EFFECT OF FUNGICIDE AND SALICYLIC ACID FOR CONTROLLING LEAF SPOT AND RUST DISEASES OF GROUNDNUT

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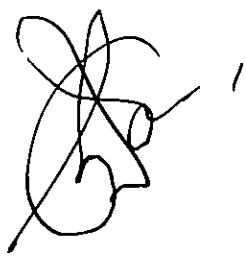

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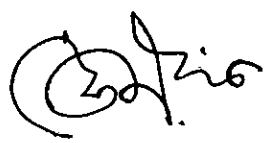

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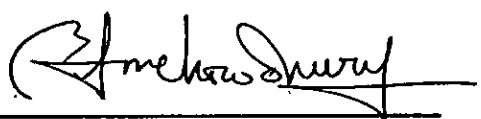

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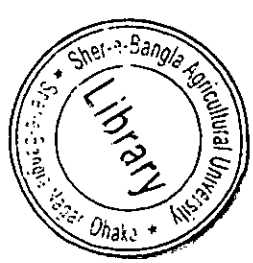
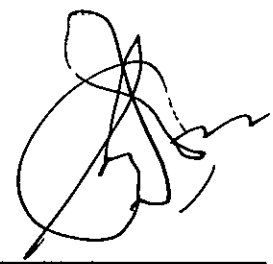


CERTIFICATE

This is to certify that the thesis entitled "**Effect of Fungicide and Salicylic Acid for Controlling Leaf Spot and Rust Diseases of Groundnut**" 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 **PLANT PATHOLOGY**, embodies the result of a piece of bonafide research work carried out by **Md. Shahidul Islam**, Registration number: **03-01158** 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.



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The Author

EFFECT OF FUNGICIDE AND SALICYLIC ACID FOR CONTROLLING LEAF SPOT AND RUST DISEASES OF GROUNDNUT

ABSTRACT

The experiment was conducted at the experimental field of Bangladesh Agricultural Research Institute (BARI), Gazipur during the period from November 2007 to April 2008 to find out the effect of fungicide and salicylic acid for controlling leaf spot and rust diseases of groundnut. The variety Dhaka-1 was selected for this study as a test crop. Consequently three experiments were conducted. **Experiment-1:** Evaluation of fungicides in controlling leaf spot and rust diseases of groundnut. The experiment comprised treatments- T_1: Predator (propiconazole, 0.5 ml/L); T_2: Blezole (hexaconazole, 1 ml/L); T_3: Magnate (mancozeb, 500-625 g/ha); T_4: Cluster (mancozeb+carbendazim, 2g/L); T_5: Ezeb (mancozeb, 1g/L); T_6: Detail (hexaconazole, 0.5ml/L); T_7: Tall (propiconazole, 0.5ml/L); T_8: Contaf (hexaconazole, 1ml/L) and T_9: Control. **Experiment-2:** Minimum spray of fungicides in controlling leaf spot and rust diseases of groundnut. The experiment comprised treatments- T_1: One spray at 105 DAS (Blezole); T_2: One spray at 105 DAS (Contaf); T_3: Two spray at 105 and 120 DAS (Blezole); T_4: Two spray at 105 and 120 DAS (Contaf); T_5: Three spray at 90, 105 and 120 DAS (Blezole); T_6: Three spray at 90, 105 and 120 DAS (Contaf) and T_7: Control. **Experiment-3:** Effect of Salicylic Acid in controlling leaf spot and rust diseases of groundnut. The experiment comprised treatments- T_1: Control; T_2: 0.5 mM salicylic acid foliar spray; T_3: 1.0 mM salicylic acid foliar spray and T_4: 1.5 mM salicylic acid foliar sprays. Disease data, yield contributing characters and yield showed significant variation for different fungicides. In case of leaf spot disease, at 90, 105 and 120 DAS the minimum disease severity (1.00%, 2.10% and 2.47%) was recorded from T_8 and the maximum disease severity ((4.60%, 6.15% and 7.60%) was found from T_9. In case of rust, at 90, 105 and 120 DAS the minimum disease severity (1.85%, 4.05% and 3.00%) was recorded from T_8 again, the maximum (5.40%, 8.25% and 9.60%) was found from T_9. The highest yield (2.38 t/ha) was found from T_8, and the lowest (1.40 t/ha) was recorded from T_9. Disease data, yield contributing characters and yield showed significant variation for different number of spraying of fungicides. In case of leaf spot disease, at 90, 105 and 120 DAS the minimum disease severity (1.14%, 1.21% and 1.90%) was recorded from T_6, whereas the maximum (3.30%, 4.51% and 7.93%) was recorded from T_7. In case of rust, at 90, 105 and 120 DAS the minimum disease severity (2.36%, 3.22 % and 1.90%) was recorded from T_6, whereas the maximum (4.49%, 6.15% and 9.73%) was recorded from T_7. The highest pod yield (2.44 t/ha) was recorded from T_6, while the lowest yield (1.11 t/ha) was found from T_7. Disease data, yield contributing characters and yield showed significant variation for different concentration of salicylic acid. In case of leaf spot disease, at 90, 105 and 120 DAS the minimum disease severity (0.63%, 1.25% and 1.84%) was recorded from T_4 and the maximum (2.06%, 3.59% and 4.19%) was recorded from T_1. In case of rust, at 90, 105 and 120 DAS the minimum disease severity (1.46%, 2.07% and 2.29%) was recorded from T_4 and, the maximum (3.04%, 5.30% and 6.39%) was recorded from T_1. The highest pods yield (2.47 t/ha) was obtained from T_4, while the lowest (1.86 t/ha) was recorded from T_1.

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CHAPTER I

INTRODUCTION

Groundnut (*Arachis hypogaea* L.), one of the promising oil crops of Bangladesh, is grown in both kharif and rabi seasons. It occupies third position among the oil crops in terms of area but second in production in Bangladesh. According to Yearbook of Agricultural Statistics of Bangladesh about 23,412 metric tons of groundnut seeds are produced in the country from 18,965 hectare of land (BBS, 2008). At present, major portion of groundnut is consumed as roasted nuts and the remaining part is used in the confectionary for making biscuits and dry foods. However, there is a vast possibility to increase per hectare production.

Groundnut is attacked by a large number of air and soil borne fungi, viruses, and bacterial pathogens (Feakin, 1973). Its pods, which develop and mature below surface soil, are attacked by many soil-borne pathogens, their nature and density being profoundly influenced by crop variety, cropping pattern, soil type and climatic conditions of the area beside other factors. Among the various factors that directly affect the yield of groundnut diseases play an important role. The world record indicates that groundnut sufferes from a total of 60 different diseases caused by fungi, bacteria, nematode, virus, mycoplasma and abiotic agents (Porter *et al.*, 1984; Thurston, 1984; Mukherji and Bhasin, 1986). So far 21 diseases are known to occur on groundnut in Bangladesh (Talukdar, 1974; Bakr, *et al.*, 1980; Ahmed and Hossain, 1985). Among them leaf spot and rust of groundnut are the important diseases.

Leaf spot caused by *Cercospora arachidicola* Hori. and *Cercosporidium personatum* Berk. and Curt. and rust caused by *Puccinia arachidis* Speg. are serious foliar fungal diseases (Fakir, 1980; Khaleque, 1985). Leaf spot and rust are the most serious fungal diseases of groundnut on a worldwide scale. Both diseases are commonly present wherever groundnut is grown. But their incidence and severity vary among localities and seasons. Both diseases cause severe foliage damage and yield losses as high as 70% (Subrahmanyam *et al.*, 1984). In addition to direct yield losses, they can lower seed quality by reducing seed size as well as pod size of groundnut and oil content (Behera and Roul, 1995.). Frequent yield reduction takes place due to severe attack by these diseases and thus by controlling the disease through a suitable control measure such loss can be minimized. Oilseed Research Center, BARI has developed eight varieties of groundnut for cultivation at the farmers' level but none of the variety is truly resistant to above diseases.

Chemical control by foliar spray is practiced in all groundnut growing courtiers. A number of fungicides have been found to give reasonable control of this disease (Ghuge *et al.*, 1981). No single fungicide yet identified as effective against both leaf spot and rust disease. Among various methods applied to control the disease, growing of resistant variety is the most effective and economically feasible. Chemicals are being successfully used in controlling the disease. However, the issue of environmental pollution is linked with indiscriminate and unplanned use of chemicals, which provokes health hazards. So, it is better to use the minimum chemical for controlling the disease.

Fungicide Bavistin (0.1%) was effective against leaf spot and Tilt was effective against rust (Dubey *et al.*, 1995 and Gangopadhyay *et al.*, 1996). Moreover, recently, Salicylic acid (SA), a phenolic compound, has been reported to play an important role in induction of disease resistance in plants (Delaney *et al.*, 1994). Effect of SA on leaf spot and rust of groundnut is not known.

In Bangladesh, like other management practices information about fungicides application in controlling leaf spot and rust is insufficient. The farmers of Bangladesh cultivate this crop according to their own choice due to the absence or unavailability of standard application of fungicides. As a result, they do not get satisfactory yield and return from investment. Considering the above factors, the present experiment was undertaken with the following objectives-

i. To find out new fungicides in controlling leaf spot and rust of groundnut and to obtain maximum yield

ii. To determine the minimum number of fungicides spray in reducing the diseases incidence and maximizing the yield

iii. To find out the effect of salicylic acid in controlling leaf spot and rust of groundnut

CHAPTER II

REVIEW OF LITERATURE

Groundnut is one of the most important and popular oil crops in Bangladesh as well as many countries of the world. Less attention has been given by the researchers on its improvement because it is parallelly cultivated with boro rice. Diseases play an important role among the various factors that related to the yield of this crop. Leaf spot and rust disease are the common diseases that cause a great loss of groundnut yield in our country. But very few studies have been carried out in our country as well as many other countries of the world in relation with the control of leaf spot and rust disease of groundnut. Therefore, the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important informative works and research findings related to the control of these diseases so far been done at home and abroad have been reviewed in this chapter under the following headings:

2.1 Fungicides in controlling leaf spot and rust diseases of groundnut

The efficiency of 5 fungicides, Bordeaux mixture, Derosal (carbendazim), Bavistin (carbendazim), Dithane M-45 (mancozeb) and Fytolan (copper oxychloride), to control *Cercospora personata* [*Mycosphaerella berkeleyi*] and *Puccinia arachidis* on groundnuts was determined by Dubey *et al.* (1995). All fungicides provided control but Derosal and Bavistin were the most effective.

In a field experiment conducted by Behera and Roul (1995) during the rabi [winter] seasons of 1991-93 at Ranital, Orissa, groundnuts cv. AK 12-24 were given 0-45 kg S/ha. Seeds were treated with a mixture of bavistin [carbendazim] + thiram or a mixture of bavistin + dithane M-45 [mancozeb] was applied as a foliar spray. Pod yield increased with up to 40 kg S. Foliar spraying of fungicides was generally far more effective than the seed treatment. The foliar treatment significantly decreased the incidence of wilt (*Sclerotium rolfsii*), tikka (*Cercospora arachidicola* [*Mycosphaerella arachidis*]) and rust (*Puccinia arachidis*) while the seed treatment was more effective in controlling collar rot (*Aspergillus niger*).

Four triazole fungicides, tebuconazole (as Folicur), propiconazole (as Tilt 250 EC), cyproconazole (SAN 619) and difenocozole (as Score-250EC), were evaluated and compared by Adiver *et al.* (1995) with conventional fungicides for the control of foliar diseases on groundnut. Tebuconazole gave significantly better control than the others, followed by cyproconazole, when applied at 0.1% for the control of late leaf spot (LLS; *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) and rust (*Puccinia arachidis*) recording 20.28 and 31.32 PDI values for LLS and 21.97 and 21.64 PDI values for rust, respectively. These 2 fungicides accounted for an increase of 53.01 and 42.42% pod yield, 7.64 and 5.85% shelling and 6.28 and 3.98% oil content over the control, respectively.

Adiver and Anahosur (1995) carried out an experiment with ergosterol biosynthesis inhibiting triazole fungicides (tebuconazole, cyproconazole,

propiconazole and difenoconazole) were effective against late leaf spot (*Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) of groundnut. They also reduced stem colonization (rot) by *S. rolfsii* [*Corticium rolfsii*]. Tebuconazole (as Folicur) and cyproconazole (SAN 619) were the most effective (64.2% reduction) against *C. rolfsii*. The plants remained healthy and intact until harvest and less predisposed to attack by *C. rolfsii*.

Gangopadhyay *et al.* (1996) reported from a field experiment in 1989-90 in Rajasthan, seed treatment of groundnuts cv. M-13 with 0.2% of 1 of 3 carbendazim formulations or thiophanate methyl + foliar application of 0.1% of these fungicides were the most effective in reducing leaf spots caused by *Cercospora arachidicola* [*Mycosphaerella arachidicola*] and *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*].

Groundnut germplasms (22) were screened by Huq *et al.* (1996) against tikka (*Cercospora arachidicola* [*Mycosphaerella arachidis*] and *Cercosporidium personatum* [*M. berkeleyi*]) and rust (*Puccinia arachidis*) under natural field conditions over consecutive years. Among the germplasms, 3 accessions (ICGV 86590, ICGV 866654 and 86707) were moderately resistant and the rest were susceptible to tikka. Dhaka-1 (control) was susceptible and the rest of the germplasms showed some degree of resistance to rust: 3 were highly resistant; 9 were resistant; and 10 were moderately resistant to the disease. Two germplasms were resistant to both diseases. Chemical control was more effective for controlling these diseases.

Fungicides (carbendazim, thiophanate-methyl, mancozeb and captafol) were assessed by Gangopadhyay *et al.* (1999) for their ability to control early and late leaf spot, caused by *Cercospora arachidicola* [*Mycosphaerella arachidis*] and *Cercosporidium personatum* [*M. berkeleyi*], respectively, on groundnuts in Rajasthan, India. Fungicides were applied as seed treatments and then, subsequently, 3 sprays were applied at 15-d intervals following the appearance of disease. Seed germination was higher in treated seeds compared with untreated. Maximum germination was observed in seeds treated with captafol. Formulations of carbendazim (as Bavistin, J. K. Stein and Derosal) and thiophanate-methyl (as Topsin-M) controlled the disease most effectively.

Groundnut seeds were treated by Basu (1998) with captafol or Bavistin (carbendazim), or a soil drench of Brassicol [quintozene] was applied, or Difolatan [also captafol] or Dithane M-45 [mancozeb] was used as foliar sprays. Growth and nodulation were best with captafol, Bavistin and Difolatan.

