the highest number of aphid (4.51) was found from S_0.

Number of aphid per plant at early fruiting stage varied significantly due to different mustard variety (Figure 5). The lowest number of aphid (4.01) was recorded from V_5 which was statistically similar (4.09 and 4.28) to V_2 and V_4, whereas the highest number of aphid (4.55) was observed from V_1 which was statistically similar (4.33) to V_3.

Statistically significant variation was recorded due to the interaction effect of different levels of salicylic acid and mustard variety in terms of number of aphid per plant at early fruiting stage (Table 2). The lowest number of aphid (3.30) was observed from the treatment combination of S_2V_5 and the highest number of aphid (4.83) from the treatment combination of S_0V_1.

4.1.5 At mid fruiting stage

Different levels of salicylic acid showed statistically significant differences in terms of number of aphid per plant at mid fruiting stage (Figure 4). The lowest number of aphid (3.51) was observed from S_2 which was statistically similar (3.57) to S_1 and the highest number of aphid (3.77) was found from S_0.

Number of aphid per plant at mid fruiting stage varied significantly due to different mustard variety (Figure 5). The lowest number of aphid (3.30) was recorded from V_5, while the highest number of aphid (3.96) was observed from V_1 which was followed by the other variety except V_5.

Statistically significant variation was recorded due to the interaction effect of different levels of salicylic acid and mustard variety in terms of number of aphid per plant at mid fruiting stage (Table 2). The lowest number of aphid (2.90) was observed from the treatment combination of S_2V_5 and the highest number of aphid (4.27) was recorded from the treatment combination of S_0V_1.

Table 2. Effect of salicylic acid and variety on number of aphid at fruiting stage of mustard

Treatment	Number of aphid at fruiting stage of		
	Early	**Mid**	**Late**
S_0V_1	4.83 a	4.27 a	3.07 a
S_0V_2	4.77 ab	3.90 bc	2.37 bc
S_0V_3	4.67 ab	3.80 bcd	2.43 b
S_0V_4	3.87 de	3.27 f	2.37 bc
S_0V_5	4.40 abc	3.60 c-f	2.17 bc
S_1V_1	4.57 ab	3.87 bc	2.80 a
S_1V_2	3.77 e	3.43 ef	2.10 bc
S_1V_3	4.03 cde	3.47 def	2.37 bc
S_1V_4	4.30 bcd	3.67 cde	2.33 bc
S_1V_5	4.33 a-d	3.40 ef	2.10 bc
S_2V_1	4.27 bcd	3.73 b-e	2.40 bc
S_2V_2	3.73 ef	3.27 f	2.10 bc
S_2V_3	4.30 bcd	3.60 c-f	2.30 bc
S_2V_4	4.67 ab	4.07 ab	2.30 bc
S_2V_5	3.30 f	2.90 g	2.03 c
$LSD_{(0.05)}$	**0.443**	**0.308**	**0.313**
Significance level	**0.01**	**0.01**	**0.05**
CV(%)	**6.22**	**5.11**	**7.95**

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

S_0: 0 mM SA (control)
S_1: 0.2 mM SA
S_2: 0.4 mM SA

V_1: BARI Sarisha-1
V_2: BARI Sarisha-13
V_3: BARI Sarisha-14
V_4: BARI Sarisha-15
V_5: BARI Sarisha-16

4.1.6 At late fruiting stage

Different levels of salicylic acid showed statistically significant differences in terms of number of aphid per plant at late fruiting stage (Figure 4). The lowest number of aphid (2.23) was observed from S_2 which was statistically similar (2.34) to S_1 and the highest number of aphid (2.48) was found from S_0.

Number of aphid per plant at late fruiting stage varied significantly due to different mustard variety (Figure 5). The lowest number of aphid (2.10) was recorded from V_5 which was statistically similar (2.19) to V_2, whereas the highest number of aphid (2.76) was observed from V_1 which was statistically similar (2.33 and 2.37) to V_4 and V_3, respectively.

Statistically significant variation was recorded due to the interaction effect of different levels of salicylic acid and mustard variety in terms of number of aphid per plant at late fruiting stage (Table 2). The lowest number of aphid (2.03) was observed from the treatment combination of S_2V_5 and the highest number of aphid (3.07) was recorded from the treatment combination of S_0V_1.

