INFLUENCE OF SALICYLIC ACID AND MEPIQUAT CHLORIDE ON PHYSIOLOGY OF DISEASE RESISTENCE IN GROUNDNUT (Arachis hypogaea L.)

Thesis submitted to the
University of agricultural sciences, Dharwad
In partial fulfillment of the requirements for the
Degree of

MASTER OF SCIENCE (AGRICULTURE)

IN
CROP PHYSIOLOGY

By
TAFSIRA NAZ

DEPARTMENT OF CROP PHYSIOLOGY
COLLEGE OF AGRICULTURE,DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD-580005

JULY,2006

ADVISORY COMMITTEE

Dharwad
July,2006

(S.M. HIREMATH)
MAJOR ADVISOR

Approved by

Chairman : _____
(S.M. HIREMATH)

Members : 1. _____

(M.B. CHETTI)

2._____

(C.M. NAWALAGATTI)

3. _____

(M.B. KURDIKERI)

CONTENTS

LIST OF TABLE

17.	Influence of salicylic acid and mepiquat chloride on leaf area duration (days) at different stages in groundnut	
18.	Influence of salicylic acid and mepiquat chloride on biomass duration (g day) at different stages in groundnut.	
19.	Influence of salicylic acid and mepiquat chloride on chlorophyll 'a' content (mg/g fresh weight) at different stages in groundnut	
20.	Influence of salicylic acid and mepiquat chloride on chlorophyll'b' content (mg/g fresh weight) at different stages in groundnut.	
21.	Influence of salicylic acid and mepiquat chloride on total chlorophyll content (mg/g dry weight) at different stages in groundnut.	
22.	Influence of salicylic acid and mepiquat chloride on total sugar content (mg/g Dry weight) at different stages in groundnut.	
23.	Influence of salicylic acid and mepiquat chloride on total phenol content (Ug/g Dry weight) at different stages in groundnut.	
24.	Influence of salicylic acid and mepiquat chloride on tannin content (ug/g dry weight) at different stages in groundnut.	
25.	Influence of salicylic acid and mepiquat chloride on nitrate reductase activity (nmoles NO_2/g fresf weight /hour) at different stages in groundnut.	
26.	Influence of salicylic acid and mepiquat chloride on perioxiidase activity (ΔOD/g dry weight /min) at different stages in groundnut.	
27.	Influence of salicylic acid and mepiquat chloride on polyphenol oxidase activity (ΔOD/gdry weight) at different stages in groundnut.	
28.	Influence of salicylic acid and mepiquat chloride on yield and yield components in groundnut.	
29.	Influence of salicylic acid and mepiquat chloride on yield components in Groundnut.	
30.	Influence of salicylic acid and mepiquat chloride on benefit: cost ratio in groundnut.	

List of figures

LIST OF PLATES

I. INTRODUCTION

The cultivated groundnut *Arachis hypogea* L. is an important annual legume originated in the North-west Argentina region in South America which is now grown throughout the tropical, subtropical and warm temperate regions of the world. It is one of the important oilseed crop in the world often known for its global economic significance not only for its wide spread distribution but also for the even wider areas of processing and consumption.

Its seeds are rich source of edible oil (43-55%) and protein (25-28%). About two thirds of world production is crushed for oil and remaining one third is consumed as food. Groundnut cake obtained after oil extraction is a high protein animal feed. Groundnut also helps to enrich poor soils as it leaves behind nitrogen and thus contributes to the sustainability of production system. It is a valuable source of vitamins B, E and K. It is the richest plant source of thiamine and is also rich in niacin, which is low in cereals.

It is cultivated in 100 countries located between 40°N to 40°S with a world production of 35.9 million tonnes from an area of 25.2 million hectare with a productivity of 1.42 tonnes per hectare (Anon., 2005). In India, groundnut is grown on 6.6 million hectare area during rainy season with a production of 5.9 million tonnes and the productivity is 0.89 tonnes per hectare. While in the post rainy season, it is grown on 0.9 million hectare area with a production of 1.5 million tonnes and an average productivity is 1.6 tonnes per hectare (Anon., 2003).

Principal groundnut growing states are Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra which account for more than 80 per cent of Indian production as well as area. In Karnataka, it is cultivated in both *kharif* and *rabi* / summer seasons and accounts for an area of 0.82 million hectare with a production of 0.48 million tonnes. While, the productivity of the state is 0.58 tonnes per ha (Anon., 2004).

Groundnut crop suffers from many diseases caused by fungi, bacteria, viruses and non-parasitic diseases etc. Among the fungal diseases, the lateleaf spot (*Phaeoisariopsis personata* (Berk and Curt) V. Arx, or *Cercosporidium personatum*), the early leafspot (*Cercospora arachidicola* Hori.) and the rust (*Puccinia arachidis* Speg.) cause severe damage to the crop. These diseases are destructive on a world wide scale as evident from maximum yield losses ranging from 10 to 50 per cent. But, this loss varies considerably from location to location and between seasons (Mc Donald *et al*., 1985). Yield losses upto 70 per cent due to combined infection of rust and leaf spot pathogens have been reported in India (Subrahmanyam *et al*., 1984).

In Karnataka, avoidable losses of up to 45 per cent due to tikka, 42 per cent due to rust and 60 per cent due to both have been reported (Siddaramaiah *et al*., 1983). In addition to losses in pod yield, these diseases also affect the yield and quality of haulm which is a nutritious fodder (Alabi *et al*., 1993). The late leafspot is more prevalent and affects the plant growth by reducing the available photosynthetic area by way of lesion formation, finally stimulating abscission of leaflets leading to extensive defoliation. The fungal diseases have adverse effect on recovery of pods especially, if harvest is delayed. In severe cases of disease outbreak quality of kernels and haulm are affected finally leading to loss in yield.

Salicylic acid belonging to a group of chemicals known as phenolics is considered as a plant “aspirin” in acetylated form. It regulates number of processes including thermogenesis, the defense response to pathogen attack, ethylene synthesis and fruit ripening. It has the role of regulating plant responses to some abiotic stresses particularly to UV radiation and ozone. It plays a key role in signal transduction pathway leading to systemic acquired resistance against a broad spectrum of pathogens. Exogenous application of salicylic acid at non-toxic concentrations to susceptible plans could enhance resistance to pathogens (Murphy *et al*., 1998).

Mepiquat chloride plays a key role in inducing resistance against diseases and pests in groundnut. The role of mepiquat chloride is well known in many crop plants. It is a anti-gibberellin and keeps the plant healthy with higher chlorophyll content. It has also a role to play in disease resistance mechanism in several crops. Mepiquat chloride checks vegetative growth and hastens the development of reproductive parts by reducing the plant

height, there by decreasing the distance between the source and sink to effect better translocation of photosynthates into developing pods,which inturn is envisaged to improve the harvest index in groundnut. The difference in partitioning of assimilates in vegetative and reproductive organs explains most of the yield differences between the cultivars of groundnut (Duncan *et al*., 1978). Excessive vegetative growth and lack of foliar senescence during pod maturity are considered to be the major limiting factors for achieving higher productivity in groundnut (Chandrababu *et al*., 1995).

Although, plant growth regulators (PGR's) have proved as boon and created the crop productivity booms in the Western Hemisphere, but it has not taken any firm root in India, a country of great agricultural potentialities, where it is needed the most (Mishra, 1989). Hence, it is suggested that the yield in groundnut could probably be subjected to improvement by several ways, of which the alteration in source-sink relationship and disease control may prove useful. Though, PGRs have great potential, non-hazardous, economical, eco-friendly and brings about host disease resistance through metabolic defense mechanism, its applications and acrual assessments etc., have to be judiciously planned in terms of optimal concentrations, stage and species specificity etc. These constitute the major impediments in PGR's applicability.

With this background , the present investigation was aimed to find out the influence of salicylic acid and mepiquat chloride on physiology of disease resistance in groundnut with the following objectives.

1. To study the effect of salicylic acid and mepiquat chloride on physiology of disease incidence in groundnut
2. To study the role of salicylic acid and mepiquat chloride on morpho physiological traits in groundnut.
3. To find out the effect of salicylic acid and mepiquat chloride on biochemical constituents in groundnut.
4. To study the effect of salicylic acid and mepiquat chloride on yield and yield components.

II. REVIEW OF LITERATURE

Groundnut is one of the most important oilseed crops and is cultivated in most of the tropical and subtropical countries of the world. The productivity is very low in India which is ascribed to many physiological and pathological constraints.

More recently, secondary metabolites and plant growth regulators have been suggested to have important ecological functions in plants, of which, the protection against infection by microbial pathogens is most important. The recent research work has revealed that plants resist attack by parasites, bacteria, fungi or other agents with a diverse way of defense strategies of which core role of salicylic acid, a molecule with chemical structure close to aspirin has been stressed. It is the key element in both local and systemic defense.

Mepiquat chloride also plays an important role in increasing the productivity in groundnut. It is a anti-gibberellins and keeps the plant healthy with higher chlorophyll content. Mepiquat chloride checks vegetative growth and hasten reproductive development. Groundnut is highly prone for early and late leafspot followed by rust. The present study would highlight the role of salicylic acid and mepiquat chloride on physiology of disease resistance in groundnut. An attempt is made to review the relevant research work related to the present investigations.

2.1 MORPHOLOGICAL CHARACTERS

Several workers have observed a decrease in plant height due to the application of growth retardants. Wainland and Taylor (1965) reported that phenolic compounds act as analogues of growth hormones. Exogenous application of salicylic acid was found to effect various growth processes of crop and as well as yield performance (Raskin,1992a). Handro *et al*. (1997) reported that under short day conditions, salicylic acid significantly increased the production of flower buds but under long days, 50 per cent of flowers produced buds and were all vegetative. Shoots were significantly longer at 0.5 or 1.0 mM salicylic acid. While, the stem growth was significantly inhibited by acetyl salicylic acid at 10^{-3} to 10^{-4} M/L under *in vitro* condition in potato (Lopez and Scott, 1997).

A significant variation in the number of branches per plant and plant height was observed with the application of phenolic compounds in greengram (Singh, 2001). Pankaj and Sharma (2003) observed that the shoot length of okra significantly increased at 50 and 100 µg /ml of salicylic acid. While, there was a decrease in plant growth with an increase in salicylic acid concentration.

Thomas (1964) reported a reduction in the elongation of the main stem and fruiting branches of cotton plant, which was due to the application of mepiquat chloride. Khangara and Sandhu (1972) found a strong positive correlation between the number of primary and secondary branches, lateral spread, length of primary and secondary branches and pod yield. They emphasized that the length of primary branch is the most important character having direct effect on pod yield. Mepiquat chloride (Pix or DPC) is a growth regulator and is known to suppress the vegetative growth in cotton (Cothren, 1979; Willard, 1979 and York, 1982).

Megie (1980) showed that the application of 0.6 l/ha and 1.0 l/ha of mepiquat chloride in cotton at flowering stage reduced the plant height by 20 cm. Mulder *et al* (1981) reported that spraying of DPC (50, 75, 100 or 50 + 25 g a.i. ha^{-1}) at early reproductive stage of cotton reduced the plant height slightly at all the concentrations.

The reduction of plant height and internodal length was observed when the application of DPC (25, 50, 75 or 50 + 25 g ha^{-1}) twice at 6 days after sowing and 15 days later in cotton (Varella and Yellejo, 1982). Mepiquat chloride is relatively a new chemical and the literature available on the effect of this chemical on crops other than cotton is very meager. Schott and Ritting (1982) found that DPC, when treated to crops generally inhibits both the horizontal and vertical growth.

In cotton treatment with DPC resulted in thin and apparently more rigid stem, whereas in cereals, the application of DPC resulted in thicker culms, and offered more resistant to lodging. The application of DPC at first bloom stage in cotton reduced the plant height by 28 per cent

(Walter *et al*., 1980). Kerby (1983) studied the effect of DPC treatment and reported that the plant height and number of nodes were reduced by 15 per cent and 4 per cent, respectively in cotton.

Application of mepiquat chloride considerably reduced the plant height and internodal length in cotton from 10 to 24.15 per cent depending on the cultivar (Ramesh babu *et al*., 1993). Norton and Silvertooth (2000) reported that mepiquat chloride is a gibberellic acid suppressant that is absorbed by the green portions of the plant and serves to reduce cell elongation, thus offering the potential of decreasing leaf area and restricting additional plant height increases, thus enhancing earliness with regards to fruiting development in cotton. Alexander *et al*. (2001) noticed a linear reduction in plant height was observed over increasing rates of mepiquat chloride in cotton.

While, Lama *et al*. (2000) found that increasing dose of mepiquat chloride decreases the plant height, leaf, stems and total above ground dry matter, number of nodes and branching, branch length, number of damaged fruits, total number of bolls and the number of fully opened bolls in cotton.

Gasti and Madalageri (1995) observed that the spraying of mepiquat chloride at 175 ppm resulted in increased number of branches and leaves per plant in okra. Azevedo *et al*. (1998) reported that the application of 50 g Mepiquat chloride reduced plant height significantly from 96.95 to 86.45 cm whereas higher rate of application significantly reduced yield without further significant reduction in plant height in irrigated cotton.

Jayachandran *et al*. (1999) noticed that increasing dose of mepiquat chloride decreased plant height, leaf stems and total above ground dry matter, number of nodes and branching, branch length in cotton crop and in rice crop. Shahawy *et al*. (2000) noted that spraying pix decreased final plant height, number of main stem nodes in cotton plants. Jayakumar *et al*. (2001) reported that the foliar application of mepiquat chloride in potato has consistently decreased the plant height with increasing levels.

2.2 DRY MATTER PRODUCTION AND ITS PARTITIONING

It has been reported that resistance to foliar diseases is associated with low yield potential in groundnut. Franje (1977) reported that the dry weight of infected plant were related to the degree of infection, the total dry matter decreased and the plant with fewer rust pustules had higher net assimilation rate.

Duncan *et al*. (1978) observed that potential growth rates were fairly constant, whereas the yield differences between high yielding cultivars were attributed largely to the differences in partitioning. A progressive increase in total dry matter upto harvest and early cessation of dry matter accumulation in the stem has been found desirable in groundnut (Sastry *et al*., 1980). Kumari and Singh (1990) reported that groundnut puts on lot of vegetative growth leading to higher dry matter production and the assimilate partitioning has the greatest effect on pod yield. Dry matter accumulation in root, stem, leaf and plant was found to increase with an advancement in crop age (Kataria and Bhatt, 1994).

Knauft and Gorbet (1990) reported that pod initiation in resistant lines lagged behind that of susceptible cultivars by 10 to 30 days.Total dry weight of he plant was significantly affected by leaf spot disease (Valand *et al*. (1997). Sanaa *et al*. (2001) reported that increasing levels of NAA and salicylic acid increased the fresh and dry weights of plants.The highest dry matter production (41.9 kg/ha) was noticed due to the foliar spray of 100 ppm salicylic acid was reported by Radhamani *et al*. (2002).

The thickness of the leaf was increased by the application of DPC (Gausman *et al*., 1980). Walter *et al*. (1980) also observed that the application of DPC to cotton at first bloom stage reduced the leaf area by 17 per cent and increased the leaf thickness by 16 per cent and increased the photosynthesis there by increasing the dry matter production.

In another experiment conducted by Varella and Yellejo (1982) on the application of DPC twice (25, 50 , 75 or 50 + 25g/ha) at 60 days after sowing and 15 days later resulted in the reduction of daily growth rate. Whereas the number of leaves were unaffected with an increase in

leaf area. Schott and Ritting (1982) demonstrated that the application of DPC reduced the leaf area in cotton, but the leaf volume was not affected and thereby increasing the infiltration of light.

The application of pix reduced the vegetative growth by 20–30 per cent in cotton (Khafaga, 1983). An increase in leaf dry weight, stem dry weight and the dry weight of reproductive parts which altogether increased the total dry matter as compared to control due to the application of mepiquat chloride, lihocin and maleic hydrazide (Chetti, 1991). It was further observed that the per cent increase in dry matter of different plant parts was maximum in mepiquat chloride as compared to lihocin and maleic hydrazide.

Morandi *et al*. (1983) reported that the application of DPC in soyabean resulted in higher stem weight with lower main stem length. Chandrababu *et al*. (1995) reported that a foliar spray of 125 ppm mepiquat chloride to groundnut at 70 days after sowing increased the leaf area, leaf dry weight, haulm weight and total plant dry matter.

Chetti *et al*. (1995) observed in sunflower that the spraying of CCC (1000 ppm) and mepiquat chloride (1000ppm) reduced the stem and leaf dry weight and increased capitulum dry weight. Dhaliwal *et al*. (1997) noticed increased shoot length and shoot dry weight when the sugarcane plants are sprayed with 30 µl of mepiquat chloride. Lamas and Athayde (1999) noticed that seedling dry matter in cotton increased with increasing mepiquat chloride rate.

Zhao *et al*. (`1999) showed that mepiquat chloride promoted more efficient photosynthate partitioning into fruits. Lamas *et al*. (2000) reported that increasing dose of mepiquat chloride decreased total above ground dry matter, number of nodes and branching, branch length in cotton. Mepiquat chloride at 150 ppm recorded the highest total dry matter production (13492 kg/ha) in case of wet season rice (Jayachandran *et al*. (2000)).

2.3 GROWTH AND GROWTH PARAMETERS

Studies on the leaf parameters are important since they are the major assimilatory organs of the plant. Growth and development in many crops have been observed to be influenced by the external application of agrochemicals. It has been reported that leaf area is not a limiting factor in groundnut (David and Mack, 1991., Janmatti, 1979) and the maximum LAI ranged from 4 to 7 which occurs during the early to mid pod filling stage (Williams *et al*., 1975, Enyi, 1977) and decreased thereafter depending on several factors, particularly, leaf spot disease (Boote *et al*. (1980). LAI is important for light interception, radiation use efficiency and plant growth.

Duncan *et al*. (1978) observed that light interception was about 95 per cent at an LAI of 3.0. In all the genotypes, the values for relative growth rate (RGR) and NAR showed a decreasing trend with age of the crop. A progressive decrease in RGR values was also observed by Janmatti (1979) in groundnut cultivars. Shanthakumari *et al*. (1988) opined that, growth analysis could be used as a tool in describing and quantifying the growth stages.

Narayanan *et al*. (1991) compared different food legumes with respect to their growth characteristics, is requested that AGR in groundnut as more as compared to other legumes and it was in the order of groundnut >cowpea>pigeonpea> greengram> blackgram> chickpea.

Higher LAR at the later stages of crop growth was negatively associated with less yield in leaf spot resistant genotypes of groundnut (Vindhiyavarman *et al*., 1993). The susceptible controls were characterized by early maturity and higher rates of partitioning but suffered severely due to disease, leading to significant reduction in LAI over time. Resistant germplasm showed high levels of resistance and maintained higher LAI , but was characterized by late maturity and lower partitioning of assimilates to pods due to prolonged foliage growth (Patil *et al*., 1996).

Increased leaf area (22.6%) and leaf weight (34.0%) with foliar application of mepiquat chloride over unsprayed control was reported by Chandrababu *et al*., 1995. Maximum LAI was attained early in healthy plants than in diseased plants(Valand *et.al*.,1997). Late leaf spot of groundnut caused a significant reduction in growth parameters viz., LAI, LAR and LAD (Bhat , 1997). Phulekar *et al*. (1998) noticed that leaf area and LAI were decreased by all the growth regulator including mepiquat chloride 1000 ppm sprayed on groundnut cv. JL–24. On the contrary Zaky *et al*. (1999) noticed that the lowest concentration of mepiquat chloride (250 ppm) caused

significant increase in most of the growth parameters, while the highest concentration (1500 ppm) resulted in a reduction in these parameters of vicia faba plant.

Vijayalakshmi and Srinivasan (2000), noticed in mango cv Alphanso that the greatest mean specific leaf area was recorded from Mepiquat chloride (508.07 cm2) compared to other treatments. Hema (2001) noticed lower values of AGR and CGR in rust infected plots of soybean.

Jayakumar *et al*. (2001) reported that the leaf area index was significantly increased by foliar application of mepiquat chloride at 62.5 g/ha alone or in combination with endosulfan or mancozeb.

2.4 PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS

2.4.1 Chlorophyll content

Leaf spot infection resulted in the reduction of chlorophyll 'a', chlorophyll 'b' and total chlorophyll contents in susceptible varieties and the decrease in chlorophyll 'a' was significantly higher than that of chlorophyll 'b'(Bala and Dhillon, 1987). Benagi (1995) also concluded that by *P. personata* infection, the reduction in chlorophyll 'a' was greater than that of chlorophyll 'b' and there was less loss of chlorophyll in resistant genotypes as compared to susceptible ones.

Similarly, a decrease in the total chlorophyll content was noticed in susceptible variety after infection by P. *personata* (Kaur and Dhillon, 1990). Foliar application of salicylic acid was found to increase the chlorophyll content in cowpea (Amaresh chandra and Bhatt, 1998). Salicylic acid spray (50, 100, 150 and 200 ppm) showed its distinct role in increasing chlorophyll content in tomato crop (Kalarani *et al*., 2002). Senthil *et al.* (2003) noticed that the increased chlorophyll content in the green gram plants when sprayed with 100 ppm salicylic acid and NAA at 40 ppm at flowering stage.

Maibangsa *et al*. (1999) noticed that the rice plans treated with different growth regulators such as 125 ppm mepiquat chloride, 1 per cent coconut water, 100 ppm salicylic acid etc showed greater chlorophyll accumulation, Hill reaction, photochemcal efficiency, ribulose – biphosphate carboxylase content, photosynthetic rate, biochemical efficiency, assimilation, and biomass accumulation than untreated plants. Increased chlorophyll content was recorded in the annual moringa cv. PKM-1 when the plants are sprayed 50 ppm mepiquat chloride (Vijayakumar *et al*., 2002).

Chetti (1991) reported that the application of mepiquat chloride and lihocin increased chl 'a', chl 'b' and total chlorophyll contents significantly as compared to control in groundnut genotypes JL–24 and DH–8. Kulkarni *et al*. (1995) in an attempt to find out the effect of different growth retardants among that the foliar application of mepiquat chloride (1000 ppm) at 45 DAS significantly increased the total chlorophyll contents in both hybrid and a variety of sunflower.

Zaky *et al*. (1999) reported that all concentrations of mepiquat chloride increased chlorophyll a, chlorophyll b, chlorophyll (a+b) and carotenoid contents in vicia faba leaves. Some physiological studies conducted by Zaky *et al*. (2000) on the effect of the growth retardant (Pix) on vicia faba plant, they found that all concentrations of mepiquat chloride increased chlorophyll a, chlorophyll b, chlorophyll (a+b) and carotenoid contents in *Vicia faba* leaves.

Pravin *et al* (2000) noticed that foliar application of mepiquat chloride (500 and 1000 ppm) in combination of other plant growth retardants at 45 days after planting increased the chlorophyll a, chlorophyll b, and total chlorophyll contents in case of TPS and tuber propagated potato. When potatoes cv. HPS-7/67 were treated with 300 ppm mepiquat chloride in combination with other treatments the total chlorophyll content was highest when sprayed at 45 DAT.

Sivakumar *et al*. (2001) studied the effect of growth regulators on biochemical attributes of pearl millet, they noticed that the increased chlorophyll content in the plants when sprayed with 100 ppm Salicylic acid and 50 ppm Mepiquat chloride, etc. Sivakumar *et al*. (2002) studied the effect of foliar application of growth regulators on biochemical attributes in pearl millet; they found that 100 ppm salicylic and are 50 ppm mepiquat chloride application has increased the content of chlorophyll.

2.4.2 TOTAL SUGAR CONTENT

In general, the interaction by some pathogens bring about changes in the respiratory pathway and photosynthesis which are very vital processes occurring in the plant. This leads to a wide fluctuation in sugars in the plant pathogen interactions (Klemet and Goodman, 1967). Aulakh and Sandhu (1970) also reported that the level of total sugars and reducing sugars was low, whereas, non reducing sugars was high in resistant genotypes. Leaves infected with C. *personata* (M. *berkeleyii*) contained higher quantities of reducing sugars than healthy areas.

A sharp depletion in non reducing sugars was observed initially after infection and was gradually arrested as disease severity increased, but the total sugar levels increased with disease development (Mohapatra, 1982). Gupta *et al* (1985) in their study compared susceptible and resistant groundnut cultivars to C. *personatum* . They reported that, the presence of reducing sugars and soluble N on the leaf surface in the former favoured penetration and establishment of the pathogen.

Kaur and Dhillon (1990) reported that the cultivars resistant to C. *personatum* had higher contents of free amino acids and starch than the susceptible ones. They further reported that, infection by C. *personatum* caused a decrease in sugar and starch contents (Kaur and Dhillon, 1990). The susceptible cultivars showed a rapid decrease of sugars and starch but the decrease was relatively slow in resistant cultivars. Metabolic changes in groundnut leaf due to leaf spot pathogens were studied by Gupta *et al*. (1992) and found that the levels of total soluble sugars increased after infection in all the susceptible and tolerant cultivars.

Anandhi and Ramanujam (1995) reported that in Blackgram there would be increase in reducing sugar levels in response to the salicylic acid treatment. While, Kalappanavar and Hiremath (2000) reported that the amount of total sugars decreased significantly with the age of the plants. Increased contents of reducing sugars in green gram variety VBN – 1 due to the application of salicylic and at 100 ppm was reported by Senthil *et al*. , 2003.

Sivakumar *et al*. (2002) noticed that the application of different growth regulators such as 50 ppm mepiquat chloride and 100 ppm salicylic acid has increased the total sugar content in pearl millet. Zaky *et al*. (1999) found out that all concentrations of mepiquat chloride also increased the contents of (250, 500, 1000 and 1500 ppm) reducing sugars, sucrose polysaccharides and total sugars.

2.4.3 PHENOL CONTENT

It has been widely recognized that the aromatic compounds such as mono and dihydric phenols, phenolic glucosides, flavonoids, anthocyanins, aromatic aminoacids and coumarin derivatives are increased in host tissues invaded by a parasite. One of the major biological properties of phenolic compounds is their antimicrobial activity and it is often assumed that, their main role in plants is to act as protective compounds against disease causing agents such as fungi, bacteria, and viruses.

The role of phenolics in the mechanism of disease resistance in plants has been reviewed by several workers (Walter and Stahmann, 1955; Farkas and Kiraly, 1962; Tomiyama, 1963; Kue 1964; Klement and Goodman, 1967 and Rohringer and Samborski, 1967). Involvement of phenolic compounds in many aspects of plant parasite relationship other than plant protection has been reported (Friend, 1979). Brahmachari and Kolte (1983) reported that at all stages of groundnut plant growth, resistant plants to late leaf spot had more total phenol content than susceptible cultivars. Total phenols and ortho hydroxy phenols were found to accumulate in resistant cultivars after infection with *Puccinia arachidis* in groundnut (Ekbote and Mayee, 1983).

Gupta *et al*. (1985) compared phenol content of susceptible and resistant to C. *personatum* (M. *berkeleyii*) and noticed higher phenols in resistant genotypes after the penetration and establishment of pathogen. Concentration of phenolic compounds is usually higher in resistant than in susceptible genotypes of different crop plants (Arora and Wagle, 1985; Saini *et al*., 1988). Studies have also shown that, qualitative and quantitative changes in these compounds occur after infection (Arora and Wagle, 1985 and Luthra *et al*., 1988).

Sindhan *et al*. (1987) observed, higher levels of total phenols, orthodihydric phenols in the resistant cultivars (M- 147, G-201 and M-13) to late leafs spot than susceptible cultivars of JL-24 , MH – 1 and AK- 12-24. Sindhan and Jaglan (1988) have given evidences that, total phenols increased by application of fungicides and plant show enhanced resistance to late leaf spot of groundnut. Generally, total phenols increase with the age as well as with the advancement of disease development in groundnut (Narayan Reddy and Khare, 1988). Gupta *et al. (1992)* found out that the total phenols were markedly higher in tolerant than in susceptible cultivars of groundnut after infection by leaf spot pathogen.

In addition to this, Yadav *et al*. (1998) found that after infection, total phenol content was higher at initial stages than at later stages of plant growth in pearl millet. Total phenols and orthodihydroxy phenols were found to increase with age of the crop (Kalappanavar and Hiremath, 2000).

However, the application of salicylic acid resulted an early increase in phenolic compounds in strawberry (Malolepza *et al*., 1994). A similar increase in phenolic content was observed with the application of salicylic acid in groundnut (Meena *et al*., 2001). Phenol content was found to increase in resistant cultivar and decrease in susceptible cultivar after inoculation with two isolates of *ascochyta rabici* in chickpea (Khirbat and Jalali, 2003). After treatment with salicylic acid, the content of root soluble phenolics in FDA inoculated date palm seedling was approximately four times higher in cv. Bouthami noir than in untreated plants (Abadaelhi *et al*., 2003).

Subhendu *et al*. (2002) reported that the tolerant cultivars of *colocasia* had 100% and 81% increase of total phenol and protein, respectively, when compared to susceptible cultivars. Li – HL *et al*. (1994) studied the effects of elicitor of induction fungi on the resistance of cucumber against anthracnose. They noticed that this leads to increase in phenol content. Anandhi and Ramanujam (1995) noticed that in black gram cultivars there will be increase in ortho dihydroxy and total phenols after salicylic acid supply has been reported.

2.4.4 TANNIN CONTENT

Harris and Burns (1970) found strong relationship between the tannin content of sorghum grain and pre harvest mold infection of seeds and noted that high tannins was the factor which imparted resistance to pre harvest molding attack. Swain (1977) observed lesser susceptibility of older leaves to insects since they had higher concentration of tannins.

Absolutely there are no reviews on the influence of late leaf spot on tannins in groundnut and hence the reviews as on other crops are included here in many crops including cotton, tannins exhibited themselves as powerful factors in imparting resistance to insects and diseases. Tannins form the most important group of defensive secondary metabolites and powerful feeding deterrent to all herbivores (Swain, 1979).

Theerthaprasad and Shambulingappa (1986) noticed that susceptible cultivars contained more than twice the amounts of tannins as that of resistant cultivars of sunflower. Rao (1989) noticed low tannin content in bollworm susceptible genotypes. He had also observed a positive association of tannin content in reproductive parts and seed cotton yield.

While, Khirbat and Jalali (2003) found significantly higher tannin content in inoculated than in uninoculated resistant and susceptible cultivars of chickpea. However, the increase was significantly higher in susceptible cultivars after 10 days of inoculation as compared to resistant cultivar of chickpea.

2.4.5 OIL CONTENT

Bhat (1997) reported that late leaf spot caused a significant reduction in oil content in groundnut. Similar results were observed in soybean by Ogle *et al*. (1979).

In a study to know the effect of DPC on seed oil content of *barbadense* cotton, it was observed that DPC (50.0 g /ha) increased the seed protein and oil contents (Abdel-AL *et al*., 1986). On the contrary, Kulkarni *et al*. (1995) reported that the foliar application of MH (250 ppm),

TIBA (50 ppm), CCC (1000 ppm), mepiquat chloride (100, 250, 500 and 1000 ppm) at 45 DAS did not have any significant influence on both seed protein and oil contents in sunflower.

Mekki and Kholy (1999) noticed that seed oil content and oil yield were significantly increased due to application of mepiquat chloride in oil seed rape. They also noticed that mepiquat chloride application at 200 ppm decreased oleic and linoleic acid content, while it increased linolenic and erucic acid as compared to control plants. However, when mepiquat chloride concentration was increased upto 400 ppm an increase in oleic, linoleic and erucic acid content and a decrease in linolenic acid as compared with the 200 ppm mepiquat chloride treatment was observed. Saturated fatty acids were less affected by adding mepiquat chloride. Palmitic acid was only decreased by using 400 ppm mepiquat chloride as compared with the 200 ppm mepiquat chloride treatment over control plants.

Radhamani *et al*. (2002) noticed that treatment with 100 ppm salicylic acid in combination with 0.5% potassium chloride and other chemicals gave the highest number of capsules per plant (88 and 92), number of seeds per capsule (42 and 47), seed yield (732 and 747 kg/ha) and oil content (44.3%) in sesame.

2.4.6. Nitrate reductase activity (NRA)

Assimilation of nitrate involves a series of enzymatic steps and the initial step in which NO_3 is reduced to NO_2 is catalyzed by the enzyme nitrate reductase. The reaction takes place in the cytoplasm of the cell in both roots and shoots (Pramod Kumar *et al*., 1999). With the foliar spray of 5000ppm mepiquat chloride in combination of other growth regulators there will be increase nitrate reductase activity which increased growth and development of mango (v. alphanso. (Vijayalakshmi and Srinivasan, 1999).

Foliar application of mepiquat chloride (50 ppm) and salicylic acid (100 ppm) in combination with other growth regulators has increased the soluble protein and nitrate reductase activity in pearl millet (Sivakumar *et al*., 2001).Salicylic acid treatment (3 mM), under water stress, protected nitrate reductase activity and maintained the protein and nitrogen content of leaves compared to water sufficient seedlings thus it plays a important role in regulating the drought response of wheat plants (Bhupinder Singh and Usha, 2002). Salicylic acid spray showed its district role in increasing nitrate reductase activity in tomato (Kalarani *et al*., 2002).

Salicylic acid at 100 ppm in combination with other growth regulators when applied at flowering stage significantly increased the contents of soluble protein and NRA in the stem, root and leaves of green gram var VBN -1 (Senthil *et al*., 2003).

2.4.7 Peroxidase (POD) and polyphenol oxidase (PPO) activity

Polyphenol oxidase, peroxidase, catalase and ascorbic acid oxidase activities were higher in resistant seedlings infected by *Cochliobolus sativus* than in susceptible seedlings . This is according to Gamal *et al*., (1987).

Gupta *et al*. (1992) studied the metabolic changes in groundnut leaf due to infection by leaf spot pathogens, they notice that the PPO was reasonably active and POD was very active and hence provides resistance of plants to those pathogens. The elicitor induced resistance to *Colletotrichum orbiculare* causing anthracnose in cucumber, there was an increased peroxidase, polyphenol oxidase and phenyl alanine ammonia lyase activities was reported by Li *et al*. (1994).

Peroxidase, polyphenol oxidase and phenyl alanine ammonia lyase promote the synthesis of compounds increasing pest / disease resistance and enhance canker resistance (Chen Hui *et al*., 1997). Similarly the activities of peroxidase and polyphenol oxidase were greater in resistant cultivars than in susceptible cultivars during the initial days following infection, but there were no significant difference between them in late infection stages in cucumber leaves (Li Baoju *et al*., 1998).

With the foliar sprays of 5000 ppm mepiquat chloride at monthly intervals there will be increase in peroxidase and catalase activity which led to the increased chlorophyll metabolism

thereby enhancing the yield in off-seasons in mango cultivar alphanso (Vijayalakshmi and Srinivasan, 1999). The increasing in plant resistance was accompanied with highly positive change in polyphenol oxidase in spearmint plants against rust disease caused by *Puccinia menthae* was observed by Zaky, *et al*., 2000.

In Salicylic acid – treated plans, an increase in peroxidase and polyphenol oxidase activities was observed upon challenge inoculation with *Cercorporidium personatum* causing late leaf spot in groundnut (Meena *et al*., 2001). However, Subhendu *et al*. (2002) reported that the specific activity of peroxidase remained higher while that of polyphenol oxidase remained lower in tolerant cultivars as compared to susceptible cultivars of *colocasia esculenta* to *phytophthora* leaf blight disease.

A similar increase in polyphenol oxidase, phenyl alanine ammonialyase activity with salicylic acid application has been reported in cherry fruit. (Qin *et al*., 2003).

2.6 DISEASE MANAGEMENT USING SALICYLIC ACID AND MEPIQUAT CHLORIDE

Systemic Acquired Resistance is an inducible plant response to infection by a necrotizing pathogen. Both salicylic acid and Systemic Acquired Resistance gene expression are playing important roles in the initiation and maintenance of Systemic Acquired Resistance (Lawton *et al*., 1995).

Salicylic acid is an endogenous regulator of disease resistance, is a product of phenyl proponoid metabolism formed via decarboxylation of trans cinnamic acid to benzoic acid and its subsequent hydroxylation to salicylic acid (Raskin, 1992a and Lee *et al*., 1995). It is a key regulatory component of disease resistance in plants (Lee and Raskin, 1998). Nancy (2003) reported that induction of SAR is dependent on the accumulation of the endogenous signalling molecule, salicylic acid and the transmission of the SAR signal via the activity of the key regulatory protein NPR-1 (non expressor of pathogenesis related protein-1).

Injection of salicylic acid into tissues at concentrations found in the exudates has increased peroxidase activity and they also suggested that salicylic acid is the systemic signal of induced resistance in cucumber (Rasmussen *et al*., 1991). Salicylic acid has been found to act as an endogenous signal, responsible for inducing systemic acquired resistance against tobacco mosaic virus in tobacco (Thomas *et al*., 1993).

The systemic salicylic acid increases during systemic acquired resistance by its phloem transport from the inoculation sites (Shulaev *et al*., 1995). Salicylic acid stimulates an agonist dependent gain control operating at an early step in the signal pathway for induction of the hypersensitive response (Ken Shirasu *et al*., 1997).

Salicylic acid is synthesized at the site of pathogen induced necrosis and translocated to induce SAR in unifected leaves (Willits and Ryals, 1998). The higher salicylic acid concentration increased resistance in genetically resistant cultivars while the lower salicylic acid concentration brought about increased susceptibility of potato to late blight disease according to Quintanilla and Brishammar (1998).

Foliar application of salicylic acid at the Concentration of 1mM significantly reduced late leaf spot disease intensity in groundnut (Meena *et al*., 2001). Foliar application of salicylic acid and bion solutions to sunflower induced systemic resistance to *alternaria helianthii*. Salicylic acid at 15 mM were effective in inducing resistance, however salicylic acid at 20 mM had phytotoxic effect (Venkata Sadhu Ratnam *et al*. , 2002) The mechanism by which salicylic acid enhanced biocontrol efficacy of the antagonistic yeast may be related to its ability to induce biochemical defense responses in sweet cherry fruit rather than its fungitoxicity effects on the pathogens (Qin *et al*., 2003).

2.7 YIELD AND YIELD COMPONENTS

It has been reported that resistance to foliar disease is associated with low yield potential in groundnut. In India, losses in yield of the crop due to the leaf spots have been estimated to be in the range of 15 to 50 percent (Sulaiman and Agoshe 1965; Sulaiman, 1966; Chohan, 1974; Sundaram, 1965).

Cummins and Smith (1973) reported that, besides the loss in yield of kernels, the value of the hay which may be used as fodder for cattle is also adversely affected. Bunting *et al*. (1974) estimated that early and late leaf spots alone cause the loss of about 3m. tons of kernels per year in Northern U.S.A. Duncan *et al*., 1978 has observed that potential growth rates were fairly constant whereas the yield differences between high yielding cultivars were attributed largely to the differences in partitioning.

The disease resistance alone would not ensure increase in yield (Hegde *et al*., 1995), but the resistance has usually been associated with late maturity and low yields (Higgins, 1935; Nevill and Evans, 1980). The combined infection of rust and tikka leaf spots caused loses in peanut to the tune of 57.65 per cent of 100 kernel weight and 47.56 per cent of dry matter weight. Separately losses due to rust were 48.01 per cent in dry matter weight, while those due to leaf spots were , 43.01 per cent in pod yield, 15.95 per cent in 100 kernel weight and 31.9 per cent in dry matter weight (Ghuge *et al*., 1981).

Major effect of leaf spot disease is the loss of pods which are already produced and the increased disease pressure is poorly correlated with seed size or total mature kernels, either in resistant or susceptible lines of groundnut (Knauft *et al*., 1988).

Singh and Awasti (1998) reported that the application of SA (5 ppm) might be safe and more useful for improving crop growth, yield as well as nutritional quality in greengram. Similarly, application of SA @ 50 ppm showed significant increase in pod weight, number of pods per plant and grain yield in soybean (Promod Kumar *et al*., 1999). Meena *et al*. (2001) reported that foliar application of salicylic acid @ 1 mM significantly reduced the late leaf spot and increased the pod yield in groundnut under green house condition. While, Sanaa *et al*.(2001) reported that the combination treatment with higher concentrations of salicylic acid and NAA resulted in higher seed yield in dry bean. Application of salicylic acid (2000ppm) recorded highest yield in mango (Singh *et al*., 2001).

Similarly, increase in kernel weight with the application of mepiquat chloride at 1ml/l to the tune of 20.6 and 17.8 per cent, respectively for JL-24 and DH –8 groundnut varieties was observed by Chetti(1991). It was further observed that with an increase in the concentration of MC, there was a decrease in both kernel weight and pod weight. Though MC and lihocin recorded an increase in kernel and pod weight, but the percent increase was less as compared to the application of MC.

Foliar application of different concentrations of SA 50, 100, 150 and 200 ppm) on tomato, dramatic effect of SA was observed in induction of flowers, fruit set and yield in terms of fruit weigh, it was also concluded that among the different concentrations of salicylic acid, 100 ppm SA was optimum for enhancing the tomato productivity and quality of fruits (Kalarani *et al*., 2002).

Morandi *et al*.(1983) reported that in soybean, the percent flower set and percent of developed seeds increased with 500 and 1000 mg/l of DPC. Reproductive efficiency was also increased for both the doses as a consequence of the accumulated effects of DPC over each of the partial reproductive efficiency. The seed yield of sunflower was found to increase with the foliar application of MC and CCC (Chetti *et al*., 1995).

Similarly, the foliar spray of 125 ppm of mepiquat chloride at 70 days after sowing increased the number of mature pods per plant and harvest index as compared to control (Chandrababu *et al*., 1995). Gasti and Madalageri (1995) concluded that the application of 175 ppm of mepiquat chloride at 45 days after sowing in okra registered the highest yield of 13.6 t ha^{-1} as compared with unsprayed control (9.45 t ha^{-1}). The increase in yield was to the extent of 44 per cent over the unsprayed control as a result of retardation in vegetative growth which inturn enhanced the performance of yield attributing characters.

Foliar application of mepiquat chloride at 125 ppm on 35 DAS registered the maximum pod yield of 2611 kg ha^{-1} by showing an increase of 42 per cent over control and 24 per cent over CCC treated plants in groundnut (Jeyakumar and Thangaraj, 1998). Pod yield in Groundnut cv. JL – 24 was generally increased by growth retardants like CCC, MC etc (Phulekar *et al*., 1998). Total tuber yield was highest (26.3 t /ha) with 150 ppm mepiquat chloride sprayed at 45 days after transplanting in potato (Eyob and Krishnappa, 2000). Spraying pix decreased final plant height, number of main stem internodes, monopodium, sympodia, aborted sites percentage and number of unopened bolls / plant, and increased the boll set percentage, earliness percentage, number of open bolls, boll weight, seed index and seed cotton yield (Shahwy *et al*., 2000).

The growth regulators generally increased physiological parameters and grain yield, with mepiquat chloride generally having the greatest effect in rice cultivar . (Jayachandran *et al*., 1999). Mepiquat chloride (0, 50, 75, 100 and 125g) increased 100- seed weight, seedling dry matter with increasing MC rate (Lamas and Athayde 1999). Application of mepiquat chloride (0,100, 150, 200 and 250 cm3/ fed) tended to increase number of open bolls per plant and seed cotton yield significantly (Ghourab *et al*., 2000).

Mepiquat chloride at 150 ppm recorded the highest total dry matter production (13492 kg/ha), number of panicles/ m2 (492), 1000- grain weight (24.9g), filled grains per panicle (98.3), grain yield (5598 kg/ha) and straw yield (7744kg/ha) in wet season rice (Jayachandran *et al*., 2000). Tuber yield was also significantly higher under mepiquat chloride at 62.5g/ha which was 28 and 16% over control during first and second seasons respectively (Jayakumar *et al*., 2001).

`III. MATERIAL AND METHODS

A field experiment was conducted during *kharif*, 2005 to study the influence of salicylic acid and mepiquat chloride on physiology of disease resistance in groundnut. The details of materials used and the experimental techniques adopted during the course of investigation are described below.

3.1 EXPERIMENTAL SITE

A field experiment was conducted in plot number 126 of E block, at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, which is situated at 15°12[1] N latitude and 75°07[1]E longitude with an altitude of 678 m above mean sea level (Plate 1).

Plate 1. General view of the experimental plot

3.2 SOIL AND ITS CHARACTERISTICS

The experimental site consisted of medium black loam soil. Composite soil samples were analysed from the experimental site for various physical and chemical properties as per the procedures of Piper (1966) and Jackson (1967) and the details are presented in Table 1.

3.3 WEATHER DATA DURING CROP GROWTH PERIOD

The data on climatic parameters such as rainfall (mm), mean maximum and minimum temperatures (°C) and relative humidity (%) recorded at Meteorological Observatory, Main Agricultural Research Station, University of Agricultural sciences, Dharwad during the experimental year and the mean of the last 55 years (1950-2004) are presented in Table 2.

The mean annual rainfall for the past 55 years at the Main Agricultural Research Station, Dharwad was 802.52 mm and the maximum rainfall was received in the month of July(148.33), followed by October(130.15)

3.4 EXPERIMENTAL DETAILS

The experiment consisted of 15 treatment combinations and the groundnut genotype used was JL – 24, the salient features of which are given in Table 3. The general view of the experiment is depicted in Figure 1.

Treatment Details

T_1	Foliar application of salicylic acid (50 ppm)
T_2	Foliar application of salicylic acid (100 ppm)
T_3	Foliar application of salicylic acid (200 ppm)
T_4	Foliar application of salicylic acid (300 ppm)
T_5	Foliar application of salicylic acid (400 ppm)
T_6	Foliar application of salicylic acid (500 ppm)
T_7	Foliar application of salicylic acid (600 ppm)
T_8	Foliar application of salicylic acid (50 ppm)+ mepiquat chloride (1.0 ml/l)

T_9	Foliar application of salicylic acid (100 ppm) + mepiquat chloride (1.0 ml/l)
T_{10}	Foliar application of salicylic acid (200 ppm) + mepiquat chloride (1.0 ml/l)
T_{11}	Foliar application of salicylic acid (300 ppm) + mepiquat chloride (1.0 ml/l)
T_{12}	Foliar application of salicylic acid (400 ppm) + mepiquat chloride (1.0 ml/l)
T_{13}	Foliar application of salicylic acid (500 ppm) + mepiquat chloride (1.0 ml/l)
T_{14}	Foliar application of salicylic acid (600 ppm) + mepiquat chloride (1.0 ml/l)
T_{15}	Control

Table 1. Physical and chemical properties of the soil in the experimental site

Properties	**Value**	**Method employed**
I. Physical properties **Coarse sand (%)**	6.28	International pipettee method (Piper, 1966)
Fine sand (%)	14.27	International pipettee method (Piper, 1966)
Silt (%)	27.52	International pipettee method (Piper, 1966)
Clay (%)	51.99	International pipettee method (Piper, 1966)
Bulk density (mg m^{-3})	1.33	Core samples method (Dastane, 1967)
II. Chemical properties		
Soil pH (1:2.5 soil : water)	7.6	pH meter (Piper , 1966)
Electrical conductivity (dSm^{-1})	0.28	Conductivity Bridge (Jackson, 1973)
Organic carbon (%)	0.52	Walkley and Black wet oxidation method (Jackson, 1967)
Available nitrogen (kg ha^{-1})	221.00	Modified Kjeldahl method (Jackson, 1967)
Available phosphorus (kg ha^{-1})	32.4	Olsen's method (Jackson, 1967)
Available potassium (kg ha^{-1})	310.7	Flame photometer (Jackson, 1967)

3.5 Design and layout

The experiment was laid out in randomized block design with three replications and the plan of layout of the experiment is given in Fig.1. The plot size for each treatment was as follows (Fig.1-6)

Gross plot size – 2.8 m x 3.0 m

Net plot size – 2.4 m x 2.6 m

Figure 1. Plan of layout of the experiment

Figure 2. Description of the modified 9-point field disease scale for late leafspot in groundnut

Figure 3. Standard curve for sugars

Figure 4. Standard curve for total phenols

Figure 5. Standard curve for tannins

Figure 6. Standard curve for nitrate reductase activity

3.6 CULTURAL PRACTICES

3.6.1 Land preparation

The land was ploughed and harrowed twice to bring the soil to a fine tilth and levelled to facilitate easy sowing.

3.6.2 Seeds and sowing

Bold and well developed healthy seeds were selected and dibbled at the rate of one seed per hill.

3.6.3 Fertilizer application

Recommended dose of nitrogen, phosphorus and potash were applied @ 25,20 and 25 kg/ha, respectively in the form of urea, single super phosphate and MOP at the time of sowing. Different concentrations of salicylic acid either singly and in combination with mepiquat chloride were imposed as folier sprays on 48 and 80 days after sowing (DAS).

3.6.4 Spacing

Seeds were dibbled at a spacing of 30 cmx 1

3.6.5 After care

Intercultural operations were carried out twice at 20 and 35 days after sowing along with hand weeding. The crop was sprayed with recommended dose of plant protection chemicals to control the incidence of insect pests viz., dicopol @ 2 ml/l and nuvacran @ 1.5 ml/l at 60 DAS, as per the package of practices.

3.6.6 Harvesting

The crop was harvested at physiological maturity in all the plots. Five plants from each net plot were uprooted and separated into leaf, stem and pod for determination of dry matter and seed yield. Pods from rest of the plants were harvested and dried in the sun and used for computing yield on area basis.

3.7 COLLECTION OF EXPERIMENT DATA

Five plants from each plot were tagged randomly at 55 DAS for recording various morphological observations at 50, 70, 90 DAS and at Harvest.

3.7.1 Morphological characters

3.7.1.1 Disease scoring

The disease severity was recorded at weekly intervals as per the modified scale given by Subbarao *et al*. (1990) . The response was recorded by using the scale indicated in Figure 2 (Mayee and Datar , 1986 and Subbarao *et al*., 1990).

3.7.1.2 Plant height

The plant height was recorded from five randomly selected plants in each plot at 50 DAS and at harvest. The height was measured from base of the plant to the tip of main shoot and expressed in cm.

Table 2. Monthly meteorological data for the experimental year (*kharif*, 2005) and the mean of past 55 years (1950-2004) as recorded at the Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka)

Month	Rainfall (mm)		Temperature (°C)				Relative humidity (%)	
			Mean maximum		Mean minimum			
	2005	Mean*	2005	Mean*	2005	Mean*	2005	Mean*
January	**Trace**	**0.1**	**29.9**	**29.6**	**12.9**	**14.8**	**52**	**63**
Februarys	Trace	1.1	33.4	32.5	14.83	16.4	62	51
March	Trace	0.1	36.0	36.5	18.9	19.6	42	56
April	75	48.9	36.3	37.4	21.3	19.9	53	76
May	29.4	80.5	37.0	33.7	21.5	21.4	55	66
June	151	109.9	30.9	28.8	21.4	21.5	76	81
July	290.2	148.3	27.4	29.2	21.5	21.0	83	87
August	138.8	96.1	27.1	27.0	20.4	20.3	81	86
September	194.5	102.2	27.5	28.6	20.3	19.9	85	82
October	89.4	130.2	29.6	30.1	19.1	18.4	70	76
November	38	32.1	29.4	30.2	14.9	15.9	51	68
December	0	53.5	28.9	29.4	13.1	12.5	53	63
Total	1006.3	802.52						

* Mean of 55 years (1950-2004)

Plate 1. General view of the experimental plot

Plate1. General view of the experimental plot

Table 3. Salient features of the genotype JL – 24

Sl. No.	Character	Features
1	Pedigree	Selection from EC – 94943 released in 1978 at Jalgaon (Maharastra)
2	Botanical type	Spanish bunch
3	Branching habit and number of branches	Sequential and 4 to 5 branches per plant
4	Growing condition	*Kharif* and rainfed
5	Growth habit	Erect
6	Leaf size and colour	Large and dark green leaves
7	Pods	Large in size
8	Kernels	1-2-3 kernels / pod, smooth with prominent constriction, large in size tan coloured
9	Oil content	44-46%
10	Shelling percent	68-70%
11	100-seed weight	45-50 g
12	Plant height	35-40 cm
13	Duration	100-120 days
14	Pod yield	20-25 q per ha
15	Foliar disease reaction	
	a) leaf spot	Susceptible
	b) Rust	Susceptible

LEGEND

T_1 - Foliar application of salicylic acid (50 ppm)

T_2 - Foliar application of salicylic acid (100 ppm)

T_3 - Foliar application of salicylic acid (200 ppm)

T_4 - Foliar application of salicylic acid (300 ppm)

T_5 - Foliar application of salicylic acid (400 ppm)

T_6 - Foliar application of salicylic acid (500 ppm)

T_7 - Foliar application of salicylic acid (600 ppm)

T_8 - Foliar application of salicylic acid (50 ppm)+ mepiquat chloride (1.0 ml/l)

T_9 - Foliar application of salicylic acid (100 ppm) + mepiquat chloride (1.0 ml/l)

T_{10} - Foliar application of salicylic acid (200 ppm) + mepiquat chloride (1.0 ml/l)

T_{11} - Foliar application of salicylic acid (300 ppm) + mepiquat chloride (1.0 ml/l)

T_{12} - Foliar application of salicylic acid (400 ppm) + mepiquat chloride (1.0 ml/l)

T_{13} - Foliar application of salicylic acid (500 ppm) + mepiquat chloride (1.0 ml/l)

T_{14} - Foliar application of salicylic acid (600 ppm) + mepiquat chloride (1.0 ml/l)

T_{15} - Control

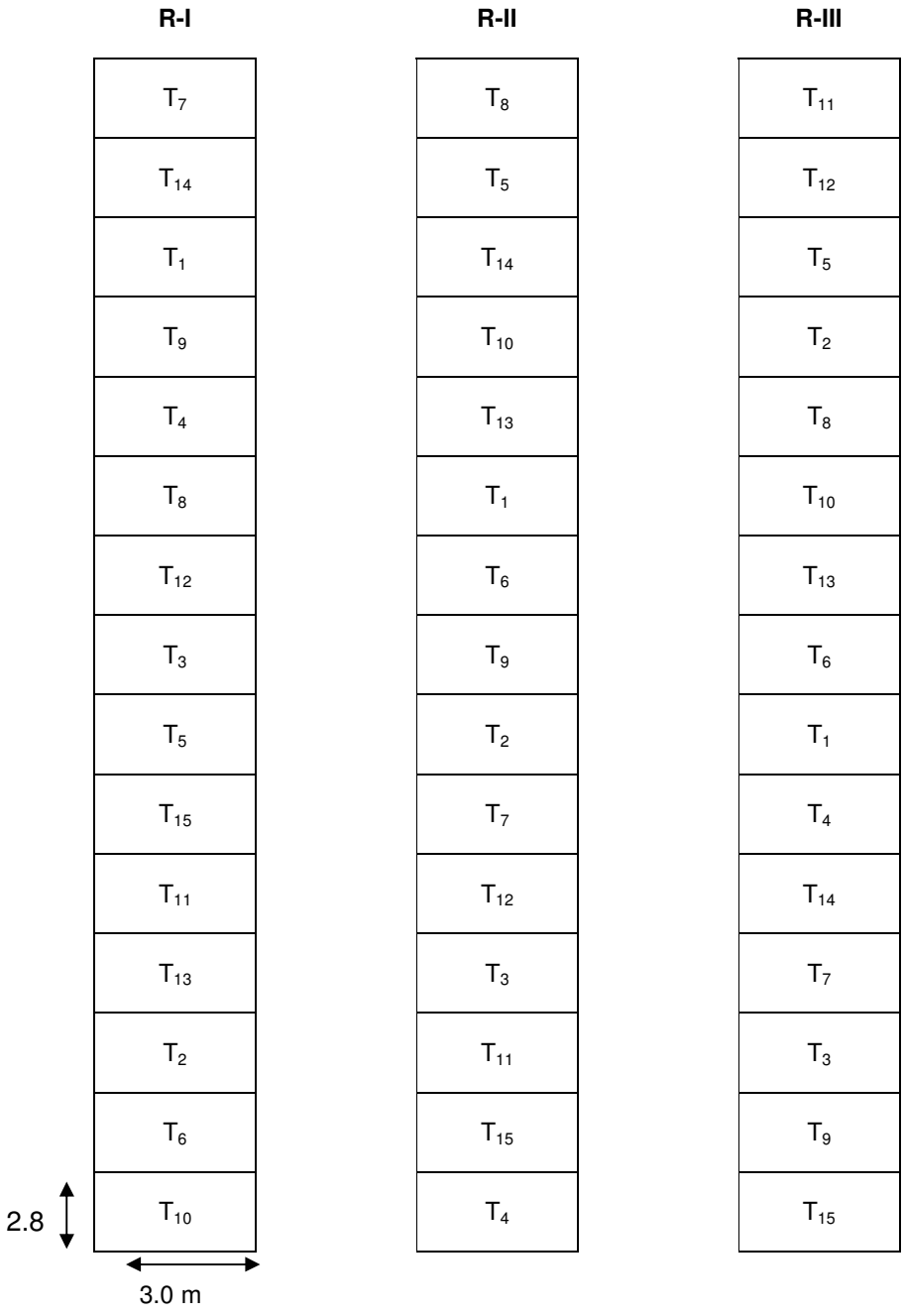

Figure 1. Plan of layout of the experiment

Figure 1. Plan of layout of the experiment

3.7.1.3 Number of branches per plant

Number of branches per plant was counted from five plans at 50 DAS and at harvest and the mean was taken as number of branches per plant.

3.7.1.4 Leaf area

Leaf area measurement was done by leaf disc method and expressed as dm^2 per plant. For this purpose, 20 leaf discs of known diameter were taken from all over the canopy at different time intervals and dried in oven at 80℃ to a constant weight. After complete drying, their dry weight was recorded accurately. Care was taken to avoid midrib portion while selecting the discs. Rest of the leaves from the plant were separated and oven dried similarly at 80℃ to a constant weight. From the area and dry weight of the discs, the leaf area per plant was calculated by gravimetric method.

3.7.1.5 Dry matter production and its partitioning

For this purpose, five plants from each plot were uprooted and the soil was removed. The plant samples were separated into leaves, stem and reproductive parts (pegs, developed and undeveloped pods) and dried separately at 80℃ in hot air oven for 72 hours at different growth stages. The completely dried samples were weighed and the dry weight of different plant parts was expressed in grams on per plant basis.

3.7.2 Growth Parameters

3.7.2.1 Absolute Growth Rate (AGR)

It is the dry matter production per unit time (g /plant/day) and was calculated by using the following formula (West *et al*., 1920).

$$AGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

where,

W_1 = Dry weight of the plant at time t_1

W_2 = Dry weight of the plant at time t_2

3.7.2.2 Crop Growth Rate (CGR)

It is the rate of dry matter production per unit ground area per unit time (Watson, 1952). It was calculated by using the following formula and expressed as g m^{-2} day^{-1}.

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} x \frac{1}{A}$$

where,

W_1 = Dry weight of the plant (g) at time t_1

W_2 = Dry weight of the plant (g) at time t_2

A = Land area (m^2)

3.7.2.3 Net Assimilation Rate (NAR)

It is the rate of dry weight increase per unit leaf area per unit time (mg dm^{-2} day^{-1}) and was calculated as suggested by Gregory (1926).

$$NAR = \frac{(W_2 - W_1)}{(t_2 - t_1)} x \frac{(\log_e L_2 - \log_e L_1)}{(L_2 - L_1)}$$

LEGEND

Disease Score	Description	Per cent disease severity
1.	No disease	0
2.	Lesions present largely on lower leaves; no defoliation	1-5
3.	Lesions present largely on lower leaves; very few lesions on middle leaves; defoliation of some leaflets evident on lower leaves	6-10
4.	Lesions are present on lower and middle leaves but severe on lower leaves; defoliation of some leaflets evident on lower leaves	11-20
5.	Lesions are present on all lower and middle leaves; over 50% defoliation of lower leaves	21-30
6.	Lesions severe on lower and middle leaves; lesions present on top leaves but less severe; extension defoliation of lower leaves; defoliation of some leaflets; evident on middle leaves	31-40
7.	Lesions present on all leaves but less severe on top leaves; defoliation of all lower and some middle leaves	41-60
8.	Defoliation of all lower and middle leaves; lesions severe on top leaves and some defoliation of top leaves evident	61-80
9.	Defoliation of almost all leaves leaving bear stems; some leaflets may be present but with severe leafspots	81-100

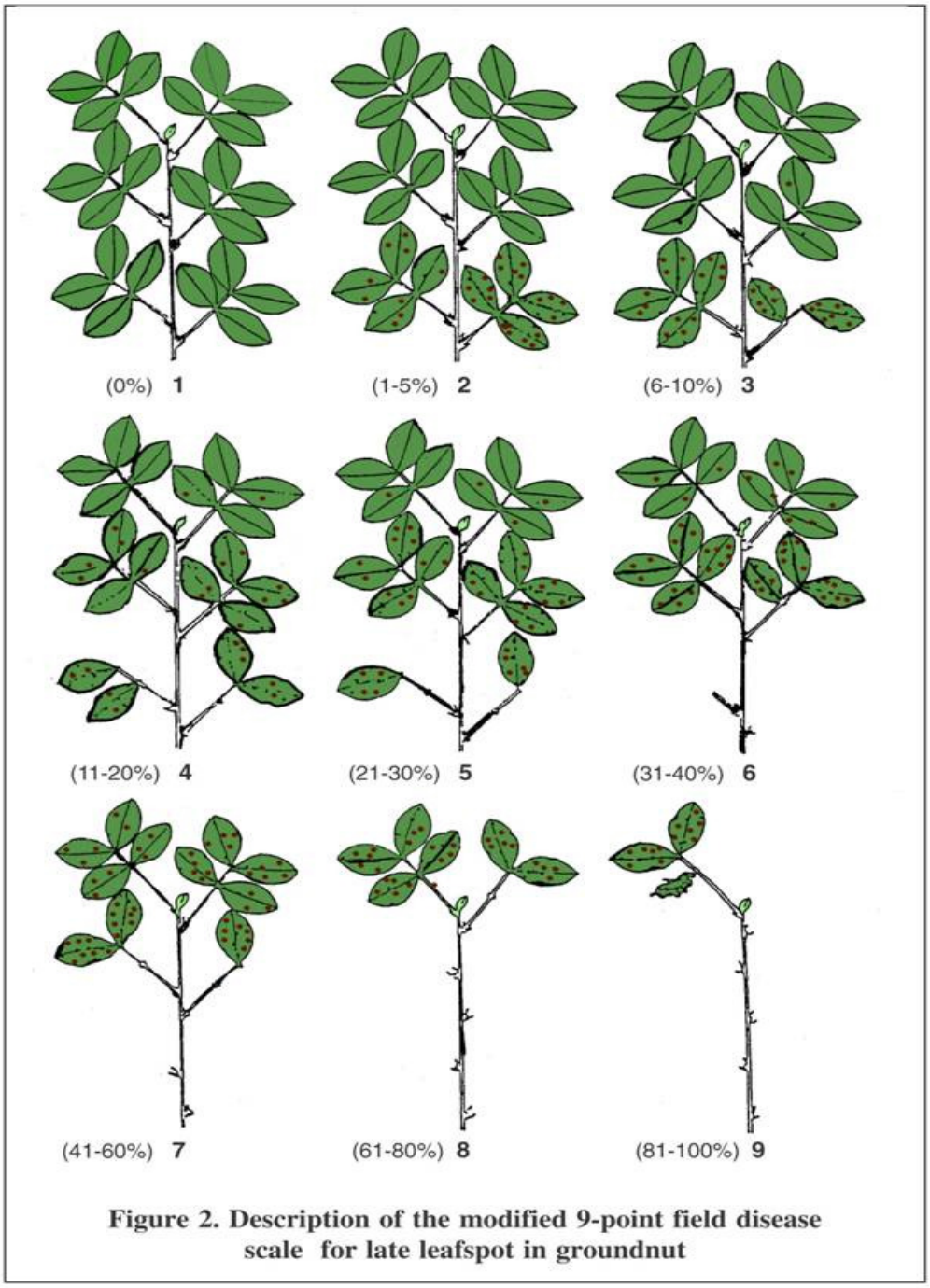

Figure 2. Description of the modified 9-point field disease scale for late leafspot in groundnut

Figure 2. Description of the modified 9-point field disease scale for late leafspot In groundnut.

where,

L_1, W_1 = Leaf area (dm^2) and dry weight of the plant (g), respectively at time t_1

L_2, W_2 = Leaf area (dm^2) and dry weight of the plant (g), respectively at time t_2

3.7.2.4 Leaf Area Index (LAI)

LAI is defined as the leaf area produced per plant per unit land area and was calculated by the formula of Sestak *et al.* (1971).

$$LAI = \frac{\text{Leaf area } (dm^2 \text{ plant}^{-1})}{\text{Land area covered by individual plant } (dm^2)}$$

3.7.2.5 Leaf Area Duration (LAD)

Leaf area duration is the measure of the ability of a plant to produce and maintain leaf area. It can be measured as the integral of leaf area index over the growth period (Watson, 1952). LAD was worked out as per the formula of Power *et al.* (1967).

$$LAD = \frac{(L_i + L_{(i+1)})}{2} \times (t_2 - t_1)$$

where,

L_i = LAI at i^{th} stage

$L_{(i+1)}$ = LAI at $(i+1)^{th}$ stage

$t_2 - t_1$ = Time interval between i and (i + 1) stage (days).

3.7.2.6 Leaf Area Ratio (LAR)

The LAR ($cm^2\ g^{-1}$) was calculated using the formula of Radford (1967).

$$LAR = \frac{\text{Leaf area } (cm^2 \text{ plant}^{-1})}{\text{Total dry weight of the plant (g)}}$$

3.7.2.7 Biomass Duration (BMD)

$$BMD = \frac{TDM_1 + TDM_{(i+1)}}{2} \times (t_2 - t_1)$$

Where,

TDM_i = Total dry matter at i^{th} stage

$TDM(i+1)$ = Total dry matter at $(i + 1)^{th}$ stage

$(t_2 - t_1)$ = Time interval between i and (i + 1) stage (days)

3.7.3 Yield and yield components

Tagged plants used for recording morphological observations were harvested at physiological maturity and were used for recording various yield components, pod and seed yield listed below.

3.7.3.1 Number of pods per plant

The average number of pods of five plants in each treatment was recorded as number of pods per plant.

3.7.3.2 100-seed weight (g)

Hundred seeds at random were selected from each treatment and their weight (g) was recorded by weighing on an electronic balance.

3.7.3.3 Pod yield (kg ha^{-1})

Plants from net plot area were harvested and developed pods were separated. Soil particles adhered to the pods were removed and sundried. The pod weight (kg per net plot) was recorded and used for converting to kg per hectare.

3.7.3.4 Harvest index (%)

It was calculated by using the formula of Donald (1962) and expressed in per cent.

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

3.7.3.5 Shelling per cent (%)

From each treatment, 500 g of clean pods were weighed, shelled and the kernel weight was recorded. The shelling per cent was worked out as follows,

$$\text{Shelling per cent} = \frac{\text{Weight of kernels (g)}}{\text{Weight of pods (g)}} \times 100$$

3.7.3.6 Oil content (%)

The oil content was estimated by Nuclear Magnetic Resonance (NMR) spectrophotometer against a standard reference sample and was expressed in per cent.

3.7.4 Biochemical parameters

3.7.4.1 Estimation of chlorophyll content

Total chlorophyll, Chl. a and Chl. b contents were determined following the method of Arnon (1949) at 60, 75 DAS and at harvest. Fresh fully opened leaves from top of the canopy were brought from the field in an ice box and cut into small pieces. 250 mg of sample was weighed from each sample and homogenized with acetone. The extract was filtered through Whatman No.1 filter paper and washed 2-3 times with 80 per cent acetone. The final volume of the extract was made up to 25 ml. The absorbance of the extract was read at 645 and 663 nm in spectrophotometer (Elico, SL-159) and for blank 80 per cent acetone was used.

The amount of chlorophyll content in the sample was calculated by using the following formulae and expressed in mg g^{-1} fresh weight.

$$\text{Chlorophyll 'a'} = (12.7 \times A_{663}) - (2.69 \times A_{645}) \, X \, \frac{V}{1000 \times W \times a}$$

$$\text{Chlorophyll 'b'} = (22.9 \times A_{645}) - (4.68 \times A_{663}) \, X \, \frac{V}{1000 \times W \times a}$$

Total chlorophyll = Chl. a + Chl. b.

where,

A_{663} = Absorbance of the extract at 663 nm

A_{645} = Absorbance of the extract at 645 nm

w = Fresh weight of the sample (0.25 g)

V = Volume of the extract (25 ml)

a = Path length of light (1 cm)

3.7.4.2 Estimation of sugars by anthrone method

Sugar content was estimated in oven dried leaf sample at 60, 75 DAS and at harvest as per the procedure of Sadasivam and Manickam (1992).

3.7.4.2.1 Dry sample extraction

1. 100 mg of dried leaf powder was taken in a conical flask and 10 ml of 80 per cent ethanol was added to that
2. Contents were boiled on hot water bath for 10 minutes, allowed to settle down and the supernatant was transferred to another dry flask.
3. To the residue in the flask, 10 ml of 80 per cent ethanol was added and extracted as before.
4. Extraction was repeated again and the final volume was made up to 25 ml with 80 per cent ethanol.
5. From this, 5 ml of the extract was taken in a beaker and evaporated on hot water bath (until the alcohol smell lost) and made up the volume of the extract to 10 ml with distilled water. This was used for estimating sugar content as follows.

3.7.4.2.2 Anthrone method

0.2 g of anthrone was dissolved in 100 ml of concentrated sulphuric acid. Fresh solution was prepared just before the use.

Procedure

One ml of the aliquot was taken in a test tube. The volume was made upto 2.5 ml with distilled water. All the test tubes were kept in the ice bath and to which 5 ml of anthrone reagent was added slowly. Contents were stirred gently with a glass rod and heated on boiling water bath exactly for 7.5 minutes and cooled immediately on ice bath. After cooling, the absorbance of the solutions were measured at 630 nm against the blank in a spectrophotometer (Elico, SL-159) and the sugar content was calculated using the standard curve (Fig. 3).

3.7.4.2.3 Standard curve

100 mg of glucose was dissolved in little quality of water and the volume was made up to 100 ml to get a stock solution. From this, different concentrations were made from 10-100 mg ml^{-1} by diluting and used for standard curve. The other procedure followed was similar to that used for plant samples (Fig. 3).

3.7.4.3 Estimation of total phenols

Estimation of total phenols in plant samples was done by following Folin ciocalteau reagent method (Sadasivam and Manickam, 1992) in oven dried samples at 60, 75 DAS and at harvest.

Reagents : 1. Folin – ciocalteau reagent (FCR) 1% - 1:1 of FCR + water

2. Sodium carbonate (2%)

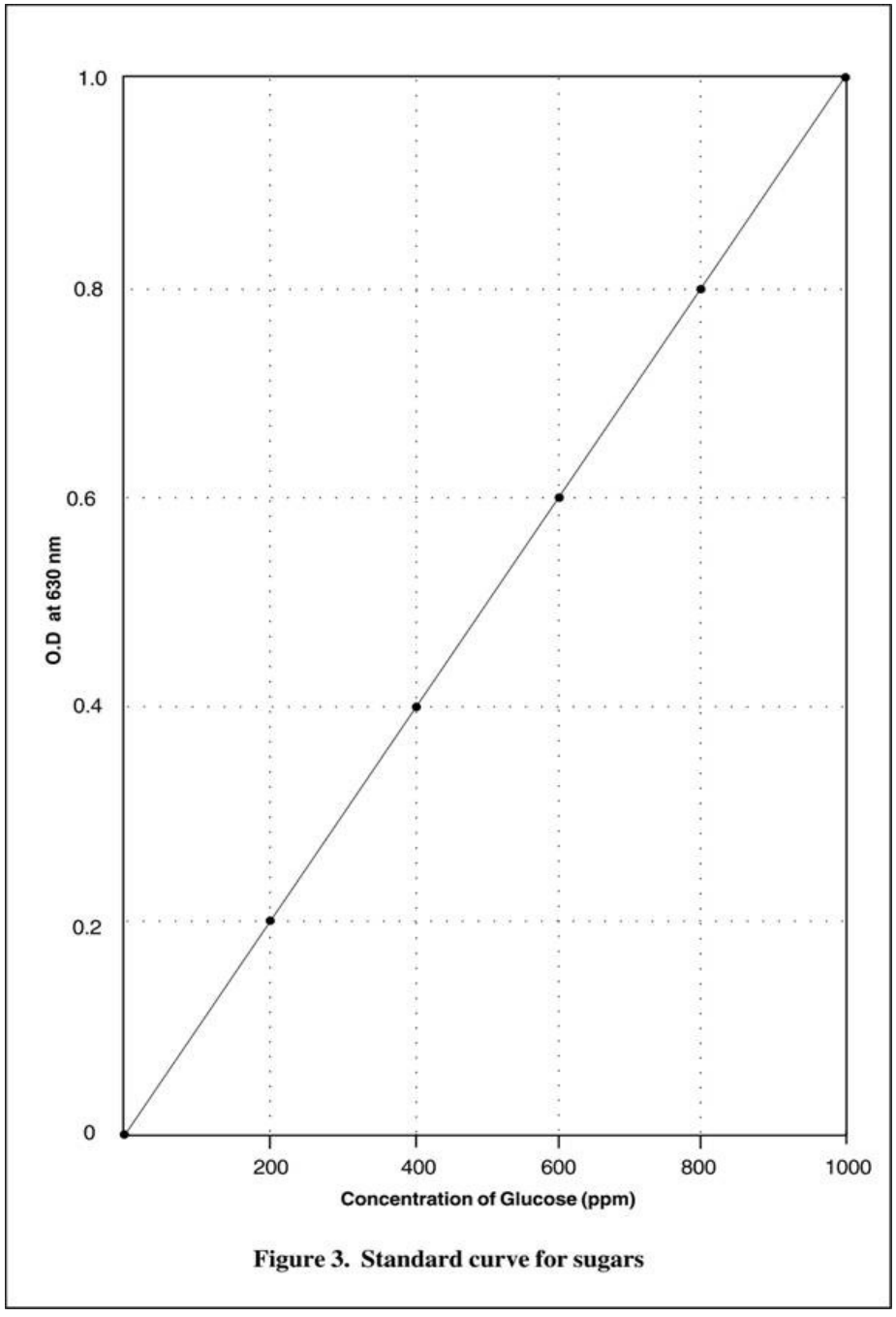

Figure 3. Standard curve for sugars

Figur3. Standard curve for sugars

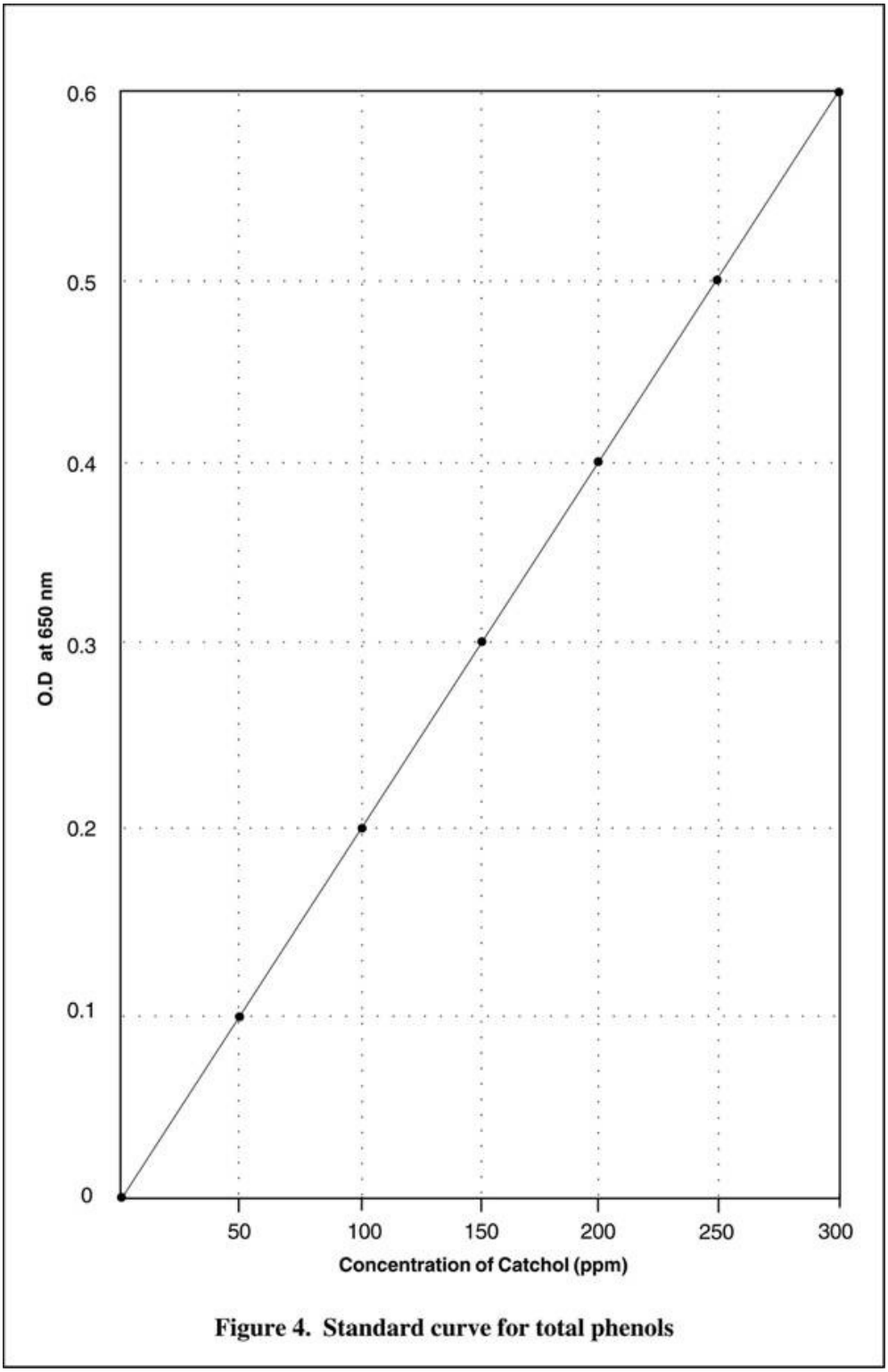

Figure 4. Standard curve for total phenols

Fig 4. Standard curve for total phenols

Procedure

One ml of the alcohol extract was taken in a test tube, to which one ml of Folin-ciocalteau reagent followed by 2 ml of sodium carbonate solution (2%) were added. The tubes were shaken well and heated on a boiling water bath for exactly one minute and then cooled under running tap water. The blue colour developed was diluted to 25 ml with distilled water and its absorbance was read at 650 nm in spectrophotometer (Elico, SL-159). The amount of phenols present in the sample was calculated from a standard curve prepared from catechol (Fig. 4).

3.7.4.4 Estimation of Tannins

Tannin content was estimated by Folin-Denis method in oven dried leaf samples at 60, 75 DAS and at harvest (Sadasivam and Manickam, 1992).

Materials

1. Folin-Denis reagent - 100 mg of sodium tungstate and 20 g of phosphomolybdic acid were dissolved in 750 ml of distilled water, to which 50 ml of phosphoric acid was added. The mixture was refluxed for 2 h and the volume was made up to one litre with distilled water. The reagent was protected from exposure to light.
2. Sodium carbonate solution – 350 g sodium carbonate was dissolved in one litre of water at 70-80°C, filtered through glass wool after allowing it to stand over night
3. Standard tannic acid solution - 100 mg of tannic acid was dissolved in 100 ml of distilled water.
4. Working standard solution - 5 ml of the stock solution was diluted to 100 ml with distilled water.

Procedure

0.5 g of the powdered leaf material was transferred to a 250 ml conical flask, to which 75 ml of water was added. The flask was heated gently and boiled for 30 min, centrifuged at 2000 rpm for 20 min. The supernatant was collected in volumetric flask and the volume was made up to 100 ml. From this, one ml of extract was transferred to a 100 ml volumetric flask containing 75 ml of water, to which 5 ml of Folin-Denis reagent and 10 ml of sodium carbonate solution were added and the volume was made up to 100 ml with distilled water. The contents were shaken well and the absorbance was read at 700 nm after 30 minutes in spectrophotometer (Elico, SL-159). Blank was prepared with water instead of the sample. The amount of tannin present in the sample was calculated from a standard curve (Fig. 5) prepared from tannic acid (0-100 µg).

3.7.4.5 Estimation of nitrate reductase activity (NRA)

Nitrate reductase activity in leaves was assayed *in vivo* at 60, 75 DAS and at harvest by the method of Saradhambal *et al*. (1978). Leaves were cut into small pieces, weighed and suspended in 25 ml flasks containing 0.1 M phosphate buffer (pH 7.6), 0.02 M KNO_3, propaol (5%) and two drops of chloramphenicol (0.5 mg/ml) was added. The flasks were incubated at 30°C for 30 minutes, after which the reaction was stopped by adding 0.1 ml of 1.0 M zinc acetate and 1.9 ml of ethanol (70%). The contents were centrifuged at 3000 g for 10 minutes and the nitrate formed was determined in an aliquat of the supernatant by adding 1 ml of sulphanilamide (1%) in 1 M HCl and 1 ml N-1 naphytelthylene diamine dihydrochloride (0.02%). The absorbance of the pink colour developed was measured at 540nm after 20 minutes. The activity of nitrate reductase was determined from a standard curve of KNO_3 (Fig.6) and expressed as nmoles NO_2 formed per g fresh weight^{-1} hour^{-1}.

3.7.4.6 Estimation of peroxidase activity

Peroxidase activity was estimated following the method of Thimmaiah (1989).

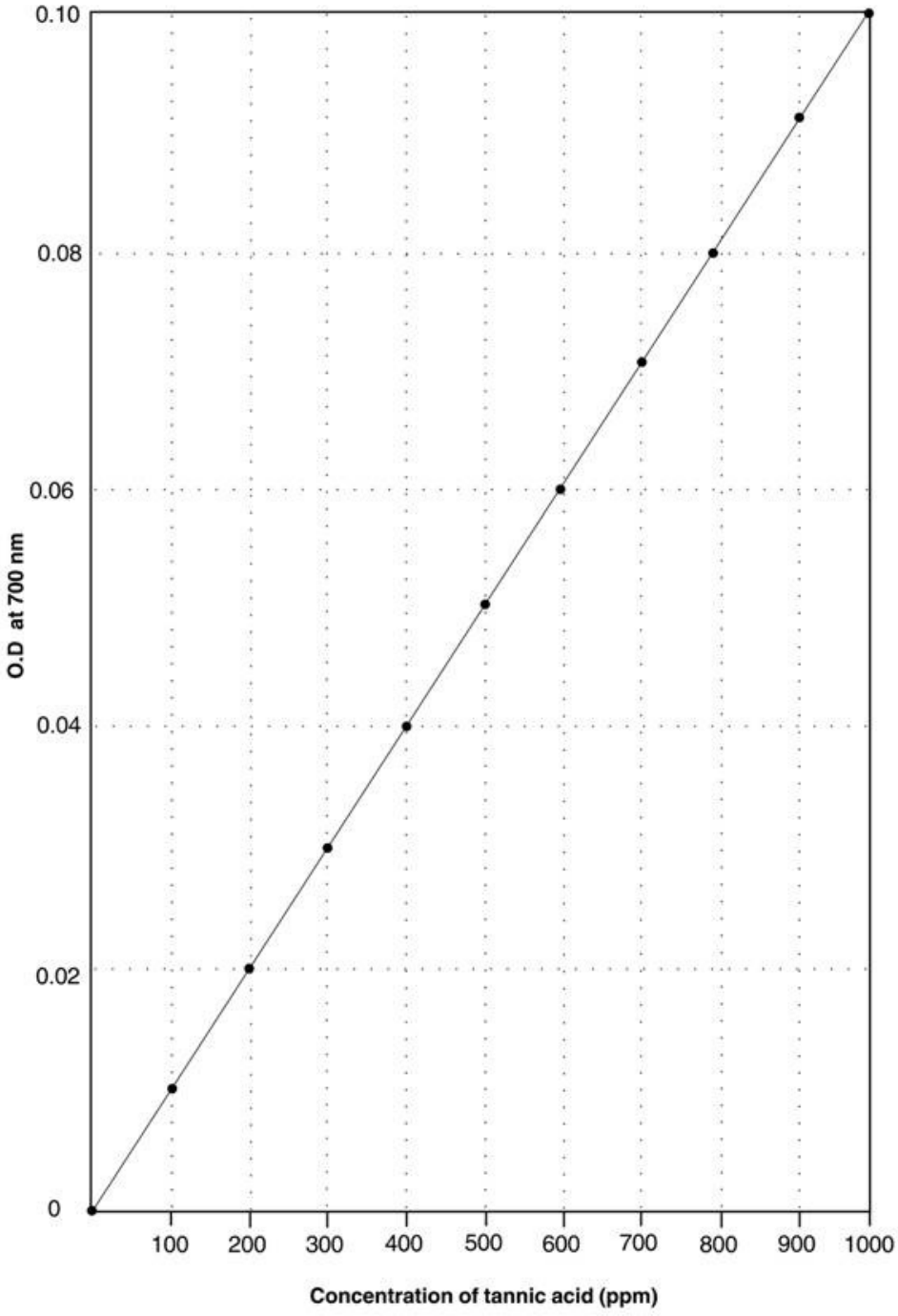

Figure 5. Standard curve for tannins

Fig 5. Standard curve for tannins

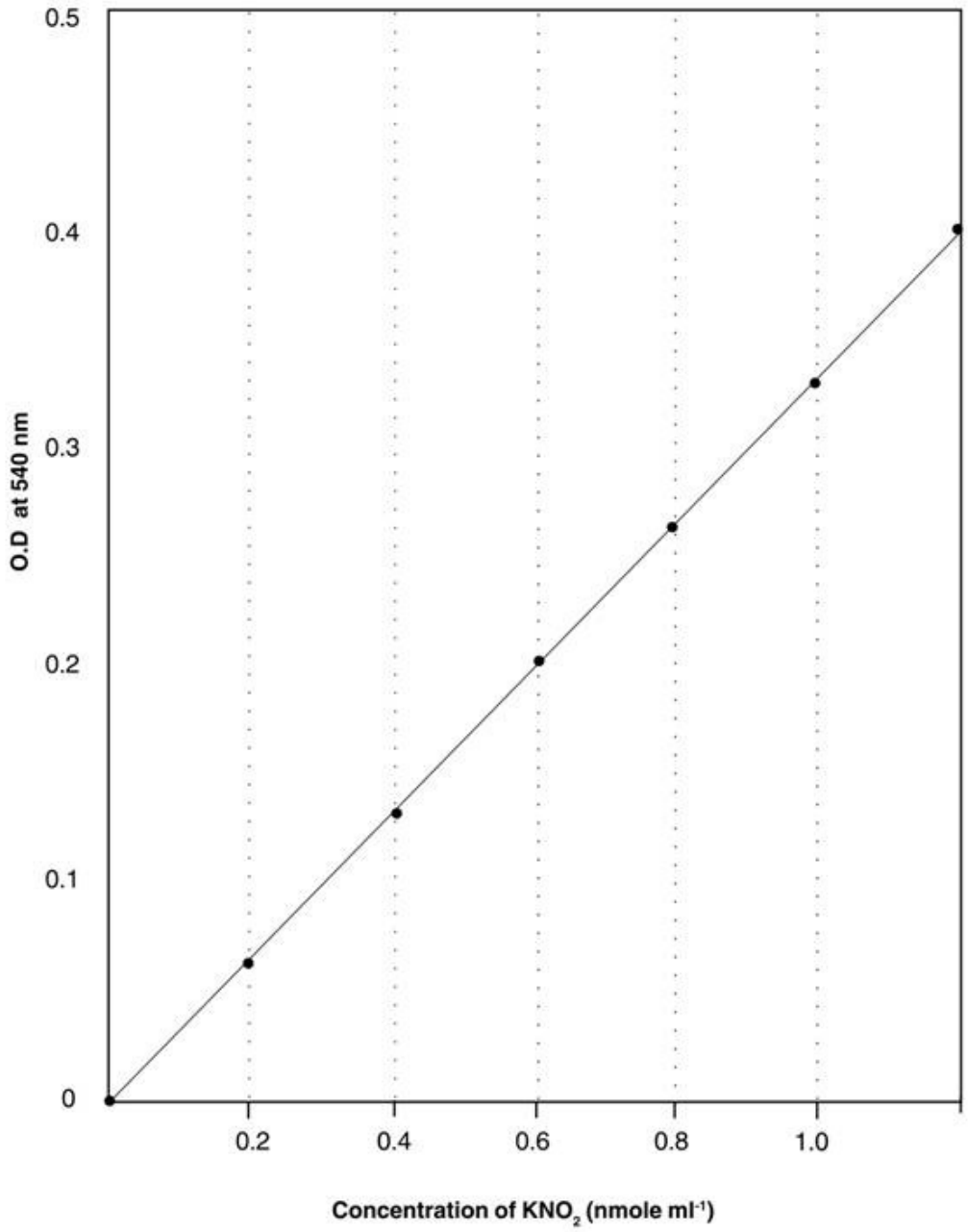

Figure 6. Standard curve for nitrate reductase activity

Fig 6. Standard curve for nitrate reductase activity

Preparation of acetone powder

Acetone powder of fresh composite leaf samples were prepared as per the procedure described by Brynt and Forrest (1979). Leaf samples were collected from the field in ice bath. These were chopped into small pieces and ground in chilled acetone. Mixture was filtered in Buchner funnel through Whatman No.1 filter paper under suction. The powder on filter paper was again ground with chilled acetone and filtered. This was repeated 2-3 times, powder was air dried and stored in freezer.

Preparation of enzyme source

100 mg of acetone powder was extracted with 10 ml of chilled 0.1 M phosphate buffer (pH = 6.0) in a precooled pestle and mortar. The mixture was centrifuged at 2000 g for 15 min at 2-4°C and the supernatant was used for assay.

Measurement of peroxidase activity

Pipetted 3 ml of guaicol (0.05 m), 0.1 ml of enzyme extract into a cuvette and the OD was adjusted to zero at 420 nm. To which, 0.5 ml of H_2O_2 was added and inverted the cuvette immediately to mix the contents and replace in a colorimeter. Changes in OD at 20 sec. interval were recorded for a period of 3 min. Then the average change in OD between 40 and 160 seconds was used to plot peroxidase activity, and compared with the control (boiled enzyme extract).

3.7.4.7 Estimation of polyphenol oxidase activity (PPO)

Polyphenol oxidase activity was estimated following the method of Thimmaiah (1989).

Preparation of enzyme source

The enzyme source was prepared by dissolving acetone powder in 0.1 M phosphate buffer (pH=6.0) as described under peroxidase.

Measurement of polyphenol oxidase activity

Pipetted out 2 ml of the extract and 3 ml of buffer into cuvette and mixed thoroughly by inverting and then placed in a colorimeter set at 495 nm and adjusted the OD to zero. Took 1 ml of extract and added 1 ml of catechol in buffer and mixed thoroughly. Then placed the tube immediately in the calorimeter and recorded changes in OD at every 30 sec. upto 3 min. Changes in OD between 30 sec. to 150 sec. of incubation were plotted to calculate the enzyme activity. Boiled enzyme extract served as control.

3.8 STATISTICAL ANALYSIS

Mean data was subjected to the analysis of variance following Panse and Sukhatme (1967) method. The level of significance used in “F” and “t” tests was P = 0.05 for field observations and P = 0.01 for laboratory studies. Critical differences were calculated whenever ‘F’ test was found significant.

IV. EXPERIMENTAL RESULTS

Plant growth substances play a major role in modifying various growth and developmental processes. Although, the crop yield depend upon the genetic make up of the plant, the interaction between environmental factors and physiological processes of the plant determines the crop yield. It is well known that the harvest index is very low in oilseeds, particularly in groundnut as compared to cereals. This could mainly be attributed to excessive vegetative growth coupled with poor source sink relationship; and leaf spot disease incidence. To improve the partitioning efficiency, and the source sink relationship, it is utmost essential at this juncture to modify the plant architecture which in turn would possibly alter the translocation efficiency within the plant. To achieve this goal, new generation of agrochemicals i.e., growth retardants may be used as effective tools in combination with salicylic acid, which induces resistance in groundnut plants to leaf spot disease.

Keeping this in mind, the present investigation was undertaken during *kharif* 2005 at University of Agricultural Sciences, Dharwad to study the influence of different concentrations of salicylic acid either alone or in combination with mepiquat chloride on the physiology and disease resistance in groundnut genotype JL –24. The experiment consisted of 15 treatments and the crop was sprayed with these chemicals at 48 and 80 DAS. The results obtained from the investigation are presented in this chapter (Table 1-15).

Table 1. Physical and chemical properties of the soil of experimental site.

Table 2. Monthly meteorological data for the experimental year (*kharif*, 2005) and the mean of past 55 years (1950-2004) as recorded at the Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka)

Table 3. Salient features of genotype(JL-24) used in the experiment.

Table 4. Influence of salicylic acid and mepiquat chloride on per cent disease index (%) at different stages in groundnut

Table 5. Influence of salicylic acid and mepiquat chloride on plant height (cm) and number of branches per plant at different stages in groundnut

Table 6. Influence of salicylic acid and mepiquat chloride on leaf area (dm^2/plant) at different stages in groundnut

Table 7. Influence of salicylic acid and mepiquat chloride on number of pods per plant at different stages in groundnut

Table 8. Influence of salicylic acid and mepiquat chloride on leaf dry weight (g/plant) at different stages in groundnut

Table 9. Influence of salicylic acid and mepiquat chloride on stem dry weight (g/plant) at different stages in groundnut

Table 10. Influence of salicylic acid and mepiquat chloride on pod dry weight (g/plant) at different stages in groundnut

Table 11. Influence of salicylic acid and mepiquat chloride on total dry weight (g/plant) at different stages in groundnut

Table 12. Influence of salicylic acid and mepiquat chloride on absolute growth rate (g/plant/day) at different stages in groundnut

Table 13. Influence of salicylic acid and mepiquat chloride on crop growth rate (g/m^2/day) at different stages in groundnut

Table 14. Influence of salicylic acid and mepiquat chloride on net assimilation rate (mg/dm^2/day) at different stages in groundnut

Table 15. Influence of salicylic acid and mepiquat chloride on leaf area index at different stages in groundnut

4.1 MORPHOLOGICAL CHARACTERS

4.1.1 DISEASE SCORING

It is evident from Table 4 that the incidence of late leaf spot progressed continuously from 70 to 90 DAS. Treatments differed significantly at both the stages and salicylic acid (500 ppm) in combination with mepiquat chloride (1000 ppm) recorded the lower per cent disease index (PDI) and the higher values were found in control.

At 70 DAS, salicylic acid (500 ppm) + mepiquat chloride (1000 ppm) recorded significantly lower PDI over salicylic acid (50 ppm), salicylic acid (100 ppm), salicylic acid (200 ppm), salicylic acid (100 ppm) + mepiquat chloride (1.0 ml/l), salicylic acid (200 ppm) + (1.0 ml/l) mepiquat chloride and control. However, treatments salicylic acid (50 ppm) and salicylic acid (50 ppm) + mepiquat chloride 1.0 ml/l) were at par with each other. However, control recorded significantly higher PDI over other treatment.

At 90 DAS, salicylic acid (500 ppm) + mepiquat chloride recorded lower PDI over all other treatments followed by salicylic acid (500 ppm), salicylic acid (600 ppm) + mepiquat chloride and salicylic acid (600 ppm) and were on par with each other. However control recorded higher PDI over other treatments followed by salicylic acid (50 ppm), salicylic acid (50 ppm) + mepiquat chloride and salicylic acid (100 ppm) + mepiquat chloride were on par with each other.

4.1.2 Plant height (cm)

Plant height increased continuously from 50 days after sowing (DAS) until harvest and the treatments differed significantly at all the stages except at 50 DAS (table 5). However the treatments which were treated with mepiquat chloride had recorded minimum plant height at all the stages than salicylic acid treatments. Among the treatments, salicylic acid (500 ppm) recorded the maximum plant height at all the stages and control had the minimum plant height. At harvest, though salicylic acid (500 ppm) had significantly higher plant height but was on par with other treatments except, the salicylic acid treatment which were combined with mepiquat chloride and control.

Among the combinations salicylic acid (500 ppm) along with mepiquat chloride recorded minimum plant height over all other treatments and control and the minimum plant height recorded in salicylic acid (500 ppm) + mepiquat chloride. The treatments having salicylic acid alone were on par with each other and recorded higher plant height, similarly there was no significant difference among the combined treatments.

However at 50 DAS, there were no significant differences between the treatments.

4.1.3 Number of branches

In general, number of branches increased from 50 DAS to harvest in all the treatments. At 50 DAS, there is no significant differences between the treatments. There was a significant difference between the treatments (Table 5). There will be increase in the number of branches with the increasing concentrations of salicylic acid. However, salicylic acid (500 ppm) had recorded maximum number of branches and was on par with the treatments involving salicylic acid (400 ppm , 600 ppm). However the treatments combined with mepiquat chloride were recorded maximum number of branches than any other treatments including control which has recorded lower number of branches. Among these treatments salicylic acid (500 ppm) + mepiquat chloride (1 ml/l) was found to have maximum number of branches.

4.1.4 Leaf area (dm^2 / plant)

Leaf area was found to increase upto 90 DAS and declined thereafter in all the treatments and the treatments differed significantly at all the stages (Table 6) except at 50 DAS. At 70 DAS, among the treatments, salicylic acid (500 ppm) recorded the highest leaf area at all the stages and was on par with all other treatments except at salicylic acid (50 ppm) + mepiquat chloride, salicylic acid (100 ppm) + mepiquat chloride, salicylic acid (200

Table 4. Influence of salicylic acid and mepiquat chloride on per cent disease index (%) at different stages in groundnut

sTreatments	Days after sowing	
	70	90
T_1 – SA (50 ppm)	18.8	32.6
T_2 – SA (100 ppm)	17.7	31.7
T_3 – SA (200 ppm)	17.3	30.8
T_4 – SA (300 ppm)	16.6	29.7
T_5 – SA (400 ppm)	16.3	27.5
T_6 – SA (500 ppm)	15.2	25.2
T_7 – SA (600 ppm)	15.7	26.3
T_8 – SA (50 ppm)+MC(1ml/l)	18.1	32.2
T_9 – SA (100 ppm) +MC(1ml/l)	17.3	31.5
T_{10} – SA (200 ppm) +MC(1ml/l)	16.9	29.6
T_{11} – SA (300 ppm) +MC(1ml/l)	16.1	28.3
T_{12} – SA (400 ppm) +MC(1ml/l)	15.8	27.4
T_{13} – SA (500 ppm) +MC(1ml/l)	14.9	24.6
T14 – SA (600 ppm) +MC(1ml/l)	15.2	25.7
T_{15} – Control	24.4	43.3
Mean	17.1	29.8
SEm±	0.59	0.54
CD (5%)	1.70	1.57

SA = Salicylic acid MC=Mepiquat chloride

Table 5. Influence of salicylic acid and mepiquat chloride on plant height (cm) and number of branches per plant at different stages in groundnut

Treatments	Plant height (cm)		Number of branches	
	Days after sowing		Days after sowing	
	50	Harvest	50	Harvest
T_1 – SA (50 ppm)	19.2	32.5	5.47	5.86
T_2 – SA (100 ppm)	19.2	32.7	5.53	6.03
T_3 – SA (200 ppm)	19.3	32.9	5.56	6.13
T_4 – SA (300 ppm)	19.4	33.0	5.63	6.10
T_5 – SA (400 ppm)	19.4	33.6	5.90	6.13
T_6 – SA (500 ppm)	19.7	33.8	6.08	6.20
T_7 – SA (600 ppm)	19.3	33.7	6.05	6.16
T_8 – SA (50 ppm)+MC(1ml/l)	17.9	29.6	6.11	7.92
T_9 – SA (100 ppm) +MC(1ml/l)	18.6	29.5	6.17	8.00
T_{10} – SA (200 ppm) +MC(1ml/l)	17.6	28.9	6.13	7.96
T_{11} – SA (300 ppm) +MC(1ml/l)	19.0	28.8	6.20	8.20
T_{12} – SA (400 ppm) +MC(1ml/l)	18.5	28.4	6.22	8.24
T_{13} – SA (500 ppm) +MC(1ml/l)	18.9	28.0	6.23	8.29
T14 – SA (600 ppm) +MC(1ml/l)	19.0	28.5	6.18	8.27
T_{15} – Control	17.1	30.9	5.16	5.51
Mean	18.8	30.9	5.89	6.98
SEm±	0.73	1.04	0.33	0.11
CD (5%)	NS	3.01	NS	0.31

SA = Salicylic acid MC=Mepiquat chloride NS=Non Significant

ppm) + mepiquat chloride which were on par with each other and the lower leaf area was recorded in control at this stage and a similar trend was noticed even at 90 DAS and harvest.

4.1.5 Number of Pods

Number of pods increased continuously from 50 DAS to harvest in all the treatments and the treatments differed significantly at all the stages except at 50 DAS. (Table 7). Among the treatments, the higher number of pods was recorded in salicylic acid (500 ppm) + mepiquat chloride at 70 DAS, 90 DAS and at harvest and the lower leaf area was recorded in control.

At 70 DAS, salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher number of pods, but it was on par with the treatments salicylic acid (400 ppm), salicylic acid (600 ppm) + mepiquat chloride and control, and there is no significant difference between the other treatments except salicylic acid (600 ppm), salicylic acid (300 ppm) + mepiquat chloride and the control had recorded less number of pods per plant.

A similar trend was noticed even at 90 DAS and at harvest However the treatments salicylic acid (300 ppm), salicylic acid (500 ppm) and salicylic acid (300 ppm), salicylic acid + mepiquat chloride (400 ppm), salicylic acid + mepiquat chloride (500 ppm), salicylic acid (600 ppm) + mepiquat chloride were on par with each other at 90 DAS and there is no significant difference between the other treatments except control. While, at harvest, salicylic acid (500 ppm) + mepiquat chloride was on par with salicylic acid (500 ppm), salicylic acid (600 ppm) and salicylic acid (300 ppm), salicylic acid (400 ppm), salicylic acid (500 ppm) + mepiquat chloride except control which was recorded less number of pods.

4.2 DRY MATTER PRODUCTION AND ITS PARTITIONING

4.2.1 Leaf dry weight (g/ plant)

The data on leaf dry weight presented in table 8 indicated that it increased up to 90 DAS and declined gradually thereafter in all the treatments and the treatments differed significantly at all the stages except at 50 DAS (Table 9). Among the treatments, salicylic acid (500 ppm) + mepiquat chloride had recorded the maximum leaf dry weight.

At 70 DAS, salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher leaf dry weight over other treatments and were on par with treatment salicylic acid (500 ppm), salicylic acid (600 ppm) and salicylic acid (300 ppm), salicylic acid + mepiquat chloride (400 ppm), salicylic acid (600 ppm) + mepiquat chloride, where as lower leaf dry matter was recorded in control.

Salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher leaf dry weight over all there treatments except salicylic acid (500 ppm), salicylic acid (10 ppm), salicylic acid (200 ppm) and salicylic acid (50 ppm) + mepiquat chloride which were on par with each other and the control had recorded minimum leaf dry weight at 90 DAS and at harvest.

4.2.2 Stem dry weight (g / plant)

Stem dry weight was found to increase continuously from 50 DAS to harvest in all the treatments (table 9). Treatments differed significantly at all the stages except at 50 DAS. Among the treatments, salicylic acid (500 ppm) + mepiquat chloride recorded the maximum stem dry weight at all the stages and control had the minimum stem dry weight. However at 70 DAS, salicylic acid (500 ppm) + mepiquat chloride was recorded higher stem dry weight over salicylic acid (50 ppm), salicylic acid (100 ppm), salicylic acid (200 ppm) and salicylic acid + mepiquat chloride (50 ppm, 100 ppm) + mepiquat chloride which were on par with each other and the control had recorded lower stem dry weight. Similar trend was noticed at the remaining stages.

4.2.3 Pod dry weight (g / plant)

Table 6. Influence of salicylic acid and mepiquat chloride on leaf area (dm^2/plant) at different stages in groundnut

Treatments	Days after sowing			
	50	70	90	Harvest
T_1 – SA (50 ppm)	6.84	11.03	14.13	9.44
T_2 – SA (100 ppm)	7.00	11.13	14.45	9.55
T_3 – SA (200 ppm)	7.17	11.19	14.76	10.26
T_4 – SA (300 ppm)	7.32	11.75	14.85	10.41
T_5 – SA (400 ppm)	7.32	12.44	15.11	10.59
T_6 – SA (500 ppm)	7.33	12.74	15.33	11.01
T_7 – SA (600 ppm)	7.21	12.32	14.80	10.42
T_8 – SA (50 ppm)+MC(1ml/l)	6.70	10.28	13.44	9.02
T_9 – SA (100 ppm) +MC(1ml/l)	6.74	10.25	13.79	9.20
T_{10} – SA (200 ppm) +MC(1ml/l)	6.76	10.79	13.88	9.53
T_{11} – SA (300 ppm) +MC(1ml/l)	6.92	10.98	14.23	9.66
T_{12} – SA (400 ppm) +MC(1ml/l)	7.02	11.18	14.57	9.81
T_{13} – SA (500 ppm) +MC(1ml/l)	7.22	11.86	15.06	10.26
T14 – SA (600 ppm) +MC(1ml/l)	7.17	11.44	14.81	9.94
T_{15} – Control	6.26	8.61	11.02	7.92
Mean	7.00	11.12	14.28	9.80
SEm±	0.38	0.52	0.53	0.36
CD (5%)	NS	1.52	1.55	1.03

SA = Salicylic acid MC=Mepiquat chloride NS=Non Significant

Table 7. Influence of salicylic acid and mepiquat chloride on number of pods per plant at different stages in groundnut

Treatments	Days after sowing			
	50	70	90	Harvest
T_1 – SA (50 ppm)	3.3	6.0	15.9	18.5
T_2 – SA (100 ppm)	3.2	6.1	16.0	18.9
T_3 – SA (200 ppm)	3.7	6.4	16.3	19.3
T_4 – SA (300 ppm)	3.4	6.5	16.5	19.7
T_5 – SA (400 ppm)	3.4	6.5	16.9	20.6
T_6 – SA (500 ppm)	3.4	6.7	17.2	21.0
T_7 – SA (600 ppm)	3.4	6.7	17.6	21.2
T_8 – SA (50 ppm)+MC(1ml/l)	3.3	6.3	16.2	19.0
T_9 – SA (100 ppm) +MC(1ml/l)	3.2	6.5	16.7	20.1
T_{10} – SA (200 ppm) +MC(1ml/l)	3.4	6.7	16.9	20.9
T_{11} – SA (300 ppm) +MC(1ml/l)	3.4	7.0	17.7	21.5
T_{12} – SA (400 ppm) +MC(1ml/l)	3.7	7.2	17.9	21.9
T_{13} – SA (500 ppm) +MC(1ml/l)	3.6	7.7	18.7	22.7
T14 – SA (600 ppm) +MC(1ml/l)	3.6	7.4	18.2	22.1
T_{15} – Control	3.6	5.5	12.8	15.9
Mean	3.4	6.6	16.8	20.2
SEm±	0.61	0.21	0.59	0.67
CD (5%)	NS	0.61	1.71	1.93

SA = Salicylic acid MC=Mepiquat chloride

There was an increase in pod dry weight as growth advanced due to the application of salicylic acid and mepiquat chloride and the treatments differed significantly at all the stages, except at 50 DAS (Table 10). Among the treatments, salicylic acid (500 ppm)+ mepiquat chloride recorded significantly higher pod dry weight at 70 DAS but it was on par with other treatments such as salicylic acid (600 ppm), salicylic acid (400 ppm) + mepiquat chloride and salicylic acid (500 ppm), salicylic acid (600 ppm). And there is no significant difference between the other remaining treatments and control recorded lower pod dry weight.

At 90 DAS and at harvest, salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher pod dry weight, but it was on par with other treatments except salicylic acid (50 ppm), salicylic acid (100 ppm), salicylic acid (200 ppm) salicylic acid (50 ppm) + mepiquat chloride and control which were on par with each other and had higher values over control.

4.2.4 Total dry weight (g / plant)

The data on total dry weight presented in Table 11 indicated significant differences between the treatments at all the stages except at 50 DAS and it was found to increase from 50 DAS till harvest. The treatment salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher total dry weight but it was on par with salicylic acid (400 ppm), salicylic acid (600 ppm) + mepiquat chloride and salicylic acid (500 ppm), salicylic acid + mepiquat chloride (600 ppm) and the control recorded lower total dry weight than any other treatments at 70 DAS.

Similar trend was continued even at 90 DAS where as at harvest, the treatment salicylic acid (500 ppm) + mepiquat chloride recorded higher total dry weight and was on par with all other treatments salicylic acid (50 ppm), salicylic acid (100 ppm), salicylic acid (200 ppm), salicylic acid (300 ppm), salicylic acid + mepiquat chloride (50 ppm), salicylic acid (100 ppm) + mepiquat chloride and control. However control recorded lower total dry weight than any other treatments at all the stages.

4.3 GROWTH PARAMETERS

4.3.1 Absolute growth rate (g / plant / day)

The data on AGR presented in Table 12 indicated that it was maximum at 50 –70 DAS and declined thereafter till harvest and the treatments differed significantly at all the stages. At 50 – 70 DAS, salicylic acid (500 ppm) + mepiquat chloride followed by salicylic acid (600 ppm) + mepiquat chloride and salicylic acid (400 ppm) + mepiquat chloride were recorded significantly higher AGR over all other treatments and lower AGR was recorded in control compared to all the treatments. However, the treatments, salicylic acid (200 ppm) + mepiquat chloride, salicylic acid)300 ppm) + mepiquat chloride, salicylic acid (400 ppm) + mepiquat chloride, salicylic acid (600 ppm) + mepiquat chloride, salicylic acid (500 ppm) + mepiquat chloride did not differ significantly among themselves. Similarly, the treatments salicylic acid (50 ppm), salicylic acid (100 ppm), salicylic acid (200 ppm), salicylic acid (300 ppm), salicylic acid (50 ppm) + mepiquat chloride and salicylic acid (100 ppm) + mepiquat chloride were at par with each other.

At 70 – 90 DAS, all the treatments except salicylic acid (50 ppm), salicylic acid (100 ppm), salicylic acid (200 ppm), salicylic acid (300 ppm), salicylic acid (500 ppm) were at par with each other and were lower than all the salicylic acid + mepiquat chloride combination treatments. However control recorded lower AGR at all the stages.

4.3.2 Crop growth rate (g/m^2/day)

The data on CGR as influenced by various treatments at different growth periods are presented in Table 13. Maximum CGR was recorded at 50 – 70 DAS and declined thereafter and the treatments showed significant differences at all the stges. At 50 – 70 DAS, salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher CGR followed by salicylic acid (600 ppm) + mepiquat chloride, salicylic acid (600 ppm), salicylic acid (400 ppm) + mepiquat chloride , salicylic acid (500 ppm) , salicylic acid (300 ppm) + mepiquat chloride, salicylic acid (200 ppm) + mepiquat chloride, salicylic acid (400 ppm) and salicylic acid

Table 8. Influence of salicylic acid and mepiquat chloride on leaf dry weight (g/plant) at different stages in groundnut

Treatments	Days after sowing			
	50	70	90	Harvest
T_1 – SA (50 ppm)	5.11	7.03	9.42	6.32
T_2 – SA (100 ppm)	5.14	7.05	9.67	6.45
T_3 – SA (200 ppm)	5.15	7.57	9.73	6.68
T_4 – SA (300 ppm)	5.30	7.66	9.97	6.77
T_5 – SA (400 ppm)	5.37	7.92	10.21	6.87
T_6 – SA (500 ppm)	5.48	8.00	10.40	7.20
T_7 – SA (600 ppm)	5.43	8.32	10.90	7.29
T_8 – SA (50 ppm)+MC(1ml/l)	5.23	7.51	9.67	6.65
T_9 – SA (100 ppm) +MC(1ml/l)	5.34	7.67	10.12	6.76
T_{10} – SA (200 ppm) +MC(1ml/l)	5.49	7.95	10.34	7.19
T_{11} – SA (300 ppm) +MC(1ml/l)	5.26	8.24	10.40	7.29
T_{12} – SA (400 ppm) +MC(1ml/l)	5.59	8.51	10.69	7.42
T_{13} – SA (500 ppm) +MC(1ml/l)	5.61	8.84	10.91	7.48
T14 – SA (600 ppm) +MC(1ml/l)	5.52	8.57	10.50	7.30
T_{15} – Control	4.79	6.03	7.72	5.55
Mean	5.32	7.79	10.04	6.88
SEm±	0.29	0.30	0.40	0.27
CD (5%)	NS	0.86	1.17	0.77

SA = Salicylic acid MC=Mepiquat chloride NS = Non significa

(300 ppm) over all over treatments. While, control recorded signficanlty lower CGR compared to all other treatments.

At 70 – 90 DAS, the treatment salicylic acid (100 ppm) + mepiquat chloride recorded the maximum CGR values over all other treatments followed by salicylic acid (200 ppm) + mepiquat chloride, salicylic acid (400 ppm), salicylic acid (300 ppm) + mepiquat chloride, salicylic acid (600 ppm) + mepiquat chloride and salicylic acid (600 ppm). But the control recorded lowest CGR values.

4.3.3 Net assimilation rate (mg/dm^2/day)

It is evident from table 14 that the NAR was maximum at 50 –70 DAS and then declined at 70 – 90 DAS in all the treatments. Among the treatments, salicylic acid (500 ppm) + mepiquat chloride and salicylic acid (600 ppm) were on par with each other and were recorded highest NAR over all other treatments.

The treatments salicylic acid (600 ppm) + mepiquat chloride , salicylic acid (500 ppm), salicylic acid (400 ppm) + mepiquat chloride, salicylic acid (400 ppm), salicylic acid (300 ppm) and salicylic acid (200 ppm) + mepiquat chloride were on par with each other. However, control recorded lowest NAR over all other treatments at 50 – 70 DAS.

At 70-90 DAS, salicylic acid (100 ppm) + mepiquat chloride recorded highest NAR values followed by as (100 ppm) , salicylic acid (50 ppm), salicylic acid (50 ppm) + mepiquat chloride and salicylic acid (500 ppm) + mepiquat chloride. However control recorded lowest NAR except salicylic acid (400 ppm) + mepiquat chloride and salicylic acid (600 ppm) + mepiquat chloride.

4.3.4 Leaf area Index

Leaf area index (LAI) as influenced by the application of salicylic acid and mepiquat chloride at various growth stages was found to increase upto 90 DAS and declined there after in all the treatments and treatments differed significantly at all the stages (table-15). Among the combinations salicylic acid (500 ppm) + mepiquat chloride recorded maximum LAI when compared to all other salicylic acid treatments either alone or in combination with mepiquat chloride, and the control had recorded lowest leaf area index at all the stages.

4.3.5 Leaf area Ratio (cm^2 / g)

The result on leaf area ratio indicated significant differences due to treatments at different stages, except at 50 DAS, where no significant differences were observed among the treatments (Table 16). At 70 DAS, salicylic acid (400 ppm) recorded highest LAR followed by salicylic acid (50 ppm) over all the treatments. However the salicylic acid + mepiquat chloride treatment combinations, but among those combination salicylic acid (600 ppm) + mepiquat chloride reported highest LAR than any other combination (Tables 16-30).

Table 16. Influence of salicylic acid and mepiquat chloride on leaf area ratio (cm^2/g) at different stages in groundnut

Table 17. Influence of salicylic acid and mepiquat chloride on leaf area duration (days) at different stages in groundnut

Table 18. Influence of salicylic acid and mepiquat chloride on biomass duration (g day) at different stages in groundnut

Table 19. Influence of salicylic acid and mepiquat chloride on chlorophyll ‘a’ content (mg/g fresh weight) at different stages in groundnut

Table 20. Influence of salicylic acid and mepiquat chloride on chlorophyll ‘b’ content (mg/g fresh weight) at different stages in groundnut

Table 21. Influence of salicylic acid and mepiquat chloride on total chlorophyll content (mg/g fresh weight) at different stages in groundnut

Table 22. Influence of salicylic acid and mepiquat chloride on total sugar content (mg/g dry weight) at different stages in groundnut

Table 23. Influence of salicylic acid and mepiquat chloride on total phenol content (µg/g dry weight) at different stages in groundnut

Table 24. Influence of salicylic acid and mepiquat chloride on tannin content (µg/g dry weight) at different stages in groundnut

Table 25. Influence of salicylic acid and mepiquat chloride on nitrate reductase activity (nmoles NO_2/g fresh weight/ hour) at different stages in groundnut

Table 26. Influence of salicylic acid and mepiquat chloride on peroxidase activity (ΔOD /g dry weight/min) at different stages in groundnut

Table 27. Influence of salicylic acid and mepiquat chloride on polyphenol oxidase activity (ΔOD /g dry weight/min) at different stages in groundnut

Table 28. Influence of salicylic acid and mepiquat chloride on yield and yield components in groundnut

Table 29. Influence of salicylic acid and mepiquat chloride on yield components in groundnut

Table 30. Influence of salicylic acid and mepiquat chloride on benefit : cost ratio in groundnut

At 90 DAS, salicylic acid (50 ppm) recorded highest LAR among the treatments having salicylic acid alone, but among the combinations salicylic acid (500 ppm) + mepiquat chloride recorded highest LAR.

At harvest, salicylic acid (500 ppm) recorded highest LAR, compared to other treatment, but among the treatment combinations control has recorded highest LAR followed by salicylic acid (500 ppm) + mepiquat chloride.

4.3.6 Leaf area Duration (days)

The leaf area duration (LAD) increased from 50 – 70 DAS and declined thereafter and the treatments differed significantly at all the stages (Table 17). At 50 – 70 DAS, the treatment salicylic acid (500 ppm) had recorded maximum LAD over all other treatments followed by salicylic acid (400 ppm) and salicylic acid (600 ppm) which were on par with each other. The minimum LAD was noticed in control. A similar was noticed even at 70-90 DAS.

4.3.7 Biomass duration (g days)

It is evident from Table 18 that biomass duration (BMD) increased from 50 – 70 DAS to 90 DAS - Harvest, irrespective of the treatments and the treatments differed significantly at all the stages. Among the treatments, salicylic acid (500 ppm) + mepiquat chloride recorded the maximum BMD value over other treatments, but was on par with salicylic acid (600 ppm) + mepiquat chloride, salicylic acid (400 ppm) + mepiquat chloride, salicylic acid (300 ppm) + m, salicylic acid (200 ppm) + mepiquat chloride, salicylic acid (500 ppm) and salicylic acid (400 ppm) at 50 –70 DAS. A similar trend was noticed even at 70-90 DAS.

At harvest, salicylic acid (500 ppm) + mepiquat chloride recorded maximum Biomass duration and was on par with all other treatments except salicylic acid (50 ppm), salicylic acid (100 ppm), salicylic acid (200 ppm), salicylic acid (300 ppm) and control, control had the minimum biomass duration at all the stages.

4.4 BIOCHEMICAL PARAMETERS

4.4.1 Chlorophyll ‘a’ content (mg / g fr. Wt.)

The data on chlorophyll ‘a’ content presented in Table 19 indicated that it decreased from 60 DAS to harvest. Signficant differences were found among the treatments at all the stages. At 60 DAS salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher chlorophyll ‘a’ content over salicylic acid (400 ppm) , salicylic acid (500 ppm) , salicylic acid (600 ppm) , salicylic acid (200 ppm) + mepiquat chloride, salicylic acid (300 ppm) + mepiquat chloride which were on par with each other. However control recorded lowest chlorophyll ‘a’ content. Similarly, significant differences were found between the lower doses of salicylic

Table 9. Influence of salicylic acid and mepiquat chloride on stem dry weight (g/plant) at different stages in groundnut

Treatments	Days after sowing			
	50	70	90	Harvest
T_1 – SA (50 ppm)	6.14	8.45	9.86	13.15
T_2 – SA (100 ppm)	6.29	8.57	9.90	13.59
T_3 – SA (200 ppm)	6.49	9.03	10.52	13.98
T_4 – SA (300 ppm)	6.44	9.35	10.62	14.03
T_5 – SA (400 ppm)	6.52	9.40	10.95	14.35
T_6 – SA (500 ppm)	6.90	9.56	11.01	14.48
T_7 – SA (600 ppm)	6.81	9.76	11.30	14.52
T_8 – SA (50 ppm)+MC(1ml/l)	6.13	9.03	10.56	13.45
T_9 – SA (100 ppm) +MC(1ml/l)	6.34	9.12	11.26	13.71
T_{10} – SA (200 ppm) +MC(1ml/l)	6.40	9.43	11.28	13.84
T_{11} – SA (300 ppm) +MC(1ml/l)	6.66	9.62	11.47	14.46
T_{12} – SA (400 ppm) +MC(1ml/l)	6.97	9.96	11.58	14.72
T_{13} – SA (500 ppm) +MC(1ml/l)	7.06	10.17	11.74	14.74
T14 – SA (600 ppm) +MC(1ml/l)	6.99	9.97	11.86	14.50
T_{15} – Control	6.99	7.17	9.72	10.78
Mean	6.54	9.24	10.91	13.89
SEm±	0.32	0.29	0.40	0.35
CD (5%)	NS	0.84	1.17	1.02

SA = Salicylic acid MC=Mepiquat chloride NS = Non significant

Table 10. Influence of salicylic acid and mepiquat chloride on pod dry weight (g/plant) at different stages in groundnut

Treatments	Days after sowing			
	50	70	90	Harvest
T_1 – SA (50 ppm)	2.04	7.33	10.68	12 .047
T_2 – SA (100 ppm)	2.14	7.63	11.15	12.27
T_3 – SA (200 ppm)	2.18	7.70	11.53	12.53
T_4 – SA (300 ppm)	2.21	7.74	11.73	12.79
T_5 – SA (400 ppm)	2.29	7.99	11.93	13.33
T_6 – SA (500 ppm)	2.25	8.72	12.13	13.67
T_7 – SA (600 ppm)	2.22	8.75	12.33	13.72
T_8 – SA (50 ppm)+MC(1ml/l)	2.36	7.53	11.32	12.64
T_9 – SA (100 ppm) +MC(1ml/l)	2.37	7.86	11.76	13.04
T_{10} – SA (200 ppm) +MC(1ml/l)	2.38	8.10	11.82	13.62
T_{11} – SA (300 ppm) +MC(1ml/l)	2.40	8.14	11.90	13.86
T_{12} – SA (400 ppm) +MC(1ml/l)	2.42	8.62	12.15	13.96
T_{13} – SA (500 ppm) +MC(1ml/l)	2.43	8.87	13.01	14.15
T14 – SA (600 ppm) +MC(1ml/l)	2.33	8.74	12.44	13.93
T_{15} – Control	1.91	6.90	8.68	10.93
Mean	2.26	8.04	11.64	13.10
SEm±	0.16	0.39	0.48	0.48
CD (5%)	NS	1.13	1.39	1.39

SA = Salicylic acid MC=Mepiquat chloride NS = Non significant

Table 11. Influence of salicylic acid and mepiquat chloride on total dry weight (g/plant) at different stages in groundnut

Treatments	Days after sowing			
	50	70	90	Harvest
T_1 – SA (50 ppm)	13.28	22.82	29.95	31.52
T_2 – SA (100 ppm)	13.56	23.34	30.72	32.31
T_3 – SA (200 ppm)	13.81	24.31	31.78	33.18
T_4 – SA (300 ppm)	13.94	24.75	32.33	33.58
T_5 – SA (400 ppm)	14.17	25.31	33.09	34.56
T_6 – SA (500 ppm)	14.63	26.28	33.54	35.35
T_7 – SA (600 ppm)	14.55	26.82	34.52	35.53
T_8 – SA (50 ppm)+MC(1ml/l)	13.72	24.07	31.55	32.74
T_9 – SA (100 ppm) +MC(1ml/l)	14.05	24.68	33.14	33.18
T_{10} – SA (200 ppm) +MC(1ml/l)	14.27	25.47	33.45	34.65
T_{11} – SA (300 ppm) +MC(1ml/l)	14.66	26.00	33.77	35.61
T_{12} – SA (400 ppm) +MC(1ml/l)	14.98	26.99	34.42	36.10
T_{13} – SA (500 ppm) +MC(1ml/l)	15.09	27.82	35.66	36.20
T14 – SA (600 ppm) +MC(1ml/l)	14.84	27.17	34.80	35.40
T_{15} – Control	12.79	19.99	26.12	27.26
Mean	14.16	25.06	32.59	33.83
S.Em±	0.49	0.43	0.74	0.65
CD (5%)	NS	1.25	2.16	1.90

SA = Salicylic acid MC=Mepiquat chloride NS=Non Significant

Table 12. Influence of salicylic acid and mepiquat chloride on absolute growth rate (g/plant/day) at different stages in groundnut

Treatments	Days after sowing	
	50-70	70-90
T_1 – SA (50 ppm)	0.48	0.36
T_2 – SA (100 ppm)	0.49	0.37
T_3 – SA (200 ppm)	0.53	0.37
T_4 – SA (300 ppm)	0.54	0.38
T_5 – SA (400 ppm)	0.56	0.39
T_6 – SA (500 ppm)	0.58	0.36
T_7 – SA (600 ppm)	0.61	0.39
T_8 – SA (50 ppm)+MC(1ml/l)	0.52	0.37
T_9 – SA (100 ppm) +MC(1ml/l)	0.53	0.38
T_{10} – SA (200 ppm) +MC(1ml/l)	0.56	0.38
T_{11} – SA (300 ppm) +MC(1ml/l)	0.57	0.39
T_{12} – SA (400 ppm) +MC(1ml/l)	0.60	0.38
T_{13} – SA (500 ppm) +MC(1ml/l)	0.64	0.39
T14 – SA (600 ppm) +MC(1ml/l)	0.62	0.38
T_{15} – Control	0.36	0.31
Mean	0.55	0.37
SEm±	0.031	0.004
CD (5%)	0.093	0.012

SA = Salicylic acid MC=Mepiquat chloride

Table 13. Influence of salicylic acid and mepiquat chloride on crop growth rate (g/m^2/day) at different stages in groundnut

Treatments	Days after sowing	
	50-70	70-90
T_1 – SA (50 ppm)	15.7	11.8
T_2 – SA (100 ppm)	16.1	12.2
T_3 – SA (200 ppm)	17.3	12.3
T_4 – SA (300 ppm)	17.8	12.5
T_5 – SA (400 ppm)	18.4	12.8
T_6 – SA (500 ppm)	19.2	12.3
T_7 – SA (600 ppm)	20.2	12.7
T_8 – SA (50 ppm)+MC(1ml/l)	17.1	12.0
T_9 – SA (100 ppm) +MC(1ml/l)	17.5	14.0
T_{10} – SA (200 ppm) +MC(1ml/l)	18.5	13.2
T_{11} – SA (300 ppm) +MC(1ml/l)	18.7	12.8
T_{12} – SA (400 ppm) +MC(1ml/l)	19.8	12.3
T_{13} – SA (500 ppm) +MC(1ml/l)	21.0	12.9
T14 – SA (600 ppm) +MC(1ml/l)	20.4	12.6
T_{15} – Control	11.9	10.1
Mean	18.0	12.4
SEm±	1.10	1.41
CD at 5%	3.17	4.19

SA = Salicylic acid MC=Mepiquat chloride

Table 14. Influence of salicylic acid and mepiquat chloride on net assimilation rate g/dm^2/day) at different stages in groundnut

Treatments	Days after sowing	
	50-70	70-90
T_1 – SA (50 ppm)	57.7	30.6
T_2 – SA (100 ppm)	58.5	31.0
T_3 – SA (200 ppm)	60.8	30.4
T_4 – SA (300 ppm)	61.6	30.3
T_5 – SA (400 ppm)	61.9	30.2
T_6 – SA (500 ppm)	63.8	27.8
T_7 – SA (600 ppm)	65.6	28.2
T_8 – SA (50 ppm)+MC(1ml/l)	59.9	29.5
T_9 – SA (100 ppm) +MC(1ml/l)	60.1	27.8
T_{10} – SA (200 ppm) +MC(1ml/l)	61.5	30.5
T_{11} – SA (300 ppm) +MC(1ml/l)	60.5	28.6
T_{12} – SA (400 ppm) +MC(1ml/l)	63.4	26.6
T_{13} – SA (500 ppm) +MC(1ml/l)	65.6	32.2
T14 – SA (600 ppm) +MC(1ml/l)	65.3	28.0
Mean	61.0	29.3
SEm±	1.49	0.89

CD (5%)	4.32	2.59
CD (5%)	4.32	2.59

SA = Salicylic acid MC=Mepiquat chloride

acid (50, 100 ppm) and higher doses of salicylic acid (500, 600 ppm) either alone or in combination with mepiquat chloride. However, no significant differences were found between salicylic acid (200 ppm) and salicylic acid (300 ppm).

The treatment salicylic acid (50 ppm) recorded the lowest chlorophyll 'a' content among all the treatments except control. A similar trend continued even at 70 and 85 DAS.

4.4.2 Chlorophyll 'b' content (mg /g fr. wt.)

Chlorophyll 'b' content decreased from 60 DAS to harvest irrespective of the treatments and the treatments showed significant differences at all the stages (Table 20). THE treatment salicylic acid (600 ppm) + mepiquat chloride recorded significantly higher chlorophyll 'b' content over other treatments at 60 DAS. However chlorophyll 'b' content was more in mepiquat chloride treatments compared to the treatments consisting of salicylic acid alone. Moreover the higher doses of salicylic acid had resulted in greater amount of chlorophyll 'b' content compared to lower doses of salicylic acid either alone or in combination with mepiquat chloride. However, control had recorded lowest chlorophyll 'b' content. A similar trend continued even at 75 DAS and at harvest.

4.4.3 Total chlorophyll content (mg / g fresh weight).

Total chlorophyll content was found to decrease from 60 DAS to harvest and the treatments differed significantly at all the stages (table 21). Among the treatments, the maximum total chlorophyll content was recorded in salicylic acid (500 ppm) + mepiquat chloride at all the stages and the lowest was in control.

At 60 DAS, salicylic acid (600 ppm) + mepiquat chloride recorded significantly hgiehr total chlorophyll content over other treatments. However the higher concentrations of salicylic acid either alone or in combination with mepiquat chloride recorded significantly higher total chlorophyll content than the lower concentration of salicylic acid. But the treatments salicylic acid (50 ppm) and salicylic acid (100 ppm) recorded lower total chlorophyll content except control which recorded least total chlorophyll content. Similar trend had recorded during remaining stages.

4.4.4 Total sugar content (mg / g dry weight)

Total sugar content as influenced by the application of salicylic acid and mepiquat chloride at various growth stages is presented in table 22. Total sugar content increased from 60 DAS to harvest in all the treatments and treatments differed significantly at all stages. Among the treatments, salicylic acid (500 ppm) + mepiquat chloride recorded significantly lower sugar content over all the treatments at all the stages followed by salicylic acid (600 ppm) + mepiquat chloride. But the highest sugar content was recorded in control followed by salicylic acid (50 ppm) and salicylic acid (100 ppm) at all the stages. But in general, the lowest sugar content was noticed in the treatments salicylic acid (500 ppm) followed by salicylic acid (600 ppm) and salicylic acid (400 ppm) either alone or in combination with mepiquat chloride. In contrast to this the higher sugar content ws recorded in salicylic acid (50 ppm), salicylic acid (100 ppm) and control.

A similar trend continued at 75 DAS and at harvest, salicylic acid (500 ppm) + mepiquat chloride had the minimum values over all other treatments.

4.4.5 Total phenol content (µg/g dry weight)

Table 15. Influence of salicylic acid and mepiquat chloride on leaf area index at different stages in groundnut

Treatments	Days after sowing			
	50	70	90	Harvest
T_1 – SA (50 ppm)	2.3	3.7	4.7	3.1
T_2 – SA (100 ppm)	2.3	3.7	4.8	3.2
T_3 – SA (200 ppm)	2.4	3.7	4.9	3.4
T_4 – SA (300 ppm)	2.4	3.9	5.0	3.5
T_5 – SA (400 ppm)	2.4	4.1	5.0	3.5
T_6 – SA (500 ppm)	2.4	4.2	5.1	3.7
T_7 – SA (600 ppm)	2.4	4.1	4.9	3.5
T_8 – SA (50 ppm)+MC(1ml/l)	2.2	3.4	4.5	3.0
T_9 – SA (100 ppm) +MC(1ml/l)	2.2	3.4	5.0	3.1
T_{10} – SA (200 ppm) +MC(1ml/l)	2.3	3.6	4.6	3.2
T_{11} – SA (300 ppm) +MC(1ml/l)	2.1	3.7	4.7	3.2
T_{12} – SA (400 ppm) +MC(1ml/l)	2.3	3.7	4.9	3.3
T_{13} – SA (500 ppm) +MC(1ml/l)	2.4	4.0	5.0	3.4
T14 – SA (600 ppm) +MC(1ml/l)	2.4	3.8	4.9	3.3
T_{15} – Control	2.1	2.7	3.7	2.6
Mean	2.3	3.7	3.8	3.3
SEm±	0.001	0.075	0.193	0.165
CD (5%)	0.003	0.216	0.568	0.479

SA = Salicylic acid MC=Mepiquat chloride NS=Non Significant

Table 16. Influence of salicylic acid and mepiquat chloride on leaf area ratio (cm^2/g) at different stages in groundnut

Treatments	Days after sowing			
	50	70	90	Harvest
T_1 – SA (50 ppm)	51.5	48.3	47.1	30.0
T_2 – SA (100 ppm)	51.5	47.7	47.0	29.6
T_3 – SA (200 ppm)	50.3	46.1	46.5	30.9
T_4 – SA (300 ppm)	49.9	47.5	45.9	31.0
T_5 – SA (400 ppm)	51.6	49.1	45.7	31.0
T_6 – SA (500 ppm)	50.2	44.7	45.7	31.1
T_7 – SA (600 ppm)	49.6	45.6	44.1	29.3
T_8 – SA (50 ppm)+MC(1ml/l)	48.1	42.7	42.6	27.7
T_9 – SA (100 ppm) +MC(1ml/l)	48.0	41.5	41.6	27.5
T_{10} – SA (200 ppm) +MC(1ml/l)	47.4	42.0	41.5	27.1
T_{11} – SA (300 ppm) +MC(1ml/l)	47.3	42.3	42.1	27.2
T_{12} – SA (400 ppm) +MC(1ml/l)	46.9	41.4	42.3	28.3
T_{13} – SA (500 ppm) +MC(1ml/l)	47.4	41.1	42.6	29.0
T14 – SA (600 ppm) +MC(1ml/l)	48.3	43.7	41.8	27.7
T_{15} – Control	49.0	43.0	42.2	27.5
Mean	49.1	44.4	43.9	29.0
SEm±	1.3	1.5	1.5	0.6
CD (5%)	NS	4.2	4.3	1.7

SA = Salicylic acid MC=Mepiquat chloride NS=Non Significant

Table 17. Influence of salicylic acid and mepiquat chloride on leaf area duration (days) at different stages in groundnut

Treatments	Days after sowing	
	50-70	70-90
T_1 – SA (50 ppm)	59.5	83.8
T_2 – SA (100 ppm)	60.3	85.2
T_3 – SA (200 ppm)	61.2	86.5
T_4 – SA (300 ppm)	63.4	88.5
T_5 – SA (400 ppm)	65.8	91.7
T_6 – SA (500 ppm)	66.8	93.5
T_7 – SA (600 ppm)	64.3	90.0
T_8 – SA (50 ppm)+MC(1ml/l)	56.4	79.0
T_9 – SA (100 ppm) +MC(1ml/l)	56.5	83.7
T_{10} – SA (200 ppm) +MC(1ml/l)	58.3	82.0
T_{11} – SA (300 ppm) +MC(1ml/l)	57.2	84.1
T_{12} – SA (400 ppm) +MC(1ml/l)	60.6	85.8
T_{13} – SA (500 ppm) +MC(1ml/l)	63.6	89.8
T14 – SA (600 ppm) +MC(1ml/l)	61.9	87.5
T_{15} – Control	47.6	72.9
Mean	60.2	85.6
SEm±	1.92	2.33
CD (5%)	5.76	6.90

SA = Salicylic acid MC=Mepiquat chloride

Table 18. Influence of salicylic acid and mepiquat chloride on biomass duration (g day) at different stages in groundnut

Treatments	Days after sowing		
	50-70	70-90	90-harvest
T_1 – SA (50 ppm)	361.0	527.7	614.7
T_2 – SA (100 ppm)	369.0	540.6	630.2
T_3 – SA (200 ppm)	381.2	560.9	649.6
T_4 – SA (300 ppm)	386.9	570.7	659.1
T_5 – SA (400 ppm)	394.8	584.0	676.4
T_6 – SA (500 ppm)	409.0	598.2	688.9
T_7 – SA (600 ppm)	413.8	613.4	700.5
T_8 – SA (50 ppm)+MC(1ml/l)	377.9	556.2	642.9
T_9 – SA (100 ppm) +MC(1ml/l)	387.3	578.2	663.2
T_{10} – SA (200 ppm) +MC(1ml/l)	397.4	589.2	681.0
T_{11} – SA (300 ppm) +MC(1ml/l)	406.5	597.6	693.7
T_{12} – SA (400 ppm) +MC(1ml/l)	419.7	614.1	705.2
T_{13} – SA (500 ppm) +MC(1ml/l)	429.1	634.8	718.6
T14 – SA (600 ppm) +MC(1ml/l)	420.1	619.7	702.0
T_{15} – Control	327.8	461.1	537.8
Mean	392.1	576.4	664.3
SEm±	12.21	14.50	19.38
CD (5%)	35.39	42.18	56.14

SA = Salicylic acid MC=Mepiquat chloride

Table 19. Influence of salicylic acid and mepiquat chloride on chlorophyll 'a' content (mg/g fresh weight) at different stages in groundnut

Treatments	Days after sowing		
	60	75	harvest
T_1 – SA (50 ppm)	1.380	1.241	0.119
T_2 – SA (100 ppm)	1.421	1.271	0.128
T_3 – SA (200 ppm)	1.488	1.310	0.130
T_4 – SA (300 ppm)	1.486	1.351	0.137
T_5 – SA (400 ppm)	1.581	1.390	0.145
T_6 – SA (500 ppm)	1.634	1.431	0.147
T_7 – SA (600 ppm)	1.655	1.470	0.152
T_8 – SA (50 ppm)+MC(1ml/l)	1.512	1.282	0.121
T_9 – SA (100 ppm) +MC(1ml/l)	1.583	1.425	0.145
T_{10} – SA (200 ppm) +MC(1ml/l)	1.628	1.480	0.148
T_{11} – SA (300 ppm) +MC(1ml/l)	1.631	1.512	0.152
T_{12} – SA (400 ppm) +MC(1ml/l)	1.710	1.577	0.153
T_{13} – SA (500 ppm) +MC(1ml/l)	1.854	1.704	0.170
T14 – SA (600 ppm) +MC(1ml/l)	1.831	1.630	0.155
T_{15} – Control	1.160	1.118	0.113
Mean	1.568	1.411	0.141
SEm±	0.021	0.001	0.001
CD at 5%	0.062	0.004	0.003

SA = Salicylic acid MC=Mepiquat chloride

Table 20. Influence of salicylic acid and mepiquat chloride on chlorophyll 'b' content (mg/g fresh weight) at different stages in groundnut

Treatments	Days after sowing		
	60	75	Harvest
T_1 – SA (50 ppm)	0.619	0.471	0.150
T_2 – SA (100 ppm)	0.632	0.483	0.161
T_3 – SA (200 ppm)	0.638	0.473	0.160
T_4 – SA (300 ppm)	0.651	0.502	0.181
T_5 – SA (400 ppm)	0.657	0.536	0.204
T_6 – SA (500 ppm)	0.683	0.538	0.226
T_7 – SA (600 ppm)	0.692	0.571	0.243
T_8 – SA (50 ppm)+MC(1ml/l)	0.722	0.592	0.234
T_9 – SA (100 ppm) +MC(1ml/l)	0.740	0.621	0.211
T_{10} – SA (200 ppm) +MC(1ml/l)	0.745	0.668	0.256
T_{11} – SA (300 ppm) +MC(1ml/l)	0.780	0.673	0.287
T_{12} – SA (400 ppm) +MC(1ml/l)	0.803	0.694	0.306
T_{13} – SA (500 ppm) +MC(1ml/l)	0.865	0.713	0.327
T14 – SA (600 ppm) +MC(1ml/l)	0.810	0.693	0.324
T_{15} – Control	0.521	0.438	0.140
Mean	0.716	0.575	0.225
SEm±	0.001	0.001	0.004
CD (5%)	0.003	0.003	0.012

SA = Salicylic acid MC=Mepiquat chloride

Table 21. Influence of salicylic acid and mepiquat chloride on total chlorophyll content (mg/g fresh weight) at different stages in groundnut

Treatments	Days after sowing		
	60	75	Harvest
T_1 – SA (50 ppm)	2.000	1.712	0.269
T_2 – SA (100 ppm)	2.053	1.754	0.289
T_3 – SA (200 ppm)	2.126	1.783	0.290
T_4 – SA (300 ppm)	2.139	1.853	0.318
T_5 – SA (400 ppm)	2.238	1.926	0.349
T_6 – SA (500 ppm)	2.317	1.969	0.373
T_7 – SA (600 ppm)	2.347	2.041	0.395
T_8 – SA (50 ppm)+MC(1ml/l)	2.234	1.874	0.355
T_9 – SA (100 ppm) +MC(1ml/l)	2.323	2.046	0.356
T_{10} – SA (200 ppm) +MC(1ml/l)	2.370	2.148	0.404
T_{11} – SA (300 ppm) +MC(1ml/l)	2.411	2.185	0.439
T_{12} – SA (400 ppm) +MC(1ml/l)	2.510	2.271	0.459
T_{13} – SA (500 ppm) +MC(1ml/l)	2.710	2.417	0.497
T14 – SA (600 ppm) +MC(1ml/l)	2.640	2.323	0.479
T_{15} – Control	1.680	1.546	0.253
Mean	2.273	1.990	0.368
SEm±	0.024	0.003	0.0003
CD (5%)	0.070	0.010	0.001

SA = Salicylic acid MC= Mepiquat chloride

Table 22. Influence of salicylic acid and mepiquat chloride on total sugar content (mg/g dry weight) at different stages in groundnut

Treatments	Days after sowing		
	60	75	harvest
T_1 – SA (50 ppm)	0.648	1.152	2.136
T_2 – SA (100 ppm)	0.626	1.104	2.018
T_3 – SA (200 ppm)	0.583	1.045	1.982
T_4 – SA (300 ppm)	0.504	0.964	1.835
T_5 – SA (400 ppm)	0.482	0.953	1.788
T_6 – SA (500 ppm)	0.378	0.828	1.582
T_7 – SA (600 ppm)	0.41	0.864	1.624
T_8 – SA (50 ppm)+MC(1ml/l)	0.561	0.985	1.964
T_9 – SA (100 ppm) +MC(1ml/l)	0.52	0.986	1.928
T_{10} – SA (200 ppm) +MC(1ml/l)	0.461	0.926	1.736
T_{11} – SA (300 ppm) +MC(1ml/l)	0.431	0.882	1.674
T_{12} – SA (400 ppm) +MC(1ml/l)	0.362	0.812	1.486
T_{13} – SA (500 ppm) +MC(1ml/l)	0.315	0.785	1.345
T14 – SA (600 ppm) +MC(1ml/l)	0.354	0.794	1.424
T_{15} – Control	0.683	1.215	2.214
Mean	0.487	0.953	1.782
SEm±	0.001	0.001	0.001
CD (5%)	0.003	0.002	NS

SA = Salicylic acid MC=Mepiquat chloride NS=NonSignificant

Table 23. Influence of salicylic acid and mepiquat chloride on total phenol content (µg/g dry weight) at different stages in groundnut

Treatments	Days after sowing		
	60	75	Harvest
T_1 – SA (50 ppm)	874	465	156
T_2 – SA (100 ppm)	893	483	168
T_3 – SA (200 ppm)	958	536	190
T_4 – SA (300 ppm)	1192	635	236
T_5 – SA (400 ppm)	1347	687	247
T_6 – SA (500 ppm)	1730	814	274
T_7 – SA (600 ppm)	1628	776	265
T_8 – SA (50 ppm)+MC(1ml/l)	928	510	182
T_9 – SA (100 ppm) +MC(1ml/l)	1035	558	218
T_{10} – SA (200 ppm) +MC(1ml/l)	1125	592	228
T_{11} – SA (300 ppm) +MC(1ml/l)	1730	814	274
T_{12} – SA (400 ppm) +MC(1ml/l)	1794	852	282
T_{13} – SA (500 ppm) +MC(1ml/l)	1945	882	296
T14 – SA (600 ppm) +MC(1ml/l)	1858	874	288
T_{15} – Control	782	352	124
Mean	1310	651	227
SEm±	24.9	1.4	1.8
CD (5%)	72.2	4.1	5.1

SA = Salicylic acid MC=Mepiquat chloride

Total phenol content content was found to decrease continuously from 60 to harvest in all the treatments and the treatments differed significantly at all the stages (Tabel 23). At 60 DAS The treatment salicylic acid(500 ppm) + mepiquat chloride recorded significantly higher phenol content followed by salicylic acid (600 ppm) + mepiquat chloride and salicylic acid (600 ppm) + mepiquat chloride. Lower phenol content was recorded in control followed by salicylic acid (50 ppm), salicylic acid (100 ppm), salicylic acid (50 ppm) + mepiquat chloride and salicylic acid (200 ppm), and were on par with each other and with the control. A similar trend continued at 75 DAS and harvest. At 75 DAS, there were no significant difference between the treatments salicylic acid (400 ppm) + m, salicylic acid (500 ppm) + mepiquat chloride, salicylic acid (600 ppm) + mepiquat chloride and salicylic acid (500 ppm).

At harvest, the treatments salicylic acid (50 ppm), salicylic acid (100 ppm), salicylic acid (50 ppm) + mepiquat chloride and salicylic acid (200 ppm) were on par with control, However control recorded lowest phenol content and highest phenol content recorded in salicylic acid (500 ppm) + mepiquat chloride.

4.4.6 Tannin content (µg/g dry weight).

The data on tannin content as influenced by various treatments at different growth periods are presented in Table 24. All the treatments differed significantly and the tannin content was found to decrease from 60 DAS to Harvest. Among the treatments, salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher tannin content over all other treatments and the lowest was in control at all the stages. However the higher tannin content was recorded in higher doses of salicylic acid either alone or in combination with mepiquat chloride treatments, compared to lower doses of salicylic acid, the control had recorded lower tannin content compared to any other treatments. This trend is noticed at all the stages.

4.4.7 Nitrate reductase activity (nmoles of NO_2 / g fresh wt. / hr)

The data on nitrate reductase activity (NRA) revealed that it decreased from 60 DAS to Harvest in all the treatments including control and the treatments differed significantly at all the stages except at harvest (table 25). The mean data of NRA indicated that it decreased from 1034.8 at 60 DAS to 295.82 at harvest. Among the treatments, salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher values at all the stages over all other treatments and significantly lower NRA values were seen in control at all the stages. However, the treatments salicylic acid (50 ppm), salicylic acid (100 ppm), salicylic acid (200 ppm) salicylic acid (300 ppm) and salicylic acid (500 ppm) and control did not differ significantly at 60 DAS.

Where as at 75 DAS, the treatments salicylic acid (400 ppm) + mepiquat chloride, salicylic acid (500 ppm) + mepiquat chloride and salicylic acid (600 ppm) were at par with each other. Similarly at harvest, the treatments did not differ much greatly but however salicylic acid (500 ppm) + mepiquat chloride recorded higher NRA values , while control recorded the least values.

4.4.8 Peroxidase activity (POD) (ΔOD/g dry weight / min.)

The data on peroxidase activity presented in table 26. The peroxidase activity in general decreased as growth advanced. The activity differed significantly between the treatments at all the stages. However, the control had recorded minimum activity over all other treatments at all stages.

4.4.9 Polyphenol oxidase activity (PPO) (ΔOD/g dry weight / min.)

Polyphenol oxidase activity as influenced by salicylic acid and mepiquat chloride at various growth stages are presented in Table 27. The PPO activity decreases from 70 DAS to 90 DAS in all the treatments and the treatments differed significantly at all the stages. Among the treatments the healthy plants in the treatment salicylic acid (500 ppm) + mepiquat chloride reported highest activity over all the treatments but however the PPO activity increases with the increase in concentration of salicylic acid.

Table 24. Influence of salicylic acid and mepiquat chloride on tannin content (µg/g dry weight) at different stages in groundnut

Treatments	Days after sowing		
	60	75	Harvest
T_1 – SA (50 ppm)	678	450	213
T_2 – SA (100 ppm)	685	470	228
T_3 – SA (200 ppm)	724	512	238
T_4 – SA (300 ppm)	765	545	252
T_5 – SA (400 ppm)	792	584	264
T_6 – SA (500 ppm)	865	658	295
T_7 – SA (600 ppm)	884	678	316
T_8 – SA (50 ppm)+MC(1ml/l)	826	636	278
T_9 – SA (100 ppm) +MC(1ml/l)	897	694	325
T_{10} – SA (200 ppm) +MC(1ml/l)	956	714	345
T_{11} – SA (300 ppm) +MC(1ml/l)	978	728	364
T_{12} – SA (400 ppm) +MC(1ml/l)	1073	772	383
T_{13} – SA (500 ppm) +MC(1ml/l)	1246	825	398
T14 – SA (600 ppm) +MC(1ml/l)	1152	796	386
T_{15} – Control	592	320	185
Mean	875	625	298
SEm±	1.2	1.4	1.3
CD (5%)	3.6	4.0	3.9

SA = Salicylic acid MC=Mepiquat chloride

Table 25. Influence of salicylic acid and mepiquat chloride on nitrate reductase activity (nmoles NO_2/g fresh weight/ hour) at different stages in groundnut

Treatments	Days after sowing		
	60	75	Harvest
T_1 – SA (50 ppm)	852	648	236
T_2 – SA (100 ppm)	858	662	252
T_3 – SA (200 ppm)	860	674	258
T_4 – SA (300 ppm)	865	680	276
T_5 – SA (400 ppm)	890	708	296
T_6 – SA (500 ppm)	878	692	284
T_7 – SA (600 ppm)	941	742	308
T_8 – SA (50 ppm)+MC(1ml/l)	885	698	293
T_9 – SA (100 ppm) +MC(1ml/l)	985	786	312
T_{10} – SA (200 ppm) +MC(1ml/l)	1025	834	318
T_{11} – SA (300 ppm) +MC(1ml/l)	1109	895	324
T_{12} – SA (400 ppm) +MC(1ml/l)	1255	986	338
T_{13} – SA (500 ppm) +MC(1ml/l)	1725	1108	368
T14 – SA (600 ppm) +MC(1ml/l)	1560	1074	344
T_{15} – Control	835	625	230
Mean	1035	788	296
SEm±	1.3	15.7	1.1
CD (5%)	3.8	45.3	3.2

SA = Salicylic acid MC=Mepiquat chloride

Table 26. Influence of salicylic acid and mepiquat chloride on peroxidase activity (ΔOD /g dry weight/min) at different stages in groundnut

Treatments	Days after sowing	
	70	90
T_1 – SA (50 ppm)	5.93	2.93
T_2 – SA (100 ppm)	8.21	4.78
T_3 – SA (200 ppm)	8.50	6.13
T_4 – SA (300 ppm)	9.28	7.02
T_5 – SA (400 ppm)	9.36	7.68
T_6 – SA (500 ppm)	10.84	9.41
T_7 – SA (600 ppm)	12.93	9.53
T_8 – SA (50 ppm)+MC(1ml/l)	6.14	3.12
T_9 – SA (100 ppm) +MC(1ml/l)	6.52	4.35
T_{10} – SA (200 ppm) +MC(1ml/l)	9.05	6.54
T_{11} – SA (300 ppm) +MC(1ml/l)	10.41	8.21
T_{12} – SA (400 ppm) +MC(1ml/l)	10.46	8.32
T_{13} – SA (500 ppm) +MC(1ml/l)	13.27	10.37
T14 – SA (600 ppm) +MC(1ml/L)	13.08	9.73
T_{15} – Control	5.38	1.46

Mean	9.29	6.64
SEm±	0.13	0.09
CD (5%)	0.37	0.28

SA = Salicylic acid MC=Mepiquat chloride

Table 27. Influence of salicylic acid and mepiquat chloride on polyphenol oxidase activity (ΔOD /g dry weight/min) at different stages in groundnut

Treatments	Days after sowing	
	70	90
T_1 – SA (50 ppm)	0.026	0.018
T_2 – SA (100 ppm)	0.037	0.028
T_3 – SA (200 ppm)	0.041	0.032
T_4 – SA (300 ppm)	0.052	0.04
T_5 – SA (400 ppm)	0.052	0.042
T_6 – SA (500 ppm)	0.069	0.062
T_7 – SA (600 ppm)	0.072	0.064
T_8 – SA (50 ppm)+MC(1ml/l)	0.027	0.022
T_9 – SA (100 ppm) +MC(1ml/l)	0.032	0.026
T_{10} – SA (200 ppm) +MC(1ml/l)	0.048	0.036
T_{11} – SA (300 ppm) +MC(1ml/l)	0.055	0.043
T_{12} – SA (400 ppm) +MC(1ml/l)	0.058	0.053
T_{13} – SA (500 ppm) +MC(1ml/l)	0.089	0.079
T14 – SA (600 ppm) +MC(1ml/l)	0.076	0.071
T_{15} – Control	0.021	0.012
Mean	0.05	0.041
SEm±	0.001	0.0003
CD (5%)	0.003	0.001

SA = Salicylic acid MC=Mepiquat chloride

Table 28. Influence of salicylic acid and mepiquat chloride on yield and yield components in groundnut

Treatments	Pod yield (g/plant)	Yield (q/ha)	Harvest index (%)
T_1 – SA (50 ppm)	3.93	13.10	27.4
T_2 – SA (100 ppm)	4.02	13.26	27.6
T_3 – SA (200 ppm)	4.11	13.73	28.2
T_4 – SA (300 ppm)	4.32	14.20	28.6
T_5 – SA (400 ppm)	4.40	14.66	29.1
T_6 – SA (500 ppm)	4.44	14.80	28.9
T_7 – SA (600 ppm)	4.50	15.00	29.1
T_8 – SA (50 ppm)+MC (1ml/l)	4.11	13.71	28.6
T_9 – SA (100 ppm) +MC(1ml/l)	4.36	14.51	29.2
T_{10} – SA (200 ppm) +MC(1ml/l)	4.39	14.66	29.3
T_{11} – SA (300 ppm) +MC(1ml/l)	4.50	15.00	29.4
T_{12} – SA (400 ppm) +MC(1ml/l)	4.55	15.10	29.7
T_{13} – SA (500 ppm) +MC(1ml/l)	4.89	15.86	30.1
T14 – SA (600 ppm) +MC(1ml/l)	4.88	15.60	29.9
T_{15} – Control	3.61	12.03	25.7
Mean	4.33	14.35	28.7
SEm±	0.02	0.44	0.67
CD at 5%	0.06	1.27	1.95

SA = Salicylic acid MC=Mepiquat chloride

4.5 YIELD AND YIELD COMPONENTS

4.5.1 Pod yield (g/plant)

The data on pod yield presented in table 28 indicated that the treatments differed significantly. Among the treatments, salicylic acid (500 ppm) + mepiquat chloride recorded the maximum pod yield (4.899 g/ plant) over all other treatments, but it did not differ significantly with salicylic acid (600 ppm) + mepiquat chloride and salicylic acid (400 ppm) + mepiquat chloride. However, significant differences were observed between lower doses of salicylic acid and higher doses of salicylic acid either alone or in combination with mepiquat chloride. The treatment control recorded the lowest pod yield (3.61g/plant) over all other treatments but was on par with salicylic acid (50 ppm), salicylic acid (100 ppm) , salicylic acid (50 ppm) + mepiquat chloride and salicylic acid (200 ppm).

4.5.2 Pod yield (q/h)

The date (Table 28) on pod yield (q/ha) as influenced by various treatments showed a similar trend as that of pod yield (g/ha). The maximum pod yield (15.867 q/ha) recorded in salicylic acid (500 ppm) + mepiquat chloride followed by salicylic acid (600 ppm) + mepiquat chloride, salicylic acid (400 ppm) + mepiquat chloride, salicylic acid (300 ppm) + mepiquat chloride, salicylic acid (100 ppm) + mepiquat chloride, salicylic acid (600 ppm and were on par with each other. However, control recorded lowest pod yield (q/ha) followed by salicylic acid (50 ppm) and salicylic acid(100 ppm).

4.5.3 Test weight (g)

The data (Table 28) on test weight indicated that the treatments do not differ significantly. But however highest test weight was noticed in the treatment salicylic acid(600 ppm) + mepiquat chloride over salicylic acid (500 ppm) + mepiquat chloride, salicylic acid (400 ppm) + mepiquat chloride ,salicylic acid (300 ppm) + mepiquat chloride, salicylic acid (200 ppm) + mepiquat chloride , salicylic acid (600 ppm), salicylic acid (500 ppm), salicylic acid (400 ppm) and salicylic acid (300 ppm) which were on par with each other. It is noticed that the test weight was more in mepiquat chloride treatments. However the lowest test weight was noticed in control which is on par with salicylic acid (50 ppm), salicylic acid (100ppm), salicylic acid 9200 ppm) and salicylic acid (50 ppm) + mepiquat chloride.

4.5.4 Shelling percentage (%)

The data on shelling per cent as influenced by various treatments presented in table 29 indicated significant differences between them and the treatment salicylic acid 1500 ppm) + mepiquat chloride fllowed by salicylic acid (600 ppm) + mepiquat chloride recorded the maximum shelling per cent over other treatments. While, salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher shelling per cent over other concentrations of salicylic acid. However, the treatments salicylic acid (100ppm), salicylic acid (200 ppm) and salicylic acid (300 ppm) were on par with each other but they are however their values are higher than the control.

4.5.5 Harvest index (%)

It is evident from table 29 that the harvest index (HI) differed significantly among the treatments and salicylic acid (500 ppm) + mepiquat chloride recorded the highest harvest index. Though, the harvest index increased with an increase in the concentration of salicylic acid. However the mepiquat chloride treatments has got more HI but it was consistent between the two consecutive concentration. In general, there was a significant increse in HI due to growth retardant. The treatments salicylic acid (200 ppm)+ mepiquat chloride salicylic acid (300 ppm) _ mepiquat chloride , salicylic acid (400 ppm) + mepiquat chloride, salicylic acid (500 ppm) + mepiquat chloride and salicylic acid (600 ppm) + mepiquat chloride were on par with each other and significant over salicylic acid treatment alone and over control.

4.5.6 Oil content

The data on oil content (table 29) indicated that salicylic acid + mepiquat chloride treatment combinations has got maximum oil content when compared to salicylic acid treatments alone. However, the control had recorded minimum oil content over other treatments, the salicylic acid treatments alone were on par with each other and the treatment combinations all also on par with each other. But the salicylic acid (500 ppm) + mepiquat chloride treatment has got maximum oil content over other treatment combinations.

Table 29. Influence of salicylic acid and mepiquat chloride on yield components in groundnut

Treatments	Test weight (g)	Shelling per cent	Oil content (%)
T_1 – SA (50 ppm)	40.76	68.44	46.50
T_2 – SA (100 ppm)	40.77	68.60	46.75
T_3 – SA (200 ppm)	40.96	68.68	47.15
T_4 – SA (300 ppm)	41.29	68.79	47.25
T_5 – SA (400 ppm)	41.34	69.01	47.50
T_6 – SA (500 ppm)	41.40	69.11	47.95
T_7 – SA (600 ppm)	41.46	69.48	48.15
T_8 – SA (50 ppm)+MC(1ml/l)	41.19	69.11	47.10
T_9 – SA (100 ppm) +MC(1ml/l)	41.12	69.22	47.30
T_{10} – SA (200 ppm) +MC(1ml/l)	41.27	69.30	47.95
T_{11} – SA (300 ppm) +MC(1ml/l)	41.30	69.47	48.25
T_{12} – SA (400 ppm) +MC(1ml/l)	41.34	69.51	48.36
T_{13} – SA (500 ppm) +MC(1ml/l)	41.41	69.66	48.55
T14 – SA (600 ppm) +MC(1ml/l)	41.63	69.52	48.33
T_{15} – Control	39.35	65.95	46.25
Mean	41.11	68.92	47.55
SEm±	0.39	0.38	0.28
CD (5%)	NS	1.11	0.80

SA = Salicylic acid MC=Mepiquat chloride NS = Non significant

V. DISCUSSION

Groundnut is one of the important oilseed crops of both tropical and temperate regions of the world. It's an important oilseed crop occupying first place both in area (45%) and production (55%) among the oilseed crops grown in India and is rightly eulogized as the king of oilseeds. However, the productivity of groundnut is low. Several factors contribute for poor yield in groundnut, of which its susceptibility to diseases mainly late leaf spot and rust and poor portioning efficiency play a dominant role. Early leaf spot, late leaf spot and rust are the major fungal diseases of groundnut on a world sale (porter *et al*., 1982). The partitioning of dry matter in different plant parts has also been found to be most important by Williams *et al*. (1975) and Duncan *et al*. (1978).

As an alternative to the application of fungicides, the induction of plant defence mechanism by exogenous application of certain chemicals is necessary. One such induced defence response known as systemic acquired resistance (SAR), could provide sufficient protection against diseases. During the last few years, extensive studies have established that salicylic acid plays an essential role in establishment of SAR induced by variety of pathogens or pathogen elicitors (Ryals *et al*., 1996). In 1828, Johann Buchner, from Germany was the first to isolate trace amounts of silicin, a glucoside of salicyl alcohol and a major salicylate in willow bark (Weismann, 1991). The active ingredient in willow bark, "salicylic acid" was named by Rafaele Piria in 1938 from the Latin word *Salix*, means willow tree. In 1874, the first commercial production of salicylic acid began in Germany, and by 1898, Aspirin which is the trade name for acetyl salicylic acid was introduced by the Bayer and Co. (Raskin, 1992b). Both aspirin and salicylic acid are being used interchangeably, though aspirin is not a natural plant product. It is probably effective because acetyl salicylic acid is readily converted to salicylic acid in aqueous system. Salicylic acid, a natural phenolic compound present in several plants is thought to be a new class of plant growth substance (Raskin, 1992a; 1992b).

It is chemically a characterized compound, ubiquitously found in the plant kingdom and has an effect on many physiological process in plants at low concentrations, but the mechanism of action is still unclear.

Similarly, lack of judicious partitioning of dry matter to reproductive organs is one of the main constraints in the productivity of groundnut. To achieve optimum vegetative growth and to effect better translocation of photosynthates into developing pods , the use of growth retardants which regulate plant growth and finally alter the plant architecture appears to be an excellent tool. Moreover, the growth retardants are capable of redistribution of dry matter into various organs of the plant body, there by bring about better source sink relationship and yield improvement (Reddy and Patil, 1981; Vallippan *et al*., 1985 and Chetti, 1991). With this background, the results obtained in the present investigation to elicit information on the role of salicylic acid and mepiquat chloride on the physiology of disease resistance in groundnut are discussed in this chapter.

5.1 MORPHOLOGICAL CHARACTERS

Basically, plant height is a genetically controlled character. There are several reports that the diseases lead to a decrease in the plant height (Srivastavan *et al*., 1975 and Rangaswami, 1988). The present investigation revealed that the salicylic acid had a significant bearing on the morphological characters such as plant height, number of branches and the development of assimilatory surface area.

It is known that the salicylic acid is promotive at lower concentrations and the higher doses bring in reduced growth. The morphological characters studied increased with an increase in concentration of salicylic acid up to 500 ppm and decreased thereafter at 600 ppm. Interestingly, when the salicylic acid was combined with mepiquat chloride there will be a reduction in plant height, since the growth retardants have been defined as the chemicals that reduce cell division and cell elongation in the shoot apex and regulate plant height physiologically, without formative effects (Cathey, 1964). True to the definition, the growth retardant used in the present investigation significantly reduced the plant height at all the

stages except at 48 DAS, since, the chemical spray requires some period to show its effect on crop plants. Similarly, the influence of growth retardants was significant on number of branches, dry weight of different plant parts, leaf area and total dry matter at all the stages, except at 50 DAS. The non-significant differences at this stage were attributed to the non-application of chemicals at this stage and the treatments were imposed only at 50 DAS. Salicylic acid alone though had promotive effect but this effect is quite less when combined with mepiquat chloride. Since, it is a growth retardants. Though, plant height is basically genetic character, there are several reports to indicate that salicylic acid increases plant height (Datta *et al*., 1978; Singh *et al*., 2001; Bidyat *et al*., 2002; Datta and Nanda, 1978 and Raskin, 1992 a). However, Lopez and Scott (1997) reported that phenolics inhibit the plant height in potato. A similar increase in plant height and number of branches by the application of phenolics like salicylic acid has been reported by Datta and Nanda (1978).

Salicylic acid prevents auxin oxidation (Sheneider and Whitman, 1974) and also inhibits the ethylene biosynthesis in plants by blocking the conversion of 1 – amino – cyclopropane – 1-1 carboxylic acid to ethylene (Leslie and Romain, 1986). Salicylic acid is known to conserve IAA and gibberellins (Tomaszewski and Thimman, 1966) in plants, which could be one of the reasons for increased plant height in peanut. Pankaj and Sharma (2003) reported that salicylic acid induced cell growth and elongation in okra plants and was regulated through pentose – phosphate pathway.

Mepiquat chloride (mepiquat chloride or DPC) is a growth regulator and is known to suppress the vegetative growth in cotton (Cothren, 1979; Willard, 1979 and York, 1982). With regard to the number of branches, significant differences were manifested between the growth retardant treatments and salicylic acid treatments,. Among the treatments, the treatments having mepiquat chloride possessed more number of branches and reduced plant height. Mepiquat chloride is a gibberellic acid suppressant that is absorbed by the green portions of the plant and serves to reduce cell elongation, thus offering the potential of decreasing leaf area and resisting additional plant height increase and thus enhancing earliness with regard to fruiting development in cotton. Ritting (1982) found that mepiquat chloride, when treated to crops generally inhibit both the horizontal and vertical growth. The spraying of mepiquat chloride at 175 ppm resulted in increased number of branches and leaves per plant in okra (Gasti and Madalageri, 1995). The increase in the number of branches could be due to the suppression of apical dominance, thereby diverting the polar transport of auxins towards the basal nodes (leading to increased branching). The mechanism of reduction in stem length due to growth retardants including mepiquat chloride (1000 ppm) appears to be due to slowing down of cell division and reduction in cell elongation because of the inhibitory action of growth retardants in the biosynthetic pathway of Gibberelic acid (Moore, 1980).

5.2 DRY MATTER PRODUCTION AND PARTITIONING

Dry matter production, particularly of reproductive parts is an important yield contributing character and the basic vegetative phase is essential for the development of reproductive organs. Although, the dry matter production in general is the indicative of the efficiency of the genotypes, the pattern in which it is distributed in different plant parts would give a better understanding of the genotype. It is well documented that plant growth regulators will have their influence on the production of dry matter and the way in which it is partitioned between different organs of the plant.

It was observed in the present study that the application of salicylic acid and mepiquat chloride resulted in a significant increase in the dry weight of different plant parts and total dry weight. The influence was more pronounced when salicylic acid was combined with mepiquat chloride, but the increase was more in the mepiquat chloride treatments, which could be attributed to increase in number of branches.

The leaf dry weight increased from 50-90 DAS as a result of foliar application of salicylic acid and mepiquat chloride over control and declined progressively at harvest. This could be because, the treatments were imposed at 50 and 80 DAS and the greater efficacy was seen immediately following the treatment imposition and it gets declined as plants grow older. While, there was a progressive increase of dry weight of stem and pods due to salicylic acid and mepiquat chloride over control until 90 DAS. At harvest, there was a drastic decline

in the per cent increase of stem dry weight (21.1%) over control due to treatments but however the increase was more pronounced in the treatments having mepiquat chloride and it was because of diversion of assimilates towards the developing pods which showed a progressive increase in pod dry weight at harvest. It indicates that there is more translocation of photosynthates from stem to the pods than from leaves to pods because of nearness to the sink, which is one of the important considerations for proper sink development. The salicylic acid and the mepiquat chloride have been found to have greater impact on development of sinks in groundnut, which is realized by a significant increase in the pod yield due to these treatments. There are number of reports in the literature showing that salicylic acid can increase the fresh and dry weights of plant (Sanaa *et al*., 2001). Chandrababu *et al*. (1995) reported that a foliar spray of 125 ppm mepiquat chloride to groundnut at 70 day after sowing increased the leaf dry weight, haulm weight and total plant dry matter. An increase in leaf dry weight, stem dry weight and the dry weight of reproductive parts, which altogether increased the total dry matter as compared to control due to the application of growth retardants, including mepiquat chloride 1000 ppm (Chetti, 1991).

Dry matter production is an important parameter that determines yield in crops. It was observed that higher leaf dry weight was recorded with the application of salicylic acid (500 ppm) + mepiquat chloride over other treatments. At the time of harvest, no significant differences were found between the treatments due to defoliation of leaf, leading to a drastic reduction in the assimilatory surface area. With respect to the distribution of dry matter in stem, it is clear that, stem dry weight increased significantly at all the stages, irrespective of treatments, except at 50 DAS. The increase may be attributed to increase in number of branches and stem thickness with an increase in growth. It was also observed that there was more accumulation of dry matter in the stem than in leaves and pods.

The dry weight of pods showed non-significant difference at 50DAS, where as, at later stages pod weight showed significant differences between the treatments. The pod dry weight increased in all the treatments at all the stages and it was due to the efficient translocation of photosynthates towards the developing sink. The phenolic compounds play a significant role in the mobilization of reserve food materials to the sinks for grain filling process by increasing the activities of amylase, IAA – oxidase, peroxidase and polyphenol oxidase enzymes (Datta *et al*., 1978 and Datta and Nanda, 1978).

The amount of total dry matter produced is an indication of the overall efficiency of the utilization of the resources and better light interception. The data pertaining to total dry weight per plant indicated that, it increased continuously from 55 DAS to harvest. At later stages of crop growth, the dry matter accumulated at a decreasing rate, which could be attributed to reduced source activity leading to lesser dry matter accumulation in leaf and stem. Raskin (1992a) reported that the powerful mobilization role of salicylic acid may be exerting its action by influencing permeability changes within the plant. Some of the sink effects might be caused by changes in the distribution of other hormones viz., auxin or gibberellins brought about by change in he shoot apex as a result of salicylic acid (Setia *et al*., 1995).

It is also clear from the data on disease incidence that it was less in mepiquat chloride treatments due to which, greenness was maintained for a longer time making the leaves photosynthetically active thereby leading to increased accumulation of leaf dry weight at harvest as compared to control. Chandrababu *et al*. (1995) also reported that the foliar spray of 125 ppm mepiquat chloride to groundnut at 75 DAS increased the leaf dry weight and TDM in groudnut.

5.3 GROWTH PARAMETERS

Several growth parameters were studied to understand the pattern of crop growth and development as influenced by he foliar application of salicylic acid and mepiquat chloride. It was observed that the salicylic acid treatments resulted in a significant increase of LAI, LAD, LAR, CGR, AGR, NAR and BMD. Although, salicylic acid alone had promotive effect on the growth parameters, but it was less compared to combined treatments with mepiquat chloride. It was noticed that mepiquat chloride has got promotory effect on CGR; AGR, NAR and BMD but it reduced LA, LAI, LAD and LAR. This clearly indicates that the production of leaf area and the maintenance of LAD alone are not important determinants of yield but the

effective partitioning of dry matter into pods/ reproductive organs is more important. It is also clear from this that groundnut produces excess leaf area and dry matter, which could be checked by the application of growth retardants. However, there was an increase in AGR and CGR due to the application of salicylic acid and mepiquat chloride at later stages compared to control. Phulekar *et al*. (1998) noticed that leaf area and LAI were decreased by all the growth retardants including mepiquat chloride 1000 ppm when sprayed on groundnut cv. JL-24. On the contrary, Zaky *et al*. (1999) noticed that the lowest concentration of mepiquat chloride (250 ppm) caused significant increases in most of the growth parameters, while the highest concentration (1500 ppm) resulted in a reduction in these parameters of *Vicia faba* plant. Walter *et al*. (1980) also observed that the application of mepiquat chloride at first bloom stage reduced the leaf area by 17 per cent and increased the leaf thickness by 16 per cent thereby, increasing the photosynthetic efficiency and TDM in cotton. The average daily increment of stand biomass is an important characteristic and is called either the rate of dry matter production or crop growth rate CGR (Watson, 1952). It is a widely used character to understand the production efficiency of crop stand and enables to make comparisons between the aspect of study. The computation of CGR at different growth stages indicated that it was maximum at 50 – 70 DAS and declined thereafter in all the treatments. This indicates that the rate of increment per unit area and time is more at early stages due to active growth of the crop stand and probably the spatial arrangement of the leaves in the canopy avoiding mutual shading at early stages.

Similar to that of CGR, the relative growth rate (RGR) also declined with the advancement in the crop growth and it increased with an application of mepiquat chloride. The increase in RGR with an increase in the concentration of mepiquat chloride could be due to effectiveness of these chemicals in increasing not only the total dry matter but also the rate of increment in total dry matter. This could also be attributed to increased photosynthetic efficiency by increasing leaf thickness and retaining chlorophyll content and efficient translocation of photosynthates by reducing the distance between source and sink which is further evidenced by increase in SLW, chlorophyll content and decrease in plant height.

Net assimilation rate (NAR) synonymously called as unit leaf rate, expresses the rate of dry weight increase at any instant on a leaf area basis with leaf representing an estimate of the size of the assimilatory apparatus. It followed the similar trend as that of RGR. The decline in NAR with advancement in the crop growth could be attributed to a decline in the rate of dry matter production and the decline in leaf area. It is clear from the data of leaf area that maximum leaf area was noticed upto 90 DAS and declined thereafter. Though, the leaf area increased upto 90 DAS, the NAR declined from 50-70 to 70-90 DAS. This is not only due to reduced rate of leaf area increase but also due to TDM which is evidenced from RGR and CGR. Among the treatments, the maximum NAR was recorded in salicylic acid (500 ppm) + mepiquat chloride which could be due to increase in TDM.

5.4 YIELD AND YIELD COMPONENTS

Yield is the manifestation of various morphological, physiological and growth parameters in any crop. In addition to pod yield in groundnut, several components such as number of pods, 100-seed weight, shelling per cent, harvest index and partitioning co–efficient are also important. Duncan *et al*. (1978) concluded that three physiological attributes viz., partitioning of assimilates between vegetative and reproductive parts, length of pod filling period and rate of pod establishment are most important for determination of yield potential in groundnut.

The data on number of pods per plant, pod yield (g/plant), pod yield (q/ ha), harvest index (%), test weight (g) and shelling per cent (%) indicated significant differences between the treatments and the treatment salicylic acid (500 ppm) + mepiquat chloride (1 ml / l) recorded higher values over all other treatments.

Singh and Awasti (1998) reported that the application of salicylic acid (5 ppm) might be safe and more useful for improving crop growth, yield as well as nutritional quality in greengram. Similarly application of salicylic acid showed a significant increase in pod weight, number of pods per plant and grain yield in soybean (Pramod Kumar *et al*. (1999). Similar reports of salicylic acid on yield enhancement were made earlier in mungbean (Sing and Kaur, 1980), Cheena millet (Datta and Nanda, 1985) and pear (Kumar *et al*., 1997). They

further reported that grain yield exhibited a significant positive correlation with NRA, total soluble proteins, floral seeds and pods per plant, pod weight, test weight and harvest index. The enhanced rate of photosynthetic activity in treated plants is possibly due ot reduced chlorophyll catabolism by salicylic acid through preventing auxin oxidation (Singh *et al*., 2001).

The growth retardants are capable of redistribution of dry matter in the plant there by bringing about improvement in yield (Reddy and Patil, 1981; Chetti, 1991 and Chandrababu *et al*., 1995). In addition, crop yield depends not only on the accumulationof photosynthate during the crop growth and development, but also on the partitioning of photosynthates between the desired storage organs. These inturn are influenced by the efficiency of metabolic processes within the plant. Similarly, Chetti (1991) reported that with an increase in the concentration of mepiquat chloride upto 1.5 ml/ litre, there was an increase in both kernel weight and pod weight and the increase was attributed to increased chlorophyll content, higher total dry matter and the greater proportion of total dry matter in reproductive parts. Increased seed oil content due to growth retardants appears to be due to increased accumulation of hexose sugars at the time of triacylglycerol synthesis resulting in more oil in oleorosome (Purohit, 1993). Similarly, increase in oil and protein contents with the application of growth retardants were reported in cotton (Abdel-AL *et al*., 1986) and sunflower (Kene *et al*., 1992 and Kulkarni, 1993). Mekki and Kholy (1999) noticed that seed oil content and oil yield were significantly increased due to application of mepiquat chloride in oil seed rape.

5.5 BIO-CHEMICAL PARAMETERS

Crop yield is a complex heritable character influenced by many morphological and physiological characteristics of the plant interacting with the environment. An attempt has been made to evaluate the influence of salicylic acid and nutrients on various biochemical constituents such as, chlorophyll, total sugar, phenol, tannin contents, nitrate reductase activity, peroxidase and polyphenoloxidase activities on yield in groundnut. Results revealed that there is a significant increase in chlorophyll 'a' chlorophyll 'b' and total chlorophyll contents as a result of foliar application salicylic acidlicylic acid and mepiquat chloride and the extent of increase was maximum when the salicylic acid was applied in combination with mepiquat chloride i.e. salicylic acid (500 ppm) + mepiquat chloride (1000 ppm) followed by salicylic acid (600 ppm) + mepiquat chloride (1000 ppm), irrespective of the stages. The chlorophyll content was maximum at 60 DAS and declined thereafter which may be due to incidence of late leaf spot and senescence.

It is evident from the data that there was decline in disease incidence which could be attributed to higher chlorophyll contents and delay in leaf senescence due to growth retardants. The present study indicated that the oil content was higher in treatment with salicylic acid @ 500 ppm + mepiquat chloride (1 ml/l). The chlorophyll content was more in the plants receiving mepiquat chloride, irrespective of the concentration of salicylic acid. The variation due to growth retardant may be attributed to decreased chlorophyll degradation and increased chlorophyll synthesis. The delay in leaf senescence, and decrease incidence could also be attributed to higher chlorophyll contents due to growth retardants.

The increase in chlorophyll content by salicylic acid was due to enhanced chlorophyll biosynthesis and inhibition of chlorophyllase enzyme leading to higher accumulation of chlorophyll (Paricha *et al*., 1977). Sivakumar *et al*. (2002) found that the foliar application of salicylic acid and mepiquat chloride has increased the contents of chlorophyll in pearl millet. Maibangsa *et al*. (1999) noticed that the rice plants treated with salicylic acid (100 ppm) and 125 ppm mepiquat chloride showed greater chlorophyll accumulation, hill reaction, photochemical efficiency, ribulose biphosphate carboxylase content, photosynthetic rate, biochemical efficiency, assimilation and biomass accumulation than untreated plants. In addition, to inhibition of cell division, they cause induction of grana and initiate the development of chloroplasts where the chlorophyll synthesis takes place (Cathey, 1961), thus leading to increased chlorophyll content. Pravin *et al*. (2000) noticed that foliar application of mepiquat chloride at 45 days after planting increased mepiquat chloride chlorophyll content in case of TPS similar work was reported by Chetti (1991) in groundnut genotypes.

Higher concentrations of sugars have been found to help the growth of pathogens (Horsfall and Diamond, 1975). Metabolic changes in groundnut leaf due to leaf spot

pathogens were studied by Gupta *et al*. (1992) and found that the levels of total soluble sugars increased after infection in all the susceptible and tolerant cultivars. It was observed in the present study that higher amount of sugar was observed in control at all the stages and sugar content increased continuously with an advancement in crop age. It was further observed that sugar content decreased with increase in salicylic acid concentration. The reason for the decreased sugar content with salicylic acid treatment could be due to the ability of salicylic acid to mimic certain aspects of pathogen infection (Vernooij *et al*., 1995). Increase in sugar content with an advancement in crop age could be due to increase in disease infection which is evidenced from the data of PDI.

A definite correlation exists between the resistance of plants to disease and the state of their phenolic complex (Hare, 1966 and Kosuge, 1969). It has been reported that phenolic compounds inhibit growth of pathogens by interfering with vital metabolic activities (Yadav *et al*., 1998). It is clear from the present study that higher phenol content was observed in the initial stages and declined thereafter. It was further observed that there was a significant increase in the total phenols due to growth retardant and the maximum was observed in salicylic acid (500 ppm) + mepiquat chloride. The increase in the phenolic contents at initial stages of plant growth after infection may be due to enhancement in the synthesis of phenolic compounds and the hydrolysis of phenolic glycosides by fungal glycosides to yield free phenols (Sharma *et al*., 1983). It was further observed in the present study that phenol content increased with an increase in salicylic acid concentration.

Similar to that of phenols, tannins have also been considered as powerful factors in imparting not only disease resistance but also resistance to insects and important group of defensive secondary metabolites. The tannin content was maximum at early stage (60 DAS) and decreased at later stages (75 DAS and at harvest), irrespective of the treatments. Among the treatments, salicylic acid (500 ppm) + mepiquat chloride recorded the maximum tannin content and lowest was in control, indicating that salicylic acid at higher concentrations results in higher tannin content.

Most of the phenols and tannins are produced through Shikimic acid pathway or deviation from TCA cycle leading to accumulation of such chemical substances in tolerant or resistant varieties of the crop. Phenols and tannins act as phytoalexins in the biochemical defence mechanism of the host. Later, it was also reported that resistance to colonization of *Aspergilus parasiticus* is associated with tannin content and tannin concentrations appears to be only one of several factors that are significantly correlated with the degree of resistance of peanuts to *Aspergillus flavus* colonization.

Nitrate reeducates, a key enzyme in nitrogen metabolism is known to be regulated by various environmental factors, apart from its own substrate nitrate. It is also believed that the reduction of nitrate to nitrite by nitrate reductase activity (NRA) is the rate limiting step for the utilization of nitrogen in the form of nitrate. It is observed from the present study that NRA increased upto 60 DAS and decreased thereafter. This coincided with the maximum chlorophyll content there by complementing the C-N balance in the plant. It is further observed that there was an increase in the NRA due to growth retardants and it increased with an increase in the concentration of salicylic acid along with mepiquat chloride. The increase in NRA due to mepiquat chloride could be due to increase in SLW, photosynthetic activity and RuBP carboxylase activity has been suggested by Sairam *et al*. (1991). Similar work was also reported by Kalarani *et al*. (2002) in tomato as salicylic acid spray showed its distinct role in increasing NRA.

Similarly foliar spray of salicylic acid and mepiquat chloride in combination with other growth regulators has increased NRA activity, N uptake, grain protein etc. (Sivakumar *et al*., 2001, Senthil *et al*., 2003).

The phenomenon of SAR has been found to be mediated by salicylic acid following the observation that exogenous treatment with salicylic acid induced PR- protein synthesis and enhanced resistance to infections. The expression of defense related protein (PR) are peroxidases, polyphenol oxidase etc. which are plant specific and released by pathogen in response to elicitors.

In the present study, peroxidase activity and polyphenol oxidase activity decreased with advance in growth. However the activity increases with increased concentration of salicylic acid. However increased activity was noticed in resistant plants. Increased levels of polyphenol oxidase and peoxidase would be needed to neutralize the peroxide radical formed during pathogensis . This was similar to the results of sudhakaran *et al*. (2000) who observed increased activity of PPO and POD enzymes in tea leaves only when infestation with *Helopeltis theivora*. The higher activity of peroxidase under severe disease condition would help in detoxifying the effect of peroxides released during disease interaction. Peroxidase generally catalyses a redox reaction between hydrogen peroxide (H_2O_2) which is an electron acceptor, and also involved in cyanide resistant O_2 uptake (oxygen activation), and has been implicated in the oxidative cross linking of lignin precursors and structural proteins in the cell wall, as a result of these oxidative cross linking reactions, cell walls are strengthened and physical barriers against invading pathogens are constructed (Miya zawa *et al*., 1999). PPO is a copper-containing enzyme, oxidizes phenolic to highly toxic quinines and involved in the terminal oxidation of diseased plant tissues, which as attributed for its role in disease resistance (Kosuge, 1969).

Meena *et al*. (2001) reported that there is increase in POD and PPO activities in salicylic acid reported plants upon challenge inoculation with *Cercosporidium personatum* causing late leaf spot in groundnut.

5.6 ECONOMICS

The data on benefit : cost ratio as influenced by salicylic acid and mepiquat chloride indicated that it was maximum with salicylic acid (500 ppm) + mepiquat chloride (1: 3.30) followed by salicylic acid (600 ppm) + mepiquat chloride (1 : 3.24). There was an increase in B: C ratio in all the treatments compared to control (1: 2.67). From the point of economics, foliar application of salicylic acid (500 ppm) + mepiquat chloride (1000 ppm) has been found to be most economical (Table 31).

Based on the above results, it is clear that application of salicylic acid (500 ppm) coupled with and mepiquat chloride (1000 ppm) is very beneficial in reducing the foliar diseases in groundnut and thus produced higher pod yield, yield components, growth analysis parameters and enzyme activities.

Table 30. Influence of salicylic acid and mepiquat chloride on benefit : cost ratio in groundnut

	Treatments	Pod yield (kg/ha)	Gross returns (Rs./ha)	Cost of treatment (Rs./ha)	Total cost of cultivation (Rs./ha)	B: C ratio
T_1	SA (50 ppm)	1310	19650	212	6962	1 : 2.82
T_2	SA (100 ppm)	1326	19890	224	6974	1 : 2.85
T_3	SA (200 ppm)	1373	20595	236	6986	1: 2.94
T_4	SA (300 ppm)	142	21300	272	7022	1 : 3.03
T_5	SA (400 ppm)	1468	22020	296	7046	1 : 3.25
T_6	SA (500 ppm)	1480	22200	320	7070	1 : 3.14
T_7	SA (600 ppm)	1500	22500	344	7094	1 : 3.17
T_8	SA (50 ppm) + MC (1 ml/l)	1371	20565	332	7082	1 : 2.90
T_9	SA (100 ppm) + MC (1 ml/l)	1451	21765	344	7094	1 : 3.06
T_{10}	SA (200 ppm) + MC (1 ml/l)	1466	21990	356	7106	1 : 3.09
T_{11}	SA (300 ppm) + MC (1 ml/l)	1500	22500	392	7142	1 : 3.15
T_{12}	SA (400 ppm) + MC (1 ml/l)	1510	22650	416	7166	1 : 3.16
T_{13}	SA (500 ppm) + MC (1 ml/l)	1586	22790	440	7190	1 : 3.30
T_{14}	SA (600 ppm) + MC (1 ml/l)	1560	23400	464	7214	1 : 3.26
T_{15}	Control	1203	18045	-	6750	1: 2.67

Basic cost of cultivation Rs. 6750 / ha
Selling price of groundnut pods Rs. 1500 / q
Cost of chemicals
1) Salicylic acid Rs. 400 / 1000 g
2) Mepiquat chloride Rs. 200 / 1000 ml

VI. SUMMARY

A field experiment was undertaken to find out he influence of salicylic acid and mepiquat chloride on various morphological, physiological, biochemical, growth and yield and yield components in groundnut cv. JL–24 during *kharif*, 2005, at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The experiment consisted of 15 treatments with 3 replications and was laid out in randomized block design. The results obtained from the present investigation are summarized in this chapter.

1. The incidence of late leafspot was severe in control as compared to other treatments and it was least in salicylic acid (500 ppm) + mepiquat chloride (1000 ppm) at all the stages. However, the intensity was less at higher concentration of salicylic acid either alone or in combination with mepiquat chloride.

2. The plant height increased significantly due to the application of salicylic acid. However, the plant height decreased significantly when it was applied along with mepiquat chloride while, the number of branches increased when salicylic acid was applied along with mepiquat chloride.

3. Leaf area increased with increasing concentration of salicylic acid, but however, decreased when salicylic acid was applied along with mepiquat chloride.

4. Salicylic acid and mepiquat chloride showed a profound effect on number of pods and this parameter increased significantly in treatment combinations and the maximum number of pods was recorded in salicylic acid (500 ppm) + mepiquat chloride.

5. The leaf dry weight, stem dry weight, dry weight of reproductive parts and total dry weight increased with the increased concentration of salicylic acid, but however the effect was more pronounced when salicylic acid was applied in combination with mepiquat chloride.

6. The growth parameters viz., AGR, CGR, NAR and BMD showed more values at 50-70 DAS and declined thereafter till harvest. Among the treatments, salicylic acid (500 ppm) + mepiquat chloride recorded maximum values over all other treatments which is due to increased total dry matter treatments.

7. LAI, LAR and LAD differed significantly among the treatments and the salicylic acid in combination with mepiquat chloride had lower values than the treatments having salicylic acid alone and the minimum values were found in the mepiquat chloride treatments and was due to reduced leaf area over all other treatments.

8. Chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll contents were significantly higher with the application of salicylic acid (500 ppm) + mepiquat chloride. However, these values were higher in treatments receiving mepiquat chloride than salicylic acid alone.

9. Total sugar content differed significantly with the application of salicylic acid and mepiquat chloride and the control recorded significantly higher sugar content over other treatments. Application of salicylic acid resulted in lower sugar content and increasing the concentrations of salicylic acid decreased the sugar content.

10. Total phenol content showed significant differences between the treatments and more phenol content was recorded at 60 DAS and declined thereafter. Among the treatments, salicylic acid (500 ppm) + mepiquat chloride recorded significantly higher phenol content over all other treatments and hence less PDI was recorded.

11. Tannin content increased significantly with the application salicylic acid and mepiquat chloride. Maximum tannin content was recorded in salicylic acid (500 ppm) + mepiquat chloride over all other treatments.

12. NRA increased up to 60 DAS and decreased thereafter. The maximum NRA was observed in the treatments having mepiquat chloride than the treatments receiving salicylic acid alone and control.

13. The activity of peroxidase and polyphenol oxidase enzymes decrease with increase in disease severity. Peroxidase and polyphenol oxidase activity was higher in control. However salicylic acid (500 ppm) + mepiquat chloride had least activity.

14. The results on yield and yield attributes indicated that all the yield contributing characters viz., pod yield, harvest index, shelling percent and test weight increased significantly with the application of salicylic acid along with mepiquat chloride.

15. Oil content (%) differed significantly between the treatments. But however, the mepiquat chloride treatment had more oil content than the treatment having salicylic acid alone.

16. The B:C ratio was found to be higher with salicylic acid (500 ppm) + mepiquat chloride (1000 ppm) followed by salicylic acid (600 ppm) + mepiquat chloride (1000 ppm) as compared to control.

VII. REFERENCES

ABADAELHI, D., JAITI, F., ZOUINE, J., EL-HARSHI, M. AND EL-HADRAMI, L., 2003, Effect of salicylic acid on phenolic compounds related to date palm resistance to *Fusarium oxysporum* f. sp. *Albedinis. Phytopathologia-Mediterranea*, **42** (1) : 9-16.

ABDEL- AL, M.H., EID, E.T., ESMAIL, M.S., EL AKKAD, M.H. AND HEGAB, A.A. T., 1986, Response of Egyptian cotton plants to mepiquat chloride with concentrations and time of application. *Annals of Agricultural Science*, **31**: 1063-1076.

*ALABI, O., OLORUNJU, P. E., MISARI, S. M., BOYE AND GONI, S. R., 1993, Management of groundnut foliar diseases in Samru, Northern Nigeria. In: *Summer Proceedings of the Third Regional Groundnut Meeting for West Africa*, Ouagadougou, Burkina Faso, 14-17 September, 1992.

*AMARESHCHANDRA AND BHATT, R.K., 1998, Biochemical and physiological response to salicylic acid in relation to the systemic acquired resistance. *Photosynthetica*, **35** (2) : 255-258.

ANANDHI, S. AND RAMANUJAM, M.P., 1995, Effect of salicylic acid on blackgram (*Vigna mungo*) cultivars. *Indian Journal of Plant Physiology*, **2**(2) : 138-141.

ANONYMOUS, 2003, *Indian Agriculture*. pp. 398.

ANONYMOUS, 2004, Agriculture Centre for Monitoring Indian Economy, pp.143.

ANONYMOUS, 2005, Food and Agriculture Organization, United Nations FAOSTA database. http:/www.fao.org.

ARNON, D. J., 1949, Copper enzyme in isolated chloroplasts: polyphenol oxidase in *Beta vulgaris. Plant Physiology*, **24**:1-15.

ARORA, Y. K. AND WAGLE, D. S., 1985, Inter-relationship between peroxidase, polyphenoloxidase activities and phenolic content of wheat for resistance to loose smut. *Biochem Physiology Pflanzen,* **180**: 75-80.

AULAKH, K. S. AND SANDHU, R. S., 1970, Free amino acids and carbohydrates in healthy and 'tikka; affected groundnut leaves. *Indian Phytopathology,* **23**: 84-87.

*AZEVEDO, D.M.P. DE., VIEIRA, D.J., BELTRAD, N.E. DE, M., NOBREGA, L.B. DA., DE AZEVEDO, D.M.P. AND DA NOBRESA, L.B., 1998, Effects of nitrogen fertilizer and a growth regulator on irrigated cotton. *Pesquisa em Andamento centro Nacional de pesquisa do Algodao*, **81**: 4

BALA, M. AND DHILLON, M., 1987, Chlorophyll contents of *cercospora* infected groundnut leaves in susceptible and resistant varieties. *Annals of Applied Biology*, **3** : 61-63.

BENAGI, V.I., 1995, Epidemiology and management of late leafspot of groundnut caused by *Phaeoisariopris personata* (Berk and Curt). *Ph.D. Thesis*, University of Agricultural Sciences, Dharwad.

BHARGAVA, L.P., SOBTI, A.K., BHARGAVA, A.K. AND NAG, A.K., 1999, Estimation of losses caused by peanut seed necrosis virus on yield parameters of groundnut. *Indian Phytopathology*, **52** (4) : 414.

BHAT, T., 1997, Source sink relationship as influenced by late leaf spot in groundnut genotypes. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad.

BHUPINDER SINGH AND USHA, K., 2002, Salicylic acid induced physiological and biochemical changes in wheat seedlings under water stress. *Plant growth Regulation*, **39**: 137-141.

*BIDYAT, N., SUKUL, N.C., BANERJEE, N., SENGUPTA, S. AND DAS, P., 2002, Salicylic acid enhances resistance in cowpea against *Meloidogyne incognita. Phytopathologia Mediterranea*, **41** (1) : 39-44.

BOOTE, K.H., JONES, J.W., SMERAGE, G.H., BARFIELD, C.S. AND BERGER, R.D., 1980, Photosynthesis of peanut canopies as affected by leaf pot and artificial defoliation. *Agronomy Journal*, **72** : 247-252.

BRAHMACHARI, B.K. AND KOLTE, S.J., 1983, Morphological and biochemical differences in two *Cercospora* leafspot resistant and susceptible varieties of groundnut. *Indian*

Phytopathology, **36**: 149-150.

BRYNT, S.D. AND FORREST, E.L., 1979, Indole 3-acetic acid oxidase from pears. *Plant Physiology,* **63**:693-699

BUNTING, A.H., GREGORY, W.C., MAUBOUSSIN, J.C. AND RAYON, J.G., 1974, A proposal for research on groundnut (*Arachis*) by *ICRISAT*, mimesa, **1**: 25-32.

CATHEY, H. M., 1961, Physiology of growth retarding chemicals. *Annual Review of Plant Physiology*, **15**: 271-302.

CATHEY, H. M., 1964, Physiology of growth retarding chemicals. *Annual Review of Plant Physiology*, **15**: 271-302.

CHANDRABABU., MANIAN, K., NAGARAJAN, M. AND RAMACHANDRAN, T.K., 1995, Effect of mepiquat chloride on growth and yield of groundnut. *Madras Agricultural Journal*, **82**(3): 229-230.

CHEN HUI., TANG MING., CHEN, H. AND TANG, M., 1997, Advances in mycorrhizae research on poplar. *Scientia Silvae Sinicae*, **33**: (2): 183-188.

CHETTI, M.B., 1991, Evaluation of chamatkar on groundnut. *Pestology*, **15**(8): 43-50.

CHETTI, M.B., KULKARNI, S.S. AND MUMMIGATTI, U.V., 1995, Influence of growth retardants on the relationship of dry matter accumulation with seed yield in sunflower. *Pestology*, **19**(8): 30-36.

CHOHAN, J.S., 1974, Recent Advances in diseases of groundnut in India (In: *Current trends in plant Pathology) Lucknow University Press. Lucknow, India* , pp. 171-184.

*COTHREN, J.T., 1979, PIX – a cotton growth regulator. *Arkansas farm Research*, USA, pp.5.

CUMMINS, D.G. AND SMITH, D.H., 1973, Effect of *cercospora* leaf spot of peanuts on forage yield and quality and on seed yield. *Agronomy Journal,* **65**: 919.

*DASTANE, N. G., 1967, *A Practical Manual for Water Use Research*. Navabharat Prakashan Publications, Pune, India.

DATTA, K.S. AND NANDA, K.K., 1978, Effect of some phenols and gibberellic acid on the growth and development of 'T22' *triticale*. *Indian Journal of Agricultural Sciences*, **48** (2) : 89-93.

DATTA, K.S. AND NANDA, K.K., 1985, Effect of some phenolic compounds and gibberellic acid on growth and development of cheena millet. *Indian Journal of Plant Physiology*, **28** : 298-302.

DATTA, K.S., SURINDERKUMAR AND NANDA, K.K., 1978, Effects of some phenolic compounds and gibberellic acid on flowering and yield characters of cheena millet (*Panicum millaceum* L.). *Journal of Agricultural Sciences,* **91** : 731-735.

DAVID, D.P. AND MACK, T.P., 1991, Relation between LAI and growth characteristics of *Florunner* southern runner and sun runner peanut. *Peanut Science*, **18** : 36-37.

DHALIWAL, R. K., MALIK, C. P. AND GOSAL, S. S. AND DHALIWAL, L. S., 1997, Studies on hardening of macropagated sugarcane plantlets. *Annals of Biology,* Ludhiana, **13**(1): 21-25.

DONALD, C. M., 1967, In search of yield. *Journal of Australian Institute of Agricultural Sciences*, **28**: 171-178.

DUNCAN, W.G., Mc CLOUD, D.E., Mc GRAW, R.G. AND BOOTE, K.G., 1978, Physiological aspects of peanut yield improvement. *Crop Sciences*, **18**:1015-1020.

DUNCAN, W.G., Mc. CLOUD, D.E., Mc. GRAW, I.G. AND BOOTE, K.G., 1978, Physiological aspects of peanut yield improvements. *Crop Science*, **18**: 1015-1020.

EKBOTE, A.V. AND MAYEE, C.D., 1983, Physiological changes in rust (*Puccinia arachidis*) resistant and susceptible groundnut after inoculation. *Indian Journal of Plant Pathology*, **1**: 170-174.

ENYI, B.A.C., 1977, Physiology of grain yield in groundnut. *Experimental Agriculture*, **13** : 101-110.

EYOB, S. AND KRISHNAPPA, K.S., 2000, Effects of growth retardants on growth and yield of potato gown from true potato seed, *Current Research.* University of Agricultural Sciences, Bangalore, **28**(9): 1-12, 173-176.

*FARKAS, G. L. AND KIRALY, Z., 1962, Role of phenolic compounds in the physiology of plant diseases and disease resistance. *Phytopathology*, **44**: 105-150.

FARIDUDDIN, Q., HAYAT, S. AND AHMAD, A., 2003, Salicylic acid influences net photosynthetic rate, carboxylation efficiency, nitrate reductase activity and seed yield in *Brassica juncea*. *Photosynthetica*, **41** (2) : 281-284.

FRANJE, N.S., 1977, The effect of rust on the photosynthetic activity of soybean (*Glycine max* (L.) Merrill). *M.Sc. (Agri.) Thesis*, University of Philippines, Los Banos.

FRIEND, J., 1979, *Phenolic substances and plant disease.* In: Biochemistry of plant phenolics (Eds. Swin, T., Harbone, B. J. and Sumere, F. V.), Plenum Press, New York, pp. 557-588.

GAMAL EL DIN, I.F., GHOBRIAL, E., EI DEEB, A.A. , AHMED, K.G.M. AND ELIAN, M.I., 1987, Enzyme activity in relation to infection with spot bloth of barley. *Agricultural Research Review,* **65**(2): 213-223.

GASTI, V. D. AND MADALAGERI, B. B., 1995, Effect of growth retardants on growth and yield of okra (*Abelmoschus esculentus* L. Moench). *Pestology*, **19**(2): 24-27.

GAUSMAN, H.W., STABENOW, J., RITTING, F.R., ESCOBAR, D.E. AND GARZA, M.V., 1980, Mepiquat chloride effects on cotton leaf anatomy. *In: Proceedings Plant growth Regulation working Group* (Ed. Abdel – Rahman, m.) Longmont, Colorado, USA, 8-14.

GHOURAB, M.H.H., WASSEL, O.M.M. AND EI NOUR, M.S.A., 2000, The effect of mepiquat chloride application on the productivity of cotton pants. *Egyptian Journal of Agricultural Research,* **78**(3):1207-1218.

GHUGE, S.S., MAYEE, C.D. AND GODBOLE, G.M., 1981, Assessment of losses in peanut due to Rust and Tikka leaf spots. *Indian Phytopathology* , **34**(2):

GREGORY, F. C., 1926, The effect of climatic conditions on the growth of barley. *Annals of Botany*, **42**: 1-26.

GUPTA, P.P., GUPTA, S.K., KAUSHIK, C.D. AND YADAVA, T.P., 1985, Biochemical changes in leaf surface washings of groundnut due to tikka disease (*Cercosporidium personatum*, *Indian Phytopath*, **38**: 339-340.

GUPTA, S.K., GUPTA, P.P., KAUSHIK, C.D. AND CHAWLA, H.K.L., 1992, Metabolic changes in groundnut leaf due to infection by leafspot pathogens. *Indian Phytopathology*, **15** : 434-438.

*HANDRO, W., MELLO, M., MANZANO, M.A. AND PLOH, E.I.S., 1997, Enhancement of stem elongation and flower bud generation by salicylic acid. *Revista brasileira fiscologia Vegetal*, **9** (2) : 139-142.

HARE, R.G., 1966, Physiology of resistance to fungal diseases in plants. *Botanical Review*, **32** : 95-98.

HARRIS, H.B. AND BURNS, R.E., 1970, Influence of tannin content in pre-harvest germination in sorghum. *Agronomy Journal*, **62** : 835-838.

HEGDE, V.M., SUBRAMANYAM, K., GOWDA, M.V.C. AND PRABHU, T.G., 1995, Estimation of yield loss due to late leafspot disease in Spanish groundnut in Karnataka. *Karnataka Journal of Agricultural Sciences*, **8**: 355-359.

HEMA, M., 2001, Effect of nutrients on rust resistance in soybean. *M. Sc. (Agri) Thesis,* University of Agricultural Sciences, Dharwad.

HIGGINS, B.B., 1935, Breeding peanuts for disease resistance. *Phytopathology*, **25**: 971-972.

*HORSFALL, J.G. AND DIAMOND, A.E., 1975, Interactions of tissue, sugar, growth substances and disease susceptibility. *Zeitschrift Pflanzenkrankh. Pflanzenschutz*, **64** : 415-421.

JACKSON, M. L., 1967, *Soil Chemical Analysis.* Prentice Hall of India Pvt. Ltd., New Delhi, pp. 182-183.

JANMATTI, V. S., 1979, Physiological aspects of growth and yield under non-stressed and stressed conditions in four genotypes of groundnut. *M.Sc.(Agri) Thesis,* University of Agricultural Sciences, Bangalore.

JAYACHANDRAN, M., RAJENDRAN, P. AND THANGARAJ, M., 2000, Effect of growth regulators on growth and yield of wet season rice. *Madras Agricultural Journal*, **87**(10-12): 679-680.

JAYACHANDRAN, M., RAMASWAMI, C. AND THANGARAJ, M., 1999, Effect of chemical and botanics spray in low irradiance susceptible rice cultivar, *Oryza*, **36**(2): 182-184.

JAYAKUMAR, R., SATHYABAMA, K. AND RAVIKUMAR, V., 2001, Influence of mepiquat chloride on bioefficacy and quality parameters of potato. *Research on Crops*, **2**(3): 368-371.

JEYKUMAR, P.AND THANGARAJ, M., 1998, Physiological and biochemical effects of mepiquat chloride on groundnut. *Madras Agricultural Journal*, **85**(1): 23-26.

KALAPPANAVAR, J.K. AND HIREMATH, R.V., 2000, Studies in stomatal characters in foliar disease resistant and susceptible sorghum genotypes. *Karnataka Journal of Agricultural Sciences*, **13**: 68-72.

KALARANI, M. K., THANGARAJ, M., SIVAKUMAR, R. AND MALLIKA, V., 2002, Effect of salicylic acid on tomato (*Lycopersicon esculentum* Mill) productivity. *Crop Research*, **23**(3): 486-492.

KATARIA, G.R. AND BHATT, P.H., 1994, Accumulation and partitioning of dry matter as a factor in pod yield in bunch type groundnut. *Indian Journal of Plant Physiology*, **37** (1) : 25-27.

KAUR, J. AND DHILLON, M., 1990, Biological alteration in groundnut (*Arachis hypogea* L.) leaf induced by *Cercosporidium personatum* (Berk is Curt). Deighton. *Indian Journal of Mycological Plant Pathology*, **19**: 151-156.

KEN SHIRASU, HIROKI NAKAJIMA, KRISHNAMACHARI RAJASHEKAR AND RICHARD DIXON, 1997, Salicylic acid potentiates an Agonist – Dependent gain control that amplifies pathogen signals in the activation of defense mechanism. *The Plant Cell*, **9**: 261-270.

*KENE, H. K., SONTAKEY, P. Y., PHANDANVIS, B. N. AND DURGO, D. V., 1992, Effect of foliar application of planofix and cycocel on growth and yield of safflower. *Bioved*, **3**(1): 21-22.

*KERBY, T.A., 1983, Cotton response to growth regulator, PIX.*California Agriculture*, **37**:4-5.

*KHAFAGA, E.R., 1983, Modification of the branching system of cotton for yield improvement. IV. Effect of growth regulators on vegetation period and yield. *Angewandte Botanik*, **57**: 257-265.

KHANGARA, B.S. AND SANDHU, R.S., 1972, Path analysis in groundnut. *Indian Journal of Agricultural Sciences*, **42** : 792-795.

KHIRBAT, S.K. AND JALALI, B.L., 2003, Influence of *Aschochyta rabici* infection on total phenol and tannin content in chickpea leaves. *Legume Research*, **26** (3) : 221-223.

KLEMENT, X. AND GOODMAN, R.N., 1967, The hypersensitive reaction to infection by bacterial plant pathogens. *Annual Review of Phytopathology*, **5**: 17-44.

KNAUFT, D.A. AND GORBET, D.W., 1990, Variability in growth characteristics and leaf pot resistance parameters of peanut lines. *Crop Science*, **30**(1) : 169-175.

KNAUFT, D.A., GORBET, D.W. AND NORDEN, A.J., 1988, Yield and market quality of seven peanut genotypes grown without leaf spot control. *Peanut Science*, **15** : 3-13.

KOSUGE, T., 1969, The role of phenolics in host response to infection. *Annual Review of Phytopathology*, **9**: 195-222.