Jadeja *et al.* (1999) carried out a field trial at Junagadh, Gujarat, India, in 1995-97 to assess the efficacy of difenoconazole and propiconazole at 0.0125% w/v, hexaconazole at 0.025% and epoxiconazole at 0.00625%, compared with carbendazim at 0.025% and mancozeb at 0.2%, applied as foliar sprays at 30, 45 and 60 days post-emergence for control of early and late leaf spot (*Cercospora arachidicola* [*Mycosphaerella arachidis*] and *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*], respectively) and rust (*Puccinia arachidis*) in groundnuts. Results indicated that all the triazole fungicides reduced both rust and

leaf spots, while carbendazim was effective against leaf spots and mancozeb against rust. Best control was achieved with hexaconazole and difenoconazole, and these treatments also gave best pod and fodder yields. The hexaconazole-treated plots gave a 71% higher pod yield and an 87% higher fodder yield than an untreated control. The highest net returns of Rs. 9,793/ha was also achieved with this treatment.

A field trial was conducted by Tirmali and Pawar (2000) during rabi 1994/95 at Dapoli, Maharashtra, India to evaluate the efficacy of different fungicide and chemical treatments against the rust disease (*Puccinia arachidis*) of groundnut. Four fungicides, i.e. Dithane M-45 [mancozeb] (0.2%), Bavistin [carbendazim] (0.2%), Neemata (5%) and Cu (1000 ppm), and three additional chemical treatments, i.e. B (1000 ppm) and K at 30 and 60 kg/ha, were evaluated. All fungicide and chemical treatments significantly reduced the disease incidence over the control. Among the different treatments, Dithane M-45 was the most effective as it resulted the highest percent of disease control (47.77%) and the lowest disease intensity (39.99%). This treatment also gave the highest values for pod yield (24.09 q/ha) and percent increase in yield over the control (70.61%).

Trials were conducted by Gururaj *et al.* (2002) at Raichur, Karnataka, India, for two years during kharif 1995 and 1996. Highly susceptible cultivar JL 24 was subjected to fungicide spraying 30 days after emergence followed by two more spray applications at fortnightly intervals. Observations on disease intensity of early leaf spot (*Cercospora arachidicola* [*Mycosphaerella arachidis*]) and late

leaf spot (*Phaeoisariopsis personata* [*M. berkeleyi*]) were recorded 15 days after the 3rd spray on a 1-9 scale. Six different fungicides were tested. Percentage disease index was calculated along with dry pod and haulm yields, and a cost-benefit analysis was conducted taking into account the cost of fungicides used and market price of the produce. All fungicides reduced the severity of leaf spots and increased pod yield. Difenoconazole (0.1%) was most effective followed by hexaconazole (0.1%) and chlorothalonil (0.2%).

Johnson and Subramanyam (2003) conducted a field experiments during the 1998 and 1999 kharif seasons in Anantapur, Andhra Pradesh, India, on groundnut cv. TMV 2 to determine the efficacy of triazole fungicides against late leaf spot (LLS; *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) and rust (*Puccinia arachidis*). The treatments comprised foliar spraying of propiconazole; tricyclazole; hexaconazole; penconazole; triadimefon; propiconazole + penconazole; propiconazole + triadimefon; and control, at 60 and 75 days after sowing. The lowest disease index for LLS (18.8%) and rust (18.5%) was obtained with hexaconazole treatments. In addition, hexaconazole-treated plants showed the highest pod yield (1924 kg/ha), haulm yield (2123 kg/ha), chlorophyll content (0.050 mg/g), gross returns (Rs 19 240), net returns (Rs 8330), and cost: benefit ratio (1:6.75).

A field experiment was conducted by Gopal *et al.* (2003) in Andhra Pradesh, India during the rainy season of 1999-2000 to determine the efficacy of difenoconazole (0.1 and 0.05%), propiconazole (0.1 and 0.05%) and

chlorothalonil (0.25%), as well as of different combinations of tridemorph (0.1%), carbendazim (0.05%) and mancozeb (0.2%) in controlling late leaf spot (*Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) and rust (*Puccinia arachidis*) of groundnuts cv. JL 42. Difenoconazole (0.1%) treatment resulted in the highest mean yield (2150 kg/ha) followed by carbendazim (0.05%) + tridemorph (0.1%) treatment (2090 kg/ha). The incidence of late leaf spot and rust were lowest with the application of 0.05% carbendazim and 0.1% tridemorph, respectively. Cost: benefit ratio was highest (1:6.9) with 0.1% difenoconazole spraying 30, 50 and 70 days after sowing.

The efficacy of 0.3% Indofil M-45 [mancozeb], 0.3% Blitox 50 [copper oxychloride], 0.3% Kocide 101 [cupric hydroxide], 0.1% cover, 0.1% carbendazim, and 0.1% Saff in controlling *Leptosphaerulina crassiasca*, *Fusarium equiseti* and *Phoma microspora* infecting groundnuts from various locations in Orissa, India were studied by Rout *et al.* (2005). All the fungicides tested inhibited the growth of the pathogens at varying degrees. Kocide 101, Bavistin and Saff completely inhibited the growth of *L. crassiasca* and *P. microspora*, whereas except for Blitox 50, all 5 fungicides completely inhibited the growth of *E. equiseti*.

Subrata and Singh (2005) conducted an experiment during 2002-04 to evaluate the efficacy of 9 fungicides for the management of groundnut (cv. JL-24) foliar diseases under 'Tilla' land (upland) condition in Tripura, India. Nine fungicides, i.e. carbendazim (0.05%), copper oxychloride (COC; 0.2%), mancozeb (0.2%),

tridemorph (0.05%), hexaconazole (0.025%), Kitazin [iprobenfos] (0.10%), propiconazole (0.025%), Ridomil [metalaxyl] (0.2%) and wettable sulfur (0.2%), as well as 3 combinations of fungicide solutions, i.e. carbendazim + mancozeb, carbendazim + COC and carbendazim+tridemorph of 1:1 (v/v) ratio, were used. Early and late leaf spot (*Cercospora arachidicola* [*Mycosphaerella arachidis*] and *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) and rust (*Puccinia arachidis*) diseases affected the groundnut. Carbendazim was the most effective to control the leaf spot diseases, followed by propiconazole. However, carbendazim spray sharply increased the rust intensity. The most effective combination of fungicides for controlling both leaf spot and rust diseases was carbendazim + tridemorph. The pod yield was increased by 1.9, 4.1, 5.4, 6.7, 6.7, 8.0, 28.7, 32.2, 35.4, 37.3 and 40.5% over the control with the spray of COC, mancozeb, kitazin, wettable sulfur, hexaconazole, tridemorph, ridomyl, propiconazole, carbendazim, carbendazim + COC, carbendazim+mancozeb and carbendazim + tridemorph, respectively.

Gururaj *et al.* (2005a) carried out an experiment to identify bio-efficacy of six fungicides in the control of leaf spots and rust (*Cercospora arachidicola* [*Mycosphaerella arachidis*], *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*] and *Puccinia arachidis*) of groundnut (JL-24) and their effects on dry pod and fodder yield during kharif 2001 and 2002 in Karnataka, India. The maximum disease control with higher dry pod and fodder yield was observed in hexaconazole, difenoconazole and propiconazole treatments. The effectiveness of chlorothalonil treatment was also better compared to those of mancozeb and

carbendazim, although carbendazim was found fairly effective against leaf spots, and mancozeb showed better control of rust. High incremental cost: benefit ratio was observed with hexaconazole (1:4.72) followed by propiconazole (1:2.05), difenoconazole (1:1.29) and chlorothalonil (1:1.13).

Field experiments were conducted by Gururaj *et al.* (2005b) during the rainy seasons (June-October) of 2002 and 2003, in Raichur, Karnataka, India, to evaluate the efficacy of neem seed kernel extract (NSKE) in combination with chlorothalonil (C), hexaconazole (H), propiconazole (P) or difenoconazole (D) against groundnut rust caused by Puccinia arachidis. Fourteen treatment combinations were evaluated for the control of rust on groundnut cv. KRG-1. The first spray was given immediately after the appearance of rust pustules on lower leaves of the plant, i.e. 45 days after sowing, and two subsequent sprays were given at 10-day intervals. The spray solution used per plot was 1.0, 1.5 and 2.0 l for the first, second and third sprays, respectively. Observations on disease intensity were recorded 10 days after the third spray at natural epidemic conditions. All treatment combinations significantly reduced the severity of rust and increased pod yield compared with the untreated control. However, combination of hexaconazole with NSKE (H-N-H) showed the highest rust control (53.93%), followed by D-N-D (53.53%) and P-N-P (52.37%). These treatments also recorded the highest pod yields.

Culbreath *et al.* (2006) conducted a fungicide programme for the control of early leaf spot (*Cercospora arachidicola* [*Mycosphaerella arachidis*]) of groundnut in

Georgia, USA, typically consists of a full-season programme initiated approximately 30 days after planting (DAP) that includes 7 applications made on 14-day intervals. Field tests were conducted in Tifton and Plains, Georgia, in 2001 and 2002 to compare full-season and reduced programmes of pyraclostrobin (168 g a.i./ha), chlorothalonil (1.26 kg a.i./ha), and tebuconazole (227 g a.i./ha). Reduced fungicide programmes were achieved by delaying initial applications at 14-day intervals from approximately 30 DAP to 45 through 105 DAP, totalling from 6 to as low as 2 applications per season, respectively. In 2003 and 2004, full-season programmes of pyraclostrobin and chlorothalonil were compared to reduced programmes of pyraclostrobin. Reduced programmes that received 6 and 5 applications were achieved by delaying the initial applications from approximately 30 DAP to 45 and 60 DAP, respectively. In 2001 and 2002, the control of early leaf spot with pyraclostrobin was superior to that with chlorothalonil or tebuconazole within the respective initiation dates.

2.2 Spraying number of fungicides in controlling leaf spot and rust diseases of groundnut

Fungicides (carbendazim, thiophanate-methyl, mancozeb and captafol) were assessed by Gangopadhyay *et al.* (1996) for their ability to control early and late leaf spot, caused by *Cercospora arachidicola* [*Mycosphaerella arachidis*] and *Cercosporidium personatum* [*M. berkeleyi*], respectively, on groundnuts in Rajasthan, India. Fungicides were applied as seed treatments and then, subsequently, 3 sprays were applied at 15-d intervals following the appearance of disease. Seed germination was higher in treated seeds compared with untreated.

The ability of seed treatments of Bavistin [carbendazim], Captaf [captan], thiram, Bavistin + Captaf, Bavistin + thiram and spraying with Indofil-M45 [mancozeb + thiophanate-methyl] to control leaf spot of groundnuts caused by *Mycosphaerella berkeleyi* and *Didymosphaeria arachidicola* was determined by Dubey (1996). Treating seeds with Bavistin + Captaf and 3 sprays of Indofil-M45 was the most effective at controlling disease while maintaining high levels of germination and maximum yield.

Naidu and Rao (1997a) reported from field trials in Tirupati, Andhra Pradesh, India that late spot of groundnuts (caused by *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) was economically controlled using 3 sprays of 0.25% mancozeb + 0.1% carbendazim at 15-day intervals.

A weather-based spray schedule was deployed in the southern zone of Andhra Pradesh, India, to assist groundnut growers to provide effective control of late leaf spot caused by *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*] by Naidu and Rao (1997b). In field trials conducted at the Regional Agricultural Research Station, Tirupati, Andhra Pradesh, during 1992-94, 4 fungicidal sprays (carbendazim at 0.25%, difenoconazole at 0.05%, propiconazole at 0.1% and mancozeb (0.25%) + carbendazim (0.1%)) gave significant control of the disease on cultivar JL-24 and increased the pod yield. Two sprays of mancozeb + carbendazim gave the greatest disease control and highest pod yields, with a net incremental benefit cost ratio of 6.14.

Studies were undertaken by Das *et al.* (1997) at Hayatnagar Research Farm, Hyderabad, India, during kharif 1992-94, to explore the effectiveness of forecasting schemes in the chemical control (chlorothalonil) of leaf spot/Tikka disease of groundnut (*Arachis hypogaea*) caused by *Cercospora arachidicola* [*Mycosphaerella arachidis*] and *Cercosporidium personatum* [*M. berkeleyi*]. Data for the 3 years showed that on the basis of weather dependable spray schedule (WDSS) only 2 sprays were required to control the disease. It was concluded that WDSS can be used successfully where the disease is endemic and the variety sown is susceptible, to minimize the number of fungicidal sprays.

Field trials were conducted by Chandra *et al.* (1998) during the rainy seasons of 1993/94 in Meghalaya, India, for chemical control of groundnut leaf spot (caused by *C. arachidicola* [*Mycosphaerella arachidis*]) using a single spray. A fungicide mixture of carbendazim 0.05% + mancozeb 0.2% was applied, and spray timings varied from 30 to 80 days after sowing (DAS) (at 10-day intervals). Spray application reduced the percentage disease index in all treatments. A statistically significant increase in pod yield was obtained in treatments sprayed up to 50 DAS in 1993. Sprays at 40 DAS in 1993 and 50 DAS in 1994 gave maximum returns. The cost of the treatment did not vary significantly. The benefit to cost ratio of treatments ranged from 1.1 to 8.1 in 1993 and from 4.1 to 5.5 in 1994.

Jadeja *et al.* (1999) conducted field trials at Junagadh, Gujarat, India, in 1995-97 to assess the efficacy of difenoconazole and propiconazole at 0.0125% w/v, hexaconazole at 0.025% and epoxiconazole at 0.00625%, compared with

carbendazim at 0.025% and mancozeb at 0.2%, applied as foliar sprays at 30, 45 and 60 days post-emergence for control of early and late leaf spot (*Cercospora arachidicola* [*Mycosphaerella arachidis*] and *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*], respectively) and rust (*Puccinia arachidis*) in groundnuts. Results indicated that all the triazole fungicides reduced both rust and leaf spots, while carbendazim was effective against leaf spots and mancozeb against rust. Best control was achieved with hexaconazole and difenoconazole, and these treatments also gave best pod and fodder yields. The hexaconazole-treated plots gave a 71% higher pod yield and an 87% higher fodder yield than an untreated control. The highest net eturn of Rs. 9,793/ha was also achieved with this treatment.