4.2 Healthy and infested plants and infestation status

4.2.1 Healthy plants at flowering stage

Statistically significant variation was recorded in terms of healthy plants per m^2 area at flowering stage due to different levels of salicylic acid (Table 3). The highest number of healthy plants ($31.07/m^2$) was found from S_2 which was closely followed ($26.53/m^2$) by S_1, while the lowest number ($24.53/m^2$) was recorded from S_0.

Different mustard variety showed statistically significant differences in terms of number of healthy plants per m^2 area at flowering stage (Table 3). The highest number of healthy plants ($31.44/m^2$) was recorded from V_5 which was statistically similar ($30.11/m^2$) to V_2, whereas the lowest number of healthy plants ($23.11/m^2$) was found from V_1 which was closely followed ($25.89/m^2$ and $26.33/m^2$) by V_3 and V_4 and they were statistically similar.

Table 3. Effect of salicylic acid and variety on health, aphid infested plant and plant infestation at flowering stage of mustard

Treatment	At flowering stage		
	Healthy plant (No.)	Infested plant (No.)	Infestation (%)
Levels of salicylic acid			
S_0	24.53 c	2.07 a	7.87 a
S_1	26.53 b	1.87 ab	6.73 b
S_2	31.07 a	1.67 b	5.27 c
$LSD_{(0.05)}$	**1.180**	**0.224**	**0.802**
Significance level	**0.01**	**0.01**	**0.01**
Different mustard variety			
V_1	23.11 c	2.11 a	8.49 a
V_2	30.11 a	1.67 b	5.36 c
V_3	25.89 b	2.00 a	7.21 b
V_4	26.33 b	2.00 a	7.14 b
V_5	31.44 a	1.56 b	4.91 c
$LSD_{(0.05)}$	**1.523**	**0.290**	**1.035**
Significance level	**0.01**	**0.01**	**0.01**
CV(%)	**5.76**	**16.11**	**16.19**

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

S_0: 0 mM SA (control)
S_1: 0.2 mM SA
S_2: 0.4 mM SA

V_1: BARI Sarisha-1
V_2: BARI Sarisha-13
V_3: BARI Sarisha-14
V_4: BARI Sarisha-15
V_5: BARI Sarisha-16

Interaction effect of levels of salicylic acid and different mustard variety showed statistically significant variation in terms of number of healthy plants m^2 area at flowering stage (Table 4). The highest number of healthy plants (36.00/m^2) was recorded from the treatment combination of S_2V_5, while the lowest number (20.67/m^2) was observed from the treatment combination of S_0V_1.

4.2.2 Infested plants at flowering stage

Statistically significant variation was recorded in terms of infested plants per m^2 area at flowering stage due to different levels of salicylic acid (Table 3). The lowest number of infested plants (1.67/m^2) was found from S_2 which was statistically similar (1.87/m^2) to S_1, while the highest number (2.07/m^2) was recorded from S_0.

Different mustard variety showed statistically significant differences in terms of number of infested plants per m^2 area at flowering stage (Table 3). The lowest number of infested plants (1.56/m^2) was recorded from V_5 which was statistically similar (1.67/m^2) to V_2, whereas the highest number of infested plants (2.11/m^2) was found from V_1 which was statistically similar (2.00/m^2) to V_3 and V_4.

Interaction effect of levels of salicylic acid and different mustard variety showed statistically significant variation in terms of number of infested plants m^2 area at flowering stage (Table 4). The lowest number of infested plants (1.00/m^2) was recorded from the treatment combination of S_2V_5, while the lowest number (2.33/m^2) was observed from the treatment combination of S_0V_1.

4.2.3 Plant infestation at flowering stage

Statistically significant variation was recorded in terms of plant infestation at flowering stage due to different levels of salicylic acid (Table 3). The lowest infested plant (5.27%) was found from S_2 which was closely followed (6.73%) by S_1, while the highest infested plant (7.87%) was recorded from S_0.

Table 4. Interaction effect of salicylic acid and variety on health, aphid infested plant and plant infestation at flowering stage of mustard