*KUE, J., 1964, Phenolic compounds and disease resistance in plants. In: *Phenolics in normal and diseased fruits and vegetables.* (Eds. Reveneckles, V. C.), pp. 63-81.

KULKARNI, S. S., 1993, Effect of growth regardants on the growth, physiology and yield potential in sunflower (*Helianthus annus* L.) genotypes. *M.Sc.(Agri) Thesis,* University of Agricultural Sciences, Dharwad.

KULKARNI, S.S., CHETTI, M.B. AND UPPAR, D.S., 1995, Influence of growth retardants on biochemical parameters in sunflower. *Journal of Maharastra Agricultural Universities*, **20**(3): 352-354.

KUMAR, P., DUBE, S.P., MANI, V.P. AND CHAUHAN, V.S,. 1997, Effect of salicylic acid on flowering, pod formation and yield of pea (*Pisum sativum* L.). Paper presented at *National Seminar on Plant Physiology for Sustainable Agriculture*, 1997, IARI, New Delhi, March 19-21, p. 69.

KUMARI, T.S. AND SINGH, B.G., 1990, Analysis of dry matter production and yield potential in groundnut genotypes. *Journal of Maharashtra Agricultural Universities*, **15** (3) : 310-313.

LAMAS, F.M., ATHAYDE, M.L.F. AND BANZATTO, D.A., 2000*, Perquisa Agropecuaria Brasileria*, **35** (3): 507-516.

LAMAS, F.M. AND ATHAYDE, M.L.F., 1999, Effect of mepiquat chloride and thiodiazuron on some characteristics of cotton seeds. *Pequisa Agropecuria Brasileira,* **34**(11): 2015- 2019.

LAWTON, K., WEYMANN, K., FRIEDRICH, L., VERNOOIJ, B., UKNER, S. AND RYALES, J., 1995, Systemic acquired resistance in Arabidopsis requires salicylic acid but not ethylene. *Molecular Plant Microbe Interactions*, **8** (6) : 863-870.

LEE, H. AND RASKIN, J., 1998, Glycoxylation of salicylic acid in *Nicotiana tabacum* cv. *Xanthi-nc. Phytopathology*, **88** (7) : 692-697.

LEE, H.I., LEON, J. AND RASKIN, I., 1995, Biosynthesis and metabolism of salicylic acid. *Proceedings of the National Academy of Sciences of the United States of America*, **92** (10) : 4076-4079.

LESLIE, C.A. AND ROMAIN, R.J., 1986, Salicylic acid : a new inhibitor of ethylene biosynthesis. *Plant Cell Reporter*, **5** : 144-146.

LI BAOJU, LI FENG YUN, LI BJ. AND LI, F.Y., 1998, Changes in activities and electrophoretic patterns of peroxidase and polyphenol oxidase in cucumbers during infecdtion with *Cladosporium cucumerinum* . *Scientia Agricultural Sinica*, **31**(1): 86-88.

*LI, H.L., WANG, S.Z., WANG, J.S. AND ZHANG, XJ., 1994, Effects of elicitor of induction fungi on the resistance of cucumber against anthracnose. *Acta Phytophysiolgocia, Sinica,* **19**(4): 320-324.

LOPEZ, D.H. AND SCOTT, I.M., 1997, Induction of *in vitro* tuberization of potato microplants by acetyl salicylic acid. *Journal of Plant Physiology*, **151**(1): 74-78.

LUTHRA, Y. P., GANDHI, S. K., JOSHI, V. N. AND ARORA, S. K., 1988, Total phenols and their oxidative enzymes in sorghum leaves resistant and susceptible to *Ramulispora sorghicola* Harris. *Acta Phytopathol, Entomol* (Hungarica), **23**: 333-339.

MAIBANGSA, S., THANGARAJ, M. AND ROY, S., 1999, Alleviation of low irradiance stress in rice (*Oryza sativa* L.) by growth regulators. *Annals of Plant Physiology*, **13** (2): 133-142.

MALOLEPZA, U., UKBANEK, H. AND POLIT, J., 1994, Some biochemical reactions of strawberry plants to infection with *Botrytis cinerea* and salicylic acid treatment. *Acta Agrobotanica*, **47** (2) : 73-81.

MAYEE, C. D. AND DATTAR, V. B., 1986, *Phytopathometry*. Marathwada Agricultural University, Parbhani, pp. 1-145.

Mc DONALD, D., SUBRAMANYAM, P., GIBBONS, R. W. AND SMITH, D. H., 1985, Early and late leaf spots of groundnut. *Information Bulletin*, No.21, ICRISAT, Patencheru, A.P., pp.19.

MEENA, B., MARIMUTHU, T. AND VELAZHAHAM, R., 2001, Salicylic acid induces systemic resistance in groundnut against late leafspot caused by *Cercosporidium personatum. Journal of Mycology and Plant Pathology*, **31** : 139-145.

*MEGIE, G., 1980, Trial of the growth regulator BAS 08301 w on cultivated cotton (*G. hursutum*) in the polders of Bol (Lake Chad). *Cotton et Fibres Tropicales*, **35**: 343-345.

MEKKI, B.B. AND EI KHOLY, M.A., 1999, Response of yield, oil and fatty acid contents in some oil seed rape varieties to mepiquat chloride. *Bulletin of the National Research Centre*, Cairo, **24**(3): 287-299.

MISHRA, S. D., 1989, Growth regulators in crop production – A brief overview. In: *National Seminar on Research Imperatives for the Nineties*, January 22-24, 1989.

MIYAZAWA, J., KAWABATA, T. AND OGASAWARA, N., 1999, Induction of an acidic isozyme of peroxidase and acquired resistance to wilt disease in response to treatment of tomato roots with 2-furoic acid, 4-hydrobezoic hydrazide or salicylic hydrazide. *Physiological and Molecular Plant Pathology*, **52**: 115-126.

*MOHAPATRA, N.K., 1982, Post infection changes in sugar content of groundnut leaves infected with *Cercospora personata*. *Go Bios*, **9**: 246-248.

MOORE, T. G., 1980, *Biochemistry and Physiology of Plant Hormone.* Naroja Publishing House, New Delhi, pp. 107-131.

MORANDI, E.N. , CASANO, L.M. AND NAKAYAMA, F., 1983, Effect on N, N – dimethyl piperdinium chloride on the vegetative and reproductive growth of soybean*, Glycine max* (L.) merr. *Phyton*, **43**: 35-44.

MULDER, C.E.G., WORTMANN, G.B. AND JENNRICH, H.H., 1981, Mepiquat chloride a plant growth regulators on cotton. *Crop Production*, **10**: 193-196.

MURPHY, A.M., CHIVASA, S., SINGH, D.P. AND CARR, J.P., 1998, Salicylic acid can induce resistance to plant virus movement. *Molecular Plant Microbe Interactions*, **11**: 860-868.

NANCY, A.E., 2003, A new twist on systemic acquired resistance. Redox control of the NPR-I. TGA-I interaction by salicylic acid. *Plant Cell*, **15** : 1947-1949.

NARAYAN REDDY, P. AND KHARE, M. N., 1988, Physiology of groundnut rust disease : changes in total sugars, phenols, ascorbic acid, peroxidase and phenoloxidase. *Journal of Oilseeds Research*, **5**: 102-106.

NARAYANAN, A., BABU, V. B. AND REDDY, G. L., 1991, Comparison of food legumes during their early vegetative phase for growth characteristics and fertilizer response. *Indian Journal of Plant Physiology*, **31**: 42-47.

NEVILL, D.J. AND EVANS, A.M., 1980, The effect of host development on the assessment of disease resistance to *Cercospora* leafspots in groundnut (*Arachis hypogea* L.). *Journal of Agricultural Sciences*, **94** : 229-237.

NORTON, E.J. AND SILVERTOOTH, 2000, Mepiquat chloride effects on irrigated cotton in Arizona. *Arizona Cotton Report*, The University of Arizona college of Agriculture.

OGLE, H.J., BYTH, D.E. AND MCLEAN, R., 1979, Effect of rust (*Phakopsora pachyrhizi*) on soybean yield and quality in south eastern Queensland. *Australian Journal of Agricultural Research*, **30** : 883-893.

PANKAJ AND SHARMA, H.K., 2003, Relative sensitivity of *Meloidogyne incognita* and *Rotylenchulus reniformis* to salicylic acid on Okra. *Indian journal of Nematology*, **33** (2) : 120-123.

PANSE, V. G. AND SUKHATME, P. V., 1967, *Statistical Methods for Agricultural Workers.* ICAR Publications, New Delhi, pp. 167-174.

PARICHA, P.C., GHOSH, B.K. AND SABOO, N.C., 1977, Further studies on the significance of cycocel on enhancing drought resistance in rice. *Science and Culture*, **43**: 230-231.

PATIL, A.G., GOWDA, M.V.C. AND MOTAGI, B.N., 1996, Growth and partitioning efficiency of late leaf spot resistant genotypes. *International Arachis Newsletter*, **16** : 40-41.

PHULEKAR, C.S., CHETTI, M.B., NALINI, A.S. AND PATIL, A.B., 1998, Relationship of leaf characters with total dry matter and yield in groundnut as influenced by growth retardants. *Indian Journal of Agricultural Research,* **32**(3): 195-200.

PIPER, C. S., 1966, *Soil and Plant Analysis*. Hans Publishers, Mumbai, pp. 47-49.

PORTER, D. M., SMITH, D. H. AND RODRIGUEZ-KABANA, R., 1982, *Peanut Diseases*. In: Peanut Science and Technology. Ed. Patteee, H.E. and Yound, C. T., American Peanut Research and Education Society, Pierce Printing Company, pp. 326-410.

POWER, J. F., WILLIS, W. O., GUNES, D. L. AND REICHMAN, G. A., 1967, Effect of soil temperature, phosphorus and plant age on growth analysis of barley. *Agronomy Journal*, **59**: 231-234.

PRAMOD KUMAR, .D., DUBE AND CHAUHAN, V.S., 1999, Effect of salicylic acid on growth, development and some biochemical aspects of soybean (*Glycine max* L. Merrill). *Indian Journal of Plant Physiology*, **4** : 327-330.

PRAVIN PRAKASH, CHETTI, M.B., HOSMANI, R.M. AND PRAKASH, P., 2000, Influence of plant growth regulators on physiological and tuber propagated potato. *Annals of plant Physiology,* **14**(1): 16-20.

PUROHIT, S. S., 1993, *In Hormonal Regulation of Plant Growth Development*. Vol. VI Agro Botanical Publishers (India0, Bikaner, pp. 161-197.

QIN GUO ZHENG, TIAN SHIPING, XU YONG, WAN YAKU, QIN, G. Z., TIAN, S. P. , XU, Y. AND WAN, Y. K., 2003, Enhancement of biocontrol efficacy of antagonistic yeasts by salicylic acid in sweet cherry fruit. *Physiological and Molecular Plant Pathology*, **62**(3): 147-154.

QUINTANILLA, P. AND BRISHAMMAR, S., 1998, Systemic induced resistance to late blight in potato by treatment with salicylic acid and *Phytophthora cryptogea. Potato Research*, **41**: 135-142.

RADFORD, P. J., 1967, Growth analysis formulae their use and abuse. *Crop Science*, **7**: 171-178.

RADHAMANI, S., BALASUBRAMANIAN, A. AND CHINNUSAMY, C., 2002, Effect of sulphur application and foliar spray of nutrient and growth regulators on seed yield and oil content of sesame. *Madras Agricultural Journal,* **38** (10-12): 732-733.

RAMESH BABU, RAO, M.V.H., SUBHASH GUMASTE, RADDER, G.D. AND ITNAL, C.J., 1993, Effect of chamatkar (mepiquat chloride)- A growth retardant on growth and yield of cotton (*Gossypium hirsutum* L.) *Pestology*, **17**(1): 33-36.

RANGASWAMI, G., 1988, In: *Diseases of Crop Plants in India*. Prentice Hall of India Pvt. Ltd., pp. 237-254.

RAO, P., 1989, Variability studies on morphological, biochemical, yield and yield components characters of bollworm tolerant and susceptible cotton genotypes. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad, pp. 99-135.

RASKIN, I., 1992a, Role of salicylic acid in plants. *Annual Review of Plant Physiology and Plant Molecular Biology*, **43** : 439-463.

RASKIN, I., 1992b, Salicylate a new plant hormone. *Plant Physiology*, 99 : 799-803.

RASMUSSEN, J. B., HAMMERSCHMIDT, R. AND ZOOK, M. N., 1991, Systemic induction of salicylic acid accumulation in cucumber after inoculation with *Pseudomonas syringae* pv. s*yringae*,. *Plant Physiology*, **97**: 1342-1347.

REDDY, S. C. AND PATIL, S. V., 1981, Effect of growth regardants on the yield and yield attributes of groundnut (*Arachis hypogaea* L.). *Mysore Journal of Agricultural Science,* **15**(2): 238-241.

ROHRINGER, R. AND SAMBORSKI, D. J., 1967, Aromatic compounds I the host-parasite interaction. *Annual Review of Phytopathology*, **5**: 77-86.

RYALS, J.A., NEVENSCHWANDER, V.H., WILLITS, M.G., MOLINA, A., STEINER, H.Y. AND HUNT, M.D., 1996, Systemic acquired resistance. *Plant Cell*, **8** : 1809-1819.

SADASIVAM, S. AND MANIKAM, A., 1992, *Biochemical Methods for Agricultural Science*. Wiley Eastern Ltd., New Delhi, pp. 189-191.

*SAINI, R. S., ARORA, Y. K., CHAWLA, H. K. L. AND WAGLE, D. S., 1988, Total phenols and sugar content in wheat cultivars resistant and susceptible to *Ustilago nuda* (Jens) Rostrup. *Biochem Physiology Pflanzen,* **183**: 89-93.

SAIRAM, R. K., DESHMUKH, P. S. AND SHUKLA, D. S., 1991, Influence of chlormequat chloride on photosynthesis and nitrate assimilation in wheat genotypes under water stress. *Indian Journal of Plant Pathology*, **34**(3): 222-227.

*SANAA, A.M.Z., IBRAHIM, S.I. AND EIDEEN, H.A.M.S., 2001, The effects of NAA, salicylic acid and their combinations on growth, fruit setting, yield and some correlated components in dry bean. *Annals of Agricultural Science*, Cairo, **46** (2) : 251-563.

SARADHAMBAL, K.V., SINGH, S. P., PRAKASH, S. AND NAIK, M. S., 1978, Effect of bacterial blight on the activities of nitrate reductase and peroxidase in rice plants. *Indian Journal of Biochemistry and Biophysics,* **15**: 105-107.

SASTRY, K.S.K., SHASHIDHAR, V.R., MEKHRI, A.A. AND PARAMESHWAR, C., 1980, Final report of the scheme for drought tolerance studies on groundnut, castor and sunflower. University of Agricultural Sciences, Bangalore.

*SCHOTT, P.E. AND RITTING, F.R., 1982, New findings on the biological activity of mepiquat chloride . *Butter worth Scientific* , 415-424.

SENTHIL, A., PATHMANABAN, G. AND THANGARAJ, M., 2003, Effect of growth regulators on certain physiological and biochemical aspects of green gram var. VBN-1. *Legume Research*, **26**(3): 200-203.

SESTAK, Z., CATASKY, J. AND JARVIS, P. G., 1971, *Plant Photosynthetic Production : Manual of Methods.* Eds. Junk, N. V., The Haque Publishers, pp. 72-78.

SETIA, R.C., BATHAL, GURMEET AND SETIA, NEELAM, 1995, Influence of paclobutrazol on growth and yield of *Brassica carinata*. *Plant Growth Regulation*, **16** : 121-127.

SHAHAWY, M.I.M. AND ABDEL MALIK, R.R., 2000, Response of giza 87 cotton cultivar to mepiquat chloride and nitrogen fertilization levels. *Egyptian Journal of Agricultural Research,* **78**(2): 769-780.

SHANTHA KUMARI, T., GOPAL SINGH, B. AND RAO, L. M., 1988, Analysis of growth stages in groundnut genotypes (*Arachis hypogeae*). *Journal of Oilseeds Research*, **5**: 62-71.

SHARMA, S.G., RAMNARAYAN, S. AND CHATURVEDI, C., 1983, Role of phenolic compounds in resistance to maize to leaf blight caused by *Drechslera* state of *Cocliobolus heterostrophus. Indian Phytopathology*, **36** : 43-46.

SHENEIDER, E.A. AND WHITMAN, F., 1974, Metabolism of auxin in higher plants. *Annual Review of Plant Physiology,* **25** : 487-513.

SHULAEV, V., LEON, J. AND RASKIN, I., 1995, Is salicylic acid a translocated signal of systemic acquired resistance in tobacco? *The Plant Cell*, **7**(10) : 1691-1701.

SIDDARAMAIH, A. L., DESAI, S. A. AND HEGDE, R. K., 1983, Studies on estimation of loss due to rust and late leafspot of groundnut. *Mysore Journal of Agricultural Sciences*, **17**: 365-367.

SINDHAN, G.S. AND JAGLAN, B.S., 1988, Role of phenolic compounds and carbohydrates in resistance of groundnut to tikka leaf spot. *Indian Journal of Mycology and Plant Pathology*, **17** (2) : 141-144.

SINDHAN, G.S., JAGLAN, B.S. AND PARESHAR, R.D., 1987, Change in phenols and carbohydrates in resistant and susceptible cultivars of groundnut in relation to tikka disease. *Plant Disease Research*, **2** (2) : 100-101.

SINGH, A.B. AND AWASTI, 1998, Effect of growth stimulators and activity of oxidative enzymes in the leaves and status of biochemical constituents in dry mature seeds of greengram. *Legume Research*, **21** (3/4) : 144-150.

SINGH, A.B., 2001, Influence of phenolic compounds on yield and protein quality of greengram (*Vigna radiata* L. Wilczek). *Legume Research*, **24** (4) : 260-263.

SINGH, G. AND KAUR, M., 1980, Effect of growth regulators on podding and yield of mung bean (*Vigna radiata* L. Wilczek). *Indian Journal of Plant Physiology*, **23** : 366-370.

SINGH, V.K., SAINI, J.P. AND MISRA, A.K., 2001, Response of salicylic acid on flowering, floral malformation, fruit set, yield and associated bio-physical and biochemical characters of mango. *Indian Journal of Horticulture*, **58** (3) : 196-201.

SIVAKUMAR, K., KALARANI, M.K., MALLIKA VANANGAMUDI, SUJATHA, K.B. AND VANANGAMUDI, M., 2001, Effect of growth regulatos on biochemical attributes, grain yield and quality in pearl millet . *Madras Agricultural Journal*, **88**(4-6): 256-259.

SIVAKUMAR, R., PATHMANABAN, G., KALARANI, M.K., MALLIKA VANANGAMUDI, SRINIVASAN, P.S., VANANGAMUDI, M., 2002, Effect of Foliar application of growth regulators on Biochemical attribute and grain yield in pearl millet . *Indian Journal of Plant Physiology* , **7**(1): 79-82.

SRIVASTAVA, K. D., JOSHI, L. M. AND MALHOTRA, R. K., 1975, Effect of brown rust on yield components of wheat vareity "Lal Bahadur". *Indian Phytopathology*, **27**: 286-2890.

SUBBARAO, P. V., SUBRAMANYAN, P. AND REDDY, P. M., 1990, A modified 9 point diseases scale for assessment of rust and late leaf spot of groundnut. *Presented at the 2nd International Congress on the French Phytopathological Society*, 28-30 November 1990, Montopellier, France.

SUBHENDU SEN., SRIKANTA DAS, DAS, A.K., SRIKUMAR PAL, SEN, S., DAS, S. AND PAL, S., 2002, Peroxidase, polyphenoloxidase, total phenol and protein content in leaf tissues of *Colocasia esculenta* var. antiquorum and their relationship to phytophthora leaf blight disease. *Journal of vegetable crop Production*, **8**(1): 83-89.

SUBRAHMANYAM, P., WILLIAMS, J.H., Mc.DONALD, D. AND GIBBONS, R.W., 1984, The influence of foliar diseases and their control of selective fungicides on a range of groundnut (*Arachis hypogaea* L.) genotypes. *Annals of Applied Biology*, **104** : 457-476.

*SUDHAKARAN, R., SELVASUNDARAM, R. AND MURALEEDHARAN, N., 2000, Physiological and biochemical changes in tea leaves due to tea mosquito bug infestation. In: *Recent Advances in Plant Science Research*, Allied Publishers, pp. 289-292.

SULAIMAN, M. AND AGASHE, N.C., 1965, Influence of climate of the Incidence of tikka disease of groundnut . *Indian Oilseeds Journal*, **9**: 176.

SULAIMAN, M., 1966, Investigations on the control of tikka disease of groundnut in the Maharastra state. *Abstract of Review of Application Mycology*, **45**: 305.

SUNDARAM, N.V., 1965, Note on creation of tikka leaf spot of groundnut. *Indian Oilseeds Journal*, **9**: 24-27.

*SWAIN, T., 1977, Secondary compounds as protective agents. *Annual Review of Plant Physiology*, **28**: 479-501.

SWAIN, T., 1979, Tannins and Lignins in herbivores : their interaction with secondary plant metabolites. Ed.s G. A. Rosenthal and D. H. Jayzen, Academic Press, New York, pp.657-700.

THEERTHAPRASAD, D. AND SHAMBULINGAPPA, K.G., 1986, Biochemical factors in *Helianthus annus* L. in relation to rust *Puccinia helianthi* resistance. *Journal of Oilseeds Research*, **3**: 268-269.

THIMAIAH, S. K., 1989, *A Manual of Research Method for Analysis of Agricultural Products*, **1**: 47-50.

THOMAS, G., LESLIE, F., BERNARD, V., DAVID, N., GORDON, N, SCOT, U., ERIC, W., HELMUT, K. AND JOHN, R., 1993, Requirement of salicylic acid for the induction of systemic acquired resistance. *Science*, **261** : 754-756.

THOMAS, R.O., 1964, Effects of application, timing and concentration of 2 – chloro – ethyl-trimethyl ammonium chloride on plant size and fruiting response of cotton. *Crop Sciences*, **4**: 403-406.

TOMASZEWSKI, M. AND THIMMAN, K.V., 1966, Interaction of phenolic acids, metallic ions and chelating agents on auxin induced growth. *Plant Physiology*, **41** : 1443-1454.

TOMIYAMA, K., 1963, Physiology and biochemistry of disease resistance of plants. *Annual Review of Phytopathology*, **53** : 295-324.

VALAND, G.B., PATEL, H.R., PATEL, J.G. AND SHEIKH, M., 1997, Impact of late leaf spot disease (*Phaeoisariopsis personata*) on growth performance of common varieties of groundnut (*Arachis hypogaea*). *Indian Journal of Agricultural Sciences*, **67** (8) : 319-321.

VALLIPPAN, K., LAKSHMANAN, A. R. AND KUMARESAN, K. R., 1985, Effect of different plant growth regulators on the reproductive characters and yield of TMV of groundnut. *Oilseeds Journal*, **1**6: 53-56.

*VARELLA, G. R. AND YALLEJO, R. R., 1982, Effect of the growth regulator Mepiquat chloride on the main agronomic characteristics and fibre quality of cotton (*Gossypium hirsutum* L.). *Revista Instituto Colombiano*. *Agropecuario*, **17**: 1-9.

VENKATA SADHU RATNAM, M., NARAYAN REDDY, P., CHANER RAO, S. AND RAMA BHADRA RAJU, 2004, Systemic induced resistance in sunflower to *Alternaria* leaf blight by foliar application of SA and Bion. *Journal of Oilseeds Research*, **21**(1): 104-107.

VERNOOIJ, B.L., FRIEDRICH, P., AHLGOY, T., STAUB, H.K. AND REYALS, J., 1995, 2, 6-Dichloroisonicotinic acid – induced resistance to pathogens without the accumulation of salicylic acid. *Molecular Plant Microbe Interaction*, **8** : 228-234.

VIJAYAKUMAR, R.M., VIJAYAKUMAR, M. AND JEYAKUMAR, P., 2002, Influence of weather factors and certain growth regulators on physiology of annual moriga cv. PKM-1. *South Indian Horticulture*, **50**(4-6): 414-420.

VIJAYALAKSHMI, D. AND SRINIVASAN, P.S., 1999, Morpho-physiological changes as influenced by chemicals and growth regulators in alternate bearing mango cv. Alphonso, *Madras agricultural Journal*, **86**(7-9): 485-487.

VIJAYALAKSHMI, D. AND SRINIVASAN, P.S., 2000, Altering the enzyme activities for enhancing yield in off year mango through chemicals and growth regulators. *Orissa Journal of Horticulture*, **28**(2): 1-7.

VINDHIYAVARMAN, P., GEETHA LAKSHMI, V. AND RAVEENDRAN, T.S., 1993, Partitioning of dry matter in foliar disease resistant genotypes of groundnut (*Arachis hypogea* L.). *Journal of oilseed Research*, **10**:187-190.

WAINLAND, R. AND TAYLOR, H.E., 1965, Phenols as plant growth regulators. *Nature*, **207** : 167-169.

*WALTER, H., GAUSMAN, H.W., RITTING, F.R., NAMKEN, L.N., ESCOBAR, DE. AND RODRIGUEZ, R.R., 1980, Effect of mepiquat chloride on cotton plant leaf and canopy structure and dry weights of its components. In : 1980 Beltwide cotton production Research conference Proceeding U.S.A , National cotton council of America, pp. 32-35.

WALTER, J. C. AN STAHMANN, M. A., 1955, Chemical nature of disease resistance in plants. *Annual Review of Plant Physiology*, **6**: 351-366.

WATSON, D.J., 1952, The physiological basis of variation in yield. *Advances in Agronomy*, **4** : 101-105.

WEISSMANN, G. ., 1991, Aspirin. *Science Am.,* **264**: 84-90.

*WEST, C., BRIGGS, G. E. AND KIDD, F., 1920, Methods of significant relations in quantitative analysis of plant growth. *New Physiologist*, **19**: 200-207.

WILLARD, J.I., 1979, Pix- plant regulator research past and future . In : M. ABDEL RAHAMAN (ed) Proceedings of 6th Annual meeting on Plant Growth Regulation working Group. *Lasvegas Nev*., 20-23, Aug. 1979, Longmont.

*WILLIAMS, J.H., WILSON, J.H.H. AND BATE, G.C., 1975, The growth of groundnuts (*Arachis hypogaea* L. cv. Matula Red) at three altitudes in Rhodesia. *Rhodesia Journal of Agricultural Research*, **13** : 33-43.

WILLITS, M.G. AND RYALS, J.A., 1998, Determining the relationship between salicylic acid levels and systemic acquired resistance induction in tobacco. *Molecular Plant Microbe Interactions*, **11** (8) : 795-800.

YADAV, N.K., THAKUR, D.P. AND RATHI, A.S., 1998, Biochemical changes in pearl millet leaves due to downy mildew infection. *Journal of Agricultural Research*, **28** (2-3) : 81-86.

YORK, A.C., 1982, Response of cotton to mepiquat chloride with varying nitrogen rates and plant population. *Agronomy Journal*, **75**: 667-672.

ZAKY, L.M., EI BAHAY, M.M. DOWIDAR, A.E. AND LATIF, H.H., 1999, Some physiological studies on the effect of the growth retardant (pix) on *vicia faba* plant. Morphological characteristics and metabolic activities during growth and development. *Egyptian Journal of Physiological Sciences*, **23**(3): 335-359.

ZAKY, W.H., EI- SHERBIENY, S.N. AND MOSA, A.A., 2000, Induced Resistance of spearmint plant against rust disease caused by *Puccinia menthae. Annals of Agricultural Sciences*, **47**(1): 417-429.

ZHAO DULI, OOSTERHUIS, D., ZHAO, D.L., DUGGER, P. AND RICHTER, D., 1999, Physiolgocial growth and yield responses of cotton to mepplus and mepiquat chloride. *Proceedings Beltwide cotton Conferences*, Florida, USA, **1**: 599-602.

---

*Originals not seen

INFLUENCE OF SALICYLIC ACID AND MEPIQUAT CHLORIDE ON PHYSIOLOGY OF DISEASE RESISTANCE IN GROUNDNUT (*Arachis hypogaea* L.)

TAFSIRA NAZ **2006** **Dr. S. M. HIREMATH**
MAJOR ADVISOR

ABSTRACT

A field experiment was conducted to find out the influence of salicylic acid and mepiquat chloride on various morphological, physiological, biochemical, growth and yield and yield components in groundnut cv. JL-24 during *kharif* 2005 at MARS, University of Agricultural Sciences, Dharwad. The experiment consisted of 15 treatments with 3 replications and was laid out in randomized block design.

The incidence of late leaf spot was severe in control as compared to other treatments and it was least in salicylic acid (500 ppm) + mepiquat chloride (1000 ppm) at all the stages. The plant height and number of branches increased significantly due to the application of salicylic acid. The leaf area increased with increasing concentration of salicylic acid. The important parameters like leaf dry weight, stem dry weight, dry weight of reproductive parts and total dry weight increased with the increasing concentration of salicylic acid, however, the effect was more pronounced when salicylic acid was applied in combination with mepiquat chloride. The growth parameters like AGR, CGR, NAR and BMD recorded maximum values with salicylic acid (500 ppm) + mepiquat chloride. LAI, LAR and LAD were found minimum with mepiquat chloride treatments. The contents of chlorophyll-a, chlorophyll-b, total chlorophyll, phenol contents and tannin contents were significantly higher with application of salicylic acid (500 ppm) + mepiquat chloride (1000 ppm). However, the total sugar content decreased with the application of salicylic acid. NRA activity was more with the application of mepiquat chloride. The activity of peroxidase and polyphenol oxidase enzymes decrease with increase in disease severity pod yield, harvest index, shelling percentage and test weight were maximum with the application of salicylic acid and mepiquat chloride. However, oil content was more in treatments with mepiquat chloride. The B:C ratio was found higher with salicylic acid (500 ppm) + mepiquat chloride (1000 ppm).