In a field trial carried out by Patil *et al.* (1999) at Rahuri, Maharashtra in kharif [monsoon] 1995, dry matter accumulation, N, P and K uptake, kernel size, kernel protein and yield of groundnuts cv. JL-24 were significantly increased due to foliar spray of 5-30% methanol. Three foliar sprays of 20% methanol, applied at 30, 45 and 65 days after sowing, gave the highest plant growth, yield and quality of groundnut.

Four field experiments were conducted by Moraes *et al.* (2001) in Ribeira Preto and Pindorama, Sao Paulo, Brazil during 1996-97 to evaluate the efficiency of fungicides (chlorothalonil, tebuconazole, difenoconazole and propiconazole applied at the rates recommended for groundnuts) for the control of late leaf spot (caused by *Cercosporidium personatum* [*Mycosphaerella berkleyi*]) and scab

(caused by *Sphaceloma arachidis*) infection on groundnut cv. Tatu. Monitoring consisted of first foliar spraying during late leaf spot infection of 5-15% of the leaflets followed by foliar spraying at a minimum of 14-day intervals between applications. Leaf spot severity was evaluated, at 84-92 days after planting, with a specific scale ranging from 1 to 4 depending on the severity of the symptoms exhibited in stems and petioles. In the monitored system, the number of sprays was reduced by 1 to 3.

Trials were conducted by Gururaj *et al.* (2002) at Raichur, Karnataka, India, for two years during kharif 1995 and 1996. Highly susceptible cultivar JL 24 was subjected to fungicide spraying 30 days after emergence followed by two more spray applications at fortnightly intervals. Observations on disease intensity of early leaf spot (*Cercospora arachidicola* [*Mycosphaerella arachidis*]) and late leaf spot (*Phaeoisariopsis personata* [*M. berkeleyi*]) were recorded 15 days after the 3rd spray on a 1-9 scale. Six different fungicides were tested. Percentage disease index was calculated along with dry pod and haulm yields, and a cost-benefit analysis was conducted taking into account the cost of fungicides used and market price of the produce. All fungicides reduced the severity of leaf spots and increased pod yield.

Ombase *et al.* (2003) carried out a field experiment was conducted in Rahuri, Maharashtra, India, in 1997 to study the effect of foliar sprays of methanol at different concentrations (0, 10, 20 and 30%), applied at 30, 30+45, 45+60 and 30+45+60 days after sowing (DAS), on the growth, nutrient uptake and yield of

groundnut cv. B-95. Plant height, number of branches per plant, number of leaves per plant, chlorophyll content of leaves, nutrient uptake (N, P and K), number of pods per plant, pod yield, kernel yield and haulm yield increased with the increase in methanol concentration up to 20%, but decreased at higher methanol concentrations. Two foliar sprays of 20% methanol applied at 30+45 DAS recorded the highest plant growth, nutrient uptake and yield of summer groundnut.

A field experiment was conducted by Gopal *et al.* (2003) in Andhra Pradesh, India during the rainy season of 1999-2000 to determine the efficacy of difenoconazole (0.1 and 0.05%), propiconazole (0.1 and 0.05%) and chlorothalonil (0.25%), as well as of different combinations of tridemorph (0.1%), carbendazim (0.05%) and mancozeb (0.2%) in controlling late leaf spot (*Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) and rust (*Puccinia arachidis*) of groundnuts cv. JL 42. Difenoconazole (0.1%) treatment resulted in the highest mean yield (2150 kg/ha) followed by carbendazim (0.05%) + tridemorph (0.1%) treatment (2090 kg/ha). The incidence of late leaf spot and rust were lowest with the application of 0.05% carbendazim and 0.1% tridemorph, respectively. Cost : benefit ratio was highest (1:6.9) with 0.1% difenoconazole spraying 30, 50 and 70 days after sowing.

Field experiments were conducted by Johnson and Subramanyam (2003) during the 1998 and 1999 kharif seasons in Anantapur, Andhra Pradesh, India, on groundnut cv. TMV 2 to determine the efficacy of triazole fungicides against late

leaf spot (LLS; *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) and rust (*Puccinia arachidis*). The treatments comprised foliar spraying of propiconazole; tricyclazole; hexaconazole; penconazole; triadimefon; propiconazole + penconazole; propiconazole + triadimefon; and control, at 60 and 75 days after sowing. The lowest disease index for LLS (18.8%) and rust (18.5%) was obtained with hexaconazole treatments. In addition, hexaconazole-treated plants showed the highest pod yield (1,924 kg/ha), haulm yield (2,123 kg/ha), chlorophyll content (0.050 mg/g), gross returns (Rs. 19,240), net returns (Rs. 8,330), and cost: benefit ratio (1:6.75).

An experiment was conducted by Tiwari *et al.* (2005) during the rainy seasons of 1998 and 1999, in Chhattisgarh, India, to evaluate the effects of sowing date (15 and 25 June and 5, 15 and 25 July) on the appearance and development of groundnut leaf spot (caused by *Cercospora arachidicola* [*Mycosphaerella arachidis*] and *Cercosporidium personatum* [*M. berkeleyi*]) and to assess the economics of the number of fungicide sprays (one and two sprays of mancozeb at 0.2% applied at 15-day intervals) applied in different dates for the control of the disease. In both years, the disease appeared in the last week of August, first on early sown crops followed by late sown crops. The period of leaf spot disease development was longer in late sowing dates compared with early sowing dates. Economic analysis indicated that fungicide spraying in early sown crop was uneconomical because the reduction in pod yield due to the disease was not significant. In contrast, two sprays, or even only one spray, were economical for late sown crops.

Kishore and Pande (2005) reported that extracts of *D. metel* (25 g/L) and *L. inermis* (50 g/L) applied as a prophylactic spray reduced the frequency of LLS lesions and rust pustules by 65-74% compared with controls. In field studies, program of four sprays of *D. metel* leaf extract at 45, 60, 75 and 90 days after sowing (DAS) was partially effective against the foliar diseases (LLS and rust) up to 95 DAS. A single spray of chlorothalonil at 45 DAS combined with three sprays of *D. metel* at 60, 75 and 90 DAS effectively reduced the combined severity of LLS and rust. The increase in pod yield by this treatment (91% over control) was comparable with the sustained application of chlorothalonil.

Field experiments were conducted by Gururaj *et al.* (2005b) during the rainy seasons (June-October) of 2002 and 2003, in Raichur, Karnataka, India, to evaluate the efficacy of neem seed kernel extract (NSKE) in combination with chlorothalonil (C), hexaconazole (H), propiconazole (P) or difenoconazole (D) against groundnut rust caused by *Puccinia arachidis*. Fourteen treatment combinations were evaluated for the control of rust on groundnut cv. KRG-1. The first spray was given immediately after the appearance of rust pustules on lower leaves of the plant, i.e. 45 days after sowing, and two subsequent sprays were given at 10-day intervals. The spray solution used per plot was 1.0, 1.5 and 2.0 l for the first, second and third sprays, respectively. Observations on disease intensity were recorded 10 days after the third spray at natural epidemic conditions. All treatment combinations significantly reduced the severity of rust and increased pod yield compared with the untreated control. These treatments also recorded the highest pod yields.

An experiment was conducted by Subrata and Singh (2005) during 2002-04 to evaluate the efficacy of 9 fungicides for the management of groundnut (cv. JL-24) foliar diseases under 'Tilla' land (upland) condition in Tripura, India. Nine fungicides, i.e. carbendazim (0.05%), copper oxychloride (COC; 0.2%), mancozeb (0.2%), tridemorph (0.05%), hexaconazole (0.025%), Kitazin [iprobenfos] (0.10%), propiconazole (0.025%), Ridomil [metalaxyl] (0.2%) and wettable sulfur (0.2%), as well as 3 combinations of fungicide solutions, i.e. carbendazim + mancozeb, carbendazim + COC and carbendazim + tridemorph of 1:1 (v/v) ratio, were used. The fungicides were applied thrice as spray at 30. 45 and 60 days of crop age after sowing at the rate of 1 l/5 m^2 plot. Diseases were recorded in 1-9 scale at 15 and 30 days after the last spray of the fungicides. Early and late leaf spot (*Cercospora arachidicola* [*Mycosphaerella arachidis*] and *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) and rust (*Puccinia arachidis*) diseases affected the groundnut. Increase in rust was observed with propiconazole after 15 and 30 days of the last spray. This study suggests that up to 45 days of crop age, for carbendazim (0.05%) or any other leaf spot-controlling fungicide, it is enough to spray one or 2 sprays of the combined solutions of carbendazim and tridemorph and carbendazim and mancozeb at 60 days onwards at 15 days interval to suppress the prevailing diseases.

Culbreath *et al.* (2006) carried out an experiment with a fungicide program for the control of early leaf spot (*Cercospora arachidicola* [*Mycosphaerella arachidis*]) of groundnut in Georgia, USA, typically consists of a full-season programme initiated approximately 30 days after planting (DAP) that includes 7 applications

made on 14-day intervals. Field tests were conducted in Tifton and Plains, Georgia, in 2001 and 2002 to compare full-season and reduced programmes of pyraclostrobin (168 g a.i./ha), chlorothalonil (1.26 kg a.i./ha), and tebuconazole (227 g a.i./ha). Reduced fungicide programmes were achieved by delaying initial applications at 14-day intervals from approximately 30 DAP to 45 through 105 DAP, totalling from 6 to as low as 2 applications per season, respectively. Fungicide programmes had no effect on yield at Plains in 2001 or Tifton in 2002. At Tifton in 2001 and Plains in 2002, yield decreased according to quadratic functions of time of spray initiation, with no indication of yield reduction until fungicide programmes were initiated after 60 to 70 DAP.

Gururaj and Srikant (2006) conducted a field studies were in Raichur, Karnataka, India, during the 2002 and 2003 kharif seasons, to assess the pod and haulm yield losses due to rust (*Puccinia arachidis*) using hexaconazole 5%EC in susceptible (KRG-1) and moderately resistant (K-134) groundnut cultivars. Comparatively lower disease index with increase in pod and haulm yield and also maximum benefit cost ratio (BCR) were recorded in plots receiving 3 sprays of hexaconazole in KRG-1 and 2 sprays of the same fungicide in K-134 with average pod yield loss of 40.20 and 34.00%, respectively.

A study was conducted by Satish *et al.* (2007) during 2004 and 2005 in Meghalaya, India, to manage the early leaf spot disease (*Cercospora arachidicola* [*Mycosphaerella arachidis*]) of groundnut (*Arachis hypogaea* cv. JL 24) by minimum application of fungicides and plant based chemicals. Maximum control

was recorded by Dithane M-45 + Bavistin (40.2%) and Saaf (39.1%) with a cost : benefit ratio of 1:2.85 and 1:2.67, respectively. It is evident from the findings that early leaf spot can be effectively and economically managed by single spraying of either Dithane M-45 + Bavistin or Saaf under rainfed conditions in hills where late leaf spot and rust are not major problems.

2.3 Salicylic acid on leaf spot and rust of groundnut

Santosh (1995) carried out an experiment with three phenolic compounds: salicylic acid (monophenol), caffeic acid (diphenol), and tannic acid (polyphenol) in field trials (1990-92) on groundnuts cv. Chandra at 2 stages (anthesis and/or pod filling) at 2 rates (20 and 40 ppm. for salicylic acid, and 50 and 100 ppm for caffeic and tannic acids). Salicylic acid at 100 ppm gave the best results with a pod yield of 47 q/ha and a 100-grain weight of 68.7 g. Oil content was 2.7%, oil yield 43.8% and protein content 5.2%. Maximum linoleic acid content (23.4%) was obtained with two 40 ppm salicylic acid sprays. There was no effect on the saturated fatty acid contents. The keeping quality of the oil was improved by the 100 ppm treatment.

An experiment was conducted by Sathiyabama and Balasubramanian (1999) with prior treatment of groundnut leaves with salicylic acid showed a reduction in the number of rust pustules, urediospores/pustule and delay in the development of rust disease. New polypeptides appeared in the intercellular space of groundnut leaves treated with salicylic acid. Enzyme activity staining on PAGE and western blot analysis showed a new isoform of glucanase in the treated groundnut leaves. It is

concluded that enhanced activities of intercellular chitinase and glucanase of treated leaves may be associated with induced resistance responses in groundnut plants against rust disease.

The effect of salicylic acid (SA) on the induction of resistance in groundnut against late leaf spot caused by *C. personatum* [*Mycosphaerella berkeleyi*] was investigated by Meena *et al.* (2001). Foliar application of SA at a concentration of 1 mM significantly reduced late leaf spot disease intensity and increased the pod yield under greenhouse conditions. Changes in the activities of phenylalanine ammonia-lyase, chitinase, beta-1, 3-glucanase, peroxidase, polyphenol oxidase [catechol oxidase] and in the contents of phenolic compounds in groundnut after application of SA and inoculation with *C. personatum* were measured. In SA-treated leaves, an increase in phenolic content was observed one day after challenge inoculation with *C. personatum*. The maximum increase in phenylalanine ammonia-lyase activity was observed 4 days after challenge inoculation with *C. personatum* in groundnut leaves pre-treated with SA. Marked increase in chitinase and beta -1,3-glucanase activities was observed in response to pathogen inoculation in SA-treated leaves. In SA-treated plants, an increase in peroxidase and polyphenol oxidase activities was observed upon challenge inoculation with pathogen. Foliar application of SA induced the accumulation of a 25-kDa thaumatin-like protein and a 30-kDa beta -1,3-glucanase in groundnut..

Chung *et al.* (2003) investigated resveratrol content and resveratrol synthase [*trihydroxystilbene synthase*] (RS) gene expression in response to various stresses

and hormones to understand the mode of resveratrol synthesis in groundnut plants. Resveratrol was present in substantial amounts (1.2-2.6 micro g/g fresh weight (FW)) in leaves, roots, and shells, but very little (0.05-0.06 micro g/g FW) was found in developing seeds and seed coats of field (Chonbuk, Korea Republic)-grown groundnuts (cv. Jinpoong). Accumulation of resveratrol in leaves increased over 200-fold in response to UV light (1.35 micro E/(m^2/s)), over 20-fold in response to paraquat (0.1 mM), and between two- and ninefold in response to wounding, H2O2 (5 mM), salicylic acid (SA, 10 mM), jasmonic acid (0.7 mM) and ethephon (5 mM), 24 h after treatment. No accumulation of resveratrol was induced by abscisic acid (100 micro M). Changes in resveratrol content were correlated with levels of RS mRNA, indicating a transcriptional control of RS activity. The results suggest that resveratrol synthesis is induced by biotic and abiotic factors through the regulation of RS transcription, and that stress hormones such as SA and ethylene are involved in the RS gene expression in groundnut.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Bangladesh Agricultural Research Institute (BARI), Gazipur during the period from November 2007 to April 2008 to find out the effect of fungicide and salicylic acid for controlling leaf spot and rust diseases of groundnut. The details of the materials and methods that used to conduct the experiment are presented below:

3.1 Description of the experimental site

3.1.1 Location

The present piece of research work was conducted at the experimental field of Bangladesh Agricultural Research Institute (BARI), Gazipur during the period of rabi season month of November 2007 to April 2008.