Treatment	At flowering stage		
	Healthy plant (No.)	Infested plant (No.)	Infestation (%)
S_0V_1	20.67 i	2.33 a	10.14 a
S_0V_2	27.00 efg	2.00 ab	6.90 b-e
S_0V_3	24.67 gh	2.00 ab	7.50 bc
S_0V_4	24.00 gh	2.00 ab	7.69 bc
S_0V_5	26.33 fg	2.00 ab	7.09 bcd
S_1V_1	22.00 hi	2.00 ab	8.33 b
S_1V_2	29.67 cde	1.67 bc	5.28 def
S_1V_3	24.33 gh	2.00 ab	7.60 bc
S_1V_4	24.67 gh	2.00 ab	7.50 bc
S_1V_5	32.00 bc	1.67 bc	4.95 ef
S_2V_1	26.67 fg	2.00 ab	6.98 bcd
S_2V_2	33.67 ab	1.33 cd	3.91 fg
S_2V_3	28.67 def	2.00 ab	6.52 b-e
S_2V_4	30.33 cd	2.00 ab	6.22 cde
S_2V_5	36.00 a	1.00 d	2.71 g
$LSD_{(0.05)}$	**2.639**	**0.502**	**1.793**
Significance level	**0.05**	**0.05**	**0.05**
CV(%)	**5.76**	**16.11**	**16.19**

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

S_0: 0 mM SA (control)
S_1: 0.2 mM SA
S_2: 0.4 mM SA

V_1: BARI Sarisha-1
V_2: BARI Sarisha-13
V_3: BARI Sarisha-14
V_4: BARI Sarisha-15
V_5: BARI Sarisha-16

Different mustard variety showed statistically significant differences in terms of plant infestation at flowering stage (Table 3). The lowest infested plant (4.91%) was recorded from V_5 which was statistically similar (5.36%) to V_2, whereas the highest infested pant (8.49%) was found from V_1 which was closely followed (7.14% and 7.21%) by V_3 and V_4 and they were statistically similar.

Interaction effect of levels of salicylic acid and different mustard variety showed statistically significant variation in terms of plant infestation at flowering stage (Table 4). The lowest infested plant (2.71%) was recorded from the treatment combination of S_2V_5, while the highest (10.14) was observed from the treatment combination of S_0V_1.

4.2.4 Healthy plants at fruiting stage

Statistically significant variation was recorded in terms of healthy plants per m^2 area at fruiting stage due to different levels of salicylic acid (Table 5). The highest number of healthy plants ($29.87/m^2$) was found from S_2 which was closely followed ($25.73/m^2$) by S_1, while the lowest number ($23.67/m^2$) was recorded from S_0.

Different mustard variety showed statistically significant differences in terms of number of healthy plants per m^2 area at fruiting stage (Table 5). The highest number of healthy plants ($30.44/m^2$) was recorded from V_5 which was statistically similar ($29.44/m^2$) to V_2, whereas the lowest number of healthy plants ($22.11/m^2$) was found from V_1 which was closely followed ($24.78/m^2$ and $25.33/m^2$) by V_3 and V_4 and they were statistically similar.

Interaction effect of levels of salicylic acid and different mustard variety showed statistically significant variation in terms of number of healthy plants m^2 area at fruiting stage (Table 6). The highest number of healthy plants ($35.00/m^2$) was recorded from the treatment combination of S_2V_5, while the lowest number ($20.33/m^2$) was observed from the treatment combination of S_0V_1.

Table 5. Effect of salicylic acid and variety on health, aphid infested plant and plant infestation at fruiting stage of mustard

Treatment	At fruiting stage		
	Healthy plant (No.)	Infested plant (No.)	Infestation (%)
Levels of salicylic acid			
S_0	23.67 c	2.33 a	9.04 a
S_1	25.73 b	2.13 ab	7.83 b
S_2	29.87 a	1.87 b	6.09 c
$LSD_{(0.05)}$	**1.140**	**0.345**	**1.201**
Significance level	**0.01**	**0.05**	**0.01**
Different mustard variety			
V_1	22.11 c	2.33 a	9.63 a
V_2	29.44 a	2.00 ab	6.46 b
V_3	24.78 b	2.22 a	8.23 a
V_4	25.33 b	2.33 a	8.54 a
V_5	30.44 a	1.67 b	5.41 b
$LSD_{(0.05)}$	**1.471**	**0.446**	**1.550**
Significance level	**0.01**	**0.05**	**0.01**
CV(%)	**5.77**	**21.85**	**20.98**

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

S_0: 0 mM SA (control)
S_1: 0.2 mM SA
S_2: 0.4 mM SA

V_1: BARI Sarisha-1
V_2: BARI Sarisha-13
V_3: BARI Sarisha-14
V_4: BARI Sarisha-15
V_5: BARI Sarisha-16

Table 6. Interaction effect of salicylic acid and variety on health, aphid infested plant and plant infestation at fruiting stage of mustard

