Journal of Plant Development Sciences

(An International Monthly Refereed Research Journal)

Volume 10 **Number 10** **October 2018**

Contents

RESEARCH ARTICLE

GREEN SYNTHESIS OF ZINC OXIDE NANOPARTICLE OF *THYMUS VULGARIS* L. LEAVES AND ITS ANTIBACTERIAL ACTIVITY

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Received-02.10.2018, Revised-23.10.2018

Abstract: In the present study, the green method was used for the synthesis of zinc oxide nanoparticle from the dried leaves of *Thymus vulgaris* L. The synthesized ZnO NPs was characterized by UV-Vis spectrophotometer, XR Diffractometer, Scanning Electron Microscopy (SEM) and EDX (Energy Dispersive X-ray) spectrophotometer. The result suggests that the synthesized nanoparticles are crystalline in nature and in the nanorange. The average sizes of nanoparticle are 13.06 nm. The synthesized ZnO NPs was screened for the antibacterial activity against six pathogenic bacteria. Out of six bacterial strains tested, the ZnO NPs was found active against *Salmonella typhi, Klebsiella pneumoniae, Staphylococcus aureus* and *Bacillus cereus* but it does not have shown activity against *E. coli* and *Enteococcus spp.*

Keywords: Thymus vulgaris L., ZnO NPs, Antibacterial activity

INTRODUCTION

The development of resistance in microorganism is matter of great concern for the medical science that the bacterial species which is sensitive to the basic antimicrobial drugs now become ineffective. This property of resistance is the result of mutation in gene of the bacteria, horizontal transfer of resistance gene to bacterial progeny (Srivastava *et al*., 2016) and other reason was irrational use of antimicrobial agents by medical practitioner. In most of the cases of diseases people hesitate to visit clinician due to the high cost of consultancy and expensive drugs prescribed by them. So, people consult their disease to the pharmacist or local drug distributer and take drugs without knowing the full course of the drug and after 2-3 dose he/she feel better and discontinue the drug. After sometime they again infected with same bacteria and the use of the same drug become ineffective due to development of resistance in bacterial pathogen. This problem was not only faced by India but it is global problem. The bacterial species resist or evade the mechanism of drug action by doing certain modification in itself and become resistant strain (Chandra *et al*. 2017). The researcher now in search of some alternate medicine or substance which have significant activity against these pathogenic bacterial species.

Thymus vulgaris L is aromatic plant and it is belongs to the family Lamiaceae (Labiatae) in which most of members are herbs and shrubs. It is small perennial herbs attain height upto 40 cm. The leaves of thyme are small ranges from 2.5.to 4.5 mm long and have oval to rectangular shape. Its aerial part is used for the production of essential oil. This plant does not need too much irrigation. The excessive water will make plant prone to rot disease. It has worldwide distribution and it is native to Mediterranean and cultivated in many parts of Africa such as Egypt, Morocco, Algeria, Tunisia, Libya, South Africa, France, Svizzera, Spain, Italy, Bulgaria, and Portuguese Republic. Thyme plant is known for its great medicinal value. It is used for the treatment of various ailments like intestinal infection of bacterial as well as worm's infestation. The essential oil has been known for its antimicrobial activity and its property is due to the presence of phenolic compounds (Boruga *et al*., 2014)

METHODOLOGY

Chemical and Reagent

All chemicals and media used in the study were of analytical grade and procured from HiMedia Laboratories Ltd. The dried plant sample of Thyme was purchased from the Human India, Srikot, Srinagar, Uttarakhand.

Synthesis of ZnO Nanoparticle

The synthesis of ZnO Nanoparticle was done as per the method described by Patel *et al* (2017) in which dried leaves of thyme was boiled in double distilled water for 10 min and the extract after cooling filtered and stored in refrigerator for further processing. 50 mL of leaf extract was heated at 65^{o}C with addition of zinc acetate and sodium hydroxide till the formation of color. The solution after cooling centrifuged and precipitate was collected and stored in vial after oven drying

Characterization of Synthesized ZnO NPs

The synthesized nanoparticles were characterized by using UV-Vis spectrophotometer, X-Ray Diffraction, Scanning Electron Microscopy and Energy Dispersive X-ray spectroscopy. All the characterization was done in the Centralized facility

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of USIC (University Science Instrumentation Centre), H. N. B. Garhwal University.

Antibacterial activity of synthesized nanoparticles against pathogenic bacteria

Antibacterial activity of synthesized ZnO NPs was tested according to the Agar well diffusion method described by Chandra *et al* (2016) in which appropriate well was created with help of cork borer in Mueller Hinton Agar medium which was previously inoculated with test bacteria and then well was filled with 100 mg/mL concentration of ZnO NPs. The seeded plate with ZnO NPs was incubated at 37^0C for 18-24 h. The zone of inhibition was recorded in mm. The MIC of synthesized ZnO NPs was also evaluated by method described by Chandra *et al*. (2016).

RESULTS AND DISCUSSION

The Fig 1 showed the UV absorption spectra of synthesized ZnO NPs and it was observed that the maximum absorption at 345 nm (Fig.1). The UV absorption of ZnO NPs of *Thyme* was in agreement of finding reported by Sutradhar and Saha (2015) and Azizi *et al*. (2013). The almost similar finding was also reported in earlier report of our group in which the synthesized zinc oxide nanoparticles from *Morinda citrifolia* have maximum absorption at 340 nm (Joshi *et al.* 2018). The other researcher also reported the absorption of ZnO NPs in the range of 340 -380 nm (Sutradhar and Saha, 2016; Saputra and Yulizar. 2017**;** Safawoa *et al*., 2018).

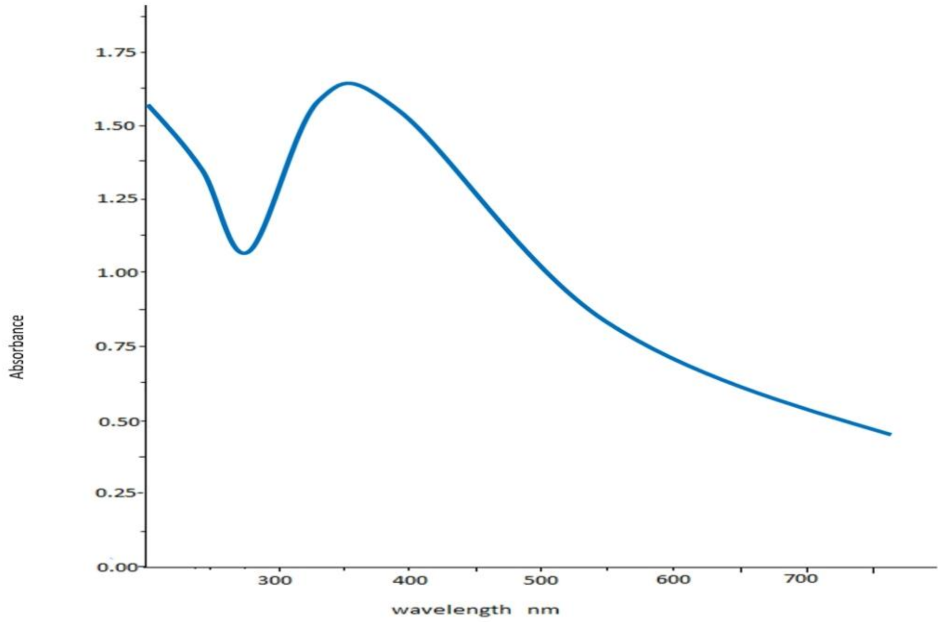

Fig.1. UV-Vis spectra of synthesized ZnO NPs

XRD analysis

Table showed the crystalline size of synthesized zinc oxide nanoparticles. The size of nanoparticle was calculated and found to have in the range of 11.2 to 14.7 nm. The average size of nanoparticle was 13.06 nm (Table 1). The XRD spectra of ZnO NPs were presented in Fig. 2

Table 1. Crystalline size of synthesized ZnO NPs synthesized using *T. vulgaris* L.

	2θ value (degree)	**d- spacing (A)**	**FWHM (degree)**	**Crystallite Size in nm**
Thyme leaf extract	31.77	2.81	0.52	12.4
	34.39	2.60	0.45	14.7
	47.50	1.9	0.69	11.2
	56.54	1.6	0.57	13.8
	62.76	1.4	0.72	13.2

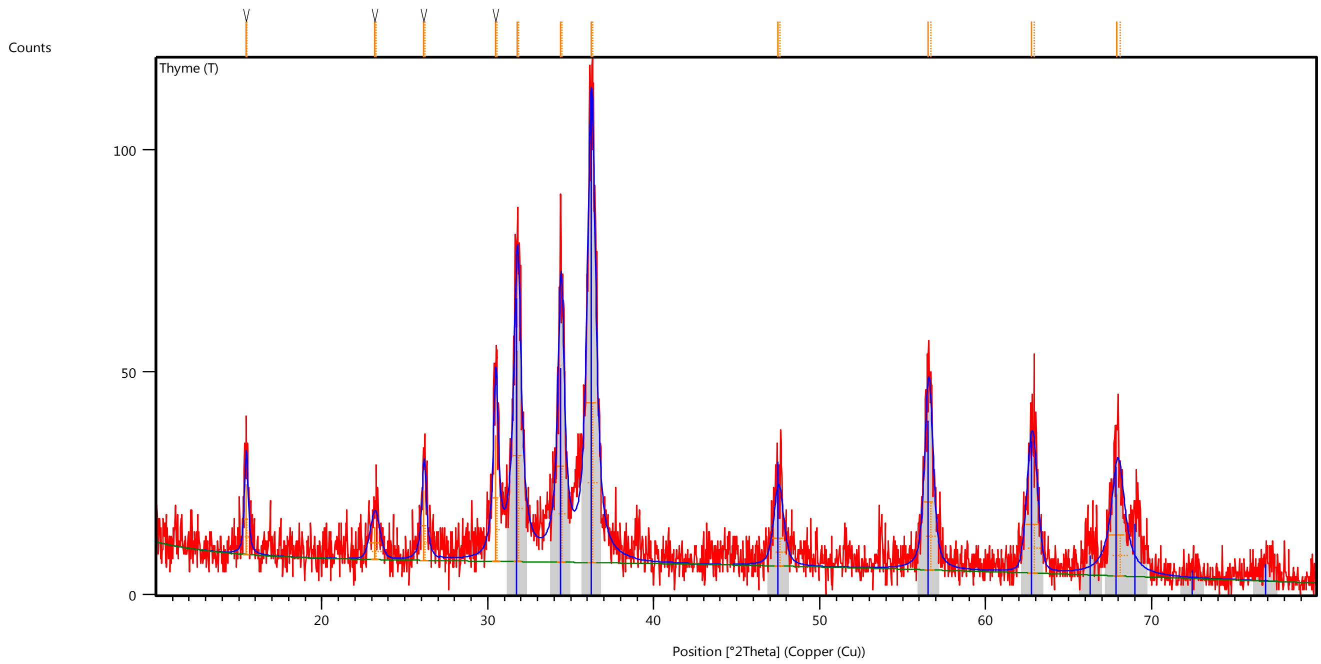

Fig. 2 XRD spectra of ZnO NPs synthesized from *T. vulgaris*

The peak shown in the Fig. confirmed the crystalline nature of synthesized nanoparticle. The peak obtained at 2θ angle value ranges from 31.77, 34.39, 47.50, 56.54 and 62.56 which clearly suggestive of formation of crystalline nanoparticles. The results obtained are in agreement with the finding of Suresh *et al*. (2018)

SEM analysis

The SEM image of synthesized ZnO nanoparticle was presented in Fig.3. The SEM image was take at two different magnification i.e. 2 µm and 10 µm. The irregular and rectangular shape nanoparticles are clearly seen in Fig.3.

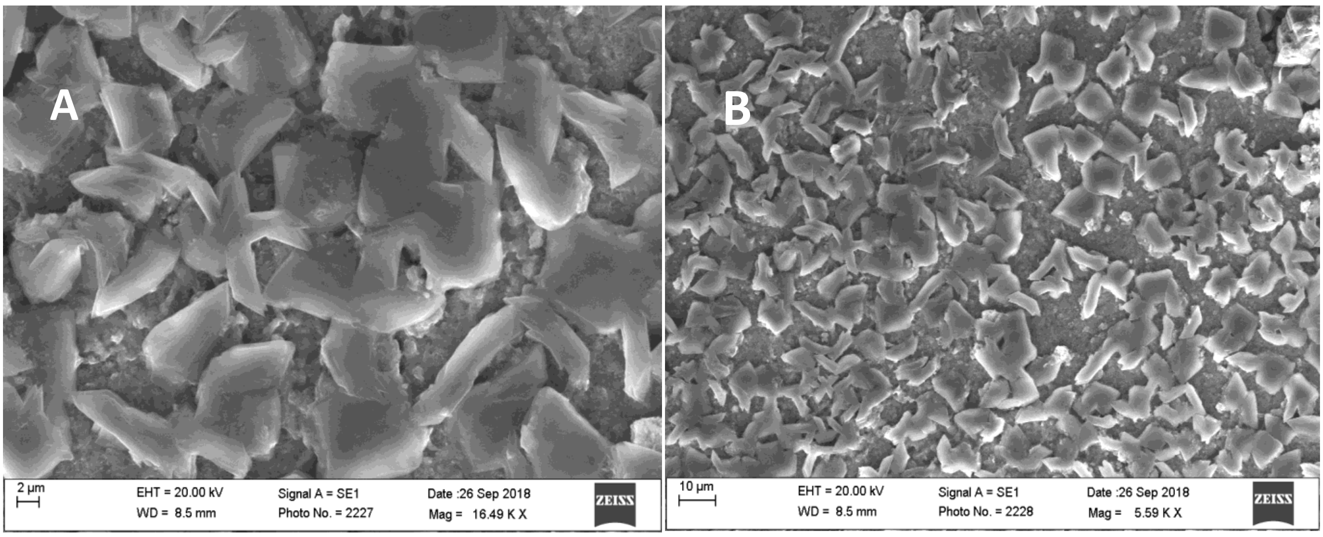

Fig. 3. SEM image of ZnO NPs at different magnification A.) 2 µm B.) 10 µm.

EDX

The Energy dispersive X-ray Spectroscopy generally done to know the elemental composition of synthesized nanoparticle. The Fig 3 confirmed that the synthesized nanoparticles were composed of zinc and oxide. There was appearance of major peak of O and Zn at 0.5 keV and 1 KeV repectively. This is in agreement of our previous reports (Joshi *et al*., 2018) and Patel *et al*., 2017)

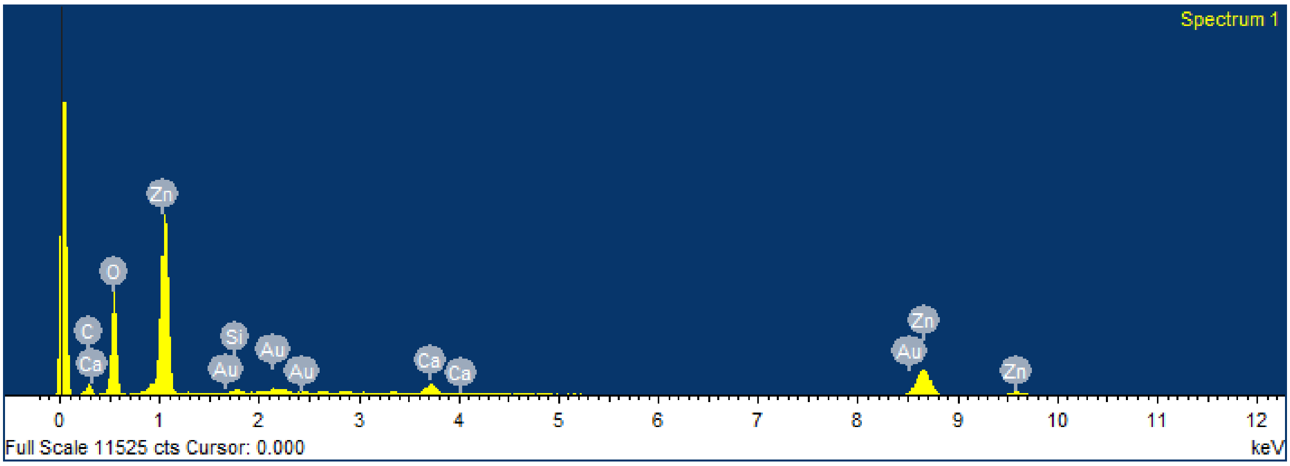

Fig. 4. EDX spectra of Synthesized ZnO NPs from *T. vulgaris*.

Antibacterial activity of synthesized Nanoparticle

The synthesized ZnO Nanoparticle was evaluated against five uropathogens i.e. *S.typhi*, *Enterococcus* spp., *Klebsiella pneumoniae*, *E. coli*, *S. aureus* and sixth bacteria isolated from other source, B. cereus. The Table showed the antibacterial activity of ZnO NPs synthesized from Thyme. Out of six bacterial species tested no activity was reported against *E. coli* and Enterococcus spp. However, highest antibacterial activity was seen against *Staphylococcus aureus* (20.0 ± 0.0mm) followed by B. cereus (16.0 ± 0.5 mm) and moderate activity was seen in case of *S.typhi* (9.0 ± 0.0 mm) and *K. pneumoniae* (13.0 ± 0.2 mm).

S.No.	Name of Microorganism	Gram Reaction	Zone of inhibition in mm			
			DMSO	Chloramphenicol	ZnO NPs	MIC µg/ml
1	*Salmonella typhi*	GNB	NA	16.0±0.2	9.0 ± 0.0	512
2	*Klebsiella pneumoniae*	GNB	NA	21.0±1.1	13.0 ± 0.2	256
3	*Escherchia coli*	GNB	NA	26.0±0.5	NA	NA
4	*Enterococcus spp.*	GPB	NA	19.2±0.2	NA	NA
5	*Staphylococcus aureus*	GPB	NA	23.5±1.1	20.0 ± 0.0	128
6	*Bacillus cereus*	GPB	NA	20.0±0.2	16.0 ± 0.5	256

The antibacterial activity of synthesized ZnO NPs from *Morinda citrifolia* against uropathogens was reported by our group (Joshi *et al*., 2018).

The antimicrobial property of photosynthesized nanoparticle may be attributed due to the presence of potential phytochemicals present in the Thyme. The essential oil of thyme was reported to have significant activity against both Gram positive and Gram negative bacteria (Prasanth *et al*., 2014; Saleh *et al*., 2015). The synthesized nanoparticle shown excellent activity against *S. aureus* and almost shown similar inhibition zone as compared to standard antibiotic i.e. Chloramphenicol. This antibiotic is broad spectrum antibiotic which is quite effective against both Gram positive and Gram negative bacteria. The *S. aureus* is known for causing boils, cellulitis and also responsible for causing septicemia. So, our synthesized ZnO NPs can be utilized for the preparation of medicated skin creams

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RESEARCH ARTICLE

EFFECTS OF SALINITY ON MORPHOLOGICAL AND BIOCHEMICAL PARAMETERS OF *DALBERGIA SISSOO AND ACACIA NILOTICA* UNDER SALT STRESS

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Received-02.10.2018, Revised-22.10.2018

Abstract: For the past hundreds of year's trees like *Dalbergia sissoo* (shisham), *Acacia nilotica* (Kikar), *Prosopis cinneraria* (Khejri) etc. have inhabited vast areas in the plains of Afghanistan, Pakistan, India, Nepal and Myanmar. These have also been widely used for afforestation in many parts of the country except in the very hot, cold and wet tracts. These have good atmospheric N_{2-} fixing ability, therefore, are extensively planted in social and agro-forestry programmes. In order to evaluate the effect of soil salinity, present investigation was conducted on two tree species i.e. *Dalbergia sissoo* Roxb. ex DC (Shisham) and *Acacia nilotica* (L.) willd. ex Delile (Kikar) growing under field conditions in Hisar district during the year 2011-2012. It was noteworthy that overall decrease in leaf area due to salinity in *Dalbergia sissoo* was 11.36 % as compared *Acacia nilotica* where it was 9.81 %, indicating that overall sensitivity of *Dalbergia sissoo* to saline conditions was more vis-à-vis *Acacia nilotica.* In *Acacia nilotica* show that specific leaf weight was in the range of 9.53 to 10.96 mg/cm^2 in healthy trees which was higher i.e. 9.62 to 11.99 mg/cm^2 in trees growing under saline sites. The mean specific leaf weight was 10.31 mg/cm^2 under non-saline conditions which was significantly lower than 10.89 mg/cm^2 obtained under saline environment. *Acacia nilotica* tree leaves sampled from the saline sites showed total soluble salts in the higher range of 222.7 to 279.0 mg/g as compared 223.0 to 263.7 mg/g dry weight in trees growing under non-saline sites. The mean value of total soluble solids in *Acacia nilotica* also showed significant increase in non-saline conditions over saline site trees. Relative stress injury in case of *Dalbergia sissoo* was interestingly in the higher range of 52.1 to 60.2 % as compared to 39.8 to 39.9 % in trees growing under saline soils. Hence, the mechanism of salt tolerance is relatively better in *Acacia nilotica* than in *Dalbergia sissoo* as found from morpho-physiological and biochemical studies.