3.1.2 Climate

Details of the metrological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh Agricultural Research Institute, Gazipur and have been presented in Appendix I.

3.1.3 Soil

The soil of the experimental area was loamy and belongs to the Madhupur tract (UNDP, 1988) under AEZ 28. The selected plot was medium high land. The characteristics of the soil under the experimental plot were analyzed and details of the soil characteristics are presented in Appendix II.

3.2 Test crop and its characteristics

Seeds of susceptible variety Dhaka-1 (Myschar Badam) were selected for this experiment. This variety was developed at the Bangladesh Agricultural Research Institute in the year of 1976. The plant height of this variety is 30-40 cm and life cycle 140-150 days for robi season and 120-130 days for kharif season cultivation.

3.3 Experimental details

Consequently three experiments were conducted to find out the effective and economic control measure for leaf spot and rust diseases of groundnut under the filed condition.

3.3.1 Experiment-1: Evaluation of fungicides in controlling leaf spot and rust diseases of groundnut

The experiment comprised of the following treatments-

T_1: Predator (propiconazole, 0.5 ml/L)

T_2: Blezole (hexaconazole, 1 ml/L)

T_3: Magnate (mancozeb, 500-625 g/ha)

T_4: Cluster (mancozeb+carbendazim, 2 g/L)

T_5: Ezeb (mancozeb, 1 g/L)

T_6: Detail (hexaconazole, 0.5 ml/L)

T_7: Tall (propiconazole, 0.5 ml/L)

T_8: Contaf (hexaconazole, 1 ml/L)

T_9: Control

3.3.2 Experiment-2: Minimum spray of fungicides in controlling leaf spot and rust diseases of groundnut

The experiment comprised of the following treatments-

T_1: One spray at 105 DAS (Blezole)

T_2: One spray at 105 DAS (Contaf)

T_3: Two spray at 105 and 120 DAS (Blezole)

T_4: Two spray at 105 and 120 DAS (Contaf)

T_5: Three spray at 90, 105 and 120 DAS (Blezole)

T_6: Three spray at 90, 105 and 120 DAS (Contaf)

T_7: Control

3.3.3 Experiment-3: Effect of Salicylic Acid in controlling leaf spot and rust diseases of groundnut

The experiment comprised of the following treatments-

T_1: Control

T_2: 0.5 mM salicylic acid foliar spray

T_3: 1.0 mM salicylic acid foliar spray

T_4: 1.5 mM salicylic acid foliar spray

3.3.4 Experimental design and layout

All of the three experiments were laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing all of the treatments.

3.3.4.1 Experiment-1

The experiment consists of total 27 plots of size 3.0 m × 2.5 m in each of 3 replications. All the 9 treatment of the experiment was assigned at random into 9 plots of each replication.

3.3.4.2 Experiment-2

The experiment consists of total 21 plots of size 3.0 m × 2.5 m in each of 3 replications. All the 7 treatment of the experiment was assigned at random into 7 plots of each replication.

3.3.4.3 Experiment-3

The experiment consists of total 12 plots of size 3.0 m × 2.5 m in each of 3 replications. All the 4 treatment of the experiment was assigned at random into 4 plots of each replication.

3.4 Growing of crops

3.4.1 Preparation of the main field

The experiment plot was opened in the second week of November 2007 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for groundnut seed sowing.

3.4.2 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of Urea, TSP, MP, Gypsum, Zinc sulphate and borax, respectively were applied. The entire amount of TSP, MP,

Gypsum, Zinc sulphate and borax were applied during the final preparation of land. Urea was applied in two equal installments at final land preparation and before flowering after 45 days of seeds sowing. The dose and method of application of fertilizer are shown in Table 1.

Table 3.1. Dose and method of application of fertilizers in groundnut field

Fertilizers	Dose (kg/ha)	Application (%)	
		Basal	1st installment
Urea	30	50	50
TSP	170	100	--
MP	90	100	--
Gypsum	180	100	--
Znic sulphate	5	100	
Borax	10	100	--

Source: BARI 2005, Joydebpur, Gazipur

3.4.3 After care

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the groundnut plant.

3.4.3.1 Irrigation and drainage

No irrigation was provided but it was arranged well drained facilities as prevention process of removing rain water if any.

3.4.3.2 Weeding

Weeding was done in the field to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at flowering stage by mechanical means.

3.4.3.3 Top dressing

After basal dose, the remaining doses of urea were top-dressed at 45 days after sowing before flowering. The fertilizers were applied on both sides of the rows with the soil.

3.4.3.4 Earthing up

Earthing up was done during the period of flowering at 45 days after sowing groundnut seeds.

3.5 Harvesting, threshing and cleaning

The groundnut was harvested at the maturity of plant and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of groundnut pod. The pods were cleaned and finally the weight was calculated and converted into per hectare yield.

3.6 Data recording

Data were recorded on the following parameters-

3.6.1 Leaf spot disease

Disease data were recorded for estimating leaf spot disease on the basis of 0-9 disease scoring scale at 90, 105 and 120 DAS and the scale is -

0: No spot/leaf	1: 1-5 spot/leaf
2: 6-10 spots/leaf	3: 11-20 spots/leaf
4: 21-30 spots/leaf	5: 21-30 spots/leaf
6: 31-40 spots/leaf	7: 41-60 spots/leaf
8: 61-80 spots/leaf	9: 81-100 spots/leaf

3.6.2 Rust disease

Disease data were recorded for estimating rust disease on the basis of 0-9 disease scoring scale at 90, 105 and 120 DAS and the scale is -

0: No spot/leaf	1: 1-5 spot/leaf
2: 6-10 spots/leaf	3: 11-20 spots/leaf
4: 21-30 spots/leaf	5: 21-30 spots/leaf
6: 31-40 spots/leaf	7: 41-60 spots/leaf
8: 61-80 spots/leaf	9: 81-100 spots/leaf

3.6.3 Plant height

Height of plant refers to the length of the plant from ground level up to the tip of the longest leaf and it measured in cm at harvest.

3.6.4 Number of branches per plant

Number of branches produced in each plant was recorded by counting all the branches of each plant. It was measured in number at harvest.

3.6.5 Percent of normal pods

Five plants from each unit plot were randomly selected at the time of harvest and counted the total number of normal pods then the percentage of normal pods were calculated by the following formula-

$$\text{Percent normal pods} = \frac{\text{Normal pods}}{\text{Total pods}} \times 100$$

3.6.6 Percent of abnormal pods

Five plants from each unit plot were randomly selected at the time of harvest and counted the total number of abnormal pods then the percentage of abnormal pods were calculated by the following formula-

$$\text{Percent abnormal pods} = \frac{\text{Abnormal pods}}{\text{Total pods}} \times 100$$

3.6.7 Weight of 1000 pods

One thousand seeds were counted randomly from the total cleaned harvested pods of each individual plot and then weighed the seeds in a weighing machine and recorded.

3.6.8 Pod yield

Pod obtained from each unit plot were sun-dried and weighed carefully with the help a weighing machine. The dry weight of pods per unit was calculated and the pod yield plot^{-1} was converted to t ha^{-1}.

3.7 Statistical Analysis

The data related to disease incidence and different yield contributing characters were statistically analyzed to observe the significant difference among the treatment. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to find out the effective and economic control measure for leaf spot and rust diseases of groundnut. Consequently three experiments were conducted. Data on disease severity and yield contributing characters and yield was recorded. The analyses of variance (ANOVA) of the data on different parameters are given in Appendix III-VIII. The results have been presented and discussed, and possible interpretations have been given experiment wise under the following headings:

4.1 Experiment-1: Evaluation of fungicides in controlling leaf spot and rust diseases of groundnut

4.1.1 Leaf spot disease

Disease data were recorded for estimating leaf spot disease on the basis of 0-9 disease scoring scale at 90, 105 and 120 DAS and found significant variation for different treatment (Appendix III). At 90, 105 and 120 DAS the minimum disease severity (1.00%, 2.10% and 2.47%) was recorded from T_8 [contaf (hexaconazole, 1 ml/L)] which was similar (1.05%, 2.25% and 2.80%) with T_2 [blezole (hexaconazole, 1 ml/L)]. On the other hand the maximum disease severity (4.60%, 6.15% and 7.60%) was found from T_9 i.e. control (Table 4.1.1) which was statistically identical (2.53%, 3.70% and 5.80%), respectively with T_7 [tall (propiconazole, 0.5 ml/L)]. Gangopadhyay *et al.* (1996) reported that 0.2% of 1 of 3 carbendazim formulations or thiophanate methyl + foliar application of 0.1% of these fungicides were the most effective in reducing leaf spots.

Table 4.1.1. Efficiency of fungicides in controlling leaf spot diseases of groundnut

Treatment	Leaf spot disease severity (0-9 scale) at		
	90 DAS	105 DAS	120 DAS
T_1	1.20 f	2.30 ef	5.00 c
T_2	1.05 f	2.25 ef	2.80 fg
T_3	1.18 f	2.60 de	3.40 ef
T_4	1.80 d	3.00 c	4.20 d
T_5	1.40 e	2.75 cd	3.80 de
T_6	2.20 c	3.05 c	3.67 de
T_7	2.53 b	3.70 b	5.80 b
T_8	1.00 f	2.10 f	2.47 g
T_9	4.60 a	6.15 a	7.60 a
$LSD_{(0.05)}$	0.319	0.355	0.641
CV(%)	12.10	7.08	8.83

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

T_1: Predator (propiconazole, 0.5 ml/L)

T_2: Blezole (hexaconazole, 1 ml/L)

T_3: Magnate (mancozeb, 500-625 g/ha)

T_4: Cluster (mancozeb+carbendazim, 2 g/L)

T_5: Ezeb (mancozeb, 1 g/L)

T_6: Detail (hexaconazole, 0.5 ml/L)

T_7: Tall (propiconazole, 0.5 ml/L)

T_8: Contaf (hexaconazole, 1 ml/L)

T_9: Control

4.1.2 Rust disease

Disease data was recorded for estimating rust disease on the basis of 0-9 disease scoring scale at 90, 105 and 120 DAS and recorded significant variation for different treatment (Appendix III). At 90, 105 and 120 DAS the minimum disease severity (1.85%, 4.05% and 3.00%) was recorded from T_8 [contaf (hexaconazole, 1 ml/L)] which was similar (2.00%, 4.35% and 3.20%) with T_2 [blezole (hexaconazole, 1 ml/L)]. On the other hand the maximum disease severity (5.40%, 8.25% and 9.60%) was found from T_9 i.e. control (Table 4.1.2) which was statistically identical (3.13%, 6.10% and 6.40%), respectively with T_7 [tall (propiconazole, 0.5 ml/L)]. Gopal *et al.* (2003) reported that rust were lowest with the application of fungicides in groundnut.

4.1.3 Plant height

Plant height of groundnut differs significantly due to the application of different fungicide (Appendix IV). The tallest plant (43.10 cm) was found from T_8 [contaf (hexaconazole, 1 ml/L)] which was similar (42.75 cm) with T_2 [blezole (hexaconazole, 1 ml/L)], whereas the shortest plant (35.82 cm) was obtained from T_9 i.e. control (Table 4.1.3) which was statistically identical (38.60 cm) with T_7 [tall (propiconazole, 0.5 ml/L)]. From the findings it was revealed that contaf and blezole reduced the severity of leaf spot and rust diseases of groundnut that helps in plant elongation with ensuring maximum photosynthesis and vegetative growth of groundnut and the ultimate results was the longest plant for the application of hexaconazole fungicides.

Table 4.1.2. Efficiency of fungicides in controlling rust diseases of groundnut

Treatment	Rust disease severity (0-9 scale) at		
	90 DAS	105 DAS	120 DAS
T_1	2.05 d	4.45 ef	3.80 e
T_2	2.00 d	4.35 ef	3.20 f
T_3	2.20 cd	4.85 de	4.00 de
T_4	2.95 b	5.50 bcd	4.40 d
T_5	2.25 cd	5.85 bc	4.20 de
T_6	2.55 c	5.20 cd	5.20 c
T_7	3.13 ab	6.10 b	6.40 b
T_8	1.85 d	4.05 f	3.00 f
T_9	5.40 a	8.25 a	9.60 a
$LSD_{(0.05)}$	0.371	0.668	0.402
CV(%)	8.64	7.30	4.79

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

T_1: Predator (propiconazole, 0.5 ml/L)

T_2: Blezole (hexaconazole, 1 ml/L)

T_3: Magnate (mancozeb, 500-625 g/ha)

T_4: Cluster (mancozeb+carbendazim, 2 g/L)

T_5: Ezeb (mancozeb, 1 g/L)

T_6: Detail (hexaconazole, 0.5 ml/L)

T_7: Tall (propiconazole, 0.5 ml/L)

T_8: Contaf (hexaconazole, 1 ml/L)

T_9: Control

Table 4.1.3. Efficiency of fungicides on yield contributing characters and yield of groundnut

Treatment	Plant height (cm)	Normal pods (%)	Abnormal pods (%)	Yield (t/ha)
T_1	40.00 ab	89.61 b	10.39 fg	2.12 bc
T_2	42.75 ab	89.73 b	10.27 fg	2.13 b
T_3	42.50 ab	88.45 c	11.55 ef	1.63 e
T_4	40.80 ab	86.52 e	13.48 cd	1.90 bcd
T_5	40.95 ab	87.30 d	12.70 de	1.85 cd
T_6	42.10 ab	85.33 f	14.67 bc	1.75 de
T_7	38.60 bc	84.13 g	15.87 b	1.45 f
T_8	43.10 a	90.57 a	9.43 g	2.38 a
T_9	35.82 c	82.29 h	17.71 a	1.40 f
$LSD_{(0.05)}$	3.954	0.782	1.730	0.164
CV(%)	5.61	6.22	7.59	5.78