Treatment	At fruiting stage		
	Healthy plant (No.)	Infested plant (No.)	Infestation (%)
S_0V_1	20.33 i	2.67 a	11.54 a
S_0V_2	26.67 def	2.33 ab	7.99 b-e
S_0V_3	23.33 gh	2.33 ab	9.04 a-d
S_0V_4	23.00 ghi	2.33 ab	9.18 abc
S_0V_5	25.00 efg	2.00 ab	7.43 b-e
S_1V_1	21.33 hi	2.33 ab	9.84 ab
S_1V_2	29.00 cd	2.00 ab	6.46 cde
S_1V_3	23.33 gh	2.00 ab	7.91 b-e
S_1V_4	23.67 gh	2.33 ab	8.93 a-d
S_1V_5	31.33 bc	2.00 ab	6.01 de
S_2V_1	24.67 fg	2.00 ab	7.50 b-e
S_2V_2	32.67 ab	1.67 bc	4.95 ef
S_2V_3	27.67 de	2.33 ab	7.75 b-e
S_2V_4	29.33 cd	2.33 ab	7.49 b-e
S_2V_5	35.00 a	1.00 c	2.78 f
$LSD_{(0.05)}$	**2.549**	**0.772**	**2.685**
Significance level	**0.05**	**0.05**	**0.05**
CV(%)	**5.77**	**21.85**	**20.98**

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

S_0: 0 mM SA (control)
S_1: 0.2 mM SA
S_2: 0.4 mM SA

V_1: BARI Sarisha-1
V_2: BARI Sarisha-13
V_3: BARI Sarisha-14
V_4: BARI Sarisha-15
V_5: BARI Sarisha-16

4.2.5 Infested plants at fruiting stage

Statistically significant variation was recorded in terms of infested plants per m^2 area at fruiting stage due to different levels of salicylic acid (Table 5). The lowest number of infested plants ($1.87/m^2$) was found from S_2 which was statistically similar ($2.13/m^2$) to S_1, while the highest number ($2.33/m^2$) was recorded from S_0.

Different mustard variety showed statistically significant differences in terms of number of infested plants per m^2 area at fruiting stage (Table 5). The lowest number of infested plants ($1.67/m^2$) was recorded from V_5 which was statistically similar ($2.00/m^2$) to V_2, whereas the highest number ($2.33/m^2$) was found from V_1 which was statistically similar ($2.22/m^2$ and $2.33\ m^2$) to V_3 and V_4.

Interaction effect of levels of salicylic acid and different mustard variety showed statistically significant variation in terms of number of infested plants m^2 area at fruiting stage (Table 6). The lowest number of infested plants ($1.00/m^2$) was recorded from the treatment combination of S_2V_5, while the lowest number ($2.67/m^2$) was observed from the treatment combination of S_0V_1.

4.2.6 Plant infestation at fruiting stage

Statistically significant variation was recorded in terms of plant infestation at fruiting stage due to different levels of salicylic acid (Table 5). The lowest infested plant (6.09%) was found from S_2 which was closely followed (7.83%) by S_1, while the highest infested plant (9.04%) was recorded from S_0.

Different mustard variety showed statistically significant differences in terms of plant infestation at fruiting stage (Table 5). The lowest infested plant (5.41%) was recorded from V_5 which was statistically similar (6.46%) to V_2, whereas the highest infested pant (9.63%) was found from V_1 which was statistically similar (8.23% and 8.54%) by V_3 and V_4 and they were statistically similar.

Interaction effect of levels of salicylic acid and different mustard variety showed statistically significant variation in terms of plant infestation at fruiting stage (Table 6). The lowest infested plant (2.78%) was recorded from the treatment combination of S_2V_5, while the highest (11.54) from S_0V_1.

4.3 Yield contributing characters and yield of mustard

4.3.1 Plant height at harvest

Plant height at harvest varied significantly due to different levels of salicylic acid (Table 7). The longest plant (113.79 cm) was recorded from S_2 which was statistically similar (110.02 cm) to S_1, whereas the shortest plant (103.65 cm) was observed from S_0.

Statistically significant variation was recorded in terms of plant height at harvest for different mustard variety (Table 7). The longest plant (158.58 cm) was found from V_5 which was followed (108.93 cm) by V_4. On the other hand, the shortest plant (87.59 cm) was recorded from V_3 which was statistically similar (93.27 cm and 97.39 cm) by V_2 and V_1 and they were statistically similar.