Keywords: Acacia nilotica, Dalbergia sissoo, Relative stress injury, Salinity, Total soluble sugar

Abbreviations: LA – Leaf area, SLW- Specific leaf weight, RSI – Relative stress injury and TSS – Total soluble sugar

INTRODUCTION

For the past hundreds of year's trees like *Dalbergia sissoo* (shisham), *Acacia nilotica* (Kikar), *Prosopis cinneraria* (Khejri) etc. have inhabited vast areas in the plains of Afghanistan, Pakistan, India, Nepal and Myanmar. These have also been widely used for afforestation in many parts of the country except in the very hot, cold and wet tracts. These have good atmospheric N_{2-} fixing ability, therefore, are extensively planted in social and agro-forestry programmes.

However, the past few decades have seen strange phenomena of tree mortality in the northern part of the Indian sub-continent comprising of Uttar Pradesh, Haryana, Punjab, Rajasthan, parts of Himachal Pradesh and even adjoining Pakistan, Nepal and Myanmar. Changing environmental conditions including rising temperature, poor soil health, and hydrological imbalance are believed to have led to increasing incidence of pest diseases and abiotic stresses. Plantations of *Dalbergia sissoo* and *Acacia nilotica* are the most adversely affected by this mortality scenario (FAO 2007, Nandal and Kaushik 2007). Kaushik (2007) opined that disease problems in natural forests remain under control due to genetic diversities and presence of biological antagonists. However, at the sites raised outside the forest areas (on farm lands, along road, railways, rivers, canals and panchayat lands) the trees are also exposed to varied type of biotic and abiotic stress factors which ultimately lead to increasing incidence of mortality. As the geographical domains of the problems of tree mortality are wide spread, it is unlikely that the causes, both biotic as well as abiotic, are the same everywhere and their remedies should be looked in a location specific context.

Recognizing irrigation as a cardinal input for increasing and stabilizing yields has prompted countries throughout the world to expand their canal irrigation potential many fold. Where ever such import and liberal use of water has involved arid regions, the problem of water logging and salinity have surfaced. Presently, about one-third of the world's irrigated area of 20 million ha is salt affected (Garg and Gupta 1997, Heuperman *et al*. 2002, Ritzema *et al*. 2008). In south-west Haryana about 200 km long axis of arable land comprising the districts of Jhajjar-Rohtak-Hisar-Fatehabad-Sirsa forms an inland basin with no natural drainage, is mostly underlain with saline ground water typifies this scenario (Kumar 2004). Indiscriminate irrigation during the past 60 years or so has resulted in rise in saline water tables and infestation of soil salinity. It

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becomes pertenent therefore to specifically ascertain the role of salinity in the tree mortality phenomenon in south-west Haryana.

Salinity toxicity normally results when certain ions are taken up with the soil- water and accumulate in the leaves during water transpiration to an extent that result in damage to the plant. The degree of damage depends upon time, concentration, crop sensitivity and crop water used, and if damage is severe enough, crop yield is reduced. The usual toxic ions in irrigation water are chloride, sodium and boron. Damage can be caused by each, individually or in combination. (Tanji 1990).

In India Tewari *et al.* (2006) observed growth responses of *Dalbergia sissoo* and *Acacia nilotica* seedlings on different levels of soil sodicity and salinity. The growth and dry weight of one-year old seedlings decreased as the level of sodicity and salinity increased in both species. However, the suppression in growth caused by sodicity and salinity was relatively greater in *D. sissoo* than in *A. nilotica*. *A. nilotica* showed wider response breadth compared with *D. sissoo* on both the gradients. Further, the response breadths were comparatively higher under sodicity levels than under salinity levels. Singh *et al.* (2007) noted that *Dalbergia sissoo* in its natural and man-influenced ecosystem was being adversely affected by various abiotic stresses. Studies undertaken on the physio-chemical characteristics of soil under dead and healthy trees of *Dalbergia sissoo* and to correlate soil factors with the decline of shisham in semi-arid regions revealed that the pH, ECe, bulk density and calcium carbonate was found higher in soil under dead trees as compared to healthy trees. The value increased with increase in soil depth. The organic carbon and macro-nutrient (i.e. N, P, K, Ca, Mg and S) and micro-nutrients (Zn, Fe, Cu, and Mn) were higher under healthy trees as compared to dead trees and their concentrations decreased with increase in soil depth both in case of healthy as well as dead trees of *Dalbergia sissoo.* Bimlendra and Datta (2007) noted that out of ten provenances of *Acacia nilotica*, salinity was found to be more deleterious for growth, development, metabolism, water relations and nutrients in three provenances, viz., Chandigarh, Banaskantha, and Bhopal. Under saline conditions, plant height, number of leaves, leaf area, dry weight of plant parts was reduced remarkably (60-70 %) in provenances of Behrampur, Patna, Coimbatore and Banaskantha.

MATERIALS AND METHODS

The present investigation was conducted on two tree species i.e. *Dalbergia sissoo* Roxb. ex DC (Shisham) and *Acacia nilotica* (L.) willd. ex Delile (Kikar) growing under field conditions in Hisar district during the year 2011-2012. For this field surveys were made and sampling of soil and leaves was done. The soil and leaf samples were further analyzed in Stress Physiology Laboratory, Department of Botany & Plant Physiology, Central Instrument Laboratory and Soil Science Laboratory at the CCS Haryana Agricultural University, Hisar. For the determination of soil ECe and pH soil was sampled at a distance of 1.5 m in the East, West, North and South from the main tree trunk. Soil was excavated to the depth of 1 m with the help of an auger and soil from all the four samples at 20-100 cm were homogenized and sieved. Each sample was processed for the preparation of soil saturation extract in the laboratory by gradual shaking and addition of distilled water to get a water saturated soil paste. The paste was vacuum filtered and electrical conductivity of soil saturation extract (ECe) was measured by using digital conductivity meter and expressed as dS m^{-1} at 25^0 C. Soil pH of the saturation extract was measured with the help of pH meter (Elico India).

Leaf area was determined by counting the number of millimeter squares (mm^2) within the demarcated domain and expressed as cm^2. The leaf samples were simultaneously placed in paper envelopes and dried to a constant weight in an oven at 65 ^oC-70 ^oC for 72 h. Specific leaf weight was computed and expressed as mg/cm^2. Total soluble sugar was determined with the method of Yemm and Willis (1954). Membrane injury index was measured as percent proportion of ion leakage in to the external aqueous medium to the total ion concentration of the stressed tissue as measured by the EC of the external medium (Sullivan and Ross, 1979).

Data were subjected to analysis of variance (ANOVA) using online Statistical Analysis Package (OPSTAT, Computer Section, CCS Haryana Agricultural University, Hisar, Haryana, India) and treatment means were compared by the least significant differences (LSD) ($p < 0.05$).

RESULTS AND DISCUSSION

The results presented in Figure 1 show that leaf area in *Dalbergia sissoo* was in the range of 48.8 to 80.4 cm^2 under the non saline conditions and 44.1 to 70.0 cm^2 under the saline conditions. The results presented in Figure 2 show that leaf area in *Acacia nilotica* was in the range of 1.22 to 1.90 cm^2 under the non saline conditions and 1.07 to 1.70 cm^2 under the saline conditions. The mean leaf area was 1.63 cm^2 under non-saline conditions which was significantly lower than 1.47 cm^2 obtained under saline environment.

It was interesting to note that specific leaf weight of *Dalbergia sissoo* was in the lower range of 10.73 to 11.99 mg/cm^2 in non-saline environment trees as compared to 10.72 to 12.99 mg/cm^2 in trees growing at saline sites (Figure 3). Again the results presented in Figure 4 in *Acacia nilotica* show that specific leaf weight was in the range of 9.53 to 10.96 mg/cm^2 in healthy trees which was higher i.e. 9.62 to 11.99

mg/cm^2 in trees growing under saline sites. These results agree with findings of Longstreth and Strain (1977) who observed that in *Spartina alterniflora* growth at low illumination and high salinity (30 ppt) resulted in a 50 % reduction in photosynthesis. Photosynthetic rate of plants grown at high salinity and high illumination were reduced only slightly compared to rates of plants grown, in 10 ppt and Hoagland's solution. Interestingly in these findings high salinity and high illumination were also correlated with increases in specific leaf weight.

It is seen in Figure 5 that total soluble solids (TSS) of leaves of *Dalbergia sissoo* was interestingly in the lower range of 232.7 to 259.3 mg/g dry weight, as compared to and 234.0 to 279.0 mg/g dry weight in trees growing under saline soils. *Acacia nilotica* tree leaves sampled from the saline sites showed total soluble salts in the higher range of 222.7 to 279.0 mg/g as compared 223.0 to 263.7 mg/g dry weight in trees growing under non-saline sites (Figure 6). Our results are in agreement with Mizrahi and Pasternak (1985) who reported that increasing level of salinity cause an increase in total soluble solids in fruits of tomato, melon, peanuts and chinese cabbage. The increase in total soluble solids in fruits in response to salinity appears to be well documented. Rhoades (1996) also reported a partial correlation between the ambient salinity, electrical conductivity and total dissolve solids in tissues. It is therefore concluded that specific leaf weight increased in both *Dalbergia sissoo* and *Acacia nilotica* due to increase in per unit area total soluble and insoluble solids both organic as well as inorganic.

This is further corroborated by data presented in Table 1 that under non saline conditions the mean relative stress injury was 36.3 % which was significantly lower than 56.5 % obtained for trees growing on saline sites. The mean relative stress injury was 31.9 % under non-saline conditions which was significantly lower than 50.4 % obtained under saline environment (Table 2). The cell membrane is a phospholipid bilayer which acts as a semi permeable barrier to solutes. Any stress, particularly ionic stress, causes membrane injury and ion leakage from the cell which is proportional to the magnitude of stress (Dionisio-Sese and Tobita 1998).

CONCLUSION

Considered in totality it would appear that the salinity in the soil profile has a perpetual retarding effect on various morpho-physiological parameters of *Dalbergia sissoo* as well as *Acacia nilotica*. This alone or in combination with other abiotic and biotic factors may lead to a slow decline and ultimate mortality of the trees.

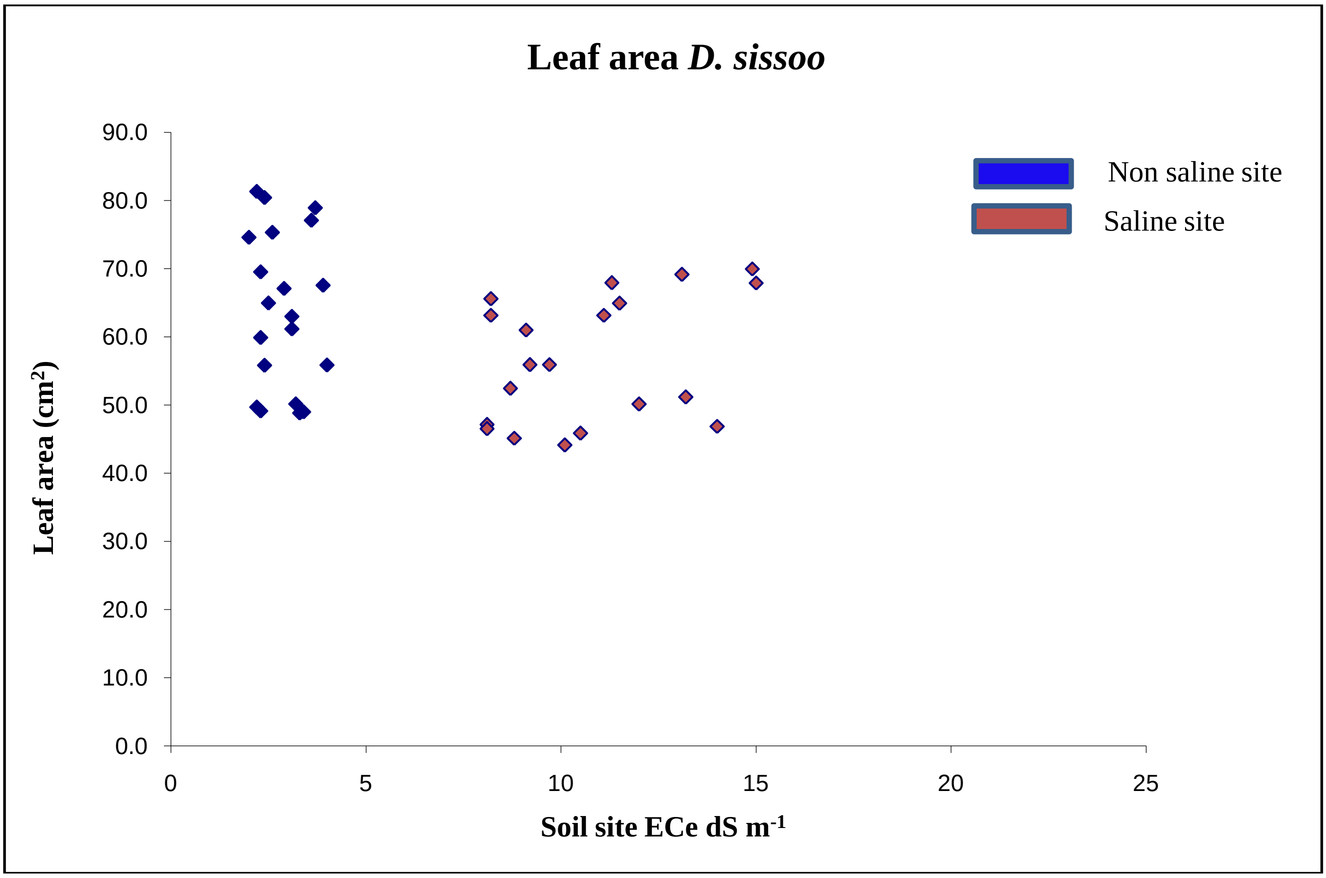

Fig 1: Leaf area (LA) of *Dalbergia sissoo* trees under non-saline (blue) and saline (red) sites.

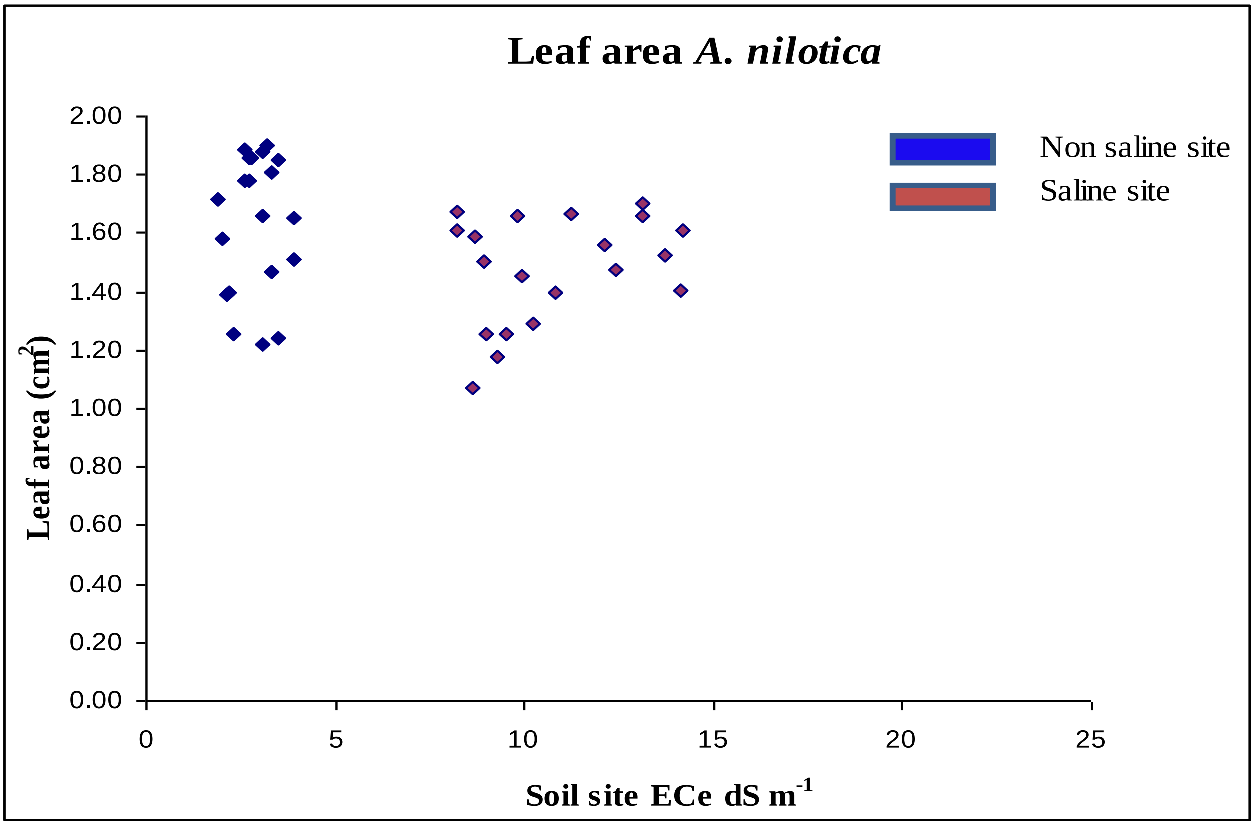

Fig 2: Leaf area (LA) of *Acacia nilotica* trees under non-saline (blue) and saline (red) sites.

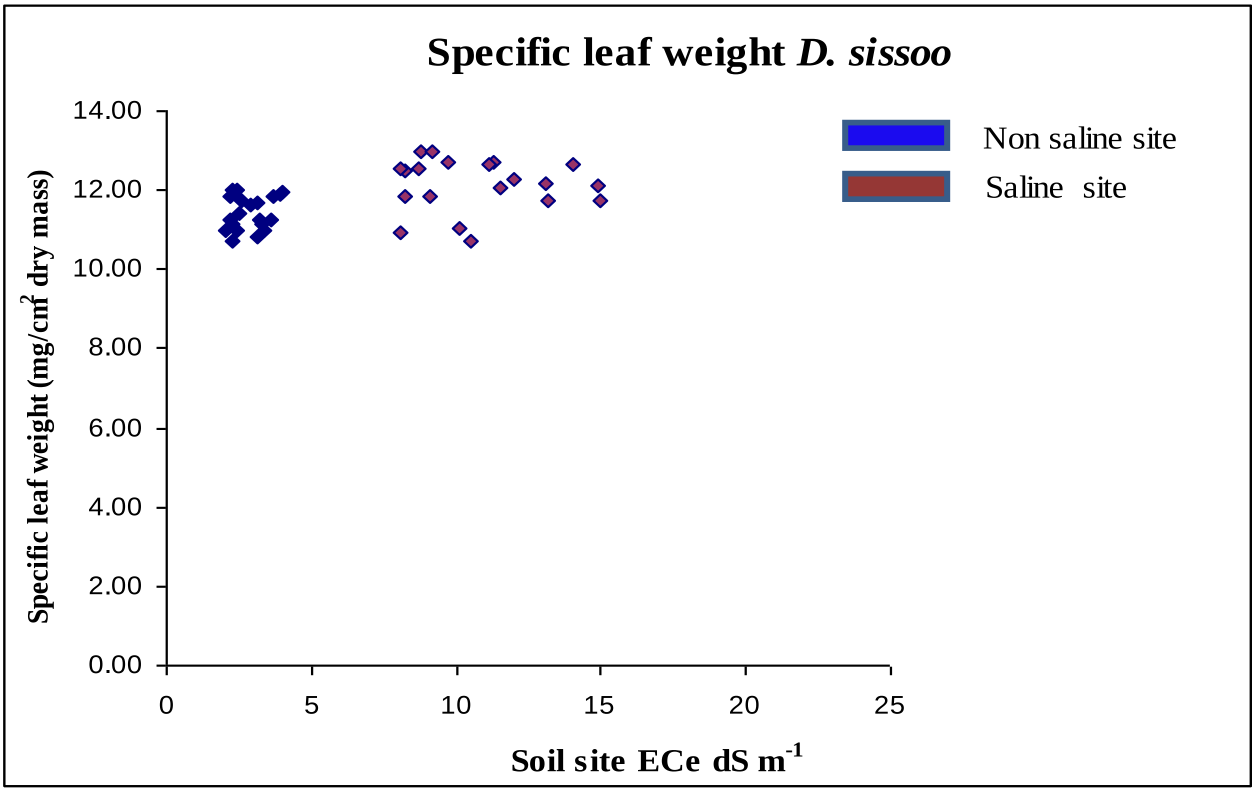

Fig 3: Specific leaf weight (SLW) of *Dalbergia sissoo* trees under non-saline (blue) and saline (red) sites.

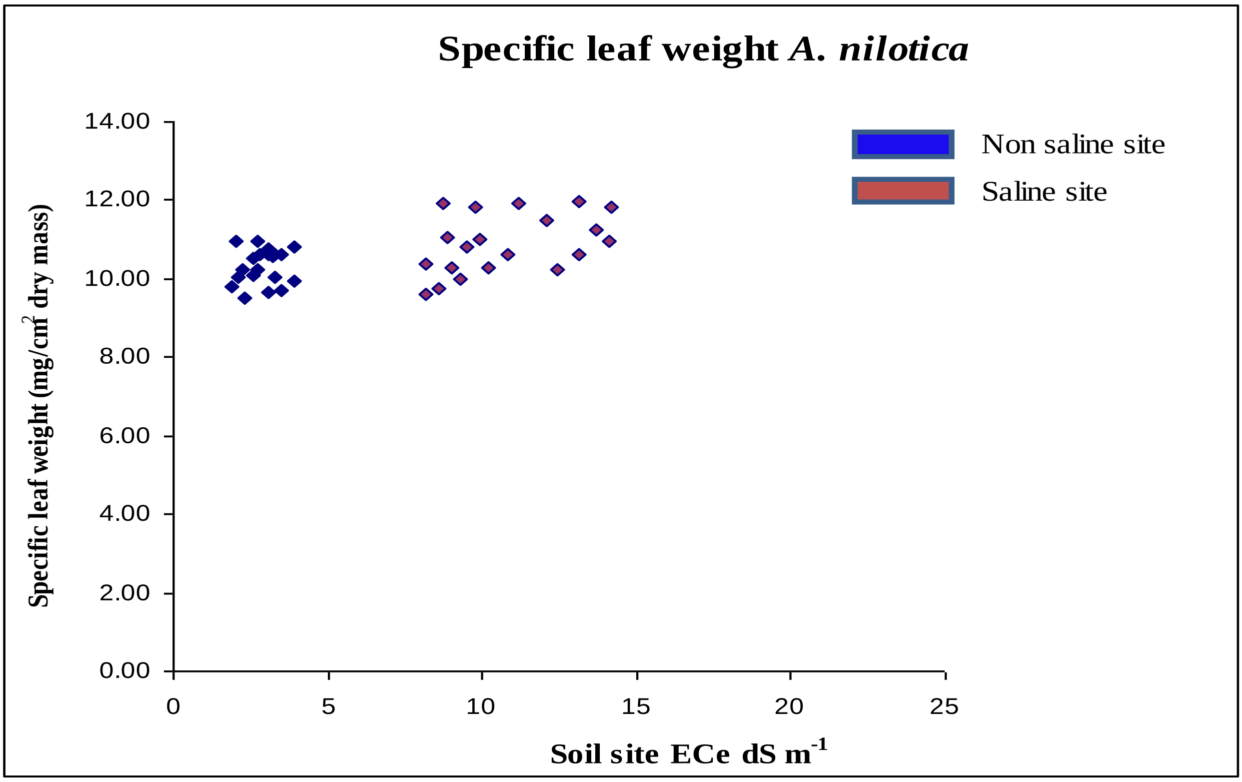

Fig 4: Specific leaf weight (SLW) of *Acacia nilotica* trees under non-saline (blue) and saline (red) sites.

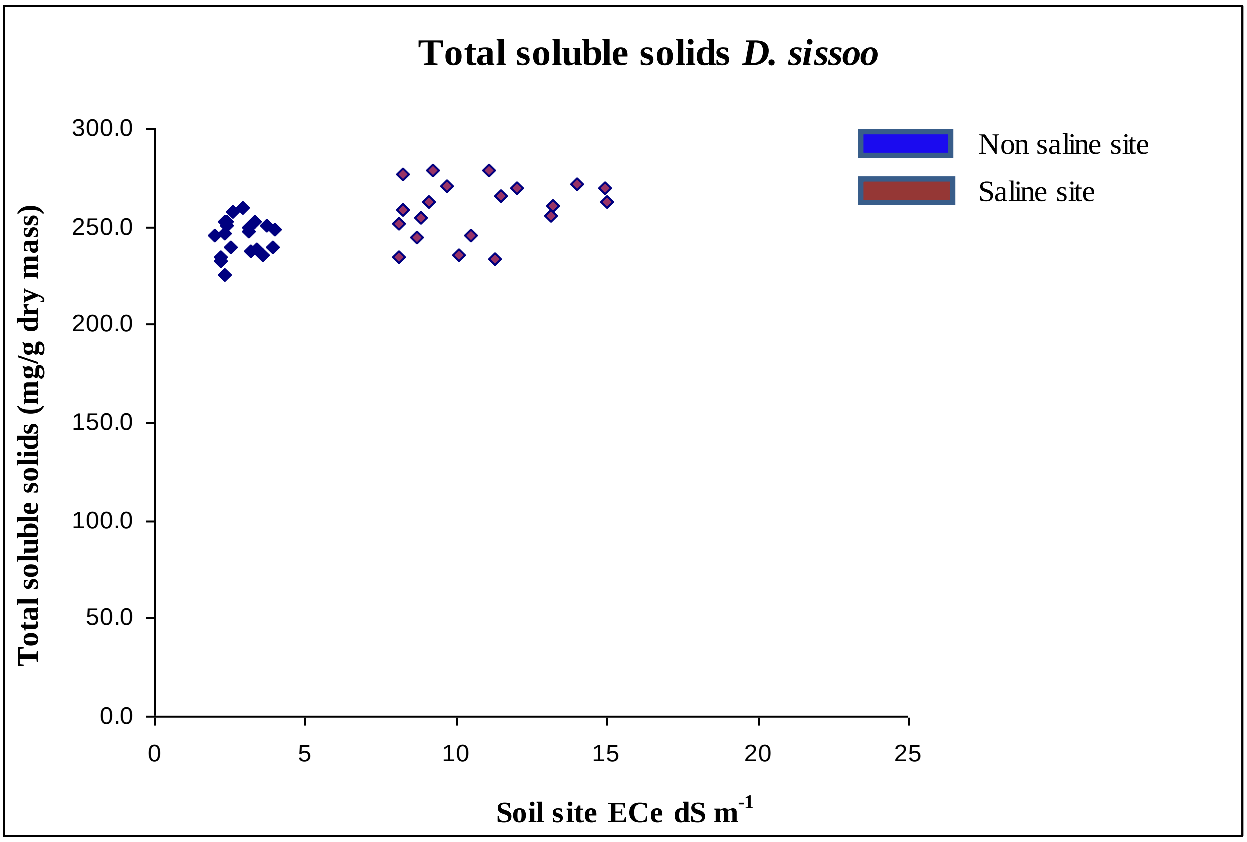

Fig 5: Total soluble solids (TSS) of *Dalbergia sissoo* trees under non-saline (blue) and saline (red) sites.

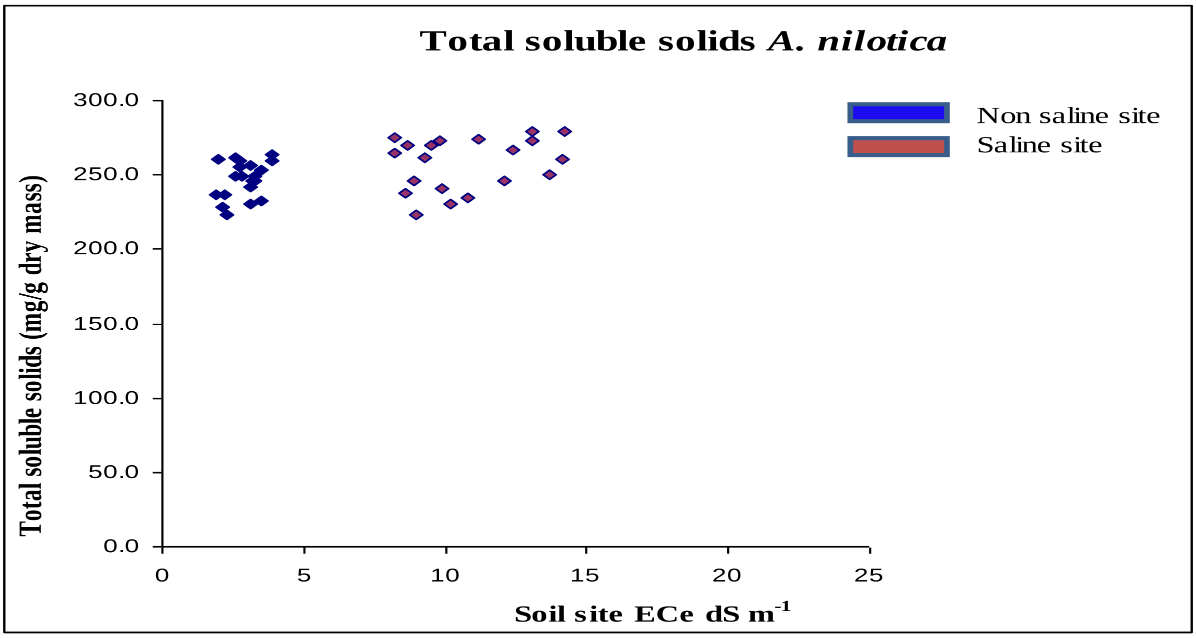

Fig 6: Total soluble solids (TSS) of *Acacia nilotica* trees under non-saline (blue) and saline (red) sites.

Table 1. Mean values of relative stress injury (RSI) of *Dalbergia sissoo* trees under non-saline and saline sites ± standard deviation (SD) and standard error (SE) along with t at P > 0.05.

Site type	RSI (%) ± SD	± SE	T
1. Non saline	36.3 ± 3.17	0.71	**22.1**
2. Saline	56.5 ± 2.54	0.56	

Table 2. Mean values of relative stress injury (RSI) of *Acacia nilotica* trees under non-saline and saline sites ± standard deviation (SD) and standard error (SE) along with t at P > 0.05.

Site type	RSI (%) ± SD	± SE	T
1. Non saline	31.9 ± 3.25	0.72	19.7
2. Saline	50.4 ± 2.61	0.58	

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RESEARCH ARTICLE

IN VITRO EVALUATION OF RHIZOSPHERE MICROBIAL ANTAGONISTIS AGAINST WILT PATHOGEN *FUSARIUM OXYSPORUM*IN CHILLI (*CAPSICUM ANNUUM* L.)

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Received-08.10.2018, Revised-27.10.2018

Abstract: The indiscriminate use of highly hazardous chemical fungicides and pesticides in the process of disease management leading to serious threat to environment. Biological control represents a viable alternative to the use of chemical fungicides and it is considered to be a safe, effective and eco-friendly method for plant disease. The percent inhibition on the growth of the pathogen by the antagonist over control was calculated for every 24 hrs of inoculation up to seven days. The experimental data on 168 hr. of inoculation revealed that all the four rhizosphere antagonistic fungi inhibited the growth of the wilt pathogens at varying levels at a range of 16.19 to 84.14 per cent (Plate 1 and Table 1). Among which, RFA 2 showed the highest mycelial (84.14%) inhibition of pathogen followed by RFA 4 (75.84%) and RFA 1 (58.09%) where as among rhizospheric bacterial antagonists isolate RBA 1 which was identified as *B.subtilis* had shown highest inhibitory effect (64.14%) and out of two tested rhizospheric fluorescent pseudomonads RFP 1 has antagonistic effect against chilli wilt pathogen which inhibited 72.81 per cent of radial growth of the pathogen.

Keywords: Rhizospheric antagonists, Fusarium, Biocontrol,Chilli, Flourescent pseudomonads

INTRODUCTION

The narrow region of the soil which is very closer to plant roots that can be highly influenced by the root secretions of the plantscalled as rhizosphere, which always associated with microorganisms.Most of the beneficial microbes can reside in the rhizosphere which can inhibit the growth of the phyto pathogens. The beneficial rhizospheric microbes can be utilised as potential biocontrol agents as they can directly interfere by inhibiting the growth of the pathogen. The proper utilisation of rhizospheric fungal and bacterial antagonists can replace the chemical fungicides there by reducing the problem of environmental pollution and resurgence effect. The disease suppressive effect of rhizospheric microorganism may involve mechanism such as production of antibiotics (Hebber *et al*., 1992).

In this context,a roving survey was conducted in the major chilli growing areas of Andhra Pradesh to collect and isolate beneficial rhizospheric microbes.Twenty isolates were collected from the rhizosphere portion of healthy chilli plants. The antagonistic effect ofrhizosphere fungal and bacterial antagonists were tested towards the wilt pathogen of chilli by dual culture method. As an initial step, all the collected rhizosphere microbes were subjected to preliminary screening to know their antagonistic property. The rhizosphere antagonists which showed antagonistic activity in preliminary screening were further, tested individually to select the most efficient ones that showed better performance in dual culture against pathogen are the rhizospheric fungal antagonists RFA 1,RFA 2, RFA 3 and RFA 4 were identified as *T.asperellum*, *Penicillium* sp.,*Asperigillus flavus* and *T.harzianum* respectively. Whereas rhizospheric bacterial antagonists were identified as *Bacillus subtilis*, *B.pumilus* and *Pseudomonas fluorescence*.

MATERIALS AND METHODS

The antagonistic effect of rhizosphere fungal and bacterial antagonists was tested towards the wilt pathogen of chilli by dual culture method. As an initial step, all the collected rhizosphere microbes were subjected to preliminary screening to know their antagonistic property.

1. Preliminary screening of rhizosphere antagonists against the pathogen Fusarium wilt pathogen of chilli

Mycelial disc of the pathogen isolated from the chilli were taken from seven day old culture on PDA plate and incubated for 2 days. For screening of rhizosphere antagonistic bacteria, the isolates were inoculated one each on the four sides of the pathogen as a line of streak one cm away from the periphery of the petri dish. Similarly, for screening of rhizosphere antagonistic fungi, the mycelial discs of rhizosphere fungal isolates were placed one each on four sides of the pathogen at equidistance from the periphery of the petri dish one cm away from the edge of Petri dish. Plates with pathogen alone served as control. The inoculated plates were incubated at room temperature and observed for inhibition of the

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pathogen for five days or when there was full growth in the control.

The rhizosphere antagonists who showed antagonistic activity in preliminary screening were further, tested individually to select the most efficient ones.

1.1 *In vitro* evaluation of antagonistic rhizosphere fungi against chilli wilt pathogen

The fungal isolates were tested for their antagonistic potential against the *Fusarium* by dual culture method (Skidmore and Dickson, 1976). Mycelial disc of the pathogen from seven-day old culture grown on PDA was placed on one side of the plate and incubated at room temperature (26 ± 2°C) for two days. The mycelial disc (10 mm) of antagonistic fungi were placed on other side of the plate, four cm away from the pathogen and incubated. Three replications were maintained for each isolate. The pathogen grown as monoculture served as control. The plates were observed daily after 24 hrs. of inoculation of antagonists till the pathogen grew and covered the plate kept as control. The percent inhibition of the pathogen was calculated using the formula suggested by Vincent (1927).

$$PI = \frac{C - T}{C} \times 100$$

PI = Percent inhibition, C = Growth of the pathogen in control (mm), T = Growth of the pathogen in dual culture (mm).

Based on the percent inhibition of mycelia growth of the pathogen, the efficient antagonists were selected for further studies.

1.2 *In vitro* evaluation of antagonistic rhizosphere bacteria against chilli wilt pathogen

All the efficient rhizosphere bacterial antagonists were evaluated for their antagonistic effect by dual culture method (Utkhede and Rahe, 1983). Mycelial disc (10mm) taken from seven day old culture of the pathogen grown on PDA was placed at the centre of PDA mediated Petri dish and incubated for two days. The antagonistic bacteria were inoculated as a line of streak on both sides, one cm away from the edge of petri dish. For each isolate three replications were maintained. Plates with pathogen alone served as control. The plates were incubated at room temperature and observed daily,upto seven days of inoculation until the control exhibited full growth of the pathogen. The per cent inhibition was calculated by which the efficient ones can be selected.

RESULTS AND DISCUSSION

2. Antagonistic reaction of promising microbes against *fusarium* wilt in chilli

Ten bacteria, eight fungi and two fluorescent Pseudomonads were isolated from healthy rhizosphere portion of chilli by following standard serial dilution method as described in materials and methods (Plate 1 and Plate 2).

2.1 Rhizosphere fungal antagonists (RFA)

A total of eight fungal antagonists isolated from rhizosphere, were subjected to preliminary screening, out of which only 4 isolates have showed good inhibitory effect on radial growth of *Fusarium in vitro*. (table 1 and Plate 1). The efficient isolates obtained after preliminary screening were further evaluated for their antagonistic potential against the Fusarium wilt pathogen in terms of percent inhibition over the control.

The percent inhibition on the growth of the pathogen by the antagonist over control was calculated for every 24 hrs of inoculation up to seven days. (Table 1). The experimental data on 168 hr. of inoculation revealed that all the four rhizosphere antagonistic fungi inhibited the growth of the wilt pathogens at varying levels at a range of 16.19 to 84.14 per cent (Plate 1 and Table 1). Among which, RFA 2 showed the highest mycelial (84.14%) inhibition of pathogen followed by RFA 4 (75.84%) and RFA 1(58.09%), whereas the isolate RFA 3 showed the lowest inhibition of 16.19 per cent against Fusarium. The RFA 2 and RFA 4 had the fast mycelial growing capacity compared to the pathogen, they were overgrown and locked the growth of pathogen after 72 hrs. of inoculation µm (Plate 1). Hence the inhibitory effect of RFA2 was higher followed by RFA 4.

2.2 Rhizospheric bacterial antagonists (RBA)

Based on the performance of biocontrol activity in preliminary screening, out of ten bacteria isolated from rhizosphere, only four efficient bacteria were further evaluated for *in vitro* antagonistic activity. The results from the Table 1, Plate 2.) revealed that the isolate RBA 1 had shown highest inhibitory effect(64.14%) on *Fusarium* followed by RBA 3 (58.21%) and RBA 2 (23.44%) whereas the lowest inhibition of per cent was recorded by RBA 5 (18.84%) against *Fusarium oxysporum* at 168 hrs. of inoculation.

2.3 Rhizospheric fluorescent Pseudomonads (RFP)

Out of 2 fluorescent Pseudomonads isolates evaluated in the preliminary screening, only one *i.e.*, RFP 1 has antagonistic effect against chilli wilt pathogen which inhibited 72.81 per cent of radial growth of the pathogen.

The results are in agreement with Patel *et al*. (2017) who isolated a total of 35 isolates from the rhizospheric soil of tomato. Out of which, 11 isolates have shown antagonistic activity against *F. oxysporum* f. sp. *lycopersici*. Among those, two isolates showed maximum inhibition of fungal growth were MSS9 (83%) and MSS1(84.5%), respectively, against *F. oxysporum* f. sp. *lycopersici*. The similar results obtained by Hanan and Mohamed (2014) who observed the variability in degree of inhibition from one strain to another, *Trichoderma harzianum* was found highly antagonistic compared to *Trichoderma viride* isolates as it inhibited the mycelial growth of *F. oxysporum* f. sp. *ciceris* and *F. solani* by 85.29% and 86.21% after 12 days of *invitro* incubation.Thesimilar results were obtained by Suraiya Yasmin *etal*. (2014), Sundaramoorthy *et al*. (2013), Ngueko *et al*., 2002, Goudar and Srikant kulkarni (1999) who reported that *T. harzianum* strain significantly reduced the mycelial growth of the *Fusarium oxysporum* upto 52 – 87%. Ramezani *et al*. (2010) and Basco *et al*. (2017) made extensive studies *in vitro* and concluded *T. harzianum* as the most promising antagonist for *F. oxysporum* f. sp. *lycopersici* by inhibiting the growth of *Fusarium* upto 95-100%. Basco *et al.* (2017) were evaluated for antagonistic activities against *F. oxysporum* f. sp. *lycopersici* after 4 days in dual culture assay. *B. subtilis* (83%) and *P. fluorescens* (88%) against the radial growth of *F. oxysporum* f. sp. *lycopersici*. Dilila Toua *et al*. (2013) have studied, the biocontrol capacity of *Pseudomonas fluorescens* against fusarium wilt of tomato and flax was evaluated both in vitro and *in vivo*. As compared to the untreated control, the mycelial growth decreased by 8.33 to 49.33%. Conidial germination and germ tube elongation weresignificantly inhibited and reduced, respectively, by 6.15 to 47.33% and by 1.63 to 45.45%. The Mycelial growth of *F. oxysporum* and *A. alternata* was strongly reduced in the presence of antagonistic fluorescent *Pseudomonas* sp. with the inhibition rate varying between 25 to 38%. This result was in agreement with Ommati and Zaker (2012), they found that *T. asperellum* had the significant inhibition of the growth of *F. oxysporum.* Dilila Toua *et al.* (2013) have studied, the biocontrol potential of *Pseudomonas fluorescens* against *Fusarium* wilt of tomato and flax both *in vitro* and in *vivo*. As compared to the untreated control, the mycelial growth decreased by 8.33 to 49.33%. Conidial germination and germ tube elongation was inhibited by 6.15 to 47.33% and 1.63 to 45.45% respectively.

Table 1.*Invitro* antagonistic activity of rhizosphere antagonists against *Fusarium oxysporum* at 168 hrs. of inoculation

S.No.	Rhizosphere antagonist	Radial growth of pathogen (mm)	PIOC (%)
1	RFA 1	37.00	58.09 (49.60)
2	RFA 2	14.00	84.14 (66.50)
3	RFA 3	74.00	16.19 (23.66)
4	RFA 4	21.33	75.84 (60.53)
5	RBA 1	31.66	64.14 (53.19)
6	RBA 2	67.66	23.44 (28.93)
7	RBA 3	36.33	58.21 (49.72)
8	RBA 4	71.66	18.84 (25.70)
9	RFP 1	24.00	72.81 (58.56)
10	CONTROL	88.33333	0 .00 (0)
	CD at 5%	0.479	
	SEM ±	0.161	

*Mean of three replications

**Figures in parenthesis are arc sin transformed values

Table 2. Percent inhibition of radial growth of pathogen by rhizosphere antagonists

S.no	Rhizosphere antagonists	Percent Inhibition Over Control (PIOC) %						
		24 hrs.	48 hrs.	72 hrs.	96 hrs.	120 hrs.	144 hrs.	168 hrs.
1	RFA 1	7.53	37.34	48.83	50.32	56.6	59.05	58.09
2	RFA 2	56.62	63.84	72.45	74.33	77.16	80.63	84.14
3	RFA 3	1.86	4.8	5.5	7.54	13	13.78	16.19
4	RFA 4	37.71	48.19	56.69	59.81	65.25	70.49	75.84
5	RBA 1	16.98	26.5	40.9	47.16	48.35	56.21	64.14
6	RBA 2	3.73	7.23	23.62	28.3	23.98	17.01	23.44
7	RBA 3	13.19	24.07	40.16	42.83	46.72	50.67	58.21
8	RBA 4	3.73	7.23	7.56	10.69	10.83	13.33	18.84

9	RFP 1	35.84	46.99	52.09	58.49	60.84	66.8	72.81
10	Control	0	0	0	0	0	0	0

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RESEARCH ARTICLE

ASSESSMENT OF CHANGE IN LAND USE PATTERN OF KANTHALLOR PANCHAYATH, IDUKKI, KERALA

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Received-01.10.2018, Revised-19.10.2018

Abstract: Kerala is highly vulnerable to climate change effects due to its high dependency of climate sensitive agriculture, fisheries, forest, and water resource and health sectors. Climate together with soil, natural resources, human resources and economic considerations, determines land use patterns. The present study examined the changes in cropping pattern in Kanthallor Panchayath from 2010-2018. The land use change over a period from 2010 to 2018 was tabulated from the available Land use maps by Kerala State Land Use Board and the land use map generated using Google Earth Pro by creating *kml* file. It was found that total forest area including all kinds of forest has been reduced from 77. 28 sq.km to 72.61 sq.km.It can also be seen that the area under Eucalyptus has increased from 7.70 Km² to 9.96 Km². But the area under Sandal wood remains unchanged as there are legal restrictions and the entire area is under government control. There was a drastic increase in area under vegetables from 2.36Km² to 10.15Km² within a span of eight years which indicate that the main livelihood option is annual cool season vegetables and there is a good market support from the Agricultural Department. The traditional food grain crops cultivated in the panchayath were Rice, Wheat and Millets which were now replaced by vegetables and sugarcane.

Keywords: Kerala, Kanthallor panchayath, Land use pattern, Land use map

INTRODUCTION

Indian economy is an agriculture based economy, similarly food production is much sensitive to changing climate such as variations in monsoon rainfall and temperature. Changes in rainfall pattern mainly affect rain fed agriculture which leads to reduced crop productivity and increased risk for farming. It is really necessary to reduce the climate change impact of a local environment through the timely application of adaptive measures. Agriculture in Kanthallor panchayath of Idukki district has undergone some conversions in response to many factors, including advances in technology, variations in weather elements changing market forces and some socio economic factors. Farmers adjust to changing conditions by using their land in a way which yields the greatest return on their investment of energy, time and money. External factors that contributed to the change in land use change in the past continue to plan the direction of land use change in the future. An inventory of land use pattern prevailing in a special agricultural zone of Kerala with a unique climatic and ecological situation helps in development of suitable farming system models. Hence the present study was undertaken with an objective to find out the changes in land use pattern in Kanthallor panchayath.

MATERIALS AND METHODS

Study Area

Kanthallor panchayath of Devikulam Block of Idukki district comes under Marayur dry hills agro ecological unit (AEU 17), representing low rainfall region with a tropical sub humid monsoon with annual temperature 23.7°C and rainfall 1276 mm. This panchayath is flourished with a diversity of tropical, subtropical and temperate crops including field crops, plantation crops, spices, aromatic crops and vegetables. There were three cropping season for Rice, Aadi, Avani and Masi. Presently two cropping seasons are prevailing for cultivation of annuals .The panchayth is blessed with natural beauty and cool pleasant climate. Earlier this area was the granaries of Keralaand later paddy cultivation declined and settlers planted *Eucalyptus grandis.*

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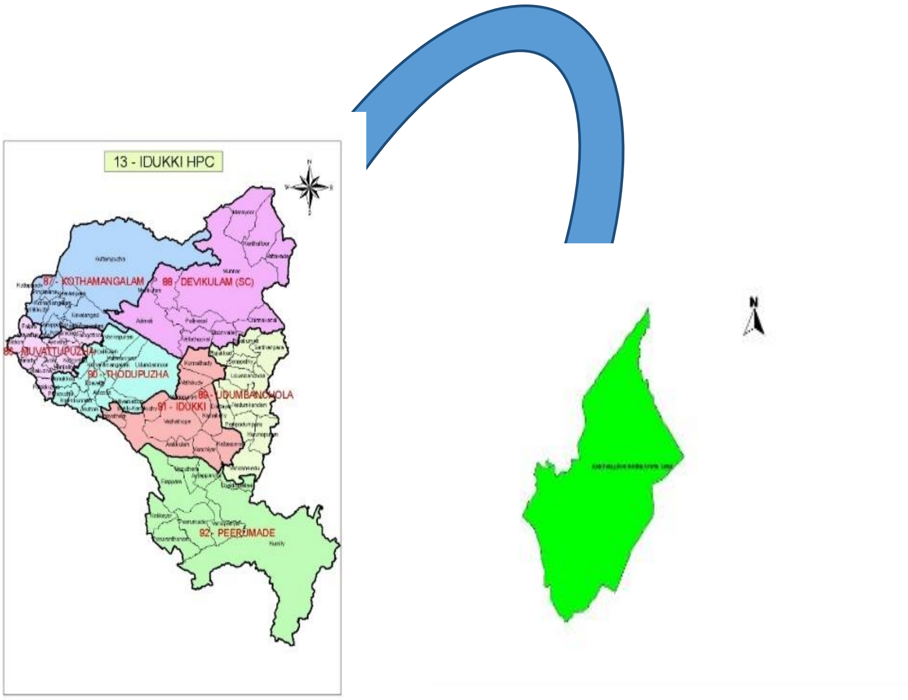

Figure 1: The location map of Kanthallor panchayath

QGIS Map and Land Use change

Resource maps were collected from Kerala Land Use Board Thiruvananthapuram prepared by using GIS technology, for period of 2010 and land use map of study area for the year of 2018 was prepared by using Google Earth Pro by creating *kml* file and QGIS version 1.8 software. A supervised classification method was used for analyzing land use change and its characterization in Kanthalloor panchayath. Crop cover was mainly classified into various groups. Random visit to the various location of Kanthalloor panchayath was also carried out to cross check the land use cover.

Focused group discussions and key informant interviews

The qualitative data on socio economic parameters was also collected by conducting focused group discussions and key informant interviews. The major crops cultivated and major cropping seasons prevailed in the locality were also collected through focused group discussion.

RESULTS AND DISCUSSION

Land use pattern for the year 2010

The land use map of Kanthallor Panchayath were analyzed from land use map for the year 2010 collected from Kerala State Land Use Board and is depicted in Figure2. The per cent occurrence of each crop in the land use is depicted in Figure.3.The land use area under various crops in Kanthallor panchayath showed that 46.92 Km^2 was under degraded forest area and it clearly showed that more than 50% (77.28Km^2) area of panchayath was forest of various types. Among the agriculture crops, the area under Sugarcane was the highest with 5.77 Km^2 followed by area under mixed crops (3.03 Km^2) contributing the homestead. The major annual agricultural crop in this area was vegetable comprising 2.36Km^2. It can also be observed that the area under Eucalyptus was 7.71Km^2.

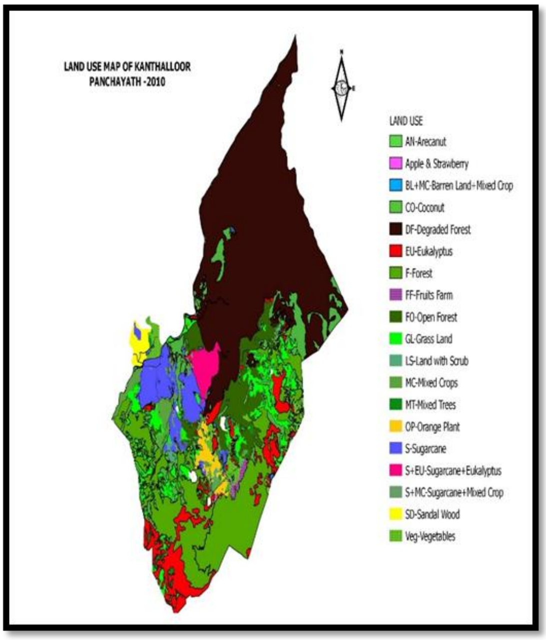

Figure 2. Collected land use map of Kanthalloor Panchayath 2010

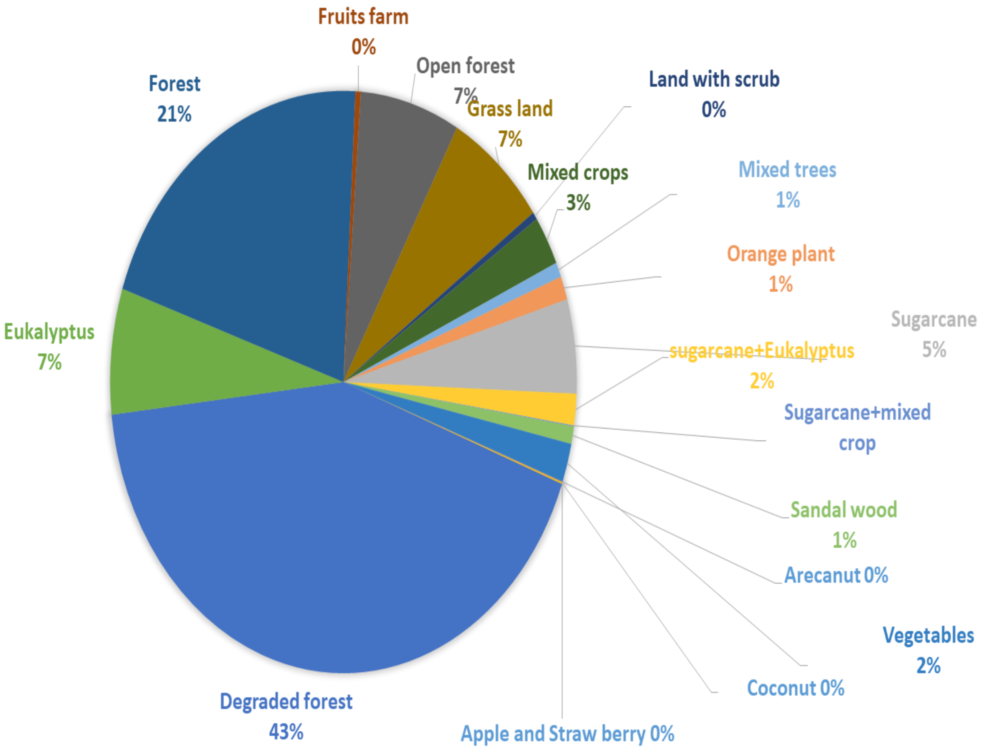

Figure 3. Area distribution of cropping pattern 2010

Land use area under various crops in Kanthallor Panchayath 2018

The land use map of Kanthallor Panchayath for the year 2018 prepared by using Google Earth pro and QGIS version 1.8 depicted in Figure.4. The per cent occurrence of each crop in the land use is depicted in figure.5The land use area under various crops in Kanthallor panchayath showed that 43.81Km² was under degraded forest and it also clearly showed that more than 50% (72.61Km²) of panchayath area is under forest of various types.Among the perennial agricultural crops, the area under Sugarcane the highest with 5.55 Km² followed by area under mixed crops 3.04 Km² contributing the homestead. The major agriculture crop in this area is vegetable comprising 10.14 Km². It can also be observed that the area under Eucalyptus was 9.96 Km².

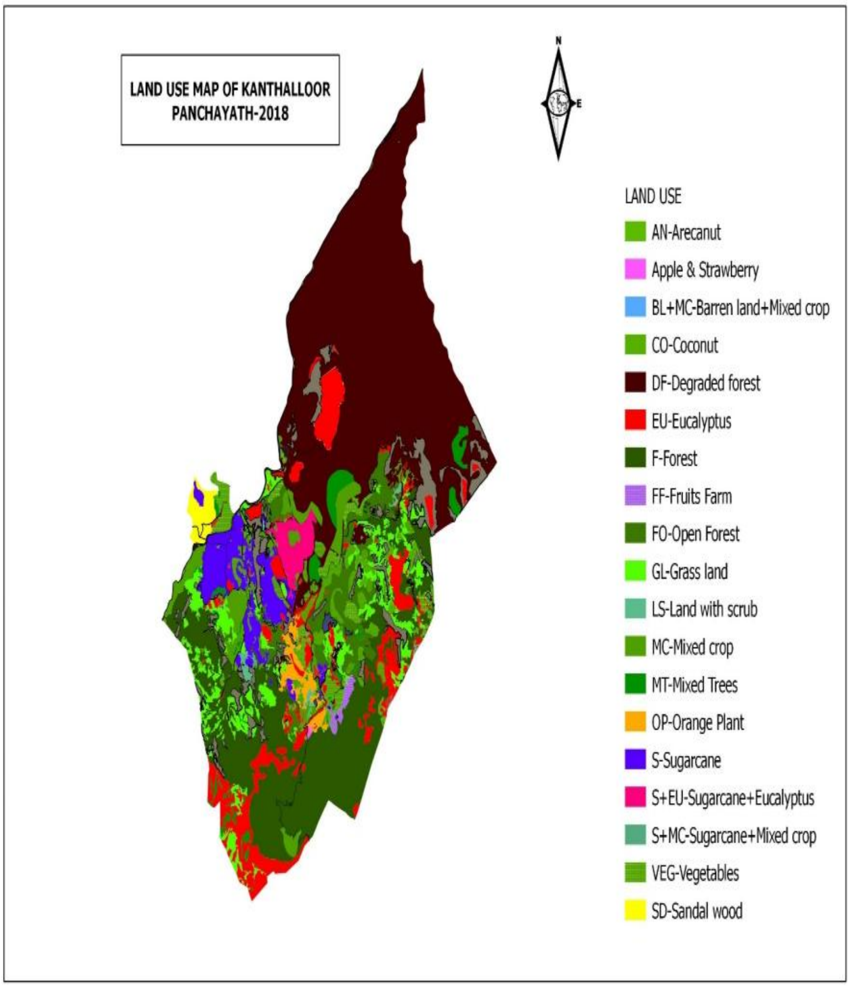

Figure 4. Created land use map of Kanthalloor Panchayath 2018

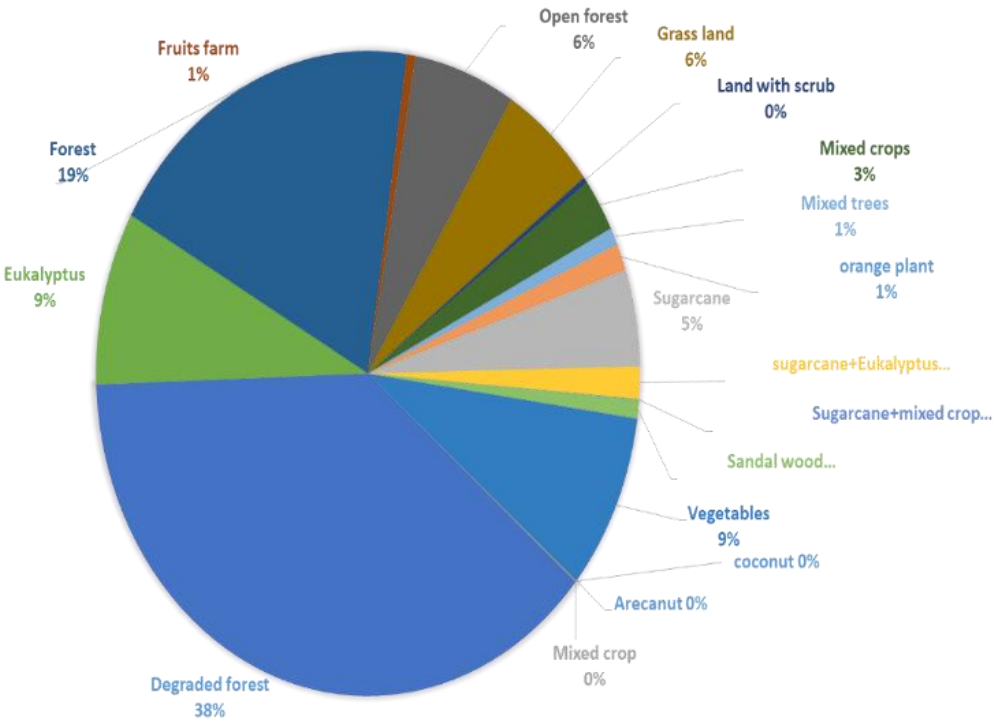

Figure 5. Area distribution of cropping pattern 2018

The change in Land use pattern

The total forest area including open forest, degraded forest and forest has reduced from 77.28 Km² to 72.61 Km².These area might have been used for other agricultural crops or even Eucalyptus. It can also be observed that the area of Eucalyptus has increased from 7.70 km² to 9.96 Km².It was noted that 60 per cent of Kanthallor village is hidden by *E. grandis* estates and they are under private occupation. Almost all of these plantations have been raised in the 1990s and the owners of these plantations are non-residents, mostly from other towns and cities in Kerala. In focused group discussion also it has been pointed out that introduction of *E. grandis* has influenced water availability and that resulted in a switching over to other crops.

Table 1. Changes in cropping pattern in Kanthallor panchayath area

Name	Area (Km^2)		Changing Cropping Area(Km²)
	2010	2018	
Arecanut	0.02	0.00	-0.02
Apple &strawberry	0.04	0.03	-0.01
Coconut	0.08	0.01	-0.07
Degraded forest	46.91	43.81	-3.10
Eucalyptus	7.70	9.96	+2.25
Forest	22.76	21.89	-0.87
Fruits farm	0.41	0.57	+0.15
Open forest	7.61	6.91	-0.69
Grass land	7.75	6.58	-1.17
Land with scrub	0.46	0.35	-0.11
Mixed crops	3.03	3.04	+0.01
Mixed trees	0.90	1.00	+0.1
Orange plant	1.44	1.54	+0.10
Sugarcane	5.76	5.55	-0.21
Sugarcane +mixed crop	0.05	0.04	-0.01
Sandal wood	1.06	1.06	0
Vegetables	2.36	10.14	+7.78

The change in land use pattern from 2010 to 2018 compared and given in Table.1. There was a tremendous increase in area under vegetables from 2010 (2.36Km²) to 2018 (10.15Km²) recording an increase of 7.78 Km². It might be due to improved market facility by the intervention of Department of Agriculture like VFPCK and Horticorp. Traditional crops in kanthalloor panchayath were Wheat, Rice and Millets. There were some traditional rice varieties such as Motta pokkali, Chadapokkali, Karumpokkali,Vennellu were occurred. The farmers used to cultivate three or more crops together in each cropping season (Panchayath Padadhirega, 2016)

CONCLUSION

Climate change impacts have become an important limiting factor for land use management. To reduce the negative effects of climate change, generally researchers developed adaptation measures to existing cropping systems, such as the adjustment of planting date, selection of suitable variety and better agronomic practices.

The land use change analyzed for the last eight years has also projected the decline in forest area and a tremendous increase in area under annual vegetables. A shift from the traditional wet land paddy to crops like Sugarcane and short duration vegetables had affected the cropping pattern. The traditional wet land paddy needs to be revived to enable a sustainable cropping pattern and land use. Accordingly a change in cropping pattern or even a shift to newer crops can be expected in future, if sustainable management practices and cropping system are not assured.

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RESEARCH ARTICLE

IN VITRO STUDIES ON EFFICACY OF VARIOUS BOTANICAL AGAINST COLLAR ROT OF TOMATO CAUSED BY *SCLEROTIUM ROLFSII* SACC. IN MANIPUR

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Received-10.10.2018, Revised-28.10.2018

Abstract: *Sclerotium rolfsii* is a soil inhabitant, non-target, polyphagous, and a ubiquitous facultative parasite. Its geographic distribution, profuse mycelial growth, persistent sclerotia and large number of hosts attacked by it indicate that, economic losses are substantial every year due to infection. The present study was carried out to understand about the *in vitro* efficacy of various locally available plant extracts against collar rot pathogen. Three commonly available plant extracts were selected and three concentrations of each was evaluated. Percent inhibition was observed and recorded, it was ranged from 16 to 100% among various extracts under study. Cent percent inhibition had shown by *ocimum* at 5 and 10 % and onion at 10% as the best, whereas *Parthenium* at 2.5% had shown the least inhibition of 16.6%.

Keywords: *Sclerotium rolfsii*, Tomato, *Trichoderma*

INTRODUCTION

Sclerotium rolfsii is a soil inhabitant, polyphagous, non-target, and a ubiquitous facultative parasite it is widely distributed in tropics, subtropics and warmer part of temperate zone of the world. In India, it is wide spread in almost all the states and causing economic losses in many crops, every year. *S. rolfsii* was first reported by Rolfs (1892) later pathogen was named as *S. rolfsii* by Saccardo (1911). In India the root rot caused by pathogen was first time reported by Shaw and Ajrekar (1915) who had isolated the pathogen from rotting of potatoes and identified as *Rhizactonia destruens* Tassi. Later studies convinced Ajrekar that fungus was *S. rolfsii* but not *Rhizactonia destruens.* It has wide host range infecting cultivated crops,It is documented that fungus can infect more than 500 plant species. Among soil borne diseases, collar rot caused by *S. rolfsii* is gaining a serious status. This disease also referred as sclerotium blight, sclerotium wilt southern blight, southern stem rot and white mold. This fungus is distributed throughout the world and is particularly prevalent in warmer climate and significant yield losses can be seen in monoculture or short rotation with other crops which are susceptible to this pathogen. *S. rolfsii* preferentially infects on stem, but it can also infect any parts of the plant including root, leaf, flower, and fruit. On erect plant, yellowing wilting symptoms are usually preceded by light to dark brown lesions at collar region of the plant adjacent to the ground. Drying or shrivelling of the foliage and ultimately death of plants occur after wilting. Sclerotia are at first white later, become brown to black which are produced on mats of mycelium on the plant or soil. It is very difficult to manage the pathogen because of its diverse nature of survival, large number of sclerotia produced and their ability to persist in the soil for several years.Among the crops viz., ground nut, soybean, pepper, tomato, sugar beet and potato suffer maximum losses, whereas sorghum, tobacco, sun hemp, chrysanthemum and other ornamental species suffer minor damage. Garren (1961) has estimated the losses due to *S. rolfsii to* the extent of 10 - 20 million dollars annually in southern USA. The yield loss up to 75-80 percent has been reported in New Mexico (Aycock, 1966). In India, stem rot caused by *S. rolfsii* is a major problem in most of the states accounting for 10-11 per cent yield loss (Prasad *et al*., 2012).

Tomato is an excellent source of lycopene, and numerous studies have confirmed that people who consume increased amounts of tomato products experience marked reduction in cancer risk (Giovaanucci et al. 1995). Because of the health benefits associated with tomato in the diet, it is ranked as the 13th among all fruits and vegetables as a source of vitamin C and 16thin vitamin A. Also, it has been ranked as the single most important fruit or vegetable of western diet in terms of overall source of vitamins and minerals (Jones 1999). Major methods employed to manage S. rolfsii are fungicide applications, soil solarization, and use of antagonistic microbes, deep summer ploughing, regular crop rotation and application of various organic and inorganic residues (Punja 1986). Fungicides such as hexaconazole and tricyclazole have been used (Dinesh *et al.* 2018). Chemicals such as methyl bromide and Chloropicrin as soil fumigants for the control of this pathogen. Moreover, these chemicals are hazardous to environment and therefore difficult to adopt in subsistence agriculture (Okereke and

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to adopt in subsistence agriculture (Okereke and Wokocha 2007). The inherent hazardous effect involved conventional, chemical management couple with inclination of farmer towards organic farming and non-chemical, bio-pesticides etc. for plant protection measures are gaining importance.There is therefore the need to search for the use of environmentally friendly and readily available alternatives such as plant extracts for the control of *S. rolfsii*. In view of this, this in vitro evaluation has been carried out by using regular available plant materials like *parthenium spp.*, onion and *ocimum spp*.

MATERIAL AND METHODS

In-vitro evaluation of botanicals for their effect on the growth of fungus was done by the Poison food technique (Nene and Thapliyal, 1973). Required quantity of extract was added into sterilized molten and cooled potato dextrose agar to get the desired concentrations. For extraction of botanicals, the leaves of the botanicals collected were washed in tap water and finally passed through sterile distilled water. Hundred grams of the sample was crushed in pestle and mortar by adding 100 ml of sterile distilled water (1:1 w/v). The extracts were strained through two layers of muslin cloth. Later, these extracts were centrifuged for 15 minutes at 500 revolutions per minute to separate the plant debris and to get clear supernatant of plant extract. The supernatant thus obtained was used as the standard stock extract (100per cent). The stock extract was finally made up to required concentrations, viz., 5.0 and 10 per cent by adding 5.0 and 10 ml of stock extract to 95.0 and 90.0 ml of potato dextrose agar medium respectively. The plant extracts were added to the potato dextrose agar medium at molten state after sterilization. The medium was shaken thoroughly for uniform mixing of test extract. Mycelial discs of 5 mm size of five day old culture of the fungus were cut by using sterile cork borer and one such disc was placed at the centre of each agar plate. Control treatment was maintained without adding any chemical or botanical to the medium. Three replications were maintained for each concentration of the fungicide, insecticide, herbicide and botanicals. Then such plates were incubated in BOD at temperature 25 ± 1°C for six days and radial growth was measured when fungus attained maximum growth in the control plates. The per cent inhibition of mycelial growth over control which was calculated by using the formula given by
Vincent (1927) given below:

Percent inhibition = (C-T)/C x100

Where C= linear growth of the fungus in control.
T=linear growth of the fungus in treatment.

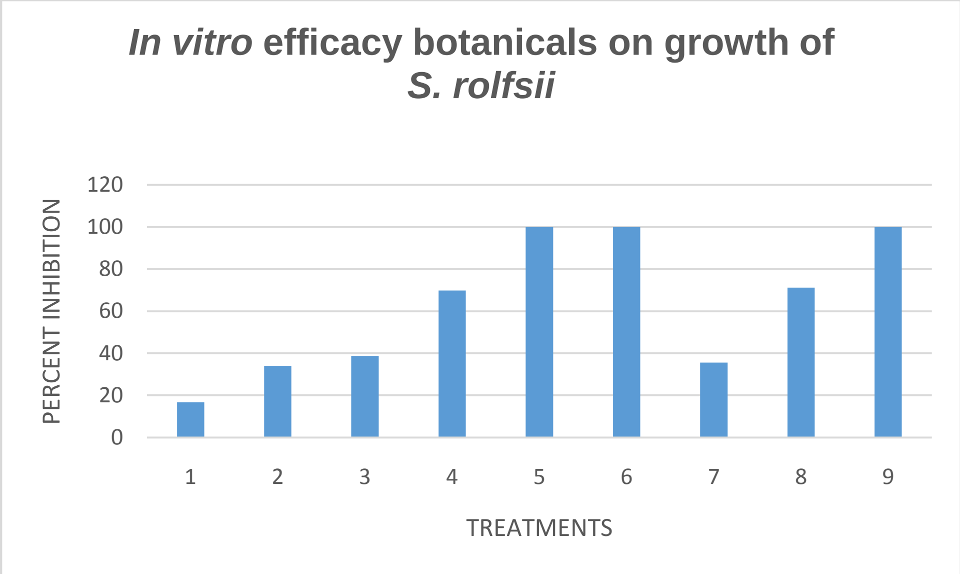
Table 1. *In vitro* efficacy botanicals on growth of *S. rolfsii*

Botanical	Plant part used	Treatment	Concentration (%)	Inhibition (%)
Parthenium sp.	Leaf	T1	2.5	16.66* (4.06)**
		T2	5	34.06 (5.89)
		T3	10	38.75 (6.24)
Ocimum sp.	Leaf	T4	2.5	69.76 (8.36)
		T5	5	100 (10.02)
		T6	10	100 (10.02)
Allium cepa	Bulb	T7	2.5	35.65 (5.99)
		T8	5	71.12 (8.49)
		T9	10	100 (10.02)
SE(d)				0.040
$CD_{(P=0.05)}$				0.084

*Mean of three replications

**Figures in parenthesis are square root transformed values

Graph 1. *In vitro* efficacy botanicals on growth of *S. rolfsii*



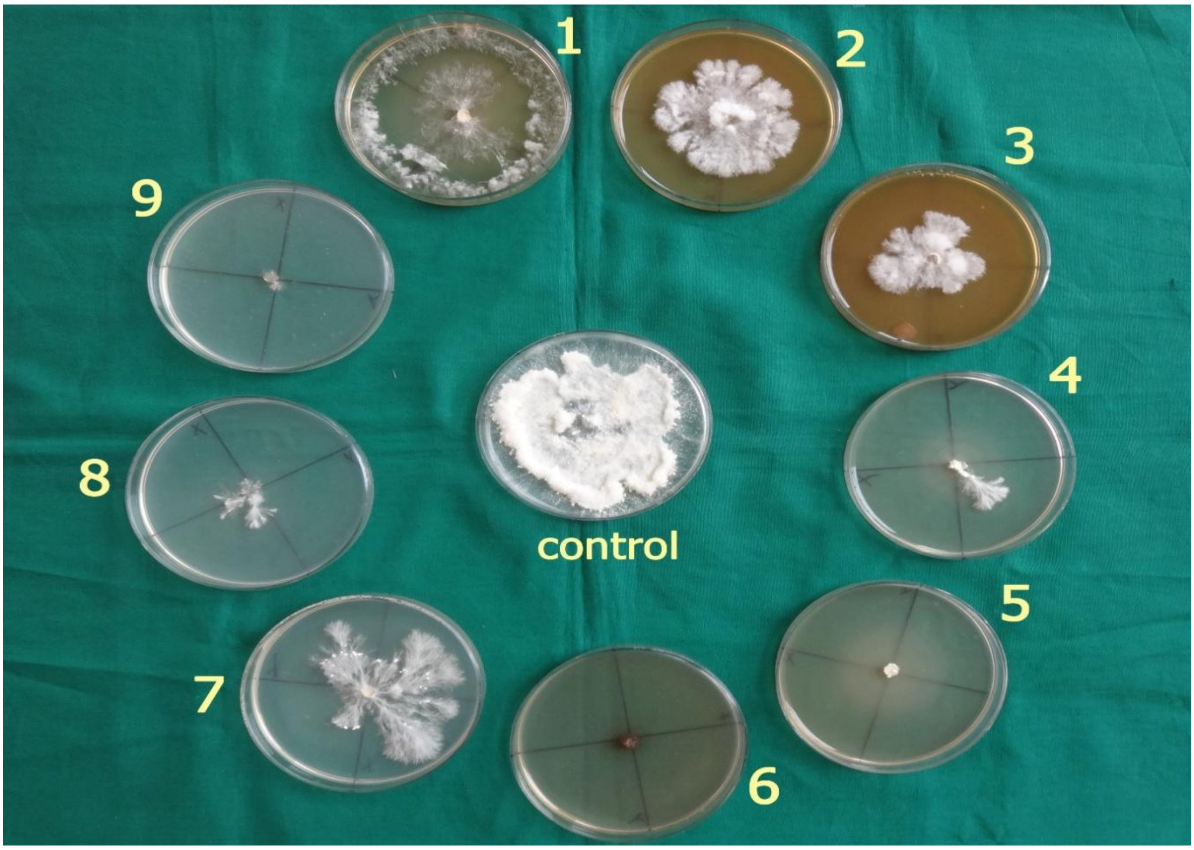


Plate 1. *In vitro* efficacy of botanicals on the growth of *S. rolfsii*.C. Control, 1.*Parthenium* (2.5 %), 2. *Parthenium* (5 %), 3. *Parthenium* (10 %), 4. *Ocimum* (2.5 %), 5. *Ocimum* (5 %), 6. *Ocimum* (10 %), 7. Onion (2.5 %), 8. Onion (5 %), 9. Onion (10 %).

RESULTS AND DISCUSSION

4.5.4 *In vitro* efficacy of botanicals on growth of *S. rolfsii.*

The antifungal effectiveness of these plant extracts depends on the concentration and the solvent of extraction. Effectiveness of aqueous extract of *C. citratus* has been reported by Somda *et al*. (2007) and Suleiman *et al.* (2008) on *Fusarium spp.* So aqueous extraction method was selected for the study, three botanicals were used at concentrations of 2.5, 5 and 10 % each against *S. rolfsii* and percent inhibition was recorded (table 1, plate 1 graph 1). Cent percent inhibition had shown by *ocimum* at 5 and 10 % and onion at 10%. At 2.5% concentration *Parthenium*, onion and *ocimum* had shown 16.6, 35.6 and 69.7 percent inhibition respectively. *Parthenium* at 5 and 10 % had shown 34.06 and 38.75 percent inhibition respectively. Onion at 5% had shown 71.12% inhibition. The aqueous plant extracts under *in vitro* revealed that higher doses were relatively more efficient than the lower doses. The present findings are in agreement with the findings of Darvin 2013 and islam and Faruq, 2012 who reported inhibitory effects of *Ocimum* and Onion on growth of *S. rolfsii* respectively. Anti-fungal activity of *Ocimum* may be due to the metabolites present in their leaf (saponins, tannins, volatile oil alkaloids, glycosides, and ascorbic acid), leaf wax (n-alkenes), essential oils (the general composition will be camphor, caryophyllene, eugenol, caryophyllene methyl chavicol pinene etc.). The results obtained In this study are in accordance with those of Derbalah *et al*. (2011) who reported the antifungal activity of crude extracts of seven plant species (*Cassia senna, Caesalpinia gilliesii, Thespesia populnea var. acutiloba, Chrysanthemum frutescens, Euonymus japonicus, Bauhinia purpurea and Cassia fistula*) against *A. solani*, the causal organism of early blight of tomato, at 150 and 200 ppm. Plant extracts are effective antimicrobial agents against soil-borne fungi and do not produce any residual effects, cost effective, non-hazardous to environment, easily available and do not disturb the ecological balance (Babu *et al*. 2008).

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RESEARCH ARTICLE

INSECT- PESTS SUCCESSION, NATURAL ENEMIES AND THEIR CORRELATION WITH WEATHER PARAMETERS IN MUSTARD CROP

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Received-01.10.2018, Revised-19.10.2018

Abstract: A field experiment was conducted at research station Ambikapur, (C.G.) during Rabi season, 2017-18 to assess the insect- pests succession in mustard crop and their natural enemies and its correlation with weather parameters. The incidence of Aphid and Flea beetle population commenced from 1st week of December with 1.32 aphid/ plant 5cm apical twig and 2.4 beetle/plant. The peak infestation of aphid occurred in 7th SMW which was favored by min. temp. of 11.6 ^{0}C and max. temp. of 24.3^{0}C with morning 91% and evening 44% humidity. Flea beetle was recorded attained its peak level of 15.8 beetle/plant/m^2 in 1st week of February (6th SMW) which was favoured by max. temp. 26.5^{0}C and min.temp.11.6^{0}C with morning 85% and evening 35% relative humidity. The Diamond back moth was observed 2nd week of December and saw fly was recorded from third week December and reached its peak activity 1.96 adult/plant in the 2nd week of February (7th SMW). Painted bug was observed 4th week of December with peak activity (3.8 bug/plant) 2nd week of February (7th SMW) which was favoured by max. temp. 24.3^{0}C and min. temp. 11.4^{0}C with morning 91% and evening 44% relative humidity. Bihar hairy caterpillar commenced from 2nd week of December in (50th SMW) and Semilooper commenced from 1st week of January in (1st SMW). While various natural enemies were found on mustard crop. The lady bird beetle (*Coccinella septumpunctata*) and Syrphid fly found on mustard on 4th week of December to 2nd week of March. The *Diaretella rapae* was noticed on mustard crop on second week of January to first week of March.

Keywords: Aphid, Natural enemies, Weather parameters

INTRODUCTION

Oilseed crops play a vital role in Indian agriculture economy. Mustard, *Brassica juncea* L. is one of the first domesticated oilseed crops in *Rabi* season belongs to the plant family Cruciferae. Oilseeds have been the backbone of agricultural economy of India since long. India accounts for 14.8 % of rapeseed mustard production at global level and occupies prime position in the World (Singh, 2014). Rapeseed-mustard (*Brassica spp.*) crop, grown in India are grown in diverse agro-climatic conditions ranging from north-eastern/north-western hills to down south under irrigated/rainfed, timely/late sown, saline soils and mixed cropping over an area of 6.34 million hectare with a production of 7.82 million tones and productivity of 1234 kg/ha in 2012-13 in India (Thomas *et al.* 2014). In Chhattisgarh, rapeseed mustard is cultivated over 113.10 thousand hectare area with a production of 24.2 thousand tones and productivity of 430 kg/ha.(Anonymous, 2016).

In Sarguja district mustard crop is cultivated in an area about 30.8 with the production of 6.5(000t) and productivity 652 (kg/ ha), respectively (Anonymous, 2013).

According to Bakhetia and Sekhon (1989), 38 insect pests are known to be associated with different stages of mustard growth in India. Among these aphid is major limiting factor causing 6-7 percent reduction in oil content (Shylesha *et al.* 2006). Both nymph and adult causes severe damage to the plants by sucking plant sap from the tender parts of the plants. Infested plant become weak and leads to undersized seeds in the pods.

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MATERIALS AND METHODS

A field experiment was conducted at research station Ambikapur, (C.G.) during Rabi season, 2017-18. *Brassica juncea* cultivar " Chhattisgarh sarson" was sown on 20 November with row to row and plant to plant distance as 30 cm and 15 cm respectively.This experiment was conducted in a randomized block design with three replication. The crop was raised after following standard agronomical practices in large plot for recording observations of insect pests and its natural enemies, whole plot was divided into five equal plots The plots were kept free from any insecticidal spray throughout the crop period. The observations recorded at weekly interval soon after their appearance during crop season till harvesting of the crop.

Five plants were selected randomly and tagged with label for recording the observation of aphid population at weekly interval and note the first appearance of aphid on plants from each plot. At flowering stage, the aphid population was recorded from upper per 5 cm twig. Number of coccinellids and syrphid fly's grub and adult on the five plants from each five plots were recorded at weekly interval. The population of parasite of aphid *Diaeretiellia rapae* MacIntosh, was recorded by counting number on each selected plant at weekly interval.

RESULTS AND DISCUSSION

Insect- pests succession, natural enemies and weather parameters on mustard crop depicted in table 1. and table 2.

Mustard aphid, *L. erysimi* (kalt.)

The initial incidence of mustard aphid, was recorded during first week of December (49^{th} SMW) with (1.32 aphid per five cm terminal twig). Its multiplication varies from (1.32 to 169.2 aphid per five cm terminal twig). The nymph and adult population of aphid was found maximum in 2^{nd} week of February (7^{th} SMW) which was favored by maximum temperature 24.3 and minimum temperature 11.4 with morning 91% and evening 44% relative humidity. Thereafter, from the fourth week of February onward there was a sudden decreasing trend were observed in aphid population 102.3 aphid per five cm terminal twig. In the 2^{nd} week of March 2018 declined in the aphid population (38.5 aphid per five cm terminal twig). The aphid population seems to be declining in subsequent weeks as the crop moved towards maturity. Present finding are in agreement with Singh *et al.* 2009 and Singh *et al.* 2012.

Flea beetle (*Phyllotreta striolata*)

The first appearance of incidence of flea beetle per plant recorded at weekly interval during 2017-18 on the mustard crop revealed that the population of flea beetle started from 1^{st} week of December (49^{th} SMW) with 2.4 beetle per plant and continue till 1^{st} week of February ranged from 2.4 to 15.8 beetle per plant in the 1^{st} week of February (6^{th} SMW). There after the population of flea beetle gradually decreased upto (6.3 beetle per plant) in the 2^{nd} week of March and then again increased with 7.2 beetle per plant.

Painted bug, (*Bagrada hilaris*)

The first appearance of painted bug per plant recorded at weekly interval during 2017-2018 indicated that the infestation of painted bug, *Bagrada hilaris* started from 4^{th} week of December (52^{nd} SMW) with 0.26 bug per plant. Thereafter slowly increased in population and reached to peak of 3.8 bug per plant in second week of February (7^{th} SMW). During the peak period of painted bug the maximum temperature 24.3 and minimum temperature 11.4 with morning 91% and evening 44% relative humidity. Thereafter the population gradually decreased up to 2^{nd} week of March.

Saw fly (*Athalia lugens proxima*)

The first appearance of incidence of saw fly, *A. lugens proxima* occurred from 3^{rd} week of December (51^{st} SMW) to 3^{rd} week of February (7^{th} SMW) in the range of 0.12 to 1.96 larvae per plant. The larvae population slowly increased and reached to peak 1.96 larvae per plant in 2^{nd} week of February which was favored by maximum temperature 24.3 and minimum temperature 11.4 with morning 91% and evening 44% relative humidity. There after larval population showed decreasing trend and showed minimum of 0.2 larvae/plant in the last week of February (9^{th} SMW). The incidence of saw fly disappeared in 2^{nd} week of March from the crop.

Diamond back moth, (*Plutella xylostella*)

The first appearance of incidence of Diamond back moth per plant recorded at weekly interval during 2017-2018 indicated that the infestation of Diamond back moth, (*Plutella xylostella*) started from 2^{nd} week of December (50^{th} SMW) with 0.12 larvae per plant. Thereafter slowly increased in population and reached to peak of 1.26 larvae per plant in last week of January (5^{th} SMW). Thereafter the population gradually decreased up to 3^{rd} week of February in (8^{th} SMW).

Bihar hairy catterpiller, *(Spilosoma obliqua)*

The incidence of Bihar hairy caterpillar per plant recorded at weekly interval during 2017-2018 indicated that the infestation of, Bihar hairy caterpillar (*Spilosoma obliqua*) started from 2^{nd} week of December (50^{th} SMW) with 0.02 larvae per plant. The number of Bihar hairy caterpillar ranged from 0.02 to 0.12 larvae per plant.

Semilooper, *Trichoplusia ni* (Hubner)

The incidence of cabbage Semilooper larvae per plant recorded at weekly interval during 2017-2018 indicated that the infestation of cabbage Semilooper, started from 1^{st} week of January (1^{st} SMW) with 0.02 larvae per plant. The number of Semilooper ranged from 0.02 to 0.12 larvaer per plant.

lady bird beetle, (*Coccinella septempunctata*)

The first appearance of population of Coccinellids occurred from (52^{nd} SMW) and continue till 2^{nd} week of march (11^{th} SMW) ranged from 0.28 to 4.8 lady bird beetle per plant and attained highest level of lady bird beetle population (4.8 per plant) in (7^{th} SMW) There after the number of lady bird beetle gradually decreased up to 2^{nd} week of March with 1.8 lady bird beetle per plant in (11^{th} SMW).

Syrphid fly, *(Eristalis tenax)*

The weekly observation on activity of Syrphid fly on the crop revealed that the Syrphid fly firstly appeared in the 4^{th} week of December (52^{nd} SMW) with 0.28 larvae per plant. The population of Syrphid fly gradually increased up to 2^{nd} week of February (7^{th} SMW) range of 0.28 to 1.34 adult per plant. There after the number of Syrphid fly gradually decreased up to 2^{nd} week of March with 0.2 adult per plant.

***Diaeretiella. rapae* MacIntosh**

The first appearance of population of *Diaeretiella. rapae* MacIntosh on the crop noticed that from 2^{nd} week of January (2^{nd} SMW) and continue till 1^{st} week of March (10^{th} SMW) in the range of 0.17 to 0.94 adult per plant. *Diaeretiella. rapae* population reached to its peak 0.94 adult per plant in 2^{nd} week of February (7^{th} SMW). There after adult population showed decreasing trend and showed minimum of 0.42 adult/plant in the 1^{st} week of March (10^{th} SMW). The population of *Diaeretiella. rapae* MacIntosh disappeared in 2^{nd} week of March from the crop.

Correlation studies between insect pests of mustard with weather parameters

Correlation studies revealed that mustard aphid was negatively correlated with relative humidity and positive correlation with maximum temperature, minimum temperature and rainfall but all the correlation was non- significant. Ishwarbhai (2015) were also found aphid population exbited positive correlation with maximum and minimum temperature and negative correlation with morning and evening relative humidity.

The population of Flea beetle exhibit positive non-significant correlation with Maximum Temperature (r = 0.128), Minimum Temperature (r = 0.106) and Rainfall (r = 0.095) whereas, morning RH (r = -0.319), evening RH (r = - 0.499) showed non-significantly positive correlation.

The weather parameters, Maximum Temperature (r = 0.444) were positively non-significantly and Minimum Temperature (r = 0.522*) significantly correlated with Painted bug population, Rainfall (r = 0.386) were positively and non-significantly correlated with Painted bug population. Whereas, morning RH (r = -0.559), were negatively and significantly correlated with Painted bug population and evening RH (r = -0.450) were negatively and non-significantly correlated with Painted bug population. Nagar (2011) , Laxminarayan (1987) were also reported the painted bug population showed positive correlation with Maximum and Minimum Temperature and negative correlation with morning and evening relative humidity.

The correlation between Saw fly and weather parameter are presented in table -3. The weather parameters, Maximum Temperature (r = -0.346), Minimum Temperature (r = -0.111) were negatively and non-significantly correlated with Saw fly population. Rainfall (r = -0.585*) positively and significantly correlated with Painted bug population. Whereas, morning RH (r = 0.145), and evening RH (r = 0.128) were positively and non-significantly correlated with Saw fly population. Singh (2012), Bhatt and Bapodra (2004), Patel (2005) and Singh (2012) also reported the saw fly population showed negative correlation with Maximum and Minimum Temperature and positive correlation with morning and evening relative humidity.

Diamond back moth and weather parameter on mustard crop. The result revealed that there was negative significant correlation with Maximum Temperature (r = -0.602*) and negative non-significant correlation with Minimum Temperature (r = -0.510) while non-significant positive correlation with morning RH (r = 0.267), and evening RH (r = 0.052) and Rainfall (r = 0.313).

The correlation between Cabbage semilooper and weather parameter are presented in table -3. The weather parameters, Maximum Temperature (r = -0.367), Minimum Temperature (r = -0.382), evening RH (r = - 0.123) and Rainfall (r = -0.083) were negatively and non-significantly correlated with the pest population. Whereas, morning RH (r =0.096) had positively and non-significant correlation with Cabbage semilooper population.

The correlation between Bihar hairy caterpillar and weather parameter are presented in table -3. The weather parameters viz; Maximum Temperature (r = -0.193), Minimum Temperature (r = -0.138), and Rainfall (r = -0.083) had were negatively and non-significantly correlated with the pest population. Whereas, morning RH (r =0.385) and evening RH (r = 0.321) had positively and non-significant correlation with. Bihar hairy caterpillar.

Correlation studies between natural enemies of mustard aphid with weather parameters

Correlation studies revealed that Maximum Temperature (r =0.334), Minimum Temperature (r = 0.476) and Rainfall (r = 0.479) was positive and non-significant correlation with Ladybird beetle population Whereas, morning RH (r = -0.480) and evening RH were found to be negatively correlated (r = -0.480, -0.321 respectively) with Ladybird beetle population. Ishwarbhai (2015) was also agree with that the aphid population increased, the natural enemies population was also increased visa-versa.

Correlation studies revealed that Maximum Temperature (r = 0.232), Minimum Temperature (r = 0.388) and Rainfall (r = 0.488) had positive and non-significant correlation with *D. rapae* population. Whereas, morning RH (r = -0.293), and evening RH (r = -0.218) had negative and non-significant correlation with *Diaeretiella rapae* population.

Correlation studies revealed that Maximum Temperature (r = 0.148), Minimum Temperature (r = 0.228) and Rainfall (r = 0.384) had exhibited positively and non significantly correlated with population of Syrphid fly. Whereas, morning RH (r = -0.342), and evening RH (r = -0.394) showed negative and non-significant correlation with population of Syrphid fly.

Khedar (2011), Achintya (2012) and Kewad (2013) were also reported the natural enemies showed positive correlation with Maximum and Minimum Temperature and negative correlation with morning and evening relative humidity.

CONCLUSION

It may be concluded from the result that peak activity of mustard aphid, flea beetle, painted bug ,saw fly, diamond back moth, bihar hairy caterpillar and semilooper were observed during 7^{th}, 6^{th},7^{th}, 7^{th} ,5^{th},51th and 2^{nd} SMW respectively. Population of mustard aphid was negatively correlated with relative humidity and positive correlation with maximum temperature, minimum temperature and rainfall but all the correlation was non- significant. While significant and positive correlation was observed between population buildup of painted bug and minimum temperature. Whereas the flea beetle population showed positive correlation with maximum temperature, minimum temperature and rainfall and negative correlated with morning and evening relative humidity. The saw fly negatively and non-significantly correlated with maximum temperature, minimum temperature and positive correlation with rainfall, morning and evening relative humidity. Diamond back moth showed negative significant correlation with Maximum Temperature and negative non-significant correlation with Minimum Temperature while non-significant positive correlation with morning RH and evening RH and Rainfall. The correlation between natural enemies and weather parameters revealed that the Maximum Temperature, Minimum Temperature and Rainfall was positive and non-significant correlation Whereas, morning RH and evening RH were found to be negatively correlate with Ladybird beetle population and syrphid fly. The *Diaeretiella rapae* population showed positive and non-significant correlation Maximum Temperature, Minimum Temperature and Rainfall Whereas, morning RH and evening RH were found to be negatively and non-significant correlated.

Table 1. Succession of insect pests of mustard and their natural enemies during 2017-18.

SMW	**Insect pest of mustard**							**Natural enemies**		
	Aphid	**Flea beetle**	**Painted bug**	**Saw fly**	**Diamond back moth**	**Semi looper**	**Bihar hairy caterpillar**	**Coccinellid**	**Syrphid fly**	***D. rapae***
49	1.32	2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	6.04	4.6	0.00	0.00	0.12	0.00	0.02	0.00	0.00	0.00
51	13.2	5.2	0.00	0.12	0.36	0.00	0.12	0.00	0.00	0.00
52	22.4	7.8	0.26	0.26	0.48	0.00	0.00	0.28	0.28	0.00
1	39.6	8.3	0.64	0.44	0.62	0.02	0.00	0.46	0.44	0.00
2	52.4	8.6	0.8	0.68	0.88	0.12	0.00	0.94	0.62	0.17
3	75.6	10.2	1.8	0.88	1.17	0.00	0.00	1.8	0.74	0.27
4	108.5	10.6	2.4	0.94	1.22	0.00	0.00	2.6	0.98	0.32
5	118.3	15	2.8	1.06	1.26	0.00	0.00	3.4	1.12	0.68
6	146.7	15.8	3.2	1.85	1.26	0.00	0.00	4.2	1.26	0.86
7	169.2	10.4	3.8	1.96	1.18	0.0	0.00	4.8	1.34	0.94
8	102.3	10.9	3.6	0.6	0.2	0.00	0.00	3.4	1.18	0.62
9	125.6	13.2	3.4	0.2	0.00	0.00	0.00	3.00	1.06	0.68
10	67	6.3	2.8	0.00	0.00	0.00	0.00	2.9	0.78	0.42
11	38.5	7.2	1.6	0.00	0.00	0.00	0.00	1.8	0.2	0.00

Table 2. Correlation between insect pest infesting mustard and weather parameter during Rabi, 2017-18.

Insect pests and natural enemies	Weather parameter				
	Temperature ^{0}C		Rainfall (mm)	Relative humidity %	
	Maximum	Minimum		Morning	Evening
Aphid	0.146	0.279	0.500	- 0.300	- 0.276
Flea beetle	0.128	0.106	0.095	- 0.319	- 0.499
Painted bug	0.444	0.522*	0.386	-0.559*	-0.450
Saw fly	-0.346	-0.111	0.585*	0.145	0.129
DBM	-0.602*	-0.510	0.313	0.267	0.052

Bihar hairy caterpillar	-0.193	-0.138	-0.083	0.385	0.321
Cabbage semilooper	-0.367	-0.382	-0.083	0.096	-0.123
Syrphid fly	0.148	0.228	0.384	-0.342	-0.394
Coccinellid	0.334	0.476	0.479	-0.480	-0.321
D. rapae	0.232	0.388	0.488	-0.293	-0.218

*Significant at 5% level of significance

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RESEARCH ARTICLE

YIELD GAP ANALYSIS IN COTTON PRODUCTION IN MAHARASHTRA: IMPLICATIONS FOR FARMERS' INCOME

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Received-05.10.2018, Revised-26.10.2018

Abstract: Suggestive measures for bridging yield gap are an important means of enhancing farmers' income. This paper aims at analyzing the relationship between cotton farmers output and their socio-economic characteristics, estimation of yield gap and to identify the factors responsible for yield gap in the study area. The study adopted multistage sampling technique in selecting 120 cotton farmers in four villages from Kalmeshuwa and Saona blocks in Nagpur district, Maharashtra. Both primary and secondary data were used for the study. Primary data was collected with the aid of structured questionnaires administered to the cotton farmers and secondary data on potential yield in the research station, potential yield in the demonstration plot and recommended input usage was obtained from the Central Institute for Cotton Research, Nagpur (CICR). Frequencies, percentage and cross tabulation, yield gap index and multiple regression model were used for analyzing the data obtained. Results from cross tabulation indicated that gender, farm size and educational status of the respondents might not necessarily guarantee larger cotton output in the study area. Findings from yield gap analysis showed that yield gap I, yield gap II and total yield gap in the study area were 375kg/ha, 815.11kg/ha and 1190.11kg/ha respectively, implying that there is still scope for increasing actual farmers' yield and hence more farm income. Results from the multiple regression model revealed that educational status, farm size, seed rate gap and location of the farmers were the major factors responsible for yield gap in the study area. The study therefore suggested a need to sensitize farmers by relevant Government agencies on the unfavorable effects of excess input usage with a view to minimize yield gap in the study area.

Keywords: Yield gap, Potential yield, Demonstration plot

INTRODUCTION

Cotton (Gossypium spp.) 'king of fibre' belonging to the genus Gossypium under Malvaceae family which closely linked to the human civilization itself is a large, rich and economically important cash crop comprising about 40 species of which four are commercially cultivated for cotton lint and seed (Dhandhalya, 2009). All the four cultivated species are being grown in India viz., Gossypiumhirsutum, Gossypiumbarbadense, Gossypiumarborium and Gossypiumherbacium. Gossypiumhirsutum which covers about 50 per cent of the area followed by that of Gossypiumarborium with 29 per cent and Gossypiumherbacium with 21 per cent. Area under Gossypiumbarbadense is negligible and covers only a few thousand hectares (Santhy et al., 2008).

The main cotton producing countries are USA, China, India, Pakistan, Uzbekistan, Australia, Greece, Brazil and Turkey. In total world cotton production, 70% comes from four countries; China, India, the United States and Pakistan. In the year 2012-13, cotton production increased compared to the previous years. For many developing and underdeveloped countries, the export of cotton is the main source of foreign currency earnings. The figures in Table 1 depict the main producers of cotton and share in global production from 2007-08 to 2015-16.

Table 1. Global Cotton production (Million metric tons)

Country	Years						
	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2015-16
India	5.23 (19.94)	4.92 (20.89)	5.01 (22.49)	5.53 (21.94)	5.99 (22.22)	6.21 (22.46)	5.75 (27.00)
China	8.06 (30.74)	7.99 (33.92)	6.97 (31.29)	6.64 (26.34)	7.29 (27.06)	7.62 (27.58)	4.90 (23.00)
USA	4.18 (15.95)	2.79 (11.83)	2.66 (11.93)	3.94 (15.63)	3.55 (13.17)	3.77 (13.63)	2.77 (13.00)
Pakistan	1.87 (7.14)	1.89 (8.04)	2.09 (9.39)	1.92 (7.60)	2.18 (8.08)	2.02 (7.33)	1.50 (7.00)
Brazil	1.61 (6.15)	1.20 (5.08)	1.20 (5.38)	1.96 (7.77)	1.96 (7.27)	1.31 (4.73)	1.28 (6.00)
African franc zone	0.50 (1.91)	0.48 (2.03)	0.46 (2.05)	0.46 (1.81)	0.33 (1.21)	0.85 (3.07)	1.07 (5.00)
Uzbekistan	1.18 (4.49)	1.00 (4.25)	0.85 (3.81)	0.89	0.91 (3.39)	0.98 (3.55)	0.85

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				(3.54)			(4.00)
Turkey	0.68 (2.58)	0.41 (1.76)	0.39 (1.76)	0.46 (1.81)	0.67 (2.50)	0.59 (2.13)	0.85 (4.00)
Australia	0.13 (0.50)	0.33 (1.39)	0.39 (1.76)	0.91 (3.63)	1.09 (4.04)	1.00 (3.62)	0.64 (3.00)
Rest of the world	2.79(10.63)	2.55(10.81)	2.26(10.17)	2.50(9.93)	2.98(11.07)	3.29(11.90)	1.70(8.00)
World total	**26.21**	**23.56**	**22.27**	**25.21**	**26.95**	**27.63**	**21.3**

Source: United States Department of Agriculture. *Figures in parenthesis indicate the percentage of world production

India is the largest producer of cotton in the world accounting for about 27% of the world cottonproduction. It has the distinction of having the largest area under cotton cultivation in the world ranging between 10.9 million hectares to 12.8 million hectares and constituting about 38% to 41% of the world area under cotton cultivation.

Cotton is largely grown in states like Maharashtra, Gujarat, Karnataka, Madhya Pradesh, Punjab, Rajasthan, Andhra Pradesh, Haryana and Tamil Nadu. The area under cotton cultivation has also shown significant increase over the years. This increase in area is because of the fact that more and more farmers are switching over to cotton from other crops like sugarcane, pulses. It is significant to note that the contribution of cotton to the total production in the country in 2014-15 season is estimated at about 40 percent.

The productivity (504 kg to 566 kg per hectare) is however still low against the world average of about 701 Kgs to 766 kg per hectare (Consultant and Pradesh, 2017). This may be due to inappropriate decision on how best to allocate resources thus leading to yield gap between potential farm yield and actual farm yield per hectare realized which in turn affects productivity and profitability of farmers. In order to realize increased production and efficiency, farmers in developing countries need to efficiently utilize the limited resources accessed for improved food security and farm income generation. This present paper will help in framing appropriate measures to raise productivity and profitability of farmers by minimizing total yield gap in the study area. This present study therefore seek to analyse the relationship between farmers' output and their socioeconomic characteristics, estimate the yield gap in cotton production as well as to determine the factors responsible for yield gap in the study area.

METHODOLOGY

Data Collection and Sampling Technique

Primary data was collected from 120 cotton producers using structured questionnaire administered by the researcher and well trained enumerators. Data collection was carried out in the month of January 2018. Multistage sampling technique was adopted in selecting the respondents. In the first stage, Maharashtra was purposively selected because it is at number one in terms of cotton production.In the second stage, Nagpur district was purposively selected from the thirty six districts of Maharashtra because it has the highest cotton production. The third stage involves the random selection of two blocks out of the thirteen blocks in Nagpur district (Kalmeshuwa and Saona). In the fourth stage, two villages were randomly selected from each block making a total of four villages. In the final stage, 30 cotton farmers were randomly selected from each village making a total of 120 respondents.

Data Analysis

Descriptive statistics involving frequency, percentage and cross tabulation was used to achieve the first objective. The yield obtained by the farmers was converted to per hectare and divided in to three categories; (1053-1666kg/ha, 1667- 2280kg/ha and 2281-2894kg/ha) which was cross tabulated against farmers' socio-economic characteristics such as gender, farm size and educational status. Yield gap in cotton production was estimated using the methodology developed by International Rice Research Institute (IRRI) as used by Singh (2015).

TYG = YG I + YG II

Where, TYG = Total yield gap

YG I = Yield gap I

YG II = Yield gap II

YG I = Yp – Yd

Yp = Potential Yield (Per hectare crop yield realized on the research station)

Yd = Potential farm yield of the demonstration plot.

YG II = Yd – Ya

Yd = Potential farm yield of the demonstration plot (Per hectare yield realized on the demonstration plot)

Ya = Actual farm yield realized by the farmers (per hectare yield realized by farmers on their field)

Yield gap I and II will were converted to percentages and then summed. This gave the total yield gap in percentage for the study area.

Input gap = Recommended input dose – Actual inputs used by the farmers

Multiple regression model was used to ascertain the determinants of yield gap in the study area. The model is specified as follows;

$Y= \beta_0 +\beta_1 D_1 +\beta_2 X_2 +\beta_3 X_3 +\beta_4 X_4 + \beta_5 X_5 + \beta_6 D_6 + U$

Where,

Y = Total yield gap in kg/ha

D_1 = Dummy for Educational Status (1 if farmer is educated and 0 otherwise)

X_2 = Fertilizer rategap in kg/ha X_3 = Amount expended on labour (Indian rupees)

X_3 = Labour expenses in rupees/ha

X_4 = Farm size in ha

X_5= Seed gap in kg/ha

D_6 = Dummy for location (1 = Kalmeshuwa and 0= Saona)

U = Error term

RESULTS AND DISCUSSION

Farmers Output in Relation to Socioeconomic Characteristics

The output of the cotton farmers' varied between 1053kg/ha to 2894kg/ha as indicated in Table 1. Results obtained from cross tabulation between gender and productivity indicates that only 2.5% of the respondents are female and all of them had low productivity (between 1053-1666kg/ha). On the other hand, majority of the respondents are male out of which 41.7%, 40.0% and 15.8% obtained low, average and above average yield respectively. Since, the highestpercentage of farmers in both gender (2.5% in female and 41.7% in male) had low productivity. This implies that gender of the respondents does not necessarily guaranty larger output among the respondents.

Table 1. Cotton farmers output andgender

Output range	**Gender of the respondents**		**TOTAL**
	Female	Male	
Low	3(2.5)	50(41.7)	53(44.2)
Average	0(0.0)	48(40.0)	48(40.0)
Above Average	0(0.0)	19(15.8)	19(15.8)
Total %	**2.5**	**97.5**	**100**

Source: Field Survey, 2018.*1053-1666kg/ha (Low), 1667- 2280kg/ha (Average) and 2281-2894kg/ha (Above average)

The cotton farmers output relative to their farm size is depicted in Table 2. The results indicates that majority of the respondents (51.7%) are marginal farmers (having less than 1ha) out of which 28.3%, 17.5% and 5.8% of them obtained low, average and above average yield respectively. Findings from the study further indicates that 45.0% of the cotton farmers operate on a small scale basis (between 1-2ha) out of which 15.8%, 19.2% and 10.0% obtained low, average and above average yield respectively. Further findings from the study indicates that only 3.3% of the respondents are medium scale farmers and all obtained average yield (1667-2280kg/ha). Going by this result more than half of the small and medium farmers had obtained average productivity. This implies that large farm size does not necessarily translate to higher productivity. This corroborates the findings of Salihu *et al*., (2018).

Table 2. Cotton farmers' output and farm size

Output range	**Farm size**			**Total**
	Marginal	Small	Medium	
Low	34(28.3)	19(15.8)	0(0.0)	53(44.2)
Average	21(17.5)	23(19.2)	4(3.3)	48(40.0)
Above Average	7(5.8)	12(10.0)	0(0.0)	19(15.8)
Total %	**51.7**	**45.0**	**3.3**	**100**

Source: Field Survey, 2018. *1053-1666kg/ha (Low), 1667- 2280kg/ha (Average) and 2281-2894kg/ha (Above average)

The results of cotton farmers output in relation to educational level in Table 3 showed that 41.7%, 35.8%, 0.8% and 8.3% attained 5^{th} class, 10^{th} class, 12^{th} class and tertiary education respectively while

13.3% of the farmers had no formal education. This revealed low literacy rate among the sampled farmers. Further findings from this study showed that out of the 41.7% farmers that attained 5th class, 16.7% had low yield and another 16.7% obtained average yield. Also the second largest category of farmers (35.8%) are educated up to 10th class out of which 14.2% and 16.7% obtained low and average yield respectively while only 5.0% obtained above average yield. This clearly depict that educational level of the farmers might not be a necessary factor that guarantees high yield in the study area.

Table 3. Cotton farmers output and Educational Level

Output range (kg/ha)		**Educational level**					**Total**
		No formal education	Up to 5th Class	10th Class	12th Class	Tertiary education	
Low		12(10.0)	20(16.7)	17(14.2)	0(0.0)	4(3.3)	53(44.2)
Average		4(3.3)	20(16.7)	20(16.7)	0(0.0)	4(3.3)	48(40.0)
Above Average		0(0.0)	10(8.3)	6(5.0)	1(0.8)	2(1.7)	19(15.8)
Total %		**13.3**	**41.7**	**35.8**	**0.8**	**8.3**	**100**

Source: Field Survey, 2018. *1053-1666kg/ha (Low), 1667- 2280kg/ha (Average) and 2281-2894kg/ha (Above average)

Yield Gap Estimate of the Respondents

The results in Table 4revealed that yield gap II in cotton production was 815.11kg/ha (31.43%) which was almost thrice yield gap I (12.72%). The total yield gap in the study area was estimated to be 1190.11kg/ha (44.15%). This implies that there is still scope within the farmers' control for improving cotton yield and realizing more farm income. This corroborates the findings of Zelda and Sekar (2015) who reported a high yield gap in seed cotton production in Tamil Nadu State, India.

Table 4. Average yield gap estimate in the study area

Description	**Values**
A. Experimental potential yield (kg/ha)	2950
B. Potential farm yield (kg/ha)	2575
C. Yield gap I in kg/ha (A-B)	375
D. Yield gap I expressed in percentage	12.72
E. Average farm yield (kg/ha)	1759.90
F. Yield gap II in kg/ha (B-E)	815.11
G. Yield gap II expressed in percentage	31.43
H. Total yield gap in kg/ha (C+F)	1190.11
I. Total yield gap expressed in percentage (D+G)	44.15
G. Relative yield in percentage*	68.35

*Percentage of average farm yield to farm potential yield.
Source: Author's computation based on Mondal (2011).

Factors influencing yield gap in the study area

The results of regression analysis in Table 5 shows that four out of the six variables included in the model were statistically significant. Educational status (D1) of the farmers and seed gap rate (X5) were statistically significant at 5%, farm size (X4) was significant at 1% and location of the respondents was significant at 10%. The negative coefficient for education implies that yield gap for literate farmers in the study area were 404.017kg less than that of uneducated farmers. Baksh et al., (2005) also reported a similar result among cotton farmers in Sargodha, Pakistan. The coefficient for farm size of the respondents and seed rate is also negative implying that a unit increase in each of these variables would decrease yield gap by 646.33kg and 288.596kg respectively. Results from the model further revealed that the coefficient for location of the respondents is positive and statistically significant. This implies that yield gap in Kalmeshuwa block was 252.755kg higher than that of Saona. Fertilizer gap and expenses on labour were not significant and hence do not have any impact on yield gap in the study area. This result disagrees with the findings of Zelda and Sekar 2015 who reported that nitrogen and potash gap have significant influence on yield gap of marginal cotton farmers in Tamil Nadu State, India. The regression analysis also revealed R^2 value of 0.62 implying that 62% variation in yield gap is as a result of the variables included in the model. F- Value was found to be positive and statistically significant thereby indicating a good fit and appropriateness of the functional form used for the analysis.

Table 5. Determinants of yield gap in the study area.

Variables	Parameters	Coefficient	t-ratio
Constant	β_0	200.834***	6.696
Educational status (D_1)	β_1	-404.017**	-2.010
Fertilizer gap (X_2)	β_2	-0.012NS	-0.089
Expenses on labour (X_3)	β_3	0.001NS	0.453
Farm size (X_4)	β_4	-646.337***	-2.839
Seed rate gap (X_5)	β_5	-288.596**	-2.503
Location (D_6)	β_6	252.755*	1.770
R^2 = 0.62 F = 3.362***			

Source: Field survey, 2018
***Significant at 1%
** Significant at 5%
* Significant at 10%
NS Not Significant

CONCLUSION AND RECOMMENDATIONS

The study revealed that total yield gap in the study area was 1190.11kg/ha with a relative yield of 68.35% indicating that actual farm yield was 31.65% lower than potential farm yield at the demonstration plot which implies that there is still scope for increasing yield of the farmers and hence earning more farm income. The study concludes that educational status of the respondents, farm size, seed gap rate and location of the farmers were the major factors influencing yield gap in cotton production in the study area. The yield gap differs significantly in the two blocks considered for this study In view of these, the following suggestions are made;

I. Efforts should be made to discourage land fragmentation because findings from this study indicated that a unit increase in the usage of land will reduce yield gap significantly in the study area and hence more farm income.
II. Since most of the farmers are not using the recommended dose of inputs such as seed, fertilizer etc., there is need to sensitize farmers by the relevant Government agencies on the detrimental effects of excess input usage with a view to minimize input gap in the study area.

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RESEARCH ARTICLE

KNOWLEDGE LEVEL OF FARMERS ABOUT MAIZE (*ZEA MAYS*) PRODUCTION TECHNOLOGY IN DURG DISTRICT OF CHHATTISGARH STATE

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Received-06.10.2018, Revised-24.10.2018

Abstract: Knowledge about innovation may be an important factor affecting the adoption behavior of farmers. The farmers who have more knowledge about newly developed technology also have more level of adoption of technology compare than those who have low knowledge. Operationally knowledge was used in this study as actual knowledge of farmers regarding maize production technology. The present study was investigating the overall level of knowledge about maize (*Zea mays*) production technology of rice-maize grower families of Durg district of Chhattisgarh state. Data was collected from rice-maize grower families that were selected randomly from each selected 12 villages to make a sample size of 120 rice-maize farm families, with the help of pre-tested interview schedule. The result reveals that the maximum of the respondents (48.33%) had medium level of overall knowledge, followed by 29.17 per cent of them had high level of knowledge and 22.50 per cent of them had low level of overall knowledge knowledge about maize production technology.

Keywords: Knowledge, Maize Production, Technology, Rice-Maize, Cropping system

INTRODUCTION

In India, maize is the third most important food crops after rice and wheat. According to advance estimate its production is likely to be 19.30 million tons (2016-17) mainly during *kharif* season which covers 80 per cent area. Maize in India, contributes nearly 9 per cent in the national food basket. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc. Maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, popcorn in pry-urban areas. In India the predominant maize growing states that contributes more than 80.00 per cent of the total maize production are Andhra Pradesh (20.90 %), Karnataka (16.50 %), Rajasthan (09.90 %), Maharashtra (09.10 %), Bihar (08.90 %), Uttar Pradesh (06.10 %), Madhya Pradesh (05.70 %), Himachal Pradesh (4.4 %). Apart from these states maize is also grown in Jammu and Kashmir and North-Eastern states. Hence, the maize has emerged as important crop in the non-traditional regions i.e. peninsular India as the state like Andhra Pradesh which ranks 5th in area (0.79 m ha) has recorded the highest production (4.14 m t) and productivity (5.26 t ha^{-1}) in the country although the productivity in some of the districts of Andhra Pradesh is more or equal to the USA. Jat *et al*. (2009) revealed that Rice-maize systems are practiced mostly in the south (Andhra Pradesh, Tamil Nadu, and Karnataka) and in the northeast (Bihar and West Bengal) parts of India with acreage of more than 0.5 Mha Andhra Pradesh has the highest acreage under R-M system in South India where this system is rapidly increasing under resource-conserving technologies, mostly zero tillage. Dhruw (2008) maize crop is cultivated in Chhattisgarh in 1.51 lakh ha area and its productivity is 1.2 tonnes per ha which is very low compared to national productivity (1.6 tons per ha). Narbaria (2013) reported that the majority of respondents (57.15%) had 2-3 years of experience, followed by 30.15 per cent of respondents had up to 1 years of experience, 07.15per cent had up to 4-5 years of experience and only 5.55 per cent of respondents had above 5 years of experience in rice cultivation. Prajapati *et al.* (2015) mentioned that the land holding had positive and highly significant relationship with the extent of adoption of no-cost and low-cost technologies of animal husbandry. Tailor *et al.* (1998) reported that the knowledge of selected dry land farming practices of the small and big farmers was positively related with their adoption.

MATERIALS AND METHODS

The present study was undertaken in Durg district of Chhattisgarh state during 2016-17 in all three blocks namely Patan, Dhamdha and Durg. From each selected block four villages on the basis of area under rice-maize cropping system were considered for this study. The rice-maize cropping system adopted 10 farmers from each selected block were selected as respondents from all 12 villages, thus a total of 120 farmers (10 X 12 = 120) were selected for data collection. The data were collected by

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personal interview with the help of well prepared, structured and pretested interview schedule. Data were analyzed using frequency distribution, percentages, and correlation coefficient.

RESULT AND DISCUSSION

The findings regarding farming experience of the respondents are presented in Table 1 and Fig 1. It is clear from the data that majority (94.16%) of the respondents had farming experience up to 10 years, followed by 5.84 per cent had farming experience between 11 to 20 years and none of the respondent had farming experience above 20 years.

Table 1. Distribution of respondents according to their farming experience regarding rice-maize cropping system (n=120)

Sl. No	Farming experience	Frequency	Percentage
1.	Up to 10 years	113	94.16
2.	11 to 20 years	07	5.84
3.	Above 20 years	00	0

Since all the respondents belonged to farming community and most of them were involved in farming from their childhood hence farming experience is solely influenced by their age and found quite high in the study area.

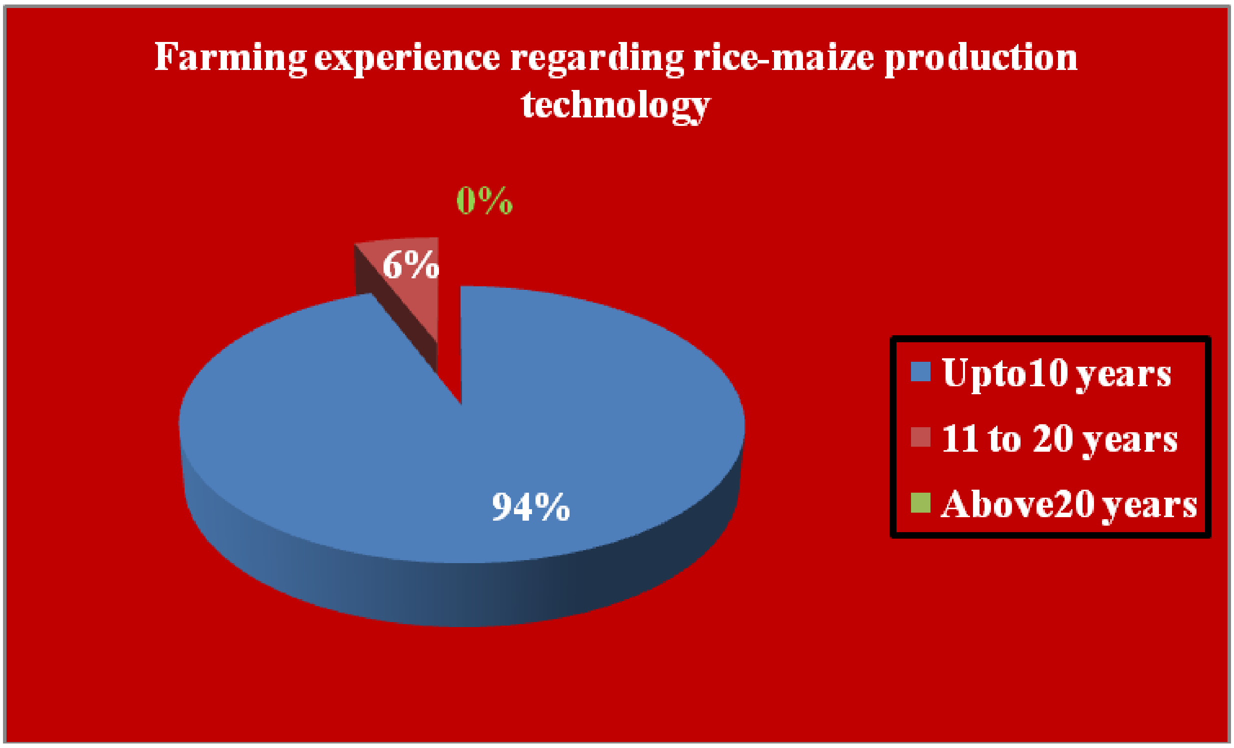

Fig 1: Distribution of respondents according to their farming experience

The data regarding knowledge about practices of recommended maize production technology are presented in Table 2. The data reveals that the majority of the respondents (62.50%) had high level of knowledge regarding preparation of land followed by 27.5 per cent of the respondents had medium level of knowledge and 10 per cent of them had low level of knowledge. Regarding selection of seed, the majority of (55%) the respondents had medium level of knowledge followed by 45 per cent of the respondents had high level of knowledge. Towards seed treatment, majority (60%) of the respondents had low level of knowledge, followed by 21.66 per cent of the respondents had medium level of knowledge and 18.34 per cent of them had high level of knowledge. Regarding application of manure fertilizers, the majority of (54.20%) the respondents had medium level of knowledge followed by 30 per cent of the respondents had high level of knowledge and 15.80 per cent of them had low level of knowledge. With respect to water management, maximum (49.17%) respondents had medium level of knowledge, followed by 31.66 per cent of the respondents had high level of knowledge and 19.17

per cent of them had low level of knowledge. Concerning to weed management, most (55.83) of the respondents had medium level of knowledge, followed by 20 per cent of the respondents had high level of knowledge and 24.17 per cent of them had low level of knowledge.

Table 2. Distribution of respondents according to their practice wise level of knowledge about maize production technology (n=120)

Sl. No.	Practices	Level of knowledge			
		Low	Medium		High
		F (%)	F (%)		F (%)
1.	Preparation of land	12	33		75
		(10)	(27.50)		(62.50)
2.	Selection of seed	00	66		54
		(0)	(55.00)		(45.00)
3.	Seed treatment	72	26		22
		(60.00)	(21.66)		(18.34)
4.	Application of manure fertilizers	19	65		36
		(15.80)	(54.20)		(30.00)
5.	Water management	23	59		38
		(19.17)	(49.17)		(31.66)
6.	Weed management	29	67		24
		(24.17)	(55.83)		(20.00)
7.	Insect management	22	63		35
		(18.33)	(52.50)		(29.17)
8.	Disease management	61	34		25
		(50.83)	(28.34)		(20.83)
9.	Time of harvesting and method of cutting	9	67		46
		(7.5)	(54.17)		(38.33)

* Figures in parenthesis show percentage F=frequency, (%) = percentage

Regarding insect management, the maximum the respondents (52.5%) had medium level of knowledge, followed by 29.17 per cent of the respondents had high level of knowledge and 18.33 per cent of them had low level of knowledge. Regarding disease management, the most of (50.83%) the respondents had low level of knowledge followed by 28.34 per cent of the respondents had medium level of knowledge and 20.83 per cent of them had high level of knowledge. Regarding time of harvesting and method of cutting, maximum (54.17%) the respondents had medium level of knowledge followed by 38.33 per cent of the respondents had high level of knowledge and 7.5 per cent of them had low level of knowledge.

Table 3. Distribution of respondents according to their overall knowledge about maize production technology

Sl. No.	Level of knowledge	Frequency	Percentage
1.	Low (up to 12 score)	27	22.50
2.	Medium (13 to 16 score)	58	48.33
3.	High (more than 16 score)	35	29.17

Mean=14.49, S.D. = 2.31

The data regarding overall knowledge about recommended maize production technology are presented in Table 3. The data clearly reveals that the majority of the respondents (48.33%) had medium level of overall knowledge, followed by 29.17 per cent of them had high level of knowledge and 22.50 per cent of them had low level of overall knowledge.

CONCLUSION

This study reveals, majority of the respondents had medium level of knowledge regarding selection of seed, application of manure fertilizers, water management, weed management, insect management, and time of harvesting and method of cutting. In case of other practices like seed treatment, disease management most of the respondents had low level of knowledge, with respect preparation of land, majority of the respondents had high level of knowledge may be due to availability of farm machinery like tractor, rotavator on hire basis.

In terms of overall knowledge about maize production technology maximum respondents had medium level of overall knowledge, followed by few of them had high level of knowledge and only some of them had low level of overall knowledge about maize production technology. The knowledge of farmers about maize production technology can be increase by organizing training programme, frequent field visit and timely conduction of demonstration programme at village level by local extension functionaries.

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SHORT COMMUNICATION

SEASONAL INCIDENCE OF MAJOR INSECT PESTS IN LINSEED

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Received-04.10.2018, Revised-25.10.2018

Abstract: A field trial was conducted at Rajmohini Devi Collage of Agriculture and Research station, Ambikapur during *Rabi* seasons of 2017-18 . The activity of major insect pest of linseed was noticed on Linseed crop during December 2017 to February 2018. Linseed thrips was observed from first week of December to last week of February with peak population of thrips occurred in third week of January. Linseed bud fly was recorded from first week of January to last week of February with peak activity during last week of February. Jassids were noticed during the third week of December to second week of February with peak incidence during third week January. Red cotton bug was observed during last week of December to second week of February with the peak incidence during third week of January .The population of linseed caterpillar larvae remained active from third week of December to first week February, with the peak activity were recorded during the third week of January. Green stink bugs were noticed during second week of January to last week of January with peak incidence during third week of January. Various natural enemies lady bird beetle and predatory spider were found on linseed plant from third week of December to first week of February.

Keywords: *Linum usitatissimum*, Linseed, Insect pests

INTRODUCTION

Linseed, (*Linum usitatissimum* L.) is one of the important oil and fiber crop belonging to family Linaceae (Flax family). This is also known as flax oil or flax seed oil. It has one-third oil and besides this it is made up of protein, fiber and mucilage. The oil content of linseed seed varies from 33 to 47 %. It is one of the rich sources of essential fatty acids and contains omega 3-essential fatty acid, alpha linolenic acid and omega 6-essential fatty acid. This oil is a rich source of proteins, vitamins, lignins, essential fatty acids, fiber and minerals.

In the world, it is cultivated over 24.37 lakh ha. area with a production of 22.0 lakh tones and productivity 903 Kg/ha. In India, the area of linseed crop was 0.630 m. ha. with total production of 0.200 m. tones and productivity 317.5 Kg/ha. Chhattisgarh is one of the important linseed growing state of India, which contribute about 19.05 % area and 16.21% production of the country. In Chhattisgarh, linseed is cultivated over 86 thousand hectare area with a production of 24.2 thousand tones and productivity of 281 kg/ha. It is a major crop grown as “Utera” during Rabi season. The important linseed growing districts of Chhattisgarh are Rajnandgaon, Durg, Bilaspur, Kabirdham, Raipur, Dhamtari, Surguja, Kanker and Raigarh . In Surguja district, linseed is cultivated over 3.016 thousand hectare area with a production of 1.508 thousand tones and productivity of 500 kg/ha .

Linseed crop is attacked by several insect pests like linseed bud fly, (*Dasyneura lini* Barnes), semilooper (*Plusia orichalsia* Fab.), thrips (*Caliothrips indicus* Bagnall) and linseed caterpillar (*Spodoptera exigua* Hub.). among them linseed bud fly, (*Dasyneura lini* Barnes) is a major pest and loss upto 88 % grain yield (Mukherji *et al*., 1999)

MATERIALS AND METHODS

The experiment was carried out during rabi season 2017-2018 at R.M.D. CARS Ambikapur, (C.G.). The variety Indira Alsi-32 was sown in second week of November in 2017-18 with plot size 5 x 4 m^2 with spacing of 30x10 cm and replicated 3 times. The recommended agronomic practices without any plant protection measure were followed. Incidence of linseed bud fly was observed at weekly interval on 10 randomly selected plants at each plot.The incidence of various insect pests were estimated by making count of the population of insect pests. linseed bud fly was observed on the basis of number of damaged bud per plants and total number of healthy buds per plant (per cent bud infestation were estimated).Based on meteorological standard weekly record of weather parameters the population dynamics of bud fly was studied. At last the population of insect pests were averaged and subjected to simple correlation, taking population as dependent factor and temperature, humidity, rainfall and sunshine as independent factors.

RESULTS AND DISCUSSION

Seasonal incidence of major insect pests of linseed, *viz*; thrips was first observed on second week of December (49^{th}SMW) with a population of (2.16 thrips/plant) the weather parameters of maximum temperature (25.4°C) and minimum temperature (8.6°C), morning relative humidity 92.6% and evening relative humidity 41.3%, respectively. The

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population reached its peak to (38.54 thrips/plant) during third week of January (3rdSMW) where the maximum (24.6°C) and minimum (6.1°C) temperatures, relative humidity morning and evening as 81.1 and 27.7 per cent, respectively; The correlation of thrips of linseed was negative correlated with maximum and minimum temperature (r= -0.44) and (r= -0.46) respectively, positive correlation with morning relative humidity (r=0.06) and negative correlation with evening relative humidity (r=-0.14) was observed and positive but non-significant correlation with rainfall (r=0.11). In case of linseed bud fly observed on the crop in the first week of January with 1.64 per cent bud damage, which was associated with 24 °C and 5.7 °C maximum and minimum temperatures and 86.6 and 28.1 per cent morning and evening relative humidity. The insect gradually increased its density and exhibited peak activity in the last week of February with 38.5 per cent bud damage. It was associated with 31.1 °C and 13.9 °C maximum and minimum temperatures and 68.6 and 23 per cent morning and evening relative humidity.There was a positive highly significant correletion between the bud fly damage and maximum temperature (r= 0.74**) and minimum temperature (r= 0.80**) and highly significant negative correlation with morning relative humidity (r= -0.80**) and negative non significant correlation with evening humidity (r= -0.51) and positive but non-significant correlation with rainfall (r=0.30). This result is found to be in close association with result obtained by Malik et al. (2011) who observed the population dynamics and management of the linseed bud-fly, *Dasyneura lini*. infestation was started in the middle of the January with initial infestation level of 1.5&2.3 per cent during 1994-95 and 1995-96, with obtained peaked incidence in mid-February during both years.

Incidence of jassid was negative but significant correlation with maximum temperature (r= -0.63*) and minimum temperature (r= -0.58*). And negative non-significant correlation with morning and evening relative humidity (r= -0.22) and (r= -0.052) . and positive non-significant correlation with rainfall (r=0.18). But in case of Red cotton bug population was showed non-significantly correlated with all weather parameters individually. Negative non-significant correlation with maximum temperature (r= -0.20) and minimum temperature (r= -0.10) and correlation with morning relative humidity (r= -0.09) and correlation with evening relative humidity (r= -0.16). On the other hand positive correlation with rainfall (r=0.35), Linseed caterpillar incidence had negative but significant correlation with maximum temperature (r= -0.53) and negative higher significant correlation with minimum temperature (r= -0.67**), on the other hand negative non -significant correlation with rainfall (r= -0.14) and positive non-significant correlation with morning (r= 0.02) and evening (r= -0.27) RH, respectively. This result is found to be in close association with result obtained by Dhamdhere and Saxena (1969) who also reported on linseed caterpillar feeding on linseed from December onward. Further, they recorded minimum larval population (3.15 larvae/30 cm rows) in variety C-604 and maximum (6.01 larvae/30 cm rows) in IPI-52.

But in case of green stink bug was showed negative non-significant correlation with all weather parameters individually. Maximum temperature (r= -0.22) and negative correlation with minimum temperature (r= -0.29) and non-significant correlation with rainfall (r= -0.15) and negative non-significant correlation with morning relative humidity (r= -0.08) and negative correlation with evening relative humidity (r= -0.07) was observed. This result is found to be in close association with result obtained by Sahu (1999) who studied on population dynamics of insect pest in linseed crop and reported that eleven insect pests and four natural enemies were in overlapping manner in linseed crop and among these pests, *Caliothrips indicus* and *D. lini* was observed as major pests during vegetative and reproductive respectively.

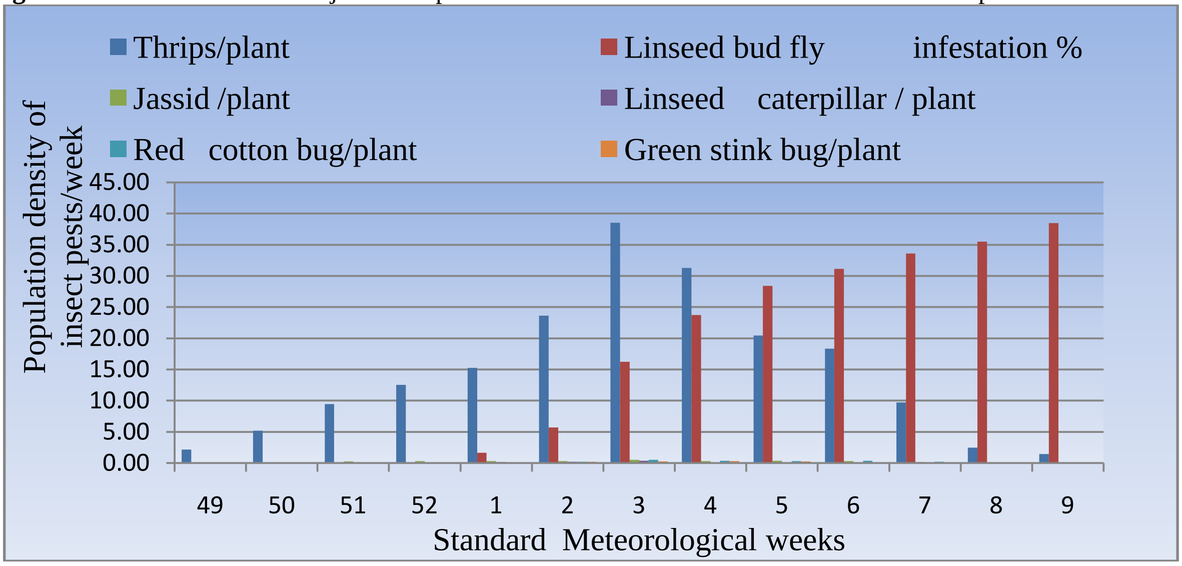
Table 1. Correlation of weather parameters with insect pests and natural enemies on linseed during Rabi, 2017-18

Insect and natural enemies	Temperature °C		Rainfall	Relative Humidity (%)	
	Maximum	Minimum		Morning	Evening
Thrips	-0.44	-0.46	0.11	0.06	-0.14
Linseed bud fly	0.74**	0.80**	0.30	-0.80**	-0.51
Jassid	-0.63*	-0.58	0.18	-0.22	-0.05
Red cotton bug	-0.20	-0.10	0.35	-0.09	-0.16
Linseed caterpillar	-0.53	-0.67*	-0.14	0.02	-0.27
Green stink bug	-0.22	-0.29	-0.15	-0.08	-0.07
Lady bird beetle	-0.35	-0.34	0.07	-0.08	-0.19
Spider	0.28	-0.29	0.01	-0.09	-0.17

Table 2. Seasonal incidence of major insect pests and associated natural enemies on linseed crop

		Population density of insect pests/week							
Standard week	**Date of observation**	**Thrips /plant**	**Linseed bud fly infestation %**	**Jassid /plant**	**Red cotton bug/ plant**	**Linseed caterpillar / plant**	**Green stink bug/plant**	**Lady Bird Beetle /plant**	**Spider /plant**
49	**04.12.2018**	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	**11.12.2018**	5.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	**18.12.2018**	9.43	0.00	0.26	0.00	0.05	0.00	0.00	0.06
52	**25.12.2018**	12.53	0.00	0.33	0.03	0.06	0.00	0.03	0.08
1	**02.01.2018**	15.26	1.64	0.31	0.06	0.19	0.00	0.65	0.44
2	**9.01.2018**	23.61	5.68	0.30	0.25	0.24	0.23	1.09	0.66
3	**16.01.2018**	38.54	16.23	0.49	0.54	0.41	0.26	1.75	1.15
4	**23.01.2018**	31.28	23.75	0.33	0.40	0.06	0.29	1.10	1.18
5	**30.01.2018**	20.45	28.4	0.38	0.35	0.05	0.16	1.01	0.75
6	**06.02.2018**	18.33	31.11	0.3	0.38	0.03	0	0.6	0.36
7	**13.02.2018**	9.7	33.6	0.14	0.24	0	0	0.4	0.29
8	**20.02.2018**	2.45	35.5	0	0	0	0	0	0
9	**27.02.2018**	1.44	38.5	0	0	0	0	0	0
	Mean	**14.65**	**16.49**	**0.22**	**0.17**	**0.08**	**0.07**	**0.51**	**0.38**

Fig 4. Seasonal incidence of major insect pests and associated natural enemies of linseed crop



ACKNOWLEDGEMENT

Authors are highly thankful to department of Agronomy and Horticulture of RMD CARS, Ambikapur for providing the necessary facilities during the research work.

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