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

T_1: Predator (propiconazole, 0.5 ml/L)

T_2: Blezole (hexaconazole, 1 ml/L)

T_3: Magnate (mancozeb, 500-625 g/ha)

T_4: Cluster (mancozeb+carbendazim, 2 g/L)

T_5: Ezeb (mancozeb, 1 g/L)

T_6: Detail (hexaconazole, 0.5 ml/L)

T_7: Tall (propiconazole, 0.5 ml/L)

T_8: Contaf (hexaconazole, 1 ml/L)

T_9: Control

4.1.4 Number of branches per plant

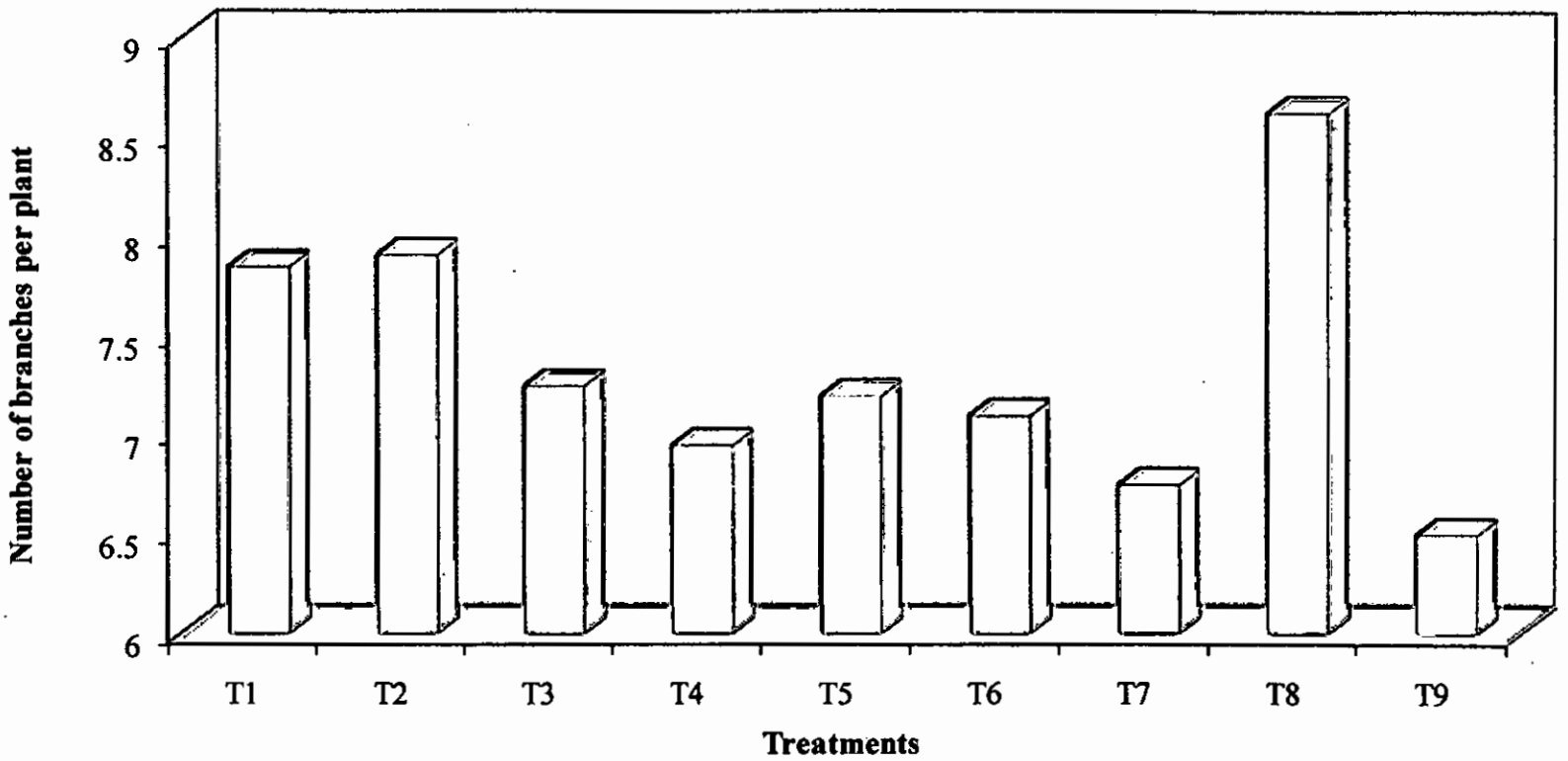
Application of different fungicide markedly influenced the number of branches per plant of groundnut (Appendix IV). The maximum number of branches per plant (8.63) was obtained from T_8 [contaf (hexaconazole, 1 ml/L)] which was followed (7.91) by T_2 [blezole (hexaconazole, 1 ml/L)], while the minimum number (6.50) was recorded from T_9 i.e. control (Figure 1.1) which was statistically identical (6.75) with T_7 [tall (propiconazole, 0.5 ml/L)]. From the findings it was revealed that contaf and blezole reduced the severity of leaf spot and rust diseases that ensures maximum number of branches per plant.

4.1.5 Percentage of normal pods

Percentage of normal pods of groundnut varied significantly for the application of different fungicide (Appendix IV). The maximum number of normal pods (90.57%) was recorded from T_8 [contaf (hexaconazole, 1 ml/L)] which was similar (89.73%) with T_2 [blezole (hexaconazole, 1 ml/L)], whereas the minimum (82.29%) was found from T_9 i.e. control (Table 4.1.3) which was statistically identical (84.13%) with T_7 [tall (propiconazole, 0.5 ml/L)]. Findings it was revealed that contaf and blezole produced the highest percentage of normal pods.

4.1.6 Percent of abnormal pods

Significant difference was recorded for abnormal pods of groundnut for the application of different fungicide (Appendix IV). The minimum abnormal pods (9.43%) was found from T_8 [contaf (hexaconazole, 1 ml/L)] which was similar (10.27%) with T_2 [blezole (hexaconazole, 1 ml/L)], while the maximum abnormal



T_1: Predator (propiconazole, 0.5 ml/L)
T_2: Blezole (hexaconazole, 1 ml/L)
T_3: Magnate (mancozeb, 500-625 g/ha)
T_4: Cluster (mancozeb+carbendazim, 2 g/L)
T_5: Ezeb (mancozeb, 1 g/L)
T_6: Detail (hexaconazole, 0.5 ml/L)
T_7: Tall (propiconazole, 0.5 ml/L)
T_8: Contaf (hexaconazole, 1 ml/L)
T_9: Control

Figure 1.1. Efficiency of fungicides on the number of branches per plant of groundnut

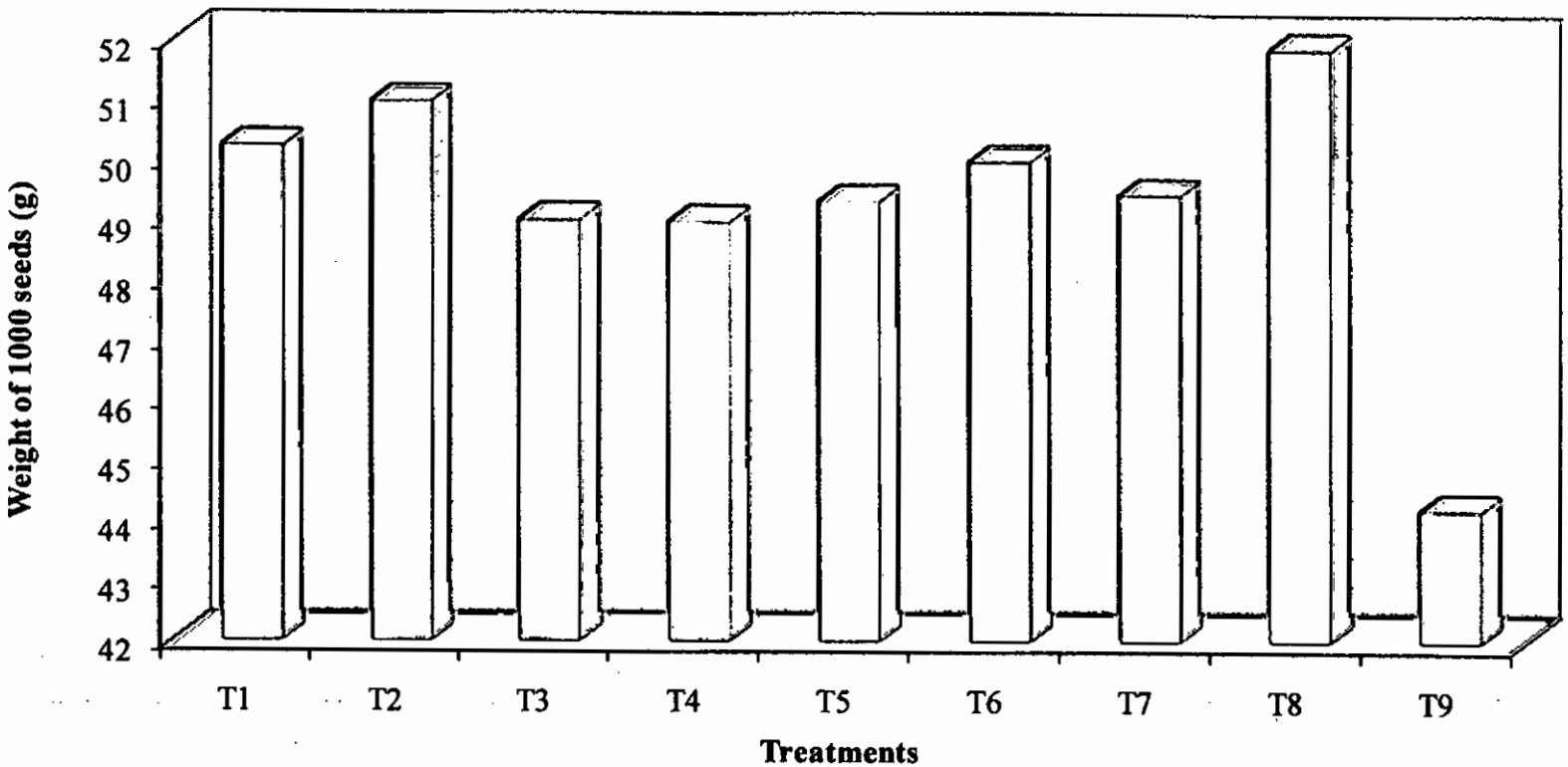
pods (17.71%) was recorded from T_9 i.e. control (Table 4.1.3) which was followed (15.87%) by T_7 [tall (propiconazole, 0.5 ml/L)].

4.1.7 Weight of 1000 seeds

Weight of 1000 seeds of groundnut showed statistically significant differences due to the application of different fungicide (Appendix IV). The highest weight of 1000 seeds (51.90 g) was recorded from T_8 [contaf (hexaconazole, 1 ml/L)] which was similar (51.00 g) with T_2 [blezole (hexaconazole, 1 ml/L)], again the lowest weight of 1000 seeds (44.20 g) was observed from T_9 i.e. control (Figure 1.2) which was statistically identical (49.00 g) with T_7 [tall (propiconazole, 0.5 ml/L)].

4.1.8 Pod yield

Statistically significant variation was recorded in terms of pod yield per hectare of groundnut due to the application of different fungicide (Appendix IV). The highest yield (2.38 t/ha) was found from T_8 [contaf (hexaconazole, 1 ml/L)] which was followed (2.13 t/ha) by T_2 [blezole (hexaconazole, 1 ml/L)], and the lowest yield (1.40 t/ha) was recorded from T_9 i.e. control (Table 4.1.3) which was followed (1.63 /ha) by T_7 [tall (propiconazole, 0.5 ml/L)]. From the findings it was revealed that contaf and blezole reduced the severity of leaf spot and rust diseases of groundnut that helps to plant elongation with ensuring maximum growth and the ultimate results was highest yield per hectare with maximum benefit. Jadeja *et al.* (1999) reported that hexaconazole-treated plots gave a 71% higher pod yield. Gururaj *et al.* (2002) reported that application of fungicides reduced the severity of leaf spots and increased pod yield.



T_1: Predator (propiconazole, 0.5 ml/L)
T_2: Blezole (hexaconazole, 1 ml/L)
T_3: Magnate (mancozeb, 500-625 g/ha)
T_4: Cluster (mancozeb+carbendazim, 2 g/L)
T_5: Ezeb (mancozeb, 1 g/L)
T_6: Detail (hexaconazole, 0.5 ml/L)
T_7: Tall (propiconazole, 0.5 ml/L)
T_8: Contaf (hexaconazole, 1 ml/L)
T_9: Control

Figure 1.2. Efficiency of fungicides on the weight of 1000 seeds of groundnut

4.2 Experiment-2: Minimum spray of fungicides in controlling leaf spot and rust diseases of groundnut

4.2.1 Leaf spot disease

Disease data were recorded for estimating leaf spot on the basis of 0-9 disease scoring scale at 90, 105 and 120 DAS and found significant differences for different treatment under the trial (Appendix V). At 90, 105 and 120 DAS the minimum disease severity (1.14%, 1.21% and 1.90%) was recorded from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was statistically similar (1.16%, 1.37% and 2.14%)) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], whereas the maximum disease severity (3.30%, 4.51% and 7.93%)) was recorded from T_7 i.e. control (Table 4.2.1) which was statistically identical (1.29%, 1.45% and 3.79%) with T_1 [one spray at 105 DAS (blezole)]. Naidu and Rao (1997a) reported that late spot of groundnuts (caused by *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) was economically controlled using 3 sprays of 0.25% mancozeb + 0.1% carbendazim at 15-day intervals.