Interaction effect of levels of salicylic acid and different mustard variety showed statistically significant variation in terms of plant height of mustard (Table 8). The longest plant (170.29 cm) was found from the treatment combination of S_2V_5, while the shortest plant (67.52 cm) was observed from the treatment combination of S_0V_3.

4.3.2 Number of siliqua per plant

Number of siliqua per plant at harvest varied significantly due to different levels of salicylic acid (Figure 6). The maximum number of siliqua per plant (116.49) was recorded from S_2 which was statistically similar (113.06) to S_1, whereas the minimum number of siliqua per plant (108.35) was observed from S_0.

Statistically significant variation was recorded in terms of number of siliqua per plant at harvest for different mustard variety (Figure 7). The maximum number of siliqua per plant (185.72) was found from V_5 which was followed (109.78) by V_1, while minimum number (87.09) was recorded from V_2 which was statistically similar (88.22 and 92.37) by V_3 and V_4 and they were statistically similar.

Table 7. Effect of salicylic acid and variety on yield contributing characters and yield of mustard

Treatment	Plant height at harvest (cm)	Length of siliqua (cm)	Seed yield (t/ha)	Stover yield (t/ha)
Levels of salicylic acid				
S_0	103.65 b	5.35 b	1.44 c	2.61 b
S_1	110.02 ab	6.08 a	1.66 b	2.72 b
S_2	113.79 a	6.35 a	1.85 a	2.86 a
$LSD_{(0.05)}$	**7.372**	**0.320**	**0.100**	**0.140**
Significance level	**0.05**	**0.01**	**0.01**	**0.01**
Different mustard variety				
V_1	97.39 c	4.97 d	1.31 c	2.32 c
V_2	93.27 c	6.36 ab	2.02 a	2.85 ab
V_3	87.59 c	5.51 c	1.33 bc	2.81 ab
V_4	108.93 b	6.15 b	1.45 b	2.72 b
V_5	158.58 a	6.66 a	2.15 a	2.97 a
$LSD_{(0.05)}$	**9.517**	**0.413**	**0.130**	**0.181**
Significance level	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**9.03**	**7.22**	**8.11**	**6.83**

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

S_0: 0 mM SA (control)
S_1: 0.2 mM SA
S_2: 0.4 mM SA

V_1: BARI Sarisha-1
V_2: BARI Sarisha-13
V_3: BARI Sarisha-14
V_4: BARI Sarisha-15
V_5: BARI Sarisha-16

Table 8. Interaction effect of salicylic acid and variety on yield contributing characters and yield of mustard

Treatment	Plant height at harvest (cm)	Length of siliqua (cm)	Seed yield (t/ha)	Stover yield (t/ha)
S_0V_1	80.11 ef	4.12 d	1.04 j	2.25 f
S_0V_2	101.67 cd	6.05 bc	1.76 cde	2.82 bc
S_0V_3	67.52 f	4.51 d	1.07 ij	2.72 bcd
S_0V_4	106.79 cd	6.01 bc	1.43 fgh	2.65 b-e
S_0V_5	162.15 a	6.07 bc	1.92 bcd	2.61 cde
S_1V_1	108.09 cd	5.41 c	1.36 gh	2.32 ef
S_1V_2	96.41 cde	7.19 a	2.36 a	2.85 bc
S_1V_3	90.24 de	5.37 c	1.23 hij	2.72 bcd
S_1V_4	112.08 c	5.87 bc	1.30 ghi	2.72 bcd
S_1V_5	143.29 b	6.59 ab	2.06 b	3.01 ab
S_2V_1	103.96 cd	5.38 c	1.53 efg	2.39 def
S_2V_2	81.74 ef	5.85 bc	1.96 bc	2.89 bc
S_2V_3	105.00 cd	6.64 ab	1.70 de	2.99 ab
S_2V_4	107.93 cd	6.56 ab	1.63 ef	2.78 bc
S_2V_5	170.29 a	7.33 a	2.46 a	3.28 a
$LSD_{(0.05)}$	**16.48**	**0.716**	**0.224**	**0.313**
Significance level	**0.01**	**0.01**	**0.01**	**0.05**
CV(%)	**9.03**	**7.22**	**8.11**	**6.83**

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

S_0: 0 mM SA (control)
S_1: 0.2 mM SA
S_2: 0.4 mM SA

V_1: BARI Sarisha-1
V_2: BARI Sarisha-13
V_3: BARI Sarisha-14
V_4: BARI Sarisha-15
V_5: BARI Sarisha-16

Interaction effect of levels of salicylic acid and different mustard variety showed statistically significant variation in terms of number of siliqua per plant of mustard (Figure 8). The maximum number of siliqua per plant (190.50) was found from the treatment combination of S_2V_5, while the minimum number of siliqua per plant (81.47) was observed from the treatment combination of S_0V_3.

4.3.3 Length of siliqua

Length of siliqua varied significantly due to different levels of salicylic acid (Table 7). The longest siliqua (6.35 cm) was recorded from S_2 which was statistically similar (6.08 cm) to S_1, whereas the shortest siliqua (5.35 cm) was observed from S_0.

Statistically significant variation was recorded in terms of length of siliqua for different mustard variety (Table 7). The longest siliqua (6.66 cm) was found from V_5 which was statistically similar (6.36 cm) by V_4 and closely followed (6.15 cm) by V_4. On the other hand, the shortest siliqua (4.97 cm) was recorded from V_1 which was closely followed (5.51 cm) by V_3.

Interaction effect of levels of salicylic acid and different mustard variety showed statistically significant variation in terms of length of siliqua of mustard (Table 8). The longest siliqua (7.33 cm) was found from the treatment combination of S_2V_5, while the shortest siliqua (4.12 cm) was observed from the treatment combination of S_0V_1.

4.3.4 Weight of 1000 seeds

Weight of 1000 seeds varied significantly due to different levels of salicylic acid (Figure 9). The highest weight of 1000 seeds (3.88 g) was recorded from S_2 which was followed (3.58 g) by S_1, whereas the lowest weight (3.43 g) from S_0.

Significant variation was recorded in terms of weight of 1000 seeds for different mustard variety (Figure 10). The highest weight of 1000 seeds (4.79 g) was found from V_5 which was closely followed (3.86 g and 3.65 g) by V_2 and V_3, whereas, the lowest weight (2.47 g) from V_1 which was followed (3.38 g) by V_4.

Interaction effect of levels of salicylic acid and different mustard variety showed statistically significant variation in terms of weight of 1000 seeds of mustard (Figure 11). The highest weight of 1000 seeds (5.07 g) was found from the treatment combination of S_2V_5, while the lowest weight of 1000 seeds (1.76 g) was observed from the treatment combination of S_0V_1.

4.3.5 Seed yield

Seed yield of mustard varied significantly due to different levels of salicylic acid (Table 7). The highest seed yield (1.85 t/ha) was recorded from S_2 which was followed (1.66 t/ha) by S_1, whereas the lowest seed yield (1.44 t/ha) was found from S_0.

Statistically significant variation was recorded in terms of seed yield for different mustard variety (Table 7). The highest seed yield (2.15 t/ha) was found from V_5 which was statistically similar (2.02 t/ha) to V_2 and closely followed (1.45 t/ha) by V_4, while, the lowest seed yield (1.31 t/ha) was recorded from V_1 which was statistically similar (1.33 t/ha) to V_3.

Interaction effect of salicylic acid and different mustard variety showed statistically significant variation in terms of seed yield of mustard (Table 8). The highest seed yield (2.46 t/ha) was found from the treatment combination of S_2V_5, while the lowest seed yield (1.04 t/ha) was observed from the treatment combination of S_0V_1.

4.3.6 Stover yield

Stover yield of mustard varied significantly due to different levels of salicylic acid (Table 7). The highest stover yield (2.86 t/ha) was recorded from S_2 which was followed (2.72 t/ha) by S_1, whereas the lowest stover yield (2.61 t/ha) was found from S_0.

Statistically significant variation was recorded in terms of stover yield for different mustard variety (Table 7). The highest stover yield (2.97 t/ha) was found from V_5 which was statistically similar (2.85 t/ha and 2.81 t/ha) to V_2 and V_3, while, the lowest stover yield (2.32 t/ha) was recorded from V_1 which was followed (2.72 t/ha) by V_4.

Interaction effect of salicylic acid and different mustard variety showed statistically significant variation in terms of stover yield of mustard (Table 8). The highest stover yield (3.28 t/ha) was found from the treatment combination of S_2V_5, while the lowest stover yield (2.25 t/ha) was observed from the treatment combination of S_0V_1.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2014 to March, 2015 to find out the effect of salicylic acid and varieties on incidence of aphid and yield of mustard. The experiment comprised of two factors; Factors A: Levels of salicylic acid (3 levels)- S_0: 0 mM SA (control), S_1: 0.2 mM SA,S_2: 0.4 mM SA and Factor B: Mustard varieties (5 mustard varieties)- V_1: BARI Sarisha-1, V_2: BARI Sarisha-13, V_3: BARI Sarisha-14, V_4: BARI Sarisha-15 and V_5: BARI Sarisha-16. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were observed on the abundance of aphid, plant infestation, yield contributing characters and yield of mustard and significance differences were observed for different treatments.