4.2.2 Rust disease

Disease data were recorded for estimating rust spot on the basis of 0-9 disease scoring scale at 90, 105 and 120 DAS and found significant differences for different treatment (Appendix V). At 90, 105 and 120 DAS the minimum disease severity (2.36%, 3.22 % and 1.90%) was recorded from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was similar (2.95%, 5.13% and 5.55%)) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], whereas the maximum (4.49%, 6.15% and 9.73%) was recorded from T_7 i.e. control (Table 4.2.2) which was

Table 4.2.1. Effect of minimum number of fungicides spray in controlling leaf spot diseases of groundnut

Treatment	Leaf spot disease severity (0-9 scale) at		
	90 DAS	105 DAS	120 DAS
T_1	1.29 b	1.45 b	3.79 b
T_2	1.28 b	1.44 b	3.99 b
T_3	1.22 bc	1.42 bc	3.98 b
T_4	1.20 bc	1.40 bc	3.83 b
T_5	1.16 c	1.37 c	2.14 c
T_6	1.14 c	1.21 d	1.90 c
T_7	3.30 a	4.51 a	7.93 a
$LSD_{(0.05)}$	0.094	0.066	0.532
CV(%)	4.90	5.41	9.00

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

T_1: One spray at 105 DAS (Blezole) T_2: One spray at 105 DAS (Contaf)

T_3: Two spray at 105 and 120 DAS (Blezole) T_4: Two spray at 105 and 120 DAS (Contaf)

T_5: Three spray at 90, 105 and 120 DAS (Blezole) T_6: Three spray at 90, 105 and 120 DAS (Contaf)

T_7: Control

Table 4.2.2. Effect of minimum number of fungicides spray in controlling rust diseases of groundnut

Treatment	Rust disease severity (0-9 scale) at		
	90 DAS	105 DAS	120 DAS
T_1	3.85 ab	6.03 a	7.59 b
T_2	3.53 ab	5.95 ab	7.58 b
T_3	3.35 abc	5.62 bc	7.26 b
T_4	2.88 bc	5.38 cd	6.86 c
T_5	2.95 bc	5.13 d	5.55 d
T_6	2.36 c	3.22 e	4.01 e
T_7	4.49 a	6.15 a	9.73 a
$LSD_{(0.05)}$	1.060	0.365	0.239
CV(%)	11.35	9.73	11.91

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

T_1: One spray at 105 DAS (Blezole) T_2: One spray at 105 DAS (Contaf)

T_3: Two spray at 105 and 120 DAS (Blezole) T_4: Two spray at 105 and 120 DAS (Contaf)

T_5: Three spray at 90, 105 and 120 DAS (Blezole) T_6: Three spray at 90, 105 and 120 DAS (Contaf)

T_7: Control

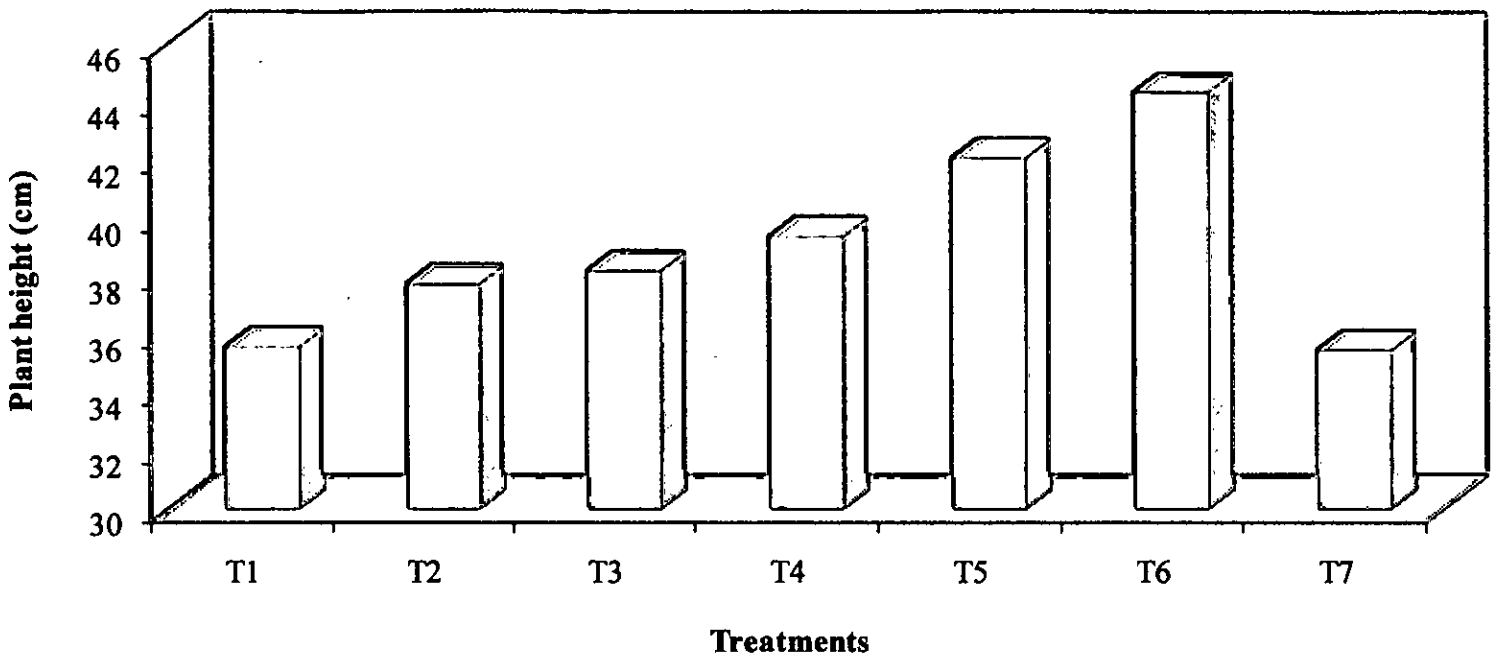
statistically identical (3.85%, 6.03% and 7.59%) with T_1 [one spray at 105 DAS (blezole)]. Gopal *et al.* (2003) reported that rust were lowest with the three application of 0.05% carbendazim and 0.1% tridemorph, respectively.

4.2.3 Plant height

Number of fungicides sprays markedly influenced plant height of groundnut (Appendix VI). The tallest plant (44.39 cm) was observed from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was statistically identical (42.12 cm) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], whereas the shortest plant (35.49 cm) was found from T_7 i.e. control (Figure 2.1) which was statistically identical (35.59 cm) with T_1 [one spray at 105 DAS (blezole)]. From the findings it was revealed that three spray of contaf reduced the severity of leaf spot and rust diseases of groundnut that helps to plant elongation with ensuring maximum photosynthesis and vegetative growth. Patil *et al.* (1999) reported that three foliar sprays of 20% methanol, applied at 30, 45 and 65 days after sowing, gave the highest plant growth of groundnut.

4.2.4 Number of branches per plant

Number of branches per plant of groundnut differs significantly due to number of fungicides spray (Appendix VI). The maximum number of branches per plant (8.56) was recorded from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was statistically similar (8.51) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], while the minimum number (5.08) was obtained in T_7 i.e. control (Table 4.2.3) which was statistically similar (6.85) with T_1 [one spray at 105 DAS



T_1: One spray at 105 DAS (Blezole)
T_2: One spray at 105 DAS (Contaf)
T_3: Two spray at 105 and 120 DAS (Blezole)
T_4: Two spray at 105 and 120 DAS (Contaf)
T_5: Three spray at 90, 105 and 120 DAS (Blezole)
T_6: Three spray at 90, 105 and 120 DAS (Contaf)
T_7: Control

Figure 2.1 Effect of minimum number of fungicides spray on plant height of groundnut

(blezole)]. From the findings it was revealed that three spray of contaf reduced the severity of leaf spot and rust diseases of groundnut that helps to produced maximum number of branches per plant.

4.2.5 Percentage of normal pods

Percentage of normal pods of groundnut differs significantly due to number of fungicides spray (Appendix VI). The highest normal pods (89.98%) were obtained from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was closely followed (88.15%) by T_5 [three spray at 90, 105 and 120 DAS (blezole)]. On the other hand, the lowest (86.55%) was recorded from T_7 i.e. control (Table 4.2.3) which was statistically identical (86.95%) with T_1 [one spray at 105 DAS (blezole)]. From the findings it was revealed that three spray of contaf reduced the severity of leaf spot and rust diseases of groundnut that helps to produced highest percentage of normal pods.

4.2.6 Percent of abnormal pods

Percentage of abnormal pods of groundnut varied significantly for the number of fungicides spray (Appendix VI). The lowest abnormal pods (10.02%) was observed from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was statistically similar (11.85%) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], while the highest (13.45%) was found from T_7 i.e. control (Table 4.2.3) which was statistically identical (13.05%) with T_1 [one spray at 105 DAS (blezole)].

Table 4.2.3. Effect of minimum number of fungicides spray on yield contributing characters and yield of groundnut

Treatment	Number of branches per plant	Normal pods (%)	Abnormal pods (%)	Weight of 1000 seeds (g)
T_1	6.85 d	86.95 d	13.05 ab	49.19 a
T_2	7.01 d	87.49 bc	12.51 bc	49.86 a
T_3	7.63 c	87.65 bc	12.35 cd	49.87 a
T_4	8.04 b	88.00 b	12.00 cd	50.05 a
T_5	8.51 a	88.15 b	11.85 d	50.82 a
T_6	8.56 a	89.98 a	10.02 e	51.44 a
T_7	5.08 e	86.55 d	13.45 a	44.75 b
$LSD_{(0.05)}$	0.326	0.452	0.607	2.166
CV(%)	8.91	6.22	7.36	6.95

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

T_1: One spray at 105 DAS (Blezole) T_2: One spray at 105 DAS (Contaf)

T_3: Two spray at 105 and 120 DAS (Blezole) T_4: Two spray at 105 and 120 DAS (Contaf)

T_5: Three spray at 90, 105 and 120 DAS (Blezole) T_6: Three spray at 90, 105 and 120 DAS (Contaf)

T_7: Control

4.2 Experiment-2: Minimum spray of fungicides in controlling leaf spot and rust diseases of groundnut

4.2.1 Leaf spot disease

Disease data were recorded for estimating leaf spot on the basis of 0-9 disease scoring scale at 90, 105 and 120 DAS and found significant differences for different treatment under the trial (Appendix V). At 90, 105 and 120 DAS the minimum disease severity (1.14%, 1.21% and 1.90%) was recorded from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was statistically similar (1.16%, 1.37% and 2.14%)) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], whereas the maximum disease severity (3.30%, 4.51% and 7.93%)) was recorded from T_7 i.e. control (Table 4.2.1) which was statistically identical (1.29%, 1.45% and 3.79%) with T_1 [one spray at 105 DAS (blezole)]. Naidu and Rao (1997a) reported that late spot of groundnuts (caused by *Phaeoisariopsis personata* [*Mycosphaerella berkeleyi*]) was economically controlled using 3 sprays of 0.25% mancozeb + 0.1% carbendazim at 15-day intervals.

4.2.2 Rust disease

Disease data were recorded for estimating rust spot on the basis of 0-9 disease scoring scale at 90, 105 and 120 DAS and found significant differences for different treatment (Appendix V). At 90, 105 and 120 DAS the minimum disease severity (2.36%, 3.22 % and 1.90%) was recorded from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was similar (2.95%, 5.13% and 5.55%)) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], whereas the maximum (4.49%, 6.15% and 9.73%) was recorded from T_7 i.e. control (Table 4.2.2) which was

Table 4.2.1. Effect of minimum number of fungicides spray in controlling leaf spot diseases of groundnut

Treatment	Leaf spot disease severity (0-9 scale) at		
	90 DAS	105 DAS	120 DAS
T_1	1.29 b	1.45 b	3.79 b
T_2	1.28 b	1.44 b	3.99 b
T_3	1.22 bc	1.42 bc	3.98 b
T_4	1.20 bc	1.40 bc	3.83 b
T_5	1.16 c	1.37 c	2.14 c
T_6	1.14 c	1.21 d	1.90 c
T_7	3.30 a	4.51 a	7.93 a
$LSD_{(0.05)}$	0.094	0.066	0.532
CV(%)	4.90	5.41	9.00

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

T_1: One spray at 105 DAS (Blezole) T_2: One spray at 105 DAS (Contaf)

T_3: Two spray at 105 and 120 DAS (Blezole) T_4: Two spray at 105 and 120 DAS (Contaf)

T_5: Three spray at 90, 105 and 120 DAS (Blezole) T_6: Three spray at 90, 105 and 120 DAS (Contaf)

T_7: Control

Table 4.2.2. Effect of minimum number of fungicides spray in controlling rust diseases of groundnut

Treatment	Rust disease severity (0-9 scale) at		
	90 DAS	105 DAS	120 DAS
T_1	3.85 ab	6.03 a	7.59 b
T_2	3.53 ab	5.95 ab	7.58 b
T_3	3.35 abc	5.62 bc	7.26 b
T_4	2.88 bc	5.38 cd	6.86 c
T_5	2.95 bc	5.13 d	5.55 d
T_6	2.36 c	3.22 e	4.01 e
T_7	4.49 a	6.15 a	9.73 a
$LSD_{(0.05)}$	1.060	0.365	0.239
CV(%)	11.35	9.73	11.91

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

T_1: One spray at 105 DAS (Blezole) T_2: One spray at 105 DAS (Contaf)

T_3: Two spray at 105 and 120 DAS (Blezole) T_4: Two spray at 105 and 120 DAS (Contaf)

T_5: Three spray at 90, 105 and 120 DAS (Blezole) T_6: Three spray at 90, 105 and 120 DAS (Contaf)

T_7: Control

statistically identical (3.85%, 6.03% and 7.59%) with T_1 [one spray at 105 DAS (blezole)]. Gopal *et al.* (2003) reported that rust were lowest with the three application of 0.05% carbendazim and 0.1% tridemorph, respectively.

4.2.3 Plant height

Number of fungicides sprays markedly influenced plant height of groundnut (Appendix VI). The tallest plant (44.39 cm) was observed from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was statistically identical (42.12 cm) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], whereas the shortest plant (35.49 cm) was found from T_7 i.e. control (Figure 2.1) which was statistically identical (35.59 cm) with T_1 [one spray at 105 DAS (blezole)]. From the findings it was revealed that three spray of contaf reduced the severity of leaf spot and rust diseases of groundnut that helps to plant elongation with ensuring maximum photosynthesis and vegetative growth. Patil *et al.* (1999) reported that three foliar sprays of 20% methanol, applied at 30, 45 and 65 days after sowing, gave the highest plant growth of groundnut.

4.2.4 Number of branches per plant

Number of branches per plant of groundnut differs significantly due to number of fungicides spray (Appendix VI). The maximum number of branches per plant (8.56) was recorded from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was statistically similar (8.51) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], while the minimum number (5.08) was obtained in T_7 i.e. control (Table 4.2.3) which was statistically similar (6.85) with T_1 [one spray at 105 DAS

(blezole)]. From the findings it was revealed that three spray of contaf reduced the severity of leaf spot and rust diseases of groundnut that helps to produced maximum number of branches per plant.

4.2.5 Percentage of normal pods

Percentage of normal pods of groundnut differs significantly due to number of fungicides spray (Appendix VI). The highest normal pods (89.98%) were obtained from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was closely followed (88.15%) by T_5 [three spray at 90, 105 and 120 DAS (blezole)]. On the other hand, the lowest (86.55%) was recorded from T_7 i.e. control (Table 4.2.3) which was statistically identical (86.95%) with T_1 [one spray at 105 DAS (blezole)]. From the findings it was revealed that three spray of contaf reduced the severity of leaf spot and rust diseases of groundnut that helps to produced highest percentage of normal pods.

4.2.6 Percent of abnormal pods

Percentage of abnormal pods of groundnut varied significantly for the number of fungicides spray (Appendix VI). The lowest abnormal pods (10.02%) was observed from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was statistically similar (11.85%) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], while the highest (13.45%) was found from T_7 i.e. control (Table 4.2.3) which was statistically identical (13.05%) with T_1 [one spray at 105 DAS (blezole)].

Table 4.2.3. Effect of minimum number of fungicides spray on yield contributing characters and yield of groundnut

Treatment	Number of branches per plant	Normal pods (%)	Abnormal pods (%)	Weight of 1000 seeds (g)
T_1	6.85 d	86.95 d	13.05 ab	49.19 a
T_2	7.01 d	87.49 bc	12.51 bc	49.86 a
T_3	7.63 c	87.65 bc	12.35 cd	49.87 a
T_4	8.04 b	88.00 b	12.00 cd	50.05 a
T_5	8.51 a	88.15 b	11.85 d	50.82 a
T_6	8.56 a	89.98 a	10.02 e	51.44 a
T_7	5.08 e	86.55 d	13.45 a	44.75 b
$LSD_{(0.05)}$	0.326	0.452	0.607	2.166
CV(%)	8.91	6.22	7.36	6.95

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

T_1: One spray at 105 DAS (Blezole) T_2: One spray at 105 DAS (Contaf)

T_3: Two spray at 105 and 120 DAS (Blezole) T_4: Two spray at 105 and 120 DAS (Contaf)

T_5: Three spray at 90, 105 and 120 DAS (Blezole) T_6: Three spray at 90, 105 and 120 DAS (Contaf)

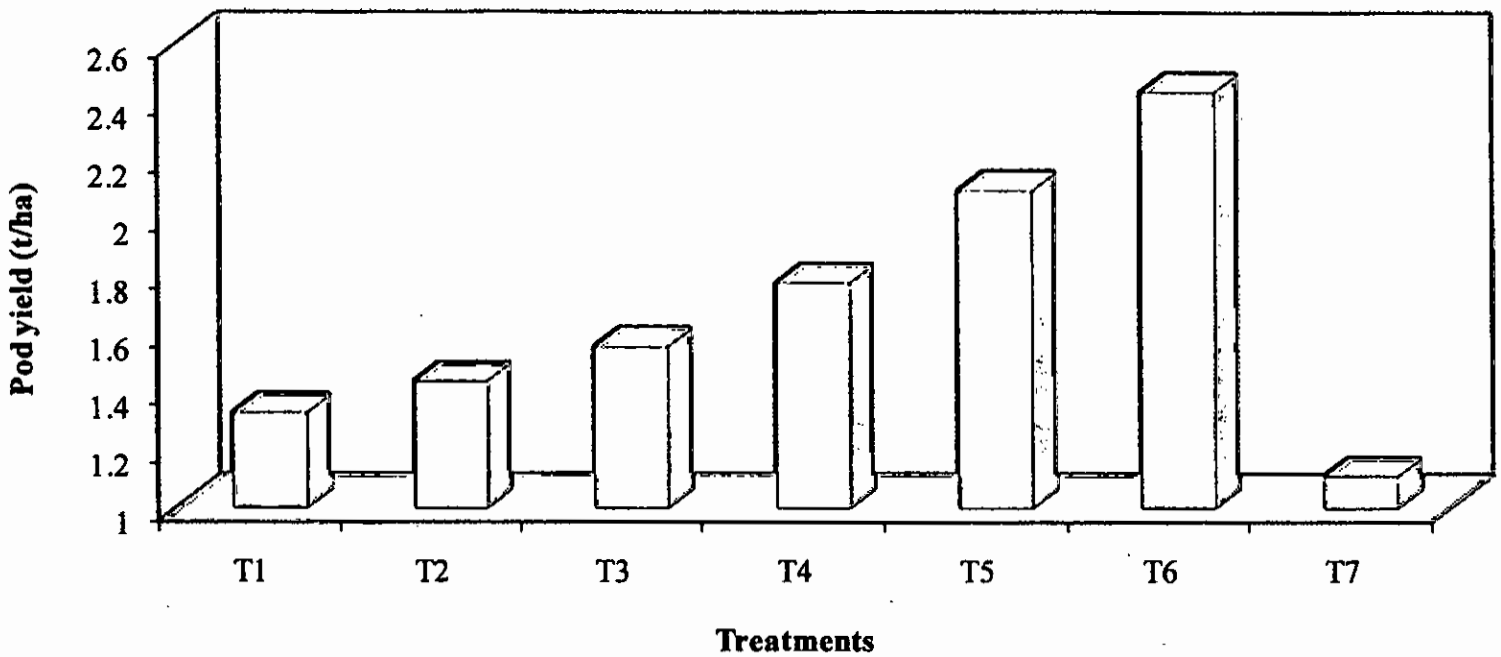
T_7: Control

4.2.7 Weight of 1000 seeds

Significant variation was recorded in terms of weight of 1000 seeds of groundnut due to number of fungicides spray (Appendix VI). The highest weight of 1000 seeds (51.44 g) was obtained from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was statistically similar (50.82 g) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], whereas the lowest weight (44.75 g) was recorded from T_7 i.e. control (Table 4.2.3) which was statistically identical (49.19) with T_1 [one spray at 105 DAS (blezole)]. From the findings it was revealed that three spray of contaf ensured the highest weight of 1000 seeds of groundnut.

4.2.8 Pod yield

Pod yield per hectare of groundnut differs significantly due to number of fungicides spray (Appendix VI). The highest pod yield (2.44 t/ha) was recorded from T_6 [three spray at 90, 105 and 120 DAS (contaf)] which was statistically similar (2.10 t/ha) with T_5 [three spray at 90, 105 and 120 DAS (blezole)], while the lowest yield (1.11 t/ha) was found from T_7 i.e. control (Figure 2.2) which was statistically identical (1.33 t/ha) with T_1 [one spray at 105 DAS (blezole)]. From the findings it was revealed that three spray of contaf reduced the severity of leaf spot and rust diseases of groundnut that ensured maximum vegetative growth, highest normal seed as wall as highest yield per hectare of groundnut. Gururaj and Srikant (2006) reported that plots receiving 3 sprays of hexaconazole in KRG-1 and 2 sprays of fungicide in K-134 with average pod yield loss of 40.20 and 34.00%, respectively.



T_1: One spray at 105 DAS (Blezole)
T_2: One spray at 105 DAS (Contaf)
T_3: Two spray at 105 and 120 DAS (Blezole)
T_4: Two spray at 105 and 120 DAS (Contaf)
T_5: Three spray at 90, 105 and 120 DAS (Blezole)
T_6: Three spray at 90, 105 and 120 DAS (Contaf)
T_7: Control

Figure 2.2 Effect of minimum number of fungicides spray on pod yield per hectare of groundnut

4.3 Experiment-3: Effect of Salicylic Acid in controlling leaf spot and rust diseases of groundnut

4.3.1 Leaf spot disease

Disease data were recorded for estimating leaf spot disease on the basis of 0-9 disease scoring scale at 90, 105 and 120 DAS and found significant differences for different concentration of salicylic acid (Appendix VII). At 90, 105 and 120 DAS the minimum disease severity (0.63%, 1.25% and 1.84%) was recorded from T_4 (1.5 mM salicylic acid foliar spray) which was closely followed (0.84%, 1.51% and 2.98%) by T_3 (1.0 mM salicylic acid foliar spray). On the other hand, the maximum disease severity (2.06%, 3.59% and 4.19%) was recorded from T_1 (control) which was statistically different (1.42%, 2.52% and 4.12%) from T_2 (0.5 mM salicylic acid foliar spray), respectively (Table 4.3.1). From the findings it was revealed that salicylic acid was more effective for controlling leaf spot disease and among the concentration 1.5 mM salicylic acid was more effective. Meena *et al.* (2001) reported that foliar application of SA at a concentration of 1 mM significantly reduced late leaf spot disease intensity.

4.3.2 Rust disease

Significant variation was recorded for estimating rust disease on the basis of 0-9 disease scoring scale at 90, 105 and 120 DAS due to different concentration of salicylic acid (Appendix VII). At 90, 105 and 120 DAS the minimum disease severity (1.46%, 2.07% and 2.29%) was recorded from T_4 (1.5 mM salicylic acid foliar spray) which was closely followed (1.70%, 2.28% and 2.46%) by T_3

Table 4.3.1. Effect of salicylic acid in controlling leaf spot diseases of groundnut

Treatment	Leaf spot disease severity (0-9 scale) at		
	90 DAS	105 DAS	120 DAS
T_1	2.06 a	3.59 a	4.19 a
T_2	1.42 b	2.52 b	4.12 a
T_3	0.84 c	1.51 c	2.98 b
T_4	0.63 d	1.25 d	1.84 c
$LSD_{(0.05)}$	0.018	0.058	0.191
CV(%)	6.88	5.90	8.20

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

T_1: Control

T_2: 0.5 mM salicylic acid foliar spray

T_3: 1.0 mM salicylic acid foliar spray

T_4: 1.5 mM salicylic acid foliar spray

Table 4.3.2. Effect of salicylic acid in controlling rust diseases of groundnut

Treatment	Rust disease severity (0-9 scale) at		
	90 DAS	105 DAS	120 DAS
T_1	3.04 a	5.30 a	6.39 a
T_2	2.65 b	4.02 b	5.02 b
T_3	1.70 c	2.28 c	2.46 c
T_4	1.46 c	2.07 d	2.29 d
$LSD_{(0.05)}$	0.271	0.082	0.173
CV(%)	4.39	7.33	5.21

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

T_1: Control

T_2: 0.5 mM salicylic acid foliar spray

T_3: 1.0 mM salicylic acid foliar spray

T_4: 1.5 mM salicylic acid foliar spray

(1.0 mM salicylic acid foliar spray). Again, the maximum disease severity (3.04%, 5.30% and 6.39%) was recorded from T_1 (control) which was statistically different (2.65%, 4.02% and 5.02%) from T_2 (0.5 mM salicylic acid foliar spray), respectively (Table 4.3.2). It was revealed that salicylic acid was more effective in controlling rust disease of groundnut and among the concentration 1.5 mM salicylic acid was more effective. Sathiyabama and Balasubramanian (1999) showed a reduction in the number of rust pustules, urediospores/pustule and delay in the development of rust disease with the application of salicylic acid.

4.3.3 Plant height

Plant height of groundnut showed significant variation due to different concentration of salicylic acid (Appendix VIII). The tallest plant (42.25 cm) was observed from T_4 (1.5 mM salicylic acid foliar spray) which was closely followed (40.68 cm and 40.50 cm) by T_3 (1.0 mM salicylic acid foliar spray) and T_2 (0.5 mM salicylic acid foliar spray), again the shortest plant (38.50 cm) was recorded from T_1 i.e. control (Table 4.3.3). From the findings it was revealed that salicylic acid reduced the severity of leaf spot and rust diseases of groundnut that helps to plant elongation with ensuring maximum photosynthesis and vegetative growth.

4.3.4 Number of branches per plant

Significant variation was recorded due to different concentration of salicylic acid in terms of number of branches per plant (Appendix VIII). The highest number of branches per plant (9.80) was recorded from T_4 (1.5 mM salicylic acid foliar spray) which was closely followed (9.20 and 9.10) by T_3 (1.0 mM salicylic acid

Table 4.3.3. Efficiency of salicylic acid on yield contributing characters and yield of groundnut

Treatment	Plant height (cm)	Number of branches per plant	Weight of 1000 seeds	Yield (t/ha)
T_1	38.50 c	7.20 c	47.00 c	1.86 d
T_2	40.50 b	9.10 b	48.00 bc	1.98 c
T_3	40.68 b	9.20 b	52.00 ab	2.24 b
T_4	42.25 a	9.80 a	54.00 a	2.47 a
$LSD_{(0.05)}$	0.446	0.270	3.972	0.113
CV(%)	5.34	7.89	9.02	6.44

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

T_1: Control

T_2: 0.5 mM salicylic acid foliar spray

T_3: 1.0 mM salicylic acid foliar spray

T_4: 1.5 mM salicylic acid foliar spray

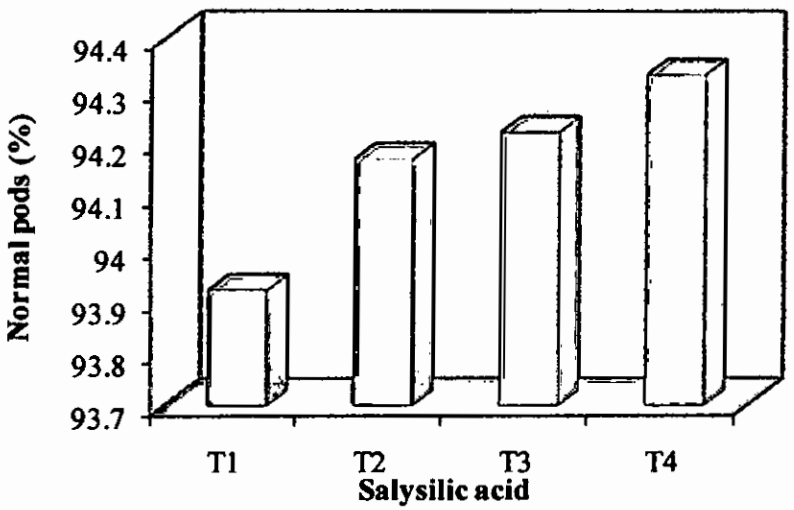
foliar spray) and T_2 (0.5 mM salicylic acid foliar spray), while the lowest number (7.20) was found from T_1 i.e. control (Table 4.3.3). From the findings it was revealed that salicylic acid reduced the severity of leaf spot and rust diseases of groundnut that helps to plant elongation with maximum number of branches per plant of groundnut.