For salicylic acid, at early flowering stage, the lowest number of aphid (2.87) was observed from S_2 and the highest number of aphid (3.12) was found from S_0. At mid flowering stage, the lowest number of aphid (3.17) was observed from S_2 and the highest number of aphid (3.52) was found from S_0. At late flowering stage, the lowest number of aphid (3.52) was observed from S_2 and the highest number of aphid (3.93) was found from S_0. At early fruiting stage, the lowest number of aphid (4.05) was observed from S_2 and the highest number of aphid (4.51) was found from S_0. At mid fruiting stage, the lowest number of aphid (3.51) was observed from S_2 and the highest number of aphid (3.77) was found from S_0. At late fruiting stage, the lowest number of aphid (2.23) was observed from S_2 and the highest number of aphid (2.48) was found from S_0.

At flowering stage, the highest number of healthy plants (31.07/m^2) was found from S_2, while the lowest number (24.53/m^2) was recorded from S_0. The lowest number of infested plants (1.67/m^2) was found from S_2, while the highest number (2.07/m^2) was recorded from S_0. The lowest infested plant (5.27%) was found

from S_2, while the highest infested plant (7.87%) was recorded from S_0. At fruiting stage, the highest number of healthy plants (29.87/m^2) was found from S_2, while the lowest number (23.67/m^2) was recorded from S_0. The lowest number of infested plants (1.87/m^2) was found from S_2, while the highest number (2.33/m^2) was recorded from S_0. The lowest infested plant (6.09%) was found from S_2, while the highest infested plant (9.04%) was recorded from S_0. The longest plant (113.79 cm) was recorded from S_2, whereas the shortest plant (103.65 cm) was observed from S_0. The maximum number of siliqua per plant (116.49) was recorded from S_2, whereas the minimum number of siliqua per plant (108.35) was observed from S_0. The longest siliqua (6.35 cm) was recorded from S_2, whereas the shortest siliqua (5.35 cm) was observed from S_0. The highest weight of 1000 seeds (3.88 g) was recorded from S_2, whereas the lowest weight (3.43 g) was observed from S_0. The highest seed yield (1.85 t/ha) was recorded from S_2, whereas the lowest seed yield (1.44 t/ha) was found from S_0. The highest stover yield (2.86 t/ha) was recorded from S_2, whereas the lowest stover yield (2.61 t/ha) was found from S_0.

Due to different mustard variety at early flowering stage, the lowest number of aphid (2.67) was recorded from V_5, whereas the highest number of aphid (3.34) was observed from V_1. At mid flowering stage, the lowest number of aphid (3.06) was recorded from V_5, whereas the highest number of aphid (3.52) was observed from V_1. At late flowering stage, the lowest number of aphid (3.46) was recorded from V_5, whereas the highest number of aphid (4.00) was observed from V_1. At early fruiting stage, the lowest number of aphid (4.01) was recorded from V_5, whereas the highest number of aphid (4.55) was observed from V_1. At mid fruiting stage, the lowest number of aphid (3.30) was recorded from V_5, while the highest number of aphid (3.96) was observed from V_1. At late fruiting stage, the lowest number of aphid (2.10) was recorded from V_5, whereas the highest number of aphid (2.76) was observed from V_1.

At flowering stage, the highest number of healthy plants (31.44/m^2) was recorded from V_5, whereas the lowest number of healthy plants (23.11/m^2) was found from

V_1. The lowest number of infested plants (1.56/m^2) was recorded from V_5, whereas the highest number of infested plants (2.11/m^2) was found from V_1. The lowest infested plant (4.91%) was recorded from V_5, whereas the highest infested pant (8.49%) was found from V_1. At fruiting stage, the highest number of healthy plants (30.44/m^2) was recorded from V_5, whereas the lowest number of healthy plants (22.11/m^2) was found from V_1. The lowest number of infested plants (1.67/m^2) was recorded from V_5, whereas the highest number (2.33/m^2) was found from V_1. The lowest infested plant (5.41%) was recorded from V_5, whereas the highest infested pant (9.63%) was found from V_1.

The longest plant (158.58 cm) was found from V_5 and the shortest plant (87.59 cm) was recorded from V_3. The maximum number of siliqua per plant (185.72) was found from V_5, while minimum number (87.09) was recorded from V_2. The longest siliqua (6.66 cm) was found from V_5 and the shortest siliqua (4.97 cm) was recorded from V_1. The highest weight of 1000 seeds (4.79 g) was found from V_5, whereas the lowest weight of 1000 seeds (2.47 g) was recorded from V_1. The highest seed yield (2.15 t/ha) was found from V_5, while the lowest seed yield (1.31 t/ha) was recorded from V_1. The highest stover yield (2.97 t/ha) was found from V_5, while the lowest stover yield (2.32 t/ha) was recorded from V_1.

In case of interaction effect, at early flowering stage the lowest number of aphid (2.27) was observed from the treatment combination of S_2V_5 and the highest number of aphid (3.67) from the treatment combination of S_0V_1. At mid flowering stage, the lowest number of aphid (2.70) was observed from the treatment combination of S_2V_5 and the highest number of aphid (3.77) was recorded from the treatment combination of S_0V_1.At late flowering stage, the lowest number of aphid (3.00) was observed from the treatment combination of S_2V_5 and the highest number of aphid (4.47) was recorded from the treatment combination of S_0V_1. At early fruiting stage, the lowest number of aphid (3.30) was observed from the treatment combination of S_2V_5 and the highest number of aphid (4.83) from the treatment combination of S_0V_1. At mid fruiting stage, the lowest number of aphid (2.90) was observed from the treatment combination of S_2V_5 and the highest

number of aphid (4.27) was recorded from the treatment combination of S_0V_1. At late fruiting stage, the lowest number of aphid (2.03) was observed from the treatment combination of S_2V_5 and the highest number of aphid (3.07) was recorded from the treatment combination of S_0V_1.

At flowering stage, the highest number of healthy plants (36.00/m^2) was recorded from the treatment combination of S_2V_5, while the lowest number (20.67/m^2) was observed from the treatment combination of S_0V_1. The lowest number of infested plants (1.00/m^2) was recorded from the treatment combination of S_2V_5, while the lowest number (2.33/m^2) was observed from the treatment combination of S_0V_1. The lowest infested plant (2.71%) was recorded from the treatment combination of S_2V_5, while the highest (10.14) was observed from the treatment combination of S_0V_1. At fruiting stage, the highest number of healthy plants (35.00/m^2) was recorded from the treatment combination of S_2V_5, while the lowest number (20.33/m^2) was observed from the treatment combination of S_0V_1. The lowest number of infested plants (1.00/m^2) was recorded from the treatment combination of S_2V_5, while the lowest number (2.67/m^2) was observed from the treatment combination of S_0V_1. The lowest infested plant (2.78%) was recorded from the treatment combination of S_2V_5, while the highest (11.54) was observed from the treatment combination of S_0V_1.

The longest plant (170.29 cm) was found from the treatment combination of S_2V_5, while the shortest plant (67.52 cm) was observed from the treatment combination of S_0V_3. The maximum number of siliqua per plant (190.50) was found from the treatment combination of S_2V_5, while the minimum number of siliqua per plant (81.47) was observed from the treatment combination of S_0V_3. The longest siliqua (7.33 cm) was found from the treatment combination of S_2V_5, while the shortest siliqua (4.12 cm) was observed from the treatment combination of S_0V_1. The highest weight of 1000 seeds (5.07 g) was found from the treatment combination of S_2V_5, while the lowest weight of 1000 seeds (1.76 g) was observed from the treatment combination of S_0V_1. The highest seed yield (2.46 t/ha) was found from the treatment combination of S_2V_5, while the lowest seed yield (1.04 t/ha) was

observed from the treatment combination of S_0V_1. The highest stover yield (3.28 t/ha) was found from the treatment combination of S_2V_5, while the lowest stover yield (2.25 t/ha) was observed from the treatment combination of S_0V_1.

Conclusion

It was revealed that 0.4 mM SA and BARI Sarisha-16 was superior for controlling aphid of mustard and also for better yield contributing characters and yield.

Recommendations

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

1. Need to conduct advance research on investigation of systemic acquired resistance in mustard with salicylic acid in relation to aphid infestation.
2. Need to examine the influence of date of sowing and salicylic acid on aphid infestation in mustard field.

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