4.3.5 Percentage of normal pods

Significant variation was recorded due to different concentration of salicylic acid for percentage of normal pods (Appendix VIII). The highest normal pods (94.33%) was recorded from T_4 (1.5 mM salicylic acid foliar spray) which was statistically similar (94.22% and 94.17%) by T_3 (1.0 mM salicylic acid foliar spray) and T_2 (0.5 mM salicylic acid foliar spray), again the lowest normal pods (93.92%) was recorded from T_1 i.e. control (Figure 3.1). From the findings it was revealed that salicylic acid reduced the severity of leaf spot and rust diseases of groundnut that helps to attaining optimum vegetative and reproductive growth that ensured highest normal pods of groundnut.

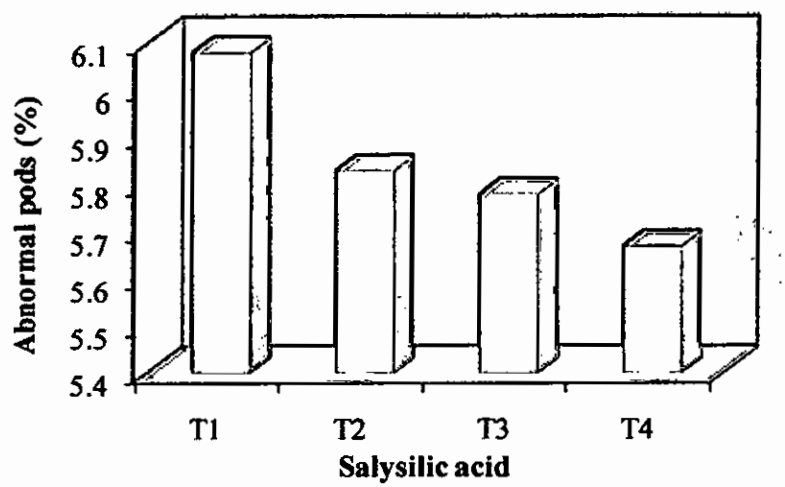
4.3.6 Percent of abnormal pods

Significant variation was recorded due to different concentration of salicylic acid for percentage of abnormal pods (Appendix VIII). The lowest abnormal pods (5.67%) was recorded from T_4 (1.5 mM salicylic acid foliar spray) which was statistically identical (5.78% and 5.83%) by T_3 (1.0 mM salicylic acid foliar spray) and T_2 (0.5 mM salicylic acid foliar spray), whereas the highest abnormal pods (6.08%) was obtained from T_1 i.e. control (Figure 3.2).



T_1: Control T_2: 0.5 mM salicylic acid foliar spray
T_3: 1.0 mM salicylic acid foliar spray T_4: 1.5 mM salicylic acid foliar spray

Figure 3.1. Efficiency of salicylic acid on percentage of normal pods of groundnut



T_1: Control T_2: 0.5 mM salicylic acid foliar spray
T_3: 1.0 mM salicylic acid foliar spray T_4: 1.5 mM salicylic acid foliar spray

Figure 3.2. Efficiency of salicylic acid on percentage of abnormal pods of groundnut

4.3.7 Weight of 1000 seeds

Weight of 1000 seeds showed significant differences due to different concentration of salicylic acid (Appendix VIII). The maximum weight of 1000 seeds (54.00 g) was observed from T_4 (1.5 mM salicylic acid foliar spray) which was closely followed (52.00 g and 48.00 g) by T_3 (1.0 mM salicylic acid foliar spray) and T_2 (0.5 mM salicylic acid foliar spray). On the other hand the minimum weight (47.00 g) was found from T_1 i.e. control (Table 4.3.3). Santosh (1995) reported that salicylic acid at 100 ppm gave the best results with 100-grain weight of 68.7 g.

4.3.8 Pod yield

Pod yield of groundnut per hectare showed significant differences due to different concentration of salicylic acid (Appendix VIII). The highest pods yield (2.47 t/ha) was obtained from T_4 (1.5 mM salicylic acid foliar spray) which was closely followed (2.24 t/ha and 1.98 t/ha) by T_3 (1.0 mM salicylic acid foliar spray) and T_2 (0.5 mM salicylic acid foliar spray), while the lowest yield (1.86 t/ha) was recorded from T_1 i.e. control (Table 4.3.3). From the findings it was revealed that salicylic acid reduced the severity of leaf spot and rust diseases of groundnut that helps to attaining optimum vegetative and reproductive growth that ensured maximum normal seeds, weight of 1000 seeds of and highest yield of groundnut. Meena *et al.* (2001) reported that foliar application of SA at a concentration of 1 mM significantly reduced late leaf spot disease intensity and increased the pod yield under greenhouse conditions. Santosh (1995) reported that salicylic acid at 100 ppm gave the best results with a pod yield of 47 q/ha.

CHAPTER V

SUMMARY AND CONCLUSION

The experiments were conducted at the experimental field of Bangladesh Agricultural Research Institute (BARI), Gazipur during the period from November 2007 to April 2008 to find out the effect of fungicide and salicylic acid for controlling leaf spot and rust diseases of groundnut. The variety Dhaka-1 was selected for this study. Consequently three experiments were conducted. **Experiment-1:** Evaluation of fungicides in controlling leaf spot and rust diseases of groundnut. The experiment comprised of 9 treatments, viz., T_1: Predator (propiconazole, 0.5 ml/L); T_2: Blezole (hexaconazole, 1 ml/L); T_3: Magnate (mancozeb, 500-625 g/ha); T_4: Cluster (mancozeb+carbendazim, 2g/L); T_5: Ezeb (mancozeb, 1g/L); T_6: Detail (hexaconazole, 0.5ml/L); T_7: Tall (propiconazole, 0.5ml/L); T_8: Contaf (hexaconazole, 1ml/L) and T_9: Control. **Experiment-2:** Minimum spray of fungicides in controlling leaf spot and rust diseases of groundnut. The experiment comprised of 7 treatments, viz., T_1: One spray at 105 DAS (Blezole); T_2: One spray at 105 DAS (Contaf); T_3: Two spray at 105 and 120 DAS (Blezole); T_4: Two spray at 105 and 120 DAS (Contaf); T_5: Three spray at 90, 105 and 120 DAS (Blezole); T_6: Three spray at 90, 105 and 120 DAS (Contaf) and T_7: Control. **Experiment-3:** Effect of Salicylic Acid in controlling leaf spot and rust diseases of groundnut. The experiment comprised of 4 treatments, viz., T_1: Control; T_2: 0.5 mM salicylic acid foliar spray; T_3: 1.0 mM salicylic acid foliar spray and T_4: 1.5 mM salicylic acid foliar sprays. All the experiments were laid out in Randomized Complete Block Design (RCBD) with three replications.

Disease data, yield and contributing characters showed significant variation for different fungicides. In case of leaf spot disease, at 90, 105 and 120 DAS the minimum disease severity (1.00%, 2.10% and 2.47%) was recorded from T_8 which was similar (1.05%, 2.25% and 2.80%) with T_2 and the maximum disease severity ((4.60%, 6.15% and 7.60%) was found from T_9. In case of rust, at 90, 105 and 120 DAS the minimum disease severity (1.85%, 4.05% and 3.00%) was recorded from T_8 again, the maximum disease severity (5.40%, 8.25% and 9.60%) was found from T_9. The tallest plant (43.10 cm) was found from T_8 whereas the shortest plant (35.82 cm) was obtained from T_9. The maximum number of branches per plant (8.63) was obtained from T_8, while the minimum number (6.50) was recorded from T_9. The maximum normal pods (90.57%) were recorded from T_8, whereas the minimum (82.29%) was found from T_9. The minimum abnormal pods (9.43%) were found from T_8, while the maximum abnormal pods (17.71%) were recorded from T_9. The highest weight of 1000 seeds (51.90 g) was recorded from T_8, again the lowest weight of 1000 seeds (44.20 g) was observed from T_9. The highest yield (2.38 t/ha) was found from T_8, and the lowest (1.40 t/ha) was recorded from T_9.

Disease data, yield and contributing characters showed significant variation for different number of spraying of fungicides. In case of leaf spot disease, at 90, 105 and 120 DAS the minimum disease severity (1.14%, 1.21% and 1.90%) was recorded from T_6, whereas the maximum disease severity (3.30%, 4.51% and 7.93%) was recorded from T_7. In case of rust, at 90, 105 and 120 DAS the minimum disease severity (2.36%, 3.22 % and 1.90%) was recorded from T_6,

whereas the maximum (4.49%, 6.15% and 9.73%) was recorded from T_7. The tallest plant (44.39 cm) was observed from T_6, whereas the shortest plant (35.49 cm) was found from T_7. The maximum number of branches per plant (8.56) was recorded from T_6, whereas the minimum number (5.08) was obtained from T_7. The highest normal pods (89.98%) were obtained from T_6 and the lowest (86.55%) was recorded from T_7. The lowest abnormal pods (10.02%) were observed from T_6, while the highest (13.45%) was found from T_7. The highest weight of 1000 seeds (51.44 g) was obtained from T_6, whereas the lowest weight (44.75 g) was recorded from T_7. The highest pod yield (2.44 t/ha) was recorded from T_6, while the lowest yield (1.11 t/ha) was found from T_7.

Disease data, yield and contributing characters showed significant variation for different concentration of salicylic acid number of spraying of fungicides. In case of leaf spot disease, at 90, 105 and 120 DAS the minimum disease severity (0.63%, 1.25% and 1.84%) was recorded from T_4 and the maximum disease severity (2.06%, 3.59% and 4.19%) was recorded from T_1. In case of rust, at 90, 105 and 120 DAS the minimum disease severity (1.46%, 2.07% and 2.29%) was recorded from T_4 and, the maximum disease severity (3.04%, 5.30% and 6.39%) was recorded from T_1. The tallest plant (42.25 cm) was observed from T_4, again the shortest plant (38.50 cm) was recorded from T_1. The highest number of branches per plant (9.80) was recorded from T_4 while the lowest number (7.20) was found from T_1. The highest normal pods (94.33%) were recorded from T_4 again the lowest normal pods (93.92%) were recorded from T_1. The lowest abnormal pods (5.67%) were recorded from T_4, whereas the highest abnormal

pods (6.08%) were obtained from T_1. The maximum weight of 1000 seeds (54.00 g) was observed from T_4 and the minimum weight (47.00 g) was found from T_1. The highest pods yield (2.47 t/ha) was obtained from T_4, while the lowest yield (1.86 t/ha) was recorded from T_1.

Considering the above findings of the present experiment, the following recommendations and suggestions may be made:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. Other fungicides with different concentration may be included for further study.
3. Number of spraying and their economic effect needs to be assessment in future study.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from November 2007 to April 2008

Month	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm)	*Sunshine (hr)
	Maximum	Minimum			
November, 2007	21.3	12.5	71	00	6.3
December, 2007	22.4	13.5	74	00	6.3
January, 2008	24.5	12.4	68	00	5.7
February, 2008	27.1	16.7	67	30	6.7
March, 2008	31.4	19.6	54	11	8.2
April, 2008	34.2	23.4	61	112	8.1

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix I. Characteristics of experimental soil

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Garden , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix III. Analysis of variance of the data on controlling leaf spot and rust diseases of groundnut as influenced by different fungicides

Source of variation	Degrees of freedom	Mean square					
		Disease severity (1-9 scale)					
		90 DAS		105 DAS		120 DAS	
		Leaf spot	Rust	Leaf spot	Rust	Leaf spot	Rust
Replication	2	0.092	0.006	0.092	0.072	0.210	0.058
Treatment	8	1.701**	1.054**	0.892**	0.844**	2.111**	1.113**
Error	16	0.105	0.089	0.042	0.065	0.387	0.104

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on yield contributing characters and yield of groundnut as influenced by different fungicides

Source of variation	Degrees of freedom	Mean square					
		Plant height (cm)	Number of branches per plant	Normal pods (%)	Abnormal pods (%)	Weight of 1000 seeds	Yield (t/ha)
Replication	2	1.491	0.014	0.183	0.056	0.128	0.081
Treatment	8	5.976**	0.872**	6.981**	1.423**	3.971**	0.298**
Error	16	1.329	0.087	1.271	0.191	0.634	0.051

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on controlling leaf spot and rust diseases of groundnut as influenced by minimum number of fungicides spray

Source of variation	Degrees of freedom	Mean square					
		Disease severity (1-9 scale)					
		90 DAS		105 DAS		120 DAS	
		Leaf spot	Rust	Leaf spot	Rust	Leaf spot	Rust
Replication	2	0.003	0.161	0.002	0.057	0.153	0.008
Treatment	6	0.018**	1.971**	0.036**	1.354**	2.016**	3.371**
Error	12	0.004	0.509	0.002	0.042	0.128	0.051

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield contributing characters and yield of groundnut as influenced by minimum number of fungicides spray

Source of variation	Degrees of freedom	Mean square					
		Plant height (cm)	Number of branches per plant	Normal pods (%)	Abnormal pods (%)	Weight of 1000 seeds	Yield (t/ha)
Replication	2	0.128	0.010	0.125	0.114	0.156	0.006
Treatment	6	0.428**	3.418**	8.458**	4.876**	19.151**	0.355**
Error	12	0.058	0.048	1.015	0.167	2.125	0.055

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on controlling leaf spot and rust diseases of groundnut as influenced by salicylic acid

Source of variation	Degrees of freedom	Mean square					
		Disease severity (1-9 scale)					
		90 DAS		105 DAS		120 DAS	
		Leaf spot	Rust	Leaf spot	Rust	Leaf spot	Rust
Replication	2	0.0001	0.054	0.003	0.023	0.017	0.123
Treatment	3	0.161**	0.196**	0.076**	0.423**	0.423**	1.921**
Error	6	0.001	0.085	0.005	0.023	0.010	0.812

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on yield contributing characters and yield of groundnut as influenced by salicylic acid

Source of variation	Degrees of freedom	Mean square					
		Plant height (cm)	Number of branches per plant	Normal pods (%)	Abnormal pods (%)	Weight of 1000 seeds	Yield (t/ha)
Replication	2	0.451	0.041	1.102	0.087	0.671	0.021
Treatment	3	2.981**	0.561**	6.862**	0.231**	4.222**	0.482**
Error	6	0.412	0.087	1.239	0.065	0.643	0.042

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability