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RESEARCH ARTICLES

RESEARCH ARTICLE

EFFECT OF *CRY*1AC PROTEIN EXPRESSED IN DIFFERENT IR-64 *BT* RICE EVENTS ON TARGET INSECT YSB, *SCIRPOPHAGA INCERTULAS* (WLK)

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Abstract: The studied was undertaken at the Ttransgenic containment facility, Department of Plant molecular biology and Biotechnology, College of Agriculture, Raipur during 2014 and 2015. The confirmation of different Bt transgenic rice events for insect bioassay against YSB, *Scirpophaga incertulas* to observed the effect of proteinase inhibitor (m*CryIAc*) gene on the growth and development of the insects by different methods such as cut stem and whole plant bioassay. The highest larval mortality of YSB(81.25%) was reported in IR64-3 followed by IR64-2 and amount of stem eaten after four days was lowest on IR64-4(0.0225 g) as against control plants IR64(C), (0.319 g) Whereas, in whole plant bioassay, on the leaf damage basis out of four transgenic lines and one control line the highest percentage dead heart of transgenic rice lines by whole plant assay of YSB was observed highest (36.46%) in IR64-4 followed by IR64-1 (29.17%) and lowest in IR64-2 (20.84%) while in control event percentage of dead heart was recorded more than 50 percent i.e. 60.42, 80.21&72.92 percent in IR64-C, TN-1&PTB-33, respectively.On the basis of this investigation, the effect of *Cry*1Ac protein expressed on target YSB in different IR-64 Bt rice events was exhibited significantly.There is an urgent need to generate biosafety data for Bt. rice under controlled conditions for taking policy decision about its cultivation in the country.

Keywords: Insect bioassay, YSB, *Scirpophaga incertulas*, Target insect, Effect of m*CryIAc*gene on YSB

INTRODUCTION

Rice is the most remunerative crop stands first among all food grain and is staple food for more than half of world's population. Insect pest are one of the major constraints of high tech agriculture and pesticides use is necessary .The transgenic plants expressing insecticidal properties are becoming environmentally safe alternatives to chemical pesticides. Genetically modified crop containing crystal protein from the bacterium *Bacillus thuringiensis* (Bt) was grown on 26.3 million ha worldwide in the year 2005 (James, 2005).Bt rice has the potential to eliminate yield losses caused by lepidopteron pests up to 2%-10% of Asia's annual rice yield of 523 million tons (High *et al.,* 2004). Genetically modified crops had provided economic benefits to growers and also offer a promising alternative to chemical insecticides for control of lepidopteran pests in rice (Zhu, 2001; High *et al.,* 2004).

Development of transgenic rice has become novel technique to combat the attack of major pests of rice *viz.,* YSB and SSB, causing 10-30% yield losses (Ramaswamy and Jatileksono, 1996). This technique offers much promise in developing agricultural practices that are in perfect harmony with the environment. There are several transgenic rice has been developed showing 100% resistance to stem borer and leaf folders under green house and natural field conditions (Wu *et al.,* 1997; Alam *et al.,* 1998; Datta*et al.,* 1998; Tu*et al.,* 1998; Ye *et al.,* 2001; Chandel, 2005).

In recent years, rice stem borers had developed resistance to some most commonly used insecticides in China and other rice growing countries. The transgenic rice on target lepidopteron pests is a important tool both for pest management and insecticide resistance management.The Bt rice has effectively controlled the three species of stem borers, *C. suppressalis, S. incertulas, S. inferens* and leaf folder, *C. medinalis* as reported by Tu*et al.* (2000).

The transgenic plants expressing insecticidal properties are becoming environmentally safe alternatives to chemical pesticides. Rice stem borer is now becoming a serious threat in rice cultivation of Chhattisgarh due to monotonous cropping. The transgenic rice on target lepidopteran pests is a important tool both for pest management and insecticide resistance management.

MATERIAL AND METHOD

All investigations related to Bt rice were carried out at the Green house of Entolomolgy and Biotechnology IGKV, Raipur during 2014 and 2015 as per the guidelines of biosafety regulations. The female adults of the target insect yellow stem borer, *Scirpophaga incertulas* (Wlk) was collected from the rice fields of IGKV, Raipur and transferred into cages containing rice seedlings. Egg masses laid by stem borer moth were collected upon reaching in

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black head stage and put in vials. After hatching from egg masses, neonate larvae were used for cut stem and whole plant bioassay at different growth stages of Bt and non-Bt rice lines.The six *viz.*, IR-64(1), IR-64(2), IR-64(3), IR-64(4) and IR-64(C) independent transgenic Bt rice lines along with the respective non-transgenic control single rice plants were planted in each pots a containment greenhouse. The plants were grown in pots (15 cm diameter and 15 cm height) and placed in the separate chamber marked for entomological testing in the greenhouse.

Insect bioassay

Cut stem assay

The cut-stem method of bioassay was employed for the feeding test of yellow stem borer (YSB) major devastating pests of rice, as per Datta*et al*. (1998). Eight-cm-long cuttings of six transgenic rice lines and the non-transgenic control plants at the booting stage were placed in a petridish (90 x 100 mm) moistened with a filter paper disc. The ten steady neonate larvae each of YSB was placed on the stem and the petridish were sealed with masking tape. The petridish was incubated for 96 h at 25°C. The bioassay was replicated three times for each plant. After incubation, the numbers of live, dead, and missing larvae were recorded for each petridish. The fig.is presented inplate-1.The mortality rate was expressed as a percentage and calculated by the following formula:

% Mortality = (No. of dead larvae/total larvae released) x 100

The missing larvae were grouped within the mortality category (Tran Thi*et. al.*, 2011).

Whole plant assay

Whole plant bioassay was conducted for YSB at vegetative stage. In this experiment, ten neonate larvae of YSB were released in each potted transgenic lines and control plants with five replications. Each potted plant was covered with wired cage, individually and Standard Evaluation System for rice was used for damage rating and damage grade. The observations were recorded after 16 days of releasing neonate larvae. Damage rate was recorded on the basis of stem damage. The fig.is presented inplate-2.

RESULT AND DISCUSSION

The confirmation of different Bt transgenic rice events were studied in laboratory and Greenhouse for insect bioassay against YSB, *Scirpophaga incertulas* to observe the effect of proteinase inhibitor (m*CryIAc*) gene on the growth and development of the insects evaluation by different methods such as cut stem, whole plant bioassay.The results are presented in table -1 and 2 & fig-1a &1b and 2.

Cut stems bioassayfor YSB

Insect bioassays were performed to establish the correlation between expression of *mCry1Ac* genes in transgenic plants and the resistance conferred against infestation of target insect larvae. The yellow stem borer (YSB) was tested to its susceptibility for Cry1Ac protein expressed in differentBttransgenic rice plants. The per cent larval mortality was significantly higher and stem feeding was significantly less on all transgenic plants of rice which contained the *mCryIAc* gene as compared to control plants. The insecticidal activity of Cry1Ac protein in the transgenic rice plants was verified by feeding neonate larvae of YSB, *Scirphophaga incertulas* with stem materials at booting stage using stem cut assay method. The results showed that maximum larval mortality after feeding for two days reached 78.33 percent in IR64-3 and minimum in IR64-1 (63.33%), all tested southern and ELISA positive plants, irrespective of levels of toxins (0.580 to 0.981µg/g of fresh tissues) produced by transgenic plants. The mortality in control dishes, which contains stems from non- transformed control plants were 8.33 percent observed in IR64C parents during 2014.Whereas, during 2015, the maximum larval mortality (76.67%) was also noticed in IR64-3 with minimum in IR64-1(61.67%). The results showed that maximum larval mortality after feeding for fourth days reached 83.33 percent in IR64-3 and minimum in IR64-2 (80.00%). The mortality in control dishes, which contains stems from non-transformed control plants were 16.67 percent observed in IR64C parents during 2014.Whereas, during 2015, the maximum larval mortality (86.67%) was also noticed in IR64-3 with minimum inIR64-1(80.00%). The mean of larval mortality within four days, the maximum feeding was reached 80.83 percent in IR64-3 followed by 74.16 percent in IR64-2 and minimum in IR64-4 (70.00%) during 2014.Whereas, during 2015, the maximum larval mortality (81.67%) was also noticed in IR64-3 with minimum in IR64-4(70.83%). Overall on basis of pooled mean of two years data of larval mortality within fourth days, the highest larval mortality of YSB (81.25%) was exhibited in IR64-3 of transgenic Bt line followed byIR64-2 (75.00%) and minimum in IR64-4 (70.42%). The mortality in control dishes, which contains stems from non- transformed control lines was 12.50 percent observed in IR64C plants.

The results showed that maximum larval mortality after feeding for two days reached 78.33 percent in IR64-3 and minimum in IR64-1 (63.33%), all tested southern and ELISA positive plants, irrespective of levels of toxins (0.580 to 0.981µg/g of fresh tissues) produced by transgenic plants. The mortality in control dishes, which contains stems from non-transformed control plants were 8.33 percent observed in IR64C parents during 2014.Whereas, during 2015, the maximum larval mortality (76.67%) was also noticed in IR64-3 with minimum in IR64-

1(61.67%). Whereas, the fourth days after results showed that maximum larval mortality after feeding for fourth days reached 83.33 percent in IR64-3 and minimum in IR64-2 (80.00%). The mortality in control dishes, which contains stems from non-transformed control plants were 16.67 percent observed in IR64C plants during 2014.Whereas, during 2015, the maximum larval mortality (86.67%) was also noticed in IR64-3 with minimum in IR64-1(80.00%). The mean of larval mortality within four days, the maximum feeding was reached 80.83 percent in IR64-3 followed by 74.16 percent in IR64-2 and minimum in IR64-4 (70.00%) during 2014.Whereas, during 2015, the maximum larval mortality (81.67%) was also noticed in IR64-3 with minimum in IR64-4(70.83%). Overall on basis of pooled mean of two years data of larval mortality within fourth days, the highest larval mortality of YSB (81.25%) was exhibited in IR64-3 of transgenic *Bt* line followed byIR64-2 (75.00%) and minimum in IR64-4 (70.42%). The mortality in control dishes, which contains stems from non- transformed control lines was 12.50 percent observed in IR64C parents.The larvae fed with Cry1Ac expressing stems showed symptoms of *Bt* intoxication; brownish to black color, soft and the body exuding liquid ooze especially when picked with forceps, whereas larvae fed with control stems were normal in their body color and other growth fitness parameters (larval weight and developmental period). In development of Bt rice Tran *et. al.,* (2011) demonstrated petri dish bioassay; a single stem section about 7 cm long was cut from each plant. Three stems were taken from each line (3 replications/line) and each stem was placed into petri-dish lined with moistened filter paper and released 5 neonatal larvae. The petridishes were sealed to revent the escape of larvae and kept in laboratory temperature of 25 ± 2ºC. Stem sections were dissected to observe larval mortality, growth stage at 5 days after infestation. In bioassay tests for resistance to yellow stemborer in the laboratory and in the net house, it was recorded that a large number of transgenic lines were highly resistance. The promising homozygous transgenic lines (F8) have been selected.

Whole plant assay

Whole plant bioassay was conducted for YSB at vegetative stage. In this experiment, ten neonate larvae of YSBwere released in each potted transgenic lines and control plants with five replications. In this experiment, the observations were recorded on the basis of dead heart after sixteenth days of infestation. The four transgenic lines were tested against *Scirpophaga incertulas*. The highest percentage dead heart (35.42%) was recorded on IR64-4 followed by IR64-3 (29.17%) and lowest in IR64-2 (18.75%) during 2014. Whereas, during 2015, the maximum percentage dead heart (37.50%) in IR64-4 followed by IR64-1 (31.25%) and lowest in IR64-2 (22.92%). Overall on basis of pooled mean weight of two years data of highest percentage dead heart of transgenic rice lines by whole plant assay of YSB was observed highest (36.46%) in IR64-4 followed by IR64-1 (29.17%) and lowest in IR64-2 (20.84%) while in control event percentage dead heart was recorded more than 50 percent i.e. 60.42, 80.21&72.92 percent in IR64-C, TN-1&PTB-33, respectivelyWhole plant bioassay was conducted for YSB at vegetative stage. In this experiment, ten neonate larvae of YSB were released in each potted transgenic lines and control plants with five replications. In this experiment, the observations were recorded on the basis of dead heart after sixteenth days of infestation. The four transgenic lines were tested against *Scirpophaga incertulas*. The highest percentage dead heart (35.42%) was recorded on IR64-4 followed by IR64-3 (29.17%) and lowest in IR64-2 (18.75%) during 2014. Whereas, during 2015, the maximum percentage dead heart (37.50%) in IR64-4 followed by IR64-1 (31.25%) and lowest in IR64-2 (22.92%). Overall on basis of pooled mean weight of two years data of highest percentage dead heart of transgenic rice lines by whole plant assay of YSB was observed highest (36.46%) in IR64-4 followed by IR64-1 (29.17%) and lowest in IR64-2 (20.84%) while in control event percentage dead heart was recorded more than 50 percent i.e. 60.42, 80.21&72.92 percent in IR64-C, TN-1&PTB-33, respectively.Feeding assay with all the transgenic rice lines expressing insecticidal protein was highly toxic to YSB larvae. Toxin showed marked anti-feedent activity and inhibited insect development. The level of expression of Cry1Ac protein from single *Bt* gene products were found similar effect on insect mortality. Transgenic plants not expressing Cry1Ac protein did not show any resistance to the growth of YSB larvae over the control form non-transgenic plants. Satpathi*et. al.,* (2012) studied the feeding by yellow stem borer (*Scirpophaga incertulas* Wlk.) larvae and the consequences of damage to internode were assessed on the paddy cultivar *Swarna mashuri*(MTU 7029).The approach consisting transgenic *Bt* (*Bacillus thuringiensis*) rice can be cited as one of the exemplary success story of agricultural biotechnology to date and several rice varieties have been transformed with various *Cry* genes and shown to have high levels of resistance against lepidopterous insects (YSB and SSB) under green house and field conditions (Ye *et al.,* 2001; Datta*et al.,* 2004).

Table 1. The cut stem bioassay with stem borer during vegetative stage of transgenic rice plants containing m*cry*IAc gene during 2014 and 2015.

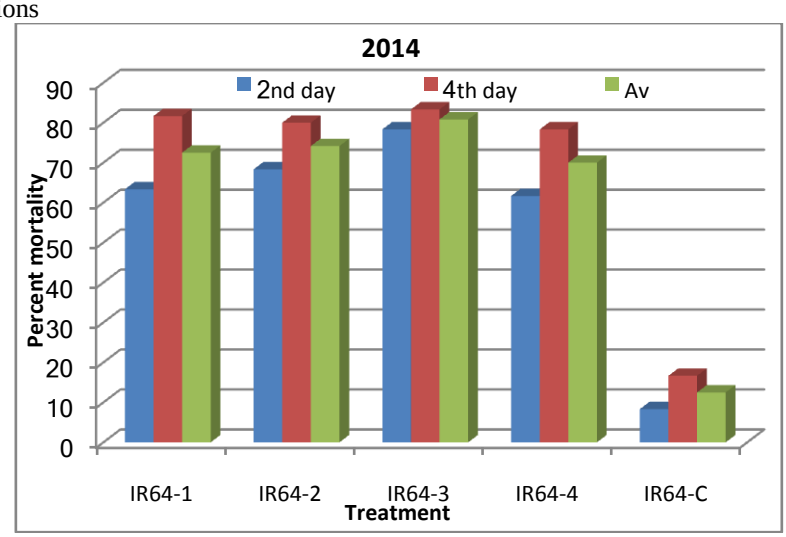
S. No.	Transgenic line	2014 Larval mortality (%)			2015 Larval mortality (%)			Pooled mean of larval mortality (%)
		2nd day	4th day	Mean (within four days)	2nd day	4th day	Mean (within four days)	
1	IR64-1	63.33 (52.84)	81.67 (65.01)	**72.50**	61.67 (51.84)	80.00 (63.90)	70.84	**71.67**
2	IR64-2	68.33 (55.97)	80.00 (63.90)	**74.16**	70.00 (56.98)	81.67 (66.98)	75.84	**75.00**
3	IR64-3	78.33 (62.90)	83.33 (66.78)	**80.83**	76.67 (61.44)	86.67 (71.15)	81.67	**81.25**
4	IR64-4	61.67 (51.84)	78.33 (62.90)	**70.00**	63.33 (52.84)	78.33 (64.87)	70.83	**70.42**
5	IR64-C	8.33 (13.64)	16.67 (23.84)	**12.50**	8.33 (13.64)	16.67 (23.84)	12.50	**12.50**
Mean		**56.66**	**68.00**		**56.00**	**68.67**		
SEM		**3.15**	**2.78**		**2.94**	**4.38**		
CD at 5%		**9.23 S**	**8.15 S**		**8.61 S**	**12.82 S**		

*The value in parenthesis are angular transformed values.
*Data based on six replications
*IR64C- control
*S: significant

Table 2. Whole plant bioassay for rice stem borerduring 2014 and 2015.

Transgenic line	Percentage of dead heart		
	2014	2015	Pooled mean
IR64-1	27.08	31.25	**29.17**
IR64-4	18.75	22.92	**20.84**
IR64-5	29.17	27.08	**28.13**
IR64-6	35.42	37.50	**36.46**
IR64-C	58.33	62.50	**60.42**
TN-1(C)	79.17	81.25	**80.21**
PTB-33(C)	68.75	77.08	**72.92**

*Av of six replications



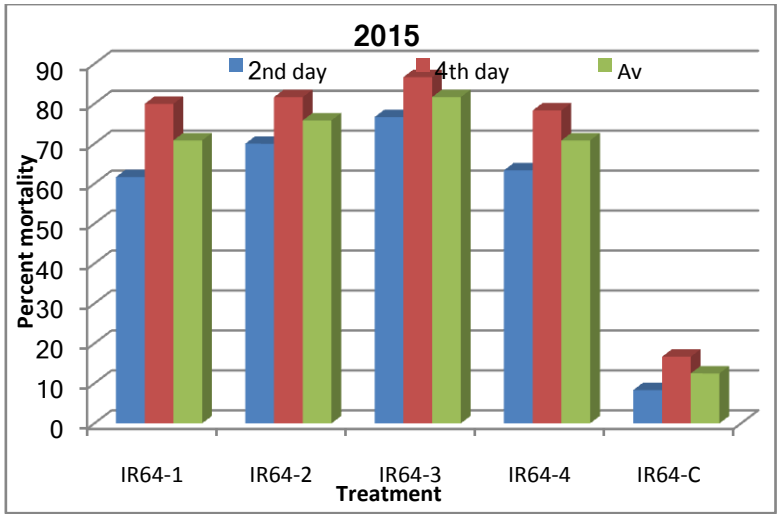


Fig.-1a: The cut stem bioassay for stem borer percent mortality at vegetative stage of transgenic rice plants containing m*cry*IAc gene during 2014 and 2015

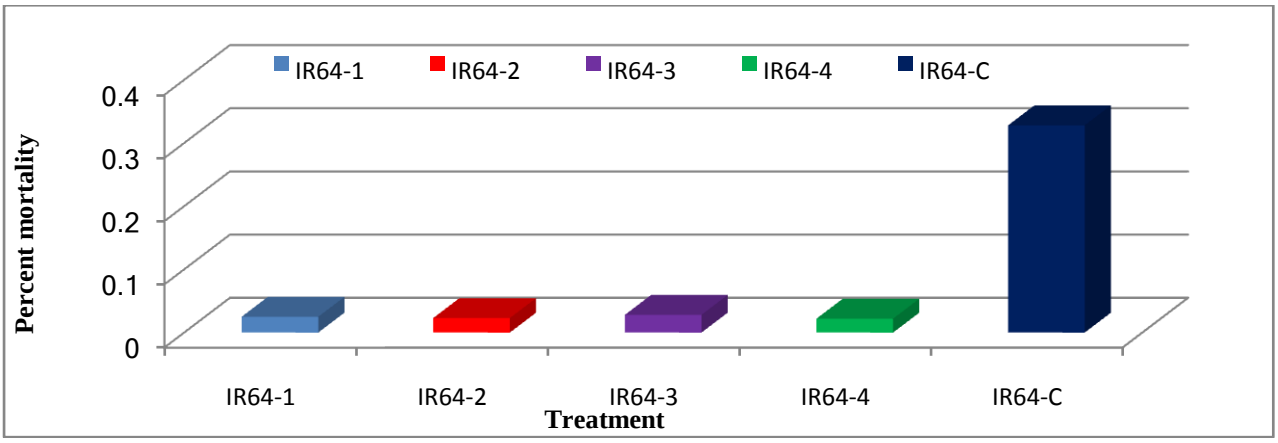


Fig.-1b: The average of two years cut stem bioassay for stem borer percent mortality at vegetative stage of transgenic rice plants containing m*cry*IAc gene

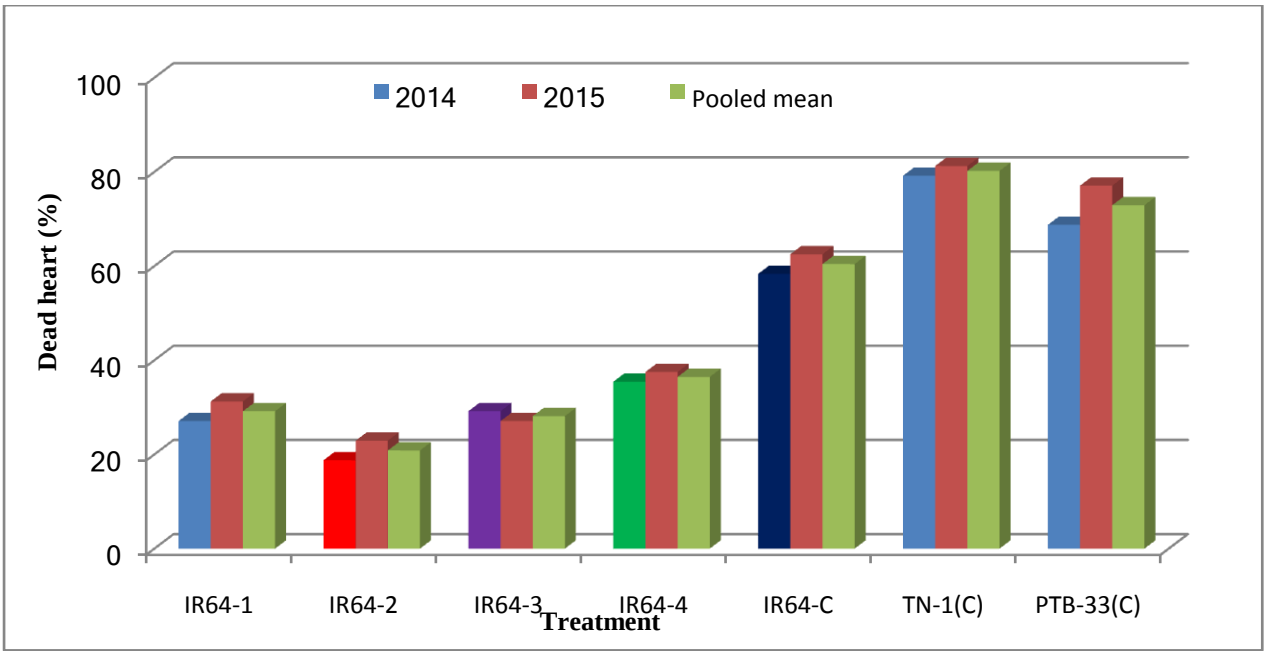


Fig.-2: Whole plant bioassay for rice stem borerduring 2014 and 2015

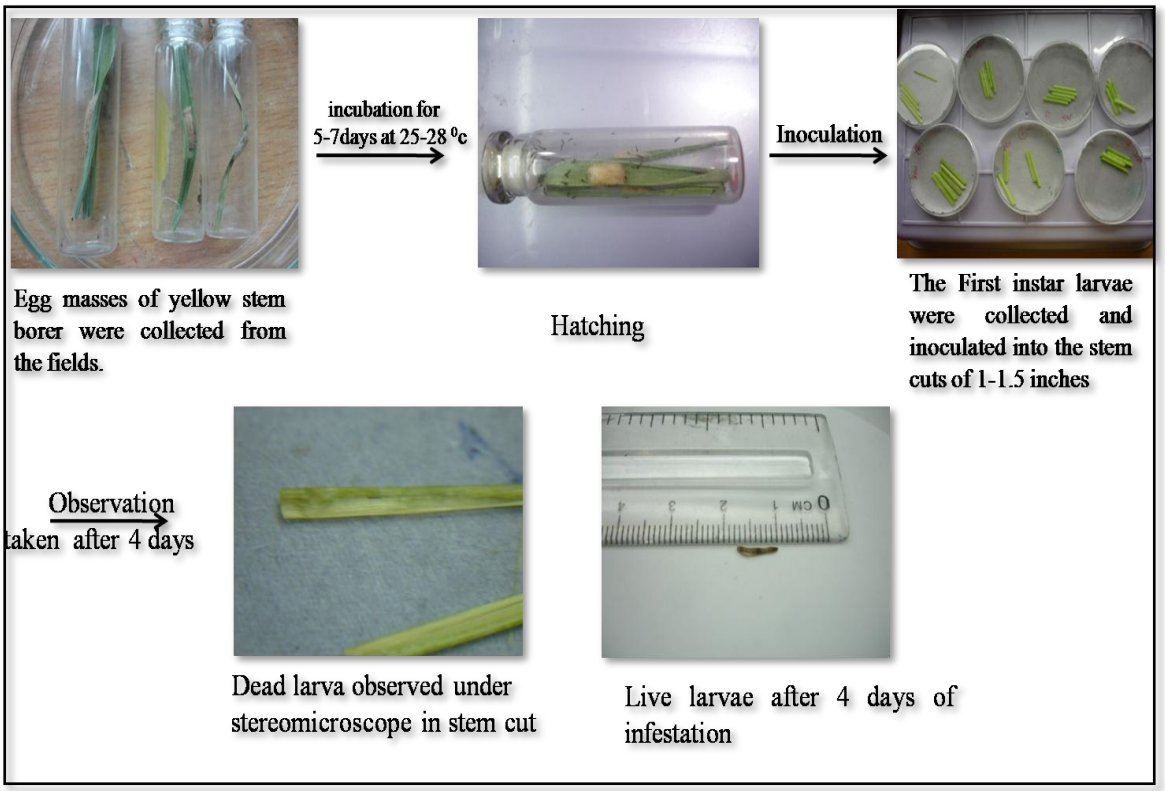


Plate-1: Cut Ste m bioassay showing different stage of yellow stem borer

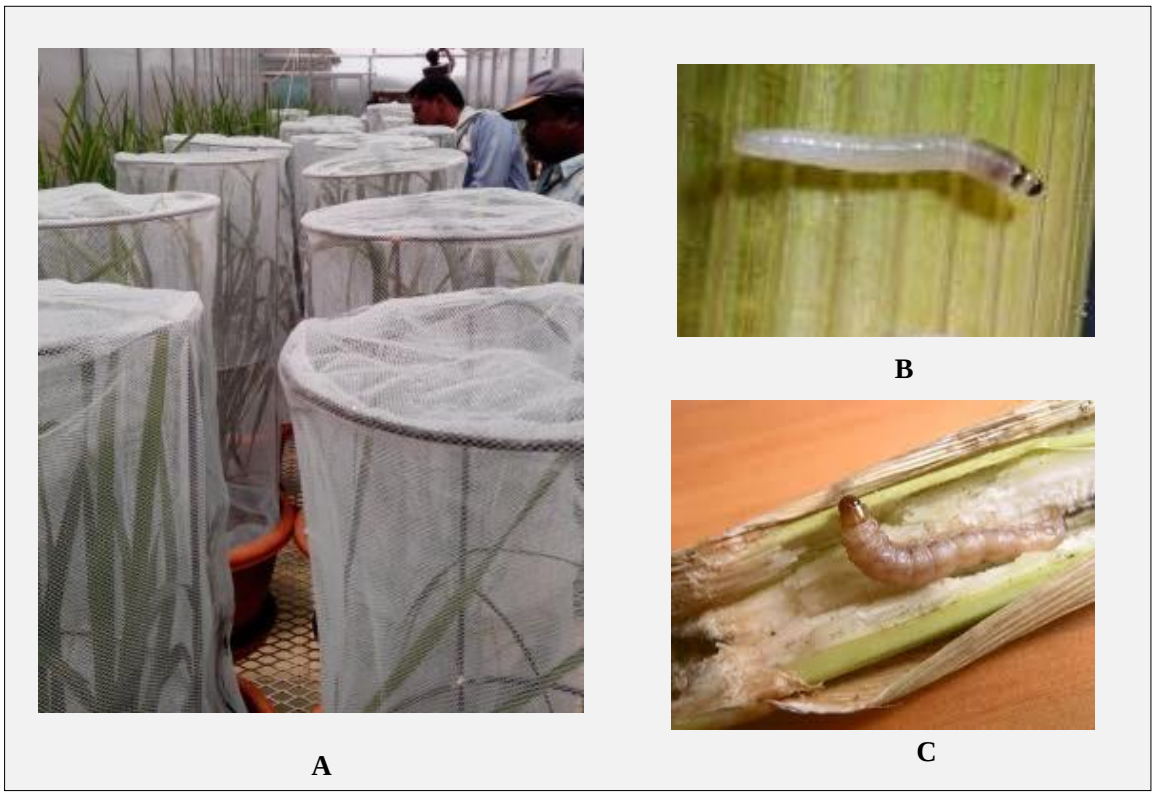


Plate-2: Whole plant bioassay showing different larval stage of *Scirpophaga incertulas* **A**. Cadged plant with released YSB egg mass, **B**.3rt instar, **C** larvae before pupation

CONCLUSION

The confirmation of different Bt transgenic rice events were studied in laboratory and greenhouse for insect bioassay against YSB, *Scirpophaga incertulas*was conducted to establish the relationship between expression of *mCry1Ac* genes in transgenic plants and the resistance conferred against infestation of target insect larvae i.e.YSB. YSB was tested to its susceptibility for Cry1Ac protein expressed in different Bt transgenic rice plants. The per cent larval mortality was significantly higher and stem feeding was significantly less on all transgenic plants of rice which contained the *mCryIAc*gene as compared to non- transgenic control plants.

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RESEARCH ARTICLE

DEVELOPMENT OF MANUAL EXPERIMENTAL PLOT SEEDER

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Abstract: The basic purpose of mechanization is to raise agricultural productivity, increase profitability and thus improve quality of life of farming community. The improvement of machine for sowing of experimental plots is a continuing problem facing by plants breeders, agronomists, plant pathologists and other agricultural scientists. Most part of the country, old traditional method is used for sowing. Traditional sowing method adversely affects result in improper placement of the seed into the soil at the correct soil depth, failure to properly keep the seeds firmly in the soil, uneven placement of the seeds at the correct interval in a row. Seed sowing is the most labour intensive operation. The labour requirement in manual sowing of gram seed is as high as 30 labour-ha^{-1} and time requirement for sowing is also high. Keeping this in mind, manual experimental plot seeder was developedfor gram. The field capacity of experimental plot seeder was observed to be 0.0547 ha h^{-1}(Digvijay variety of gram) and 0.0864 ha h^{-1} (Kripa variety of gram) &the field efficiency was observed to be 75.95 %(Digvijay variety of gram) and 80 %(Kripa variety of gram).

Keywords: Plot seeder, Field experiment, Crop, Productivity

INTRODUCTION

The plot sowing operation is an important part of field experiments. Whether the sowing accuracy is good or not will directly affect the results of field experiments. Plot seeders are specially used for breeding new and good crop varieties in field experiments and they are not different from the traditional seeders. During the plot sowing operation, the seed quantity is strictly controlled in one plot, that is, plot seeders must be able to sow quantitatively. It is well recognized that accuracy and uniformity of a plot seeder are essential for achieving satisfactory experimental results.

Pulses are the most important crop grown throughout the country. India occupies first rank in the production of pulses in the world (Indian Economy, 2012-13). It is widely grown in different part of country mainly by small and marginal farmers.Chickpea (*Cicer arientinum* L.) is a cool-season annual pulse crop that belongs to the Leguminosae family. It is the third most important pulse crop after dry beans and dry pea. Chickpea is grown in wide range of environments comprising about 44 countries in tropical, subtropical, and temperate regions of the world. Chickpea is used in a variety of food preparations that are rich in protein. Seeds have about 20 % protein, 5 % fat, and 55 % carbohydrate. It is consumed as a dry pulse crop or as a green vegetable .

Physical properties

Some of the physical properties of Digvijay and Kripa Varity of chickpea seeds were determined (Table 1). The three principle dimensions of 100 randomly selected seeds of each Digvijay and KripaVarity were measured with Vernier caliper having least count of 0.01 mm. Sphericity of chickpea was calculated as the ratio of equivalent diameter to length (Mohsenin, 1970). This physical parameter is used for deciding the cell size of seed rotor.Bulk density of the chickpea was determined by using 100cc Corning glass graduated cylinder used for measuring volume of the sample (Mohsenin, 1970). Bulk density was used for deciding the seed capacity of seed box.

Development of manual experimental plot seeder

Experimental plot seeder was designed and developed (fig. 1), on the basis of above mentioned physical properties. It consists of eight functional components: 1. Main frame, 2. Furrow opener, 3. Power transmission unit, 4. Seed metering mechanism, 5. Seed collecting unit, 6. Supporting wheel, 7. Markers, 8. Handle

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Table 1.

	Properties	**Variety of chickpea**	
		Digvijay	**Kripa**
1	Length, mm	8.610	12.504
2	Width/diameter, mm	6.382	9.206
3	Breadth, mm	5.983	8.956
4	Size($\sqrt[3]{(l \times b \times t)}$), mm	6.834	10.082
5	Sphericity ($\frac{\sqrt[3]{(l \times b \times t}}{l}$)	0.815	0.810
6	Angle of Repose, degree	29.47	28.52
7	Bulk density (kg m^{-3})	767.1	691.9

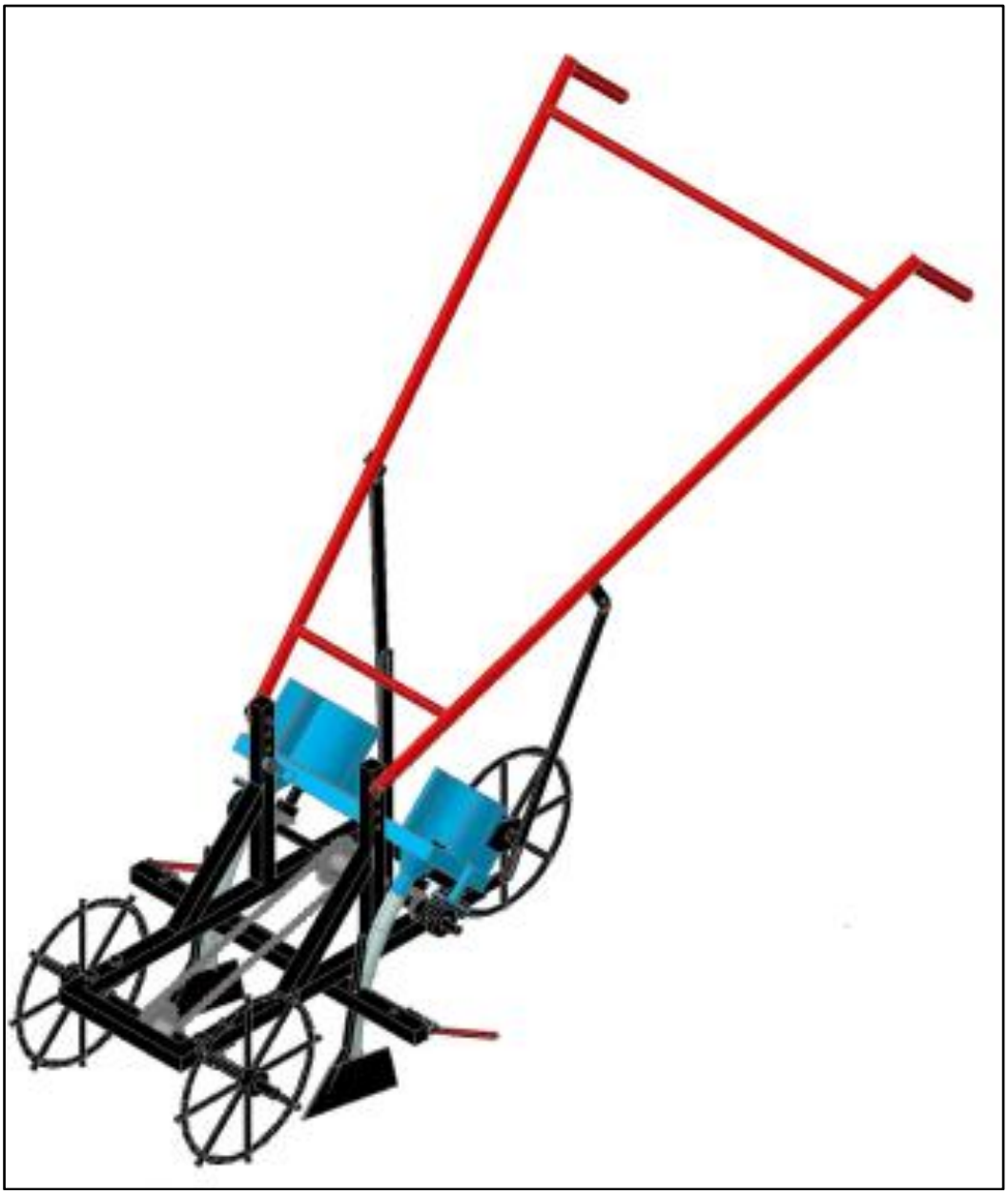

Fig. 1. Three Dimensional View of Manual Experimental Plot Seeder

Main Frame

The main frame assembly was made from MS and guage square pipe of size 25 mm. The size of the main frame assembly was 600 x 240 mm. On this main frame different systems of the machine were fixed viz. ground wheels and power transmission system, seed box and seed metering mechanism, furrow openers, handle, supporting wheel etc.

Furrow Opener

Two shovel type furrow openers for each seed metering unit was developed for this machine.The standard of furrow openers was made up of MS square rod of size 10 mm and the lower end of the standard was having a bend, on which the shovel of the furrow openers was welded and forming an obtuse angle with the soil. The shovel of the furrow openers was made up from MS sheet. The shovel was provided at the bottom of standard with overall dimensions of 147 x 90 x 60 mm. A boot was provided at the center of the shovel welded to the standard for accommodating the seed tube for dropping of seeds. The diameter of the boot was 25 mm having 2 mm thickness.

Power Transmission Unit

A chain and sprocket drive system was used to transmit the drive power from the ground wheels of the seeder to the driven shafts and from driven shaft to the rotor shaft of the seed metering mechanism.The power transmission unit consists of the following components:

1. Ground wheel: Two ground wheels were provided on the front side of the main frame. Ground wheel was made up of MS square rod of diameter 10 mm. The effective diameter of the ground wheel was 250 mm. There were 8 lugs welded on the periphery of ground wheel. Lugs have 10 mm diameter and having 100 mm length. Lugs were provided on ground wheel to avoid the slippage of the ground wheel.

2. Power transmission shafts: three types of power transmission shafts were provided i.e. Ground wheel shaft (Drive shaft), Driven shaft, and Seed rotor shaft.

a. Ground wheel shaft: The shaft was made up of MS bright bar of 18 mm diameter and having 465 mm length. A drive sprocket having 18 numbers of teeth was mounted on this ground wheel shaft at the center. This drive sprocket transmits power from ground wheel shaft to the driven sprocket with the help of chain.

b. Driven shaft: The driven shaft was made up of MS bright bar. The driven shaft was of diameter 16 mm and having 440 mm length. The step at the both ends of the shaft was made by reducing the diameter of shaft by 1 mm. This step was of 35 mm length and diameter of 15 mm at the two sides of the shaft.

c. Seed rotor shaft: Two rotor shafts were developed for two metering mechanism of manual experimental plot seeder. The rotor shaft was made up of MS bar. The diameter of the rotor shaft was 16 mm and having 90 mm length. At the bottom end of the rotor shaft an 18 teeth bevel gear was fitted with key nut for receiving the power from driven shaft.

3. Chain and sprocket arrangement: The driving sprocket was mounted at center of the ground wheel shaft having 18 numbers of teeth. Drive sprocket transmit power to the driven shaft through standard cycle chain. Driven sprocket was mounted at center of the driven shaft having 18 numbers of teeth with 12.7 mm pitch. Both the sprockets have 18 teeth. There was no power reduction between the drive and the driven shaft. Cycle chain was used to connect the two sprockets.

4. Bevel gear mechanism: The two pairs of bevel gear were used to transmit rotational power of driven shaft to seed rotor shaft at right angle. The bevel gears had 18 numbers of teeth on its periphery. The internal diameter of the bevel gear was 16 mm.

Seed metering mechanism

The inclined plate type metering mechanism was selected for manual experimental plot seeder. The inclined plate metering mechanism gives the better performance of seed placement than others. The seed metering mechanism consists of following components.

a. Seed box: The seed box was cylindrical in shape and flat at the bottom. The seed box was made up of MS sheet. The diameter of the seed box was 115 mm, which was fitted on the rectangular MS sheet having dimensions of 150 x 125 mm. Seed box assembly make an angle of 450 with the main frame. The round slot was made at the center of the bottom of the seed box having 16 mm diameter. This slot was provided for inserting the rotor shaft into the seed rotor. The rectangular slot was provided at the bottom of seed box for dropping the seeds from the rotor into seed tube. The size of this rectangular slot was 38 x 28 mm. There was one slot with flap arrangement was provided on the seed box for emptying the seed box after sowing one plot.

b. Seed rotor: The seed rotor used for this mechanism was of acrylic plastic type with cells on its periphery.The number of cells on seed rotor was calculated by the formula as given by Sharma and Mukesh. A rotor of 113 mm diameter and 6 mm thickness was developing for metering the seed. The cells were provided on the periphery of the seed rotor, as per the spacing requirement of the crop to be sown. This rotor rotated in the seed rotor box with the help of rotor shaft. The rotor had the “square” shape hole of size 16 mm for mounting on rotor shaft, so that there was no need to have a key and key way arrangement for the rotor and rotor shaft. While changing the rotor for other varieties, there was no

need to remove the rotor shaft, only nut fitted on rotor shaft remove from the top of the rotor shaft and then the rotor was remove out and another rotor will be placed in the seed box. Separate rotors were to be used for planting different varieties different crops

c. Brush: The experimental plot seeder was developed with one stationary brush in each seed box. Brush was provided for more positive unloading of seeds into the seed collecting funnel.

d. Seed drain arrangement: Separate seed drain arrangement was provided on each seed box. This flap was made from MS sheet and size of flap was 600 x 600 mm.

Seed collecting unit

There was an arrangement for collecting seeds from the seed rotors. Seed collecting funnel welded at the bottom of seed box assembly. The seed collecting funnel made up of MS sheet. The seed tubes were attached at the bottom of the funnels, which carry the seeds from the funnel to the bottom of the furrow openers through boot**.**

Supporting wheel

This wheel support and balance the weight of the seeder. The supporting wheel was made up from MS round rod of 10 mm diameter. The effective diameter of supporting wheel was 250 mm. Supporting wheel was attached at rare end of the main frame with the help of MS flat. The size of MS flat was 40 mm and having length of 180 mm.

Markers

Seeder was provided with markers. Markers were attached to the main frame with the help of nut and bolts. Markers were developed for maintaining row to row distance (PAU, Ludhiana). These were adjustable. It was fitted on square pipe of size 25 mm and having length of 600 mm with the help of nut and bolt arrangement. The provision was provided for adjusting the distance between markers according to the row to row spacing.

Handle

The handle of the seeder was designed to be adjustable for the different height of individuals thereby reducing drudgery. The handles help the operator to push the planter while in operation (Ibukun et al, 2014). It was made up from MS round pipe having 20 mm diameter. The length of handle was 1060 mm.

Operation of the manual experimental plot seeder

The developed experimental plot seeder was based on the pushing and pulling power of the operator. Two persons operates this machine, one person push the machine and another person pull the machine with help of rope. A hook was welded at the center of the front side of the main frame for tying the rope. Ground wheel rotated with the ground wheel shaft. The driving sprocket was mounted at center of the ground wheel shaft. Due to the rotation of ground wheel shaft driving sprocket will rotate. The driving sprocket transmitted power with rotary motion to the driven sprocket with the help of chain. Driven sprocket was mounted at center of the driven shaft. Both the sprockets having of same diameter and having same number of teeth and rotated at the same speed. Thus, the seed rotor was making same number of revolutions per minute as those of the ground wheel. In one rotation of the ground wheel, the seeder covers a distance of 785 mm. During this time, the seed rotor also made one rotation. There were eight cells on the seed rotor and it dropped eight seeds per rotation. Driven sprocket was mounted at the middle of the driven shaft. Motion of the driven sprocket caused the motion of driven shaft. Bevel gears were fixed on the middle of driven shaft. Two separate bevel gears fitted on driven shaft for two seed box. Due to motion of the driven shaft, bevel gear was rotated, bevel gear was provided for transmitting the rotational power of the ground wheel at right angle to the seed rotor. Bevel gear rotated the rotor shaft. The seed rotor picked up seeds from the seed box in the cells and dropped them into the collecting funnel. Brush was provided for more positive unloading of seeds into the seed collecting funnel. From collecting hopper seeds were transferred to the furrow openers through the seed tubes at recommended spacing.

Performance of the manual experimental plot seeder

The performance of developed experimental plot seeder was conductedto obtain field capacity of machine &Field efficiency. Seed rate was obtained to be 90.7kg-ha^{-1}& 137.4kg-ha^{-1}for Digvijay & Kripa Varity respectively by calibration. The effective capacity in field test was 0.047 ha-h^{-1} with average speed of 1.2 km-h^{-1}. The field efficiency of the manual experimental plot seeder in the field test was 75.95 %.

CONCLUSION

1. The developed experimental plot seeder was based on the pushing and pulling power of the operator.
2. Seed rate was obtained to be 90.7kg-ha^{-1}& 137.4kg-ha^{-1}for Digvijay & Kripa Varity respectively by calibration
3. The effective capacity in field test was 0.047 ha-h^{-1} with average speed of 1.2 km-h^{-1}
4. The field efficiency of the manual experimental plot seeder in the field test was 75.95 %.

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RESEARCH ARTICLE

EFFECT OF FOLIAR APPLICATION OF BIO-REGULATORS AND NUTRIENTS ON PHYSICO-CHEMICAL PROPERTIES OF LEMON (*CITRUS LIMON* BURMA.) CV. PANT LEMON-1 UNDER SUBTROPICAL CONDITION OF GARHWAL REGION

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Abstract: The present investigation was carried out at Horticultural Research Centre and Department of Horticulture, Chauras campus, H.N.B. Garhwal University, Srinagar Garhwal, Uttarakhand, India during 2008-09 growing seasons to study the effect of foliar application of bio-regulators and nutrients on quality of lemon (*Citrus limon* Burma.) cv. Pant Lemon-1. On the basis of overall performance of treatments on quality characters of fruits, it can be concluded that the values for fruit set, days to maturity, yield of fruits per plant, fruit length, fruit juice, total soluble solids, total sugars, shelf-life of fruits, have been obtained maximum under GA_3 (20 ppm) treatment, while the minimum fruit cracking and the maximum fruit weight, fruit volume, acidity were recorded with NAA (50 ppm). However, the maximum vitamin C was recorded under NAA (10 ppm) foliar application.

Keywords: Foliar application, Nutrients, Bio-regulators, Lemon

INTRODUCTION

Lemon (*C. limon* Burma.) belongs to the family Rutaceae, comes under the category of acid fruits and is used primarily as fresh fruit. The fresh fruits of lemon are also used for the preparation of lemonade, refreshing drinks and for a wide variety of culinary preparations like pies, cakes, dishes of vegetables, fish, meat and salad. It is extensively used with tea in Russia. Lemon is a good source of citric acid which is used for pharmaceutical purposes and for aerated waters. The lemon oil is a stimulant and carminative when given internally as medicine. Lemon juice along with common salt is recommended as a remedy for dysentery, dry bleach, putrid, sore throat and for correcting foetid breath. Lemon squash and pickles are the fine preserves used in India. Lemons are gaining popularity in India because of (i) its multiple utility, (ii) production all the year round and (iii) tolerance against citrus decline and other citrus disorders. To meet the demand of increasing population, its production has to be increased several folds. Lemon is an important fruit crop of Tarai region and valley areas of hill region as well. Among the various cultivars of lemon grown in these regions, Pant Lemon-1 has been found most promising. This variety is becoming popular among the orchardists all over the country. Therefore, modern cultural practices such as use of bio-regulators, integrated nutrient management and integrated insect pest management may be employed for increasing its production and productivity.

Among the various practices, the use of bio-regulators have been identified to play an important role in modern crop husbandry for increased production of quality fruits through improving flowering, fruit set, fruit drop control, fruit shape and size etc. These organic chemical compounds modify the physiological processes of fruit plants when applied in small concentrations (Babu *et al*., 1982). Therefore, there is a need to study the effect of bio-regulators along with varied concentrations for qualitative characters of lemon fruits. Nutrition is another important factor affecting the health of the plants. The optimum requirement of nutrition of a particular species or variety greatly varies with soil and agro-climatic conditions. Thus, there is a need to standardize the nutritional requirements for lemons under different agro-climatic conditions. Foliar application of nutrients is an ideal way of evading the problems of nutrient availability and supplementing the fertilizers to the soil. In the semi-arid areas of Garhwal region, the foliar application is the alternative and safe way of applying nutrients for quick absorption and maximum availability. In view of the above facts, it is clear that the foliar application of bio-regulators and nutrients is very important not only for increasing yield but also to improve the quality of fruits

MATERIAL AND METHOD

The present study was carried out at Horticultural Research Centre and Department of Horticulture, Chauras campus, H.N.B. Garhwal University, Srinagar Garhwal, Uttarakhand, India during 2008-09 growing season. Six-year-old bearing lemon trees of cultivar Pant Lemon-1 of uniform vigour and size were selected for the present study. All the trees were maintained under uniform cultural schedule during the course of investigation. The experiment consisted of sixteen treatments of two bio-regulators and three nutrients, and each one was applied singly and a spray of plain tap water as control. These were, NAA

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(10 ppm), NAA (25 ppm), NAA (50 ppm), GA_3 (10 ppm), GA_3 (15 ppm), GA_3 (20 ppm), Urea (0.5%), Urea (1.0%), Urea (2.0%), Zinc Sulphate (0.2%), Zinc Sulphate (0.3%), Zinc Sulphate (0.4%), Borax (0.2%), Borax (0.3%), Borax (0.4%) and Control. All the treatments were applied as a spray at the time of full bloom (when about 75% flowers had opened on the selected shoots). The experiment was laid out in Completely Randomized Block Design (CRD). Forty eight plants of Pant Lemon-1 were selected for the present study and each tree formed as a unit of treatment. All the treatments were replicated thrice. All the plants selected for the experiment were labelled as per layout of experiment and the sprays of treatment solutions were done on experimental pants of Pant Lemon-1 at full bloom stage (when about 75% flowers had opened on the selected shoots) during the spring season. The spray was done in morning around 10 AM with the help of hand sprayer at the rate of three liters per plant to ensure the maximum absorption of bio-regulators and nutrients through the leaves. Each tree was sprayed thoroughly in such a way as to completely drench it with the spray solution. All the chemical analysis of fruits was carried out in the laboratory of Department of Horticulture.

RESULT AND DISCUSSION

It is clear from the data on fruit length and breadth (Table 1.) that various foliar sprays of bio-regulators and nutrients concentrations gave significant variation in fruit length and breadth. The data revealed that the maximum fruit length (5.56 cm) was recorded in treatment GA_3 (20 ppm) and minimum length of fruits (4.64 cm) under control. However, the highest breadth of fruit (5.39 cm) was observed with Borax (0.4%) and the lowest value (4.46 cm) under control. Jackson (1968) reported that the average size of the lemon fruits was increased by spraying GA_3 in late May or early June. Similarly, sprays of (5-40 ppm) GA_3 to Eureka lemon trees increased the size of the fruits (Coggins *et al.,* 1963). Application of NAA (200 ppm) 30 days after full bloom to Unshiu orange trees greatly increased fruit size and the proportion of larger fruits (Nakajima *et al.,* 1969). Babu and Lavania (1985) reported that the maximum length of lemon fruits was recorded with NAA (10 ppm) treatment. Except for the higher concentrations each of NAA and GA_3, all other treatments increased the diameter of the fruits. NAA (10 ppm) gave the maximum response with 9.20% increase in diameter of fruits over control, followed by (4.79%) with 2, 4-D (10 ppm). The maximum number of large fruits was recorded under GA_3 (10 ppm). The lowest concentration, each of 2, 4-D and NAA decreased the proportion of large sized fruits considerably except for the higher concentrations of GA_3 (20 and 40 ppm). The maximum diameter was observed under 2, 4-D (5 ppm), followed by NAA (5 ppm) treatment. As the concentrations of these three growth regulators increased the fruit length and diameter also increased proportionally. In the present investigations GA_3 and Borax in higher concentrations increased the fruit length and diameter significantly. Earlier findings of scientists on fruit length and diameter supported the results for this character under present study.

The maximum increase in fruit weight (110.13g) was observed with the treatment NAA (50 ppm) as compared to the minimum fruit weight (77.46g) obtained under control. In general, sprays of bio-regulators and nutrients increased fruit weight during present investigation. Sprays of 40 ppm 2, 4-D to Washington Navel orange increased the fruit weight by 62% (Keleg and Minessy, 1965). Similarly, Coorg mandarin fruits treated with 25 and 50 ppm 2,4,5-T had 34% and 35% more weight, respectively, over the untreated fruits (Rodrigues and Subramanyam, 1966). An increase in fruit weight with 250-500 ppm NAA was reported by Ali *et al.,* (1973) in kinnow mandarin, when sprayed two weeks after fruit set. Singh and Singh (1981) reported that GA_3 (15 ppm) applied once in August, September and October to Kaula mandarin trees increased fruit weight by 30% over control. Reddy and Prasad (2012) also observed in pomegranate cv. Ganesh that the fruit weight was superior with the application of 2, 4-D (40 ppm), followed by GA_3 (75 ppm) and NAA (40 ppm). All above scientists have reported that NAA and GA_3 were found to increase fruit weight in different fruit crops which also encourage the results of the present investigation for these quality parameters.

The maximum increase in fruit volume (108.18 ml) was exhibited by the treatment NAA (50 ppm) against the minimum fruit volume (76.63 ml) recorded under control. Babu and Lavania (1985) reported that the highest fruit volume was recorded under NAA (10 ppm), followed by 2,4-D (20 ppm) and NAA (5 ppm). Among all treatment NAA (10 ppm) gave the maximum response (9.20% increase) over control. Reddy and Prasad (2012) reported that the fruit volume was found superior with the application of 2,4-D (40 ppm), followed by GA_3 (75 ppm) and NAA (40 ppm) in pomegranate cv. Ganesh. Rawat *et al.,* (2011) recorded the maximum fruit volume when guava trees of L-49 were sprayed with 0.4% zinc sulphate. As the concentrations of these three growth regulators increased the fruit volume also increased considerably. The results obtained for fruit volume under present study are in conformity with the results of earlier workers as mentioned above.

Data pertaining to specific gravity showed the non-significant difference between all treatments and control. The minimum specific gravity (0.96) was found with urea (1.0%) as compared to the maximum specific gravity (0.98) recorded under control. The minimum specific gravity of fruits was obtained under urea treatment presumably, because of the

effect of urea on the internal quality of the fruits, which affects the weight and volume of the fruits. Guava fruits showed minimum specific gravity when trees were sprayed with zinc sulphate at the rate of 0.4% concentration (Rawat *et al.,* 2010).

The maximum increase in fruit juice (46.87%) was recorded with the treatment GA_3 (20 ppm) as compared to minimum fruit volume (38.40%) found under control. Babu *et al.,* (1982) investigated the effects of zinc, 2, 4-D and GA_3 alone or in combination on the fruit quality of kagzi lime fruits. Zinc and 2, 4-D treatments were found to increase the physical traits and chemical composition of juice. GA_3 treatments increased the fresh weight and percentage of juice. Singh *et al.,* (1989) found significant effect of zinc spray (0.4%) and (0.5%) on juice percentage in kinnow and kagzi lime. Juice per cent was found maximum (48.3%) in fruits sprayed with (0.75%) $ZnSO_4$. Zinc sulphate (1.0%) increased juice content of Kinnow mandarin (Dixit *et al.,* 1977). Singh and Singh (1981) found that the juice content was increased with GA_3 (15 ppm) spray in Kaula mandarin. The maximum juice content was found in fruits from the trees sprayed with 1.0 and 0.8% urea and zinc sulphate but ascorbic acid content of fruits was decreased with increasing concentration of urea and zinc sulphate in Kinnow (Malik *et al.,* 2000). Sharma *et al*., (2003) reported that maximum juice content was obtained with 0.5% zinc sulphate + 50 ppm gibberellic acid in kagzi lime. Plants of Eureka lemon sprayed with NAA (20 and 40 ppm), GA_3 (10 and 20 ppm), K_2SO_4 (8 and 10%) and borax (0.5 and 1.0%) twice in the month of May showed the highest juice percentage with GA_3 sprays (Bhat *et al.,* 2006). With the present investigation, GA_3 and NAA concentrations increased fruit juice significantly over control. The findings of earlier workers with regards the fruit juice as described above are almost similar to the results obtained under present study.

Significant gradual reduction on peel thickness was shown by foliar sprays of bio-regulators and nutrients over control (Table 2). The minimum peel thickness (2.13 mm) was found with GA_3 15 ppm as compared to the maximum peel thickness (2.70 mm) found under control. Singh and Singh (1984) reported that the peel thickness increased with rising nitrogen rates in Pant Lemon-1. Nitrogen and potassium elements increased peel thickness whereas; phosphorus reduced it significantly in lemon crops (Dilipbabu, 1984; Ahmed *et al.,* 1988; and Deshraj, 1989). Sharma *et al*., (2003) reported that the maximum juice content and the minimum peel thickness was obtained with 0.5% zinc sulphate + 50 ppm gibberellic acid in kagzi lime. Bhat *et al.,* (2006) also observed the maximum juice content and the minimum peel thickness in Eureka lemon when sprayed with GA_3 in different concentrations. These findings of above scientists with respect to peel thickness match with the results of present study.

The maximum total soluble solids (6.58%) was observed with the treatment GA_3 (20 ppm) as compared to the minimum total soluble solids (5.22%) recorded under control. Significant increase in TSS over control was recorded with the sprays of GA_3 (250-1000 ppm) at full bloom stage in Sweet lime Kumar *et al.,* (1975), and sprays of GA_3 (50-100 ppm) in Washington Naval orange (Deidda, 1971). Similarly, sprays of 2,4-D or 2,4,5-T have been reported to increase the TSS in Lahore local (Singh and Randhawa, 1961) and Kinnow mandarins (Chundawat *et al.,* 1975). Application of zinc sulphate 0.4% has resulted into increased total soluble solids (5.19%) in Assam lemon as reported by Langthasa and Bhattacharya (1991). Hafeez *et al.* (1999) reported that foliar spray of zinc significantly increased TSS content in orange juice. Ram and Bose (1994) reported that the mandarin orange treated with 600g urea as soil application + 1.5% foliar application, and spray of $ZnSO_4$ (0.5%) contained more juice and total soluble solids as compared to control plants. Malik *et al.,* (2000) found the significant increase in total soluble solids with receiving 1% urea spray and 0.8% zinc sulphate separately or in combination in mandarin hybrid trees. All these findings of different workers and scientist are justifying the results obtained for total soluble solids under present investigation.

The maximum acidity (6.69%) was observed with the treatment NAA (50 ppm) as compared to the minimum acidity (4.95%) obtained under control. Zidan *et al.,* (1965) reported a reduction in titratable acidity in Balady orange with 20 ppm 2,4-D when sprayed one or two months after full bloom. Similarly, a significant decrease in acidity was reported in Satsuma with NAA sprays (Hirose *et al.,* 1974). On the other hand, Phillips and Meagher (1967) observed an increase in acidity with sprays of 20 ppm 2,4-D or 2,4,5-T in pineapple orange, when sprayed three months before harvest. Similarly, in Unshiu orange, an application of NAA (200 ppm), 30 days after full bloom has been reported to increase the acidity of the juice (Nakajima *et al.,* 1969). Likewise, post bloom sprays of GA slightly increased the acidity in Orlando tangelo and Navel orange (Krezdorn and Cohen, 1963). The nutrient treatments did not cause any significant variation in acidity of fruit of mandarin orange. Although treatments with zinc (0.5%) resulted in slightly higher acidity (1.06) over control (Ram and Bose, 1994). Joshan *et al.* (1995) also reported that the acid content was maximum under 6% and 8% K_2SO_4 treatments in lemon. The results of present study with respect to acidity are more or less similar to the findings of above scientists and little variation in acidity content might be due to the difference in climatic conditions, species and cultivars.

The maximum increase in vitamin C content (21.32 mg/100g of fruit juice) was observed in NAA (10 ppm) and the minimum increase in vitamin C content under

control. Kumar *et al.,* (1975) also reported that the ascorbic acid content was increased significantly in all the sprayed fruits. However, the maximum increase was obtained in fruits treated with PCPA at 100 ppm and 2,4-D at 7.5 ppm in Sweet lime. Singh *et al.,* (1989) reported that both zinc and potash fertilization applied through foliage or soil increased the ascorbic acid content significantly when compared with control in Kagzi lime. The maximum ascorbic acid content was observed in the fruits under 4% K_2SO_4, followed by borax and $CaCl_2$ treatments in lemon (Josan *et al.,* 1995). The ascorbic acid content in fruits was estimated to be highest in fruits treated with NAA (20 ppm), which was closely followed by Mumaur and the lowest under control in aonla cv. NA-10 (Ghosh *et al.,* 2009). Singh *et al.,* (2007) also observed higher ascorbic acid content in aonla fruits treated with micronutrients 0.5% $ZnSO_4$ and 0.4% $CuSO_4$ and plant growth regulators as 10 ppm NAA and 25 ppm GA_3. All sprayed compounds increased vitamin C contents as compared with all other treatments in both seasons, whereas phosphoric acid and activated dry yeast gave the highest vitamin C as compared with all other chemicals in both seasons. Application of NAA (0.001%) during full bloom and at 0.002% during fruit set increased the ascorbic acid content in lemon juice (Arslanov, 1979). Kumar *et al.,* (1975) reported an increase in ascorbic acid content in Sweet lime with sprays of 2,4-D (5-20 ppm) or 2,4,5-T (5-20 ppm) or 250-1000 ppm GA_3 applied at full bloom. On the other hand, sprays of 2,4-D were reported to reduce the same in Balady oranges (Zidan *et al.,* 1965). Application of boron 0.4% concentration significantly increased the vitamin C content of guava fruits as reported by Rawat *et al.,* (2010). Findings of earlier works carried out by various scientists with respect to vitamin C completely match with the results of the present study.

The maximum total sugars (0.30%) were observed with the treatment GA_3 (20 ppm) and the minimum (0.11%) under control. In lemon, application of NAA (0.001%) during full bloom and (0.002%) during fruit set increased the sugar content of the juice (Arslanov, 1979). Similarly, increase in the total sugar content was also reported with 2, 4-D (15 ppm) in Duncan grapefruit (Chundawat and Randhawa, 1973) and (Singh and Randhawa, 1961). On the other hand, in Pineapple orange (Phillips and Meagher, 1967) sprays of 2,4,5-T (20 ppm) were reported to reduce the total sugar content. Singh and Singh (1981) observed in Kaula mandarin that sprays of 15 ppm GA_3 in August, September and October increased the total sugar content by 23.5% over control. Ram and Bose (1994) reported that the mandarin orange treated with 600 g urea as soil application + 1.5% foliar application and spray of $ZnSO_4$ (0.5%) contained more total sugars as compared to control plants. Micronutrient spray with 0.4% zinc sulphate and boric acid are beneficial for improvement in fruit quality of guava (Rawat *et al.,* 2010). All these findings of different scientists are justifying the results of present investigation with regard to total sugars

GA_3 (20 ppm) gave the maximum shelf-life (26.57 days) and the minimum shelf-life (19.36 days) was found in control. Ahlawat *et al.* (1984) reported that the spray of different concentrations of GA_3 alone and in combination with captan fungicide showed the least loss in fruit weight under GA_3 (75 ppm) treatment in kinnow fruits. Kumar and Nagpal (1996) also reported that the fruits dipped in calcium nitrate, calcium chloride and gibberellic acid in mango cv. Dashehari, decreased the firmness of fruits with the increase in storage period but the decrease was much slower in fruits treated with chemicals. Brahmachari *et al.,* (1999) reported that the spray of GA_3 (50 and 100 ppm), Kinetin (20 and 40 ppm), CCC (500 and 1000 ppm) MH (500 and 1000 ppm), calcium nitrate (1 and 2%) and borax (0.4 and 0.8%) 15 days before harvest extended the shelf-life of Purbi litchi fruits as compared to control. Choudhary and Dhaka (2005) reported that gibberellic acid and their combinations were found to prolong the shelf-life of kinnow fruits. All above earlier findings reported by different scientists are almost similar to the results obtained under present study with regards the shelf-life of fruits of Pant Lemon-1.

Table 1. Effect of Foliar Application of Bio-regulators and Nutrients on Physical Characters of Lemon (*Citrus limon* Burma.) cv. Pant Lemon-1 under Subtropical Conditions of Garhwal Region

Treatments	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (gm)	Fruit volume (ml)	Specific gravity of fruits	Peel thickness (mm)
NAA (10 ppm)	5.12	4.89	96.89	97.23	0.975	2.23
NAA (25 ppm)	5.21	5.03	106.24	107.23	0.972	2.27
NAA (50 ppm)	5.31	5.19	110.25	108.25	0.967	2.25
GA_3 (10 ppm)	5.27	5.17	96.32	97.22	0.973	2.16
GA_3 (15 ppm)	5.31	5.21	101.23	100.35	0.977	2.10
GA_3 (20 ppm)	5.57	5.31	102.56	101.98	0.973	2.16
Urea (0.5%)	4.89	4.72	93.09	94.25	0.965	2.38
Urea (1.0%)	5.13	5.06	93.89	94.89	0.960	2.29
Urea (2.0%)	4.98	4.68	94.65	95.41	0.968	2.54
Zinc Sulphate	5.19	4.98	86.23	87.53	0.976	2.67

(0.2%)						
Zinc Sulphate (0.3%)	5.23	5.01	85.86	84.21	0.968	2.48
Zinc Sulphate (0.4%)	5.37	5.04	92.34	93.25	0.966	2.41
Borax (0.2%)	5.14	4.87	79.92	81.02	0.965	2.36
Borax (0.3%)	5.39	5.06	82.45	83.25	0.967	2.42
Borax (0.4%)	5.08	4.86	83.44	81.97	0.964	2.31
Control	4.65	4.46	77.68	76.58	0.986	2.68
S.Em.±	**0.110**	**0.106**	**4.03**	**4.47**	**0.007**	**0.106**
CD at 5%	**0.318**	**0.308**	**11.64**	**12.93**	**0.021**	**0.306**

Table 2. Effect of Foliar Application of Bio-regulators and Nutrients on Chemical Characters of Lemon (*Citrus limon* Burma.) cv. Pant Lemon-1 under Subtropical Conditions of Garhwal Region

Treatments	Fruit juice (%)	Total soluble solids (%)	Acidity (%)	Vitamin C (mg/100gm)	Total Sugars (%)	Shelf-life of fruits (Days)
NAA (10 ppm)	41.90	6.35	5.19	21.06	0.169	24.58
NAA (25 ppm)	42.15	6.42	5.52	19.17	0.174	25.12
NAA (50 ppm)	45.87	6.43	6.70	19.04	0.270	25.32
GA_3 (10 ppm)	44.27	6.40	5.73	19.58	0.168	25.78
GA_3 (15 ppm)	45.67	6.50	5.33	19.85	0.282	26.23
GA_3 (20 ppm)	46.40	6.56	5.38	18.90	0.302	26.39
Urea (0.5%)	42.03	6.47	5.73	20.93	0.116	23.21
Urea (1.0%)	42.91	6.33	5.70	20.52	0.125	23.56
Urea (2.0%)	41.59	6.12	5.69	19.98	0.152	23.87
Zinc Sulphate (0.2%)	43.09	6.27	5.28	18.77	0.143	23.89
Zinc Sulphate (0.3%)	42.16	5.98	5.66	18.90	0.157	24.13
Zinc Sulphate (0.4%)	41.09	5.80	5.59	18.63	0.180	24.31
Borax (0.2%)	43.12	6.01	5.57	19.17	0.133	23.11
Borax (0.3%)	40.79	5.60	5.69	19.44	0.148	23.25
Borax (0.4%)	43.71	5.73	5.49	19.04	0.150	23.27
Control	38.11	5.23	4.94	18.77	0.111	19.34
S.Em.±	**0.92**	**0.165**	**0.127**	**0.680**	**0.010**	**0.60**
CD at 5%	**2.68**	**0.477**	**0.369**	**1.966**	**0.031**	**1.75**

CONCLUSION

The findings of present study as summarized above are indicative of beneficial effects of bio-regulators and nutrients applied singly at full bloom stage (about 75% flowers opened) on lemon cv. Pant Lemon-1 under subtropical conditions of Garhwal Region. On the basis of overall performance of treatments on quality characters of fruits, it can be concluded that the values for fruit length, fruit juice, total soluble solids, total sugars, shelf-life of fruits, have been obtained maximum with minimum fruit drop under GA_3 (20 ppm) treatment, while the minimum fruit cracking and the maximum fruit weight, fruit volume, acidity were recorded with NAA (50 ppm). However, the maximum vitamin C was recorded under NAA (10 ppm) foliar application.

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RESEARCH ARTICLE

SCREENING OF *GOSSYPIUM HIRSUTUM* ENTRIES/ BREEDING MATERIAL OF COTTON FOR RESISTANCE TO DIFFERENT DISEASES UNDER RAINFED CONDITION

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Abstract: A field experiment was laid out with the two replications in different entries of cotton (*G. hirsutum*) and two rows of each entries were sown of total thirty one (31) with one check (LRA 5166) at Regional Cotton Research Station (RCRS), NAU, Bharuch, Gujarat entitled as the Screening of *Gossypium hirsutum* entries/ breeding material of cotton for resistance to different diseases under rainfed condition. Differences in resistance to all the diseases were found in the material tested under natural condition. Results revealed that the entries may vary in grade respectively. This study concludes that screening of different entries of cotton for resistance to diseases is an important factor in developing varieties/hybrids with improved resistance to different diseases in cotton crop.

Keywords: Cotton, Screening, Bacterial leaf blight, *Alternaria*, Wilt, Diseases, Resistance

INTRODUCTION

Cotton – A natural fibre. Cotton is a soft, fluffy staple fiber that grows in a boll, or protective case, around the seeds of the cotton plants of the genus Gossypium in the family of Malvaceae. The fiber is almost pure cellulose. The plant is a shrub native to tropical and subtropical regions around the world, including the Americas, Africa, and India.

Cotton is a white fibrous agricultural product that has a wide variety of uses, from textile production, to creating paper, to producing oil and food products. Cotton is grown all around the globe, and is traded internationally as well. The production is influenced by the repeated out breaks of pest and diseases and these are the major factors responsible for lower yield of cotton in India. Out of 30 diseases known to occur in cotton crop from time to time, the bacterial blight is the most wide spread and destructive disease reported to cause yield losses of about 10 to 30 per cent (Bhatti and Bhutta, 1983, Kalpana *et al*., 2004 and Sekhon *et al*., 2008) and also affect the quality of lint (Sharma and Chauhan, 1985). Bacterial leaf blight, boll rots, wilts and leaf spots are the most destructive cotton diseases (Chopra, 1977, Sandipan *et al*., 2016). Under natural, bacterial blight infection, boll yield losses up to 35 % have been reported (Sheo Raj and Verma, 1988). Leaf spots rank third among the diseases on cotton in India. Among the leaf spots, bacterial blight (*Xanthomonas campestris* pv. *malvacearum* (Smith), *Alternaria* leaf spot (*Alternaria macrospora* Zimn) and grey mildew (*Ramularia aereola*) have been reported to be damaging. Bacterial blight (BLB) of cotton caused by *Xanthomonas campestris* pv. *malvacearum* (Smith) Dye affects the entire aerial parts of cotton plant *i.e*. necrosis of parenchymatous tissue in the local phase and blockage of xylem vessels in its systemic phase (Casson *et al*., 1977). In north India, the cotton leaf curl virus disease (CLCuD) caused by a Gemini virus and transmitted by whitefly, *Bemisia tabaci* has become a major threat to cotton cultivation since its appearance in 1993 (Monga *et al*., 2011).

Resistant varieties are the valid option in any disease management strategies. Control of the disease through chemicals, seed treatment or acid delinting is recommended but bactericide alone or in combination with fungicides dose not eradicate the pathogen completely (Khan and Ilyas, 1999; Hussain and Tahir, 1993). Characterization of environment factors conductive for bacterial blight disease may provide a basis to forecast the disease and issue advance warning to cotton growers for its timely management.

Agro meteorological condition of RCRS, Bharuch

An onset of monsoon commenced from mid of June with 30.3 mm rain during 24th and 25th Standard Meteorological Week but it was insufficient for sowing of *Kharif*, 2014-15. The regular monsoon was received after mid of July *i.e.* 157 mm in 29th Standard Meteorological Week, which facilitated sowing of cotton trials which was almost completed by last week of July. The germination was good and satisfactory plant populations were maintained by proper gap filling. During the season total 849.7 mm rain was received in 37 days which was nearly half than previous year (1465 mm in 67 days). There was no rain after 38th SMW, so in absence of late rainfall, the growth of cotton crop was affected little bit but was recovered after interculturing operations.

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Centre	Particulars	2014-15								Average	Total
		June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.		
Bharuch	RF (mm)	40.3	415.8	249.8	132.0	0.0	0.0	0.0	11.8	-	849.7
	RD	4	14	10	8	0	-	-	1	-	37
	Max. Temp.	36.8	33.4	31.8	32.0	36.8	34.0	29.8	28.9	32.9	-
	Min. Temp.	27.7	26.1	24.8	23.9	22.3	20.5	14.5	13.6	21.7	-
	RH (%) Mor.	78.5	83.9	86.5	85.4	66.8	65.8	60.7	70.5	74.8	-
	RH (%) Eve.	50.8	67.8	74.3	63.6	33.8	36.8	31.9	33.9	49.1	-
	Wind Speed	11.4	7.2	5.7	2.8	1.2	0.9	3.2	3.5	4.5	-
	Sunshine hrs.	7.7	4.6	4.5	5.3	8.4	7.9	8.2	8.2	6.9	-

MATERIAL AND METHOD

The susceptible cultivar LRA – 5166 were sown after each two entry in this experiment by dibbling method with the following experimental details (Table: 1). All the recommended agronomic practices were followed for raising the good crop. In each net plot of each treatment randomly tag 5 plants and score 5 lower and 5 middle leaves of each plant in terms of 0-4 grade and work out PDI as mentioned below by using 0-4 scale as given by Sheoraj, 1988 and then these grades were converted into per cent disease incidence (PDI) by using the formula given by Wheeler, 1969 (Bacterial leaf blight and *Alternaria* leaf spot diseases). Here, in this experiment only grades were mentioned for BLB and ALS.

Disease incidence (%)

$$= \frac{\text{No. of infected plants (Numerical grades)}}{\text{No. of leaves observed x Max. Grade}} \times 100$$

For, Bacterial leaf blight (BLB) disease

Score	Description
0	DF= Immune, completely free from bacterial blight
1	R= Resistant, nearly 1 mm in diameter, not coalescing, reddish, not angular, veins free
2	MR= Moderately resistant, leaf area covered up to 2- 10 %
3	MS= Moderately susceptible, infection 11-20 %
4	S= Susceptible, infection more than 20 %

For, Alternaria leaf spot (ALS) disease

Score	Description
0	No infection
1	Few <2mm, scattered, brown spots, < 5 &% leaf area
2	Spots bigger, 3 mm , not coalescing, brown and 6-20 % leaf area covered
3	Spots 3-5 mm, irregular in shape-coalescing,21-40% leaf area covered
4	Spots coalescing to form bigger lesions, irregular->40 % leaf area

For Alternaria disease, it is standard methodology of AICCIP, Cotton and similar disease scale was used by Anil, G. H. in his thesis on Studies on leaf blight of Bt cotton caused by *Alternaria* spp. in 2013 submitted to the University of Agricultural Sciences, Dharward and Hosagoudar *et al*., 2008ab.

For, Wilt disease

Count diseased plants out of total plants assessed and work out per cent disease incidence and decide disease reaction by referring grade chart.

$$\text{PDI} = \frac{\text{No of diseased plants}}{\text{No of plant assessed}} \times 100$$

Score	Description
0	I=No infection
1	R= Slight yellowing and no defoliation, < 5 % wilting
2	MR=Yellowing and browning of leaves, 6-15 % plants showing wilting
3	MS= Yellowing, browning and discolouration of leaves, Some leaves fall off. Of late partial wilting may occur, 16-25 % plants showing wilting
4	S= In early infection seedlings wilt, adult plant show yellowing, browning and dropping off of the leaves, >25 % plants showing wilting

For wilt disease, it is standard methodology of AICCIP, Cotton.

Other scales used for wilting

Resistance has been evaluated in the field as well as in controlled environment based on several other parameters including disease incidence, disease severity, time from planting or inoculum to appearance of symptoms. Disease incidence given by Wiles (1963) as 0-25%= susceptible, 26-50%= moderately susceptible, 51-75%= moderately resistant and 76-100%= resistant. To calculate disease severity on foliar symptoms, rating scales from0-4 given by Wu *et al*., 2003 or 0-5 by Ulloa *et al*., 2006 as 0= no foliar symptoms, 1= chlorosis or

wilt restricted to cotyledons or first leaf, 2= chlorosis or wilt extending beyond the first leaf, 3= moderate to severe foliar symptoms usually based with some abscised leaves, 4= severe foliar symptoms on the entire plant and 5= dead plant and another similar 0-5 rating scale was used by Wang and Roberts 2006 as 0= no symptoms, 1= epinasty and slight dwarfing, 2= 1-30% chlorotic leaves, 3= 31-80% chlorotic leaves and severe stunting, 4= 81-100% chlorotic leaves and 5= plant death. Same rating scale was also used by Lopez-Lavalle *et al*., 2012 in Australia as 0= no disease, 1- one wilted cotyledon, 2= two wilted cotyledons, 3= first true leaf wilted, 4= whole plant wilted and 5= dead plant. In China, a 0-4 scale system was adopted as the national standard for rating leaf symptoms (Wu *et al*, 2003 and Wang *et al*., 2009) as 0= healthy, 1= 25.0% of the leaf surface exhibited disease symptoms, 2= 25.1-50.0% of the leaf surface exhibited disease symptoms or plant were slightly dwarfed in stature, 3= 50.1-75.0% of the leaf surface exhibited disease symptoms or plant obviously dwarfed in stature and 4= >75.0% of the leaf surface exhibited disease symptoms or plants completely defoliated or died.

Table 1. Details of experiment conducted at RCRS, NAU, Bharuch during 2014-15.

Sr. No.	Experiment	Location /Zone	Investigator	Treatments	Variety	Design	Replication	Plot size (m) Gross	Plot size (m) Net	Spacing (cm)	Sowing Date	Fertilizers N kg/ha	Irrigation
1	NP Patho. 1	SG II Bharuch	ARS (Ento.)	31+01	Diff. varieties/ entries	RBD	2	4.50 x 2.40	3.60 x 2.40	120 x 45	21.07.2014	80 & 120	Rainfed

RESULT AND DISCUSSION

Unremitting efforts to locate resistant sources and their utilization in resistance breeding programme are imperative to manage the diseases in the long run. Screening was therefore undertaken to evaluate a number of cotton entries s against the major diseases during *kharif* 2014. Total 31+01 (LC) entries of cotton *G. hirsutum* were evaluated under rainfed condition for their reaction against wilt, alternaria leaf spot and bacterial blight diseases. The results presented in Table 2 indicated that of, out of 31 entries of *G. hirsutum* cotton tested, 30 and 1 entries showed disease free and resistant reaction, respectively against wilt disease, whereas 13, 15 and 3 entries showed disease free, resistant and moderately resistant reaction, respectively against alternaria leaf spot disease, whereas 9, 16 and 6 entries showed disease free, resistant and moderately resistant reaction, respectively against bacterial blight disease under field condition. Among checks, LRA 5166 showed disease free, resistant and moderately resistant reaction, against wilt, alternaria leaf spot and bacterial blight disease, respectively.

Table 2.

Sr. No.	Entries (Code / Decode)		Wilt %	Wilt Grade	Wilt Reaction	Alternaria leaf spot Grade	Alternaria leaf spot Reaction	Bacterial blight Grade	Bacterial blight Reaction
MLT of *G. hirsutum* cotton									
1	1	GSHV-159	0.00	0	DF	0	DF	0	DF
2	2	GISV-216	0.00	0	DF	1	R	1	R
3	3	GISV-272	0.00	0	DF	1	R	2	MR
4	4	GBHV-170	0.00	0	DF	0	DF	1	R
5	5	GBHV-177	0.00	0	DF	1	R	1	R
6	6	GBHV-164	0.00	0	DF	1	R	1	R
7	7	GBHV-180	0.00	0	DF	0	DF	1	R
8	8	G.Cot-20 (CC)	0.00	0	DF	1	R	2	MR
9	9	G.N.Cot-22 (CC)	0.00	0	DF	0	DF	1	R
10	10	G.Cot-16 (LC)	0.00	0	DF	0	DF	1	R
LSVT of *G. hirsutum* cotton									
11	1	GSHV-172	0.00	0	DF	1	R	1	R
12	2	GSHV-173	0.00	0	DF	0	DF	0	DF

13	3	GSHV-175	0.00	0	DF	2	MR	1	R
14	4	GJHV-517	0.00	0	DF	1	R	0	DF
15	5	GJHV-519	0.00	0	DF	2	MR	1	R
16	6	GJHV-526	3.13	1	R	1	R	2	MR
17	7	GJHV-473	0.00	0	DF	0	DF	2	MR
18	8	GBHV-162	0.00	0	DF	1	R	1	R
19	9	GBHV-183	0.00	0	DF	0	DF	1	R
20	10	GBHV-184	0.00	0	DF	0	DF	0	DF
21	11	GBHV-185	0.00	0	DF	1	R	0	DF
22	12	GTHV-10/25	0.00	0	DF	1	R	1	R
23	13	GTHV-7/70	0.00	0	DF	2	MR	1	R
24	14	GTHV-10/28	0.00	0	DF	1	R	2	MR
25	15	G.Cot-20 (CC)	0.00	0	DF	1	R	2	MR
26	16	G.Cot-16 (LC)	0.00	0	DF	0	DF	0	DF
SSVT of *G. hirsutum* cotton									
27	1	GBHV-187	0.00	0	DF	1	R	0	DF
28	2	GBHV-193	0.00	0	DF	0	DF	0	DF
29	3	GBHV-195	0.00	0	DF	0	DF	1	R
30	4	GBHV-198	0.00	0	DF	1	R	1	R
31	5	GBHV-202	0.00	0	DF	0	DF	0	DF

Sr. No.	Cotton	Total entries	Wilt		Alternaria leaf spot				Bacterial blight			
			0	1	0	1	2	3	0	1	2	3
			DF	R	DF	R	MR	MS	DF	R	MR	MS
1	*G. hirsutum* {MLT, LSVT and SSVT}	31	30	1	13	15	3	-	9	16	6	-

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RESEARCH ARTICLE

FORAGING BEHAVIOUR OF ROCK BEE, *APIS DORSATA* ON LAJWANTI GRASS (*MIMOSA PUDICA)* IN SURGUJA OF CHHATTISGARH

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Abstract: An observation was undertaken for foraging activity of *Apis dorsata* on lajwanti grass (*Mimosa pudica*) and found that the maximum activity of *Apis dorsata* was at 1000-1100hrs and the lowest was at 1600-1700hrs and followed by at 0800-0900hrs. In different hours of the day low average population was recorded at 0800-0900hrs (52.44 bees/5min/m^2) and reached its peak population at 1000-1100hrs (140.33bees/5min/m^2) and found decreased lowest at 1600-1700hrs (16.22 bees/5min/m^2).

Keywords: *Apis dorsata*, Foraging behaviour, Lajwanti grass

INTRODUCTION

Lajwanti *(Mimosa pudica)* is also known as chuimui in hindi because of its unique property to droop or collapse when touched and opens up a few minutes later. The Chinese name for this plant translates to "shyness grass". Its Sinhala name is Nidikumba, where 'nidi' means 'sleep'. Its Tamil name is Thottal Sinungi, where 'Thottal' means 'touched' and 'Sinungi' means 'little cry'. Other non-English common names include Makahiya (Philippines, with maka- meaning "quite" or "tendency to be", and -hiya meaning "shy", or "shyness"), Mori Vivi in West Indies. In Urdu it is also known as Chui-Mui. In Bengali, this is known as 'Lojjaboti'. It is a native to South America and Central America.

The plant of Mimosa is usually a short prickly plant with its branches growing close to ground. It grows up to a height of about 0.5 m and spreads up to 0.3 m. The stem of this plant is erect, slender, prickly and well branched. Leaves are bipinnate fern like and pale green in colour with a tendency of closing when disturbed. These are quadri-pinnate, often reddish, leaflets 15 to 25 pairs, acute, bristly, usually 9 to 12 mm long and 1.5mm wide. The flowers of this plant are axillary in position and lilac pink in colour usually occurring in globose heads.

It a medicinal plant used in the treatment of leprosy, dysentery, vaginal and uterine complaints, inflammations, burning sensation, asthma, leucoderma, and fatigue and blood diseases. It is mainly used in herbal preparations for gynecological disorders. It has been said to have medicinal properties to cure skin diseases. It is also used in conditions like bronchitis, general weakness and impotence. It is also used to treat neurological problems. It is recommended in diarrhea, amoebic dysentery and bleeding piles. It is also used in herbal preparations of gynecological disorders. Its extract can cure skin diseases.

Looking to its medicinal value of different parts of the plant for human its flowers are also useful for honey bees it is a good source of pollen due to which attract the bees for foraging. In this paper the foraging behaviour of honey bee is being mentioned on flowers of lajwanti.

MATERIAL AND METHOD

The observations were undertaken at Medicinal garden of Rajmohini Devi College of Agriculture and Research Station, Ambikapur of Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh during 2016. The observations were made randomly selected one square meter area for five minutes from morning 0800hrs to evening 1700hrs. The observations were made on one bee sp Rock bee, *Apis dorsata* foraging on lajwanti flowers.

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RESULT AND DISCUSSION

(A) Lajwanti grass

(B) *Apis dorsata* foraging on Lajwanti flowers

The result depicted in table 1. that the population of rock bee, *Apis dorsata* was recorded minimum at 0800-0900hrs(42.00bees/5min/m^2) in morning time and reached its peak at 1000-1100hrs (156.00 bees/5min/m^2) and the lowest population was recorded at 1600-1700hrs (19.00 bees/5min/m^2) during the first week of September 2016 with mean number 69.85 bees/5min/m^2. However the lowest population was observed at 1600-1700hrs (15.00bees/5min/m2) and the maximum population was recorded at 1000-1100hrs (112.00bees/5min/m^2) with mean population 58.42 bees/5min/m^2 during the second week of September. During third week of September lowest population was recorded at 1600-1700hrs (11.00 bees/5min/m2) and the highest was recorded at 1000-1100hrs (132.00 bees/5min/m^2) with mean population (65.42bees/5min/m^2). However at the morning hour lowest population was recorded at 0800-0900hrs (32.00bees/5min/m2) and increased and reached its peak at 1000-1100hrs (123.00bees/5min/m^2) and lowest population was found at 1600-1700hrs(16.00bees/5min/m^2) during the fourth week of September.

Table 1. Foraging activity of *Apis dorsata* on different hours of the day on Lajwanti grass

	Different hours of the day(Hrs)								
Date of observations	**0800-0900**	**0900-1000**	**1000-1100**	**1100-1200**	**1400-1500**	**1500-1600**	**1600-1700**	**Total**	**Mean**
5/09/16	42	55	156	109	65	43	19	489	**69.85**
12/09/16	54	61	112	77	56	34	15	409	**58.42**
19/09/16	49	52	132	87	76	51	11	458	**65.42**
26/09/16	32	56	123	89	49	39	16	404	**57.71**
02/10/16	45	58	153	76	45	23	12	412	**58.85**
09/10/16	63	71	120	85	71	42	14	466	**66.57**
16/10/16	54	63	134	78	61	38	23	451	**64.42**
23/10/16	66	78	167	98	76	35	21	541	**77.28**
30/10/16	67	81	166	88	66	31	15	514	**73.42**
Total	**472**	**575**	**1263**	**787**	**565**	**336**	**146**	**4144**	**591.94**
Mean	**52.44**	**63.88**	**140.33**	**87.44**	**62.77**	**37.33**	**16.22**	**460.44**	**65.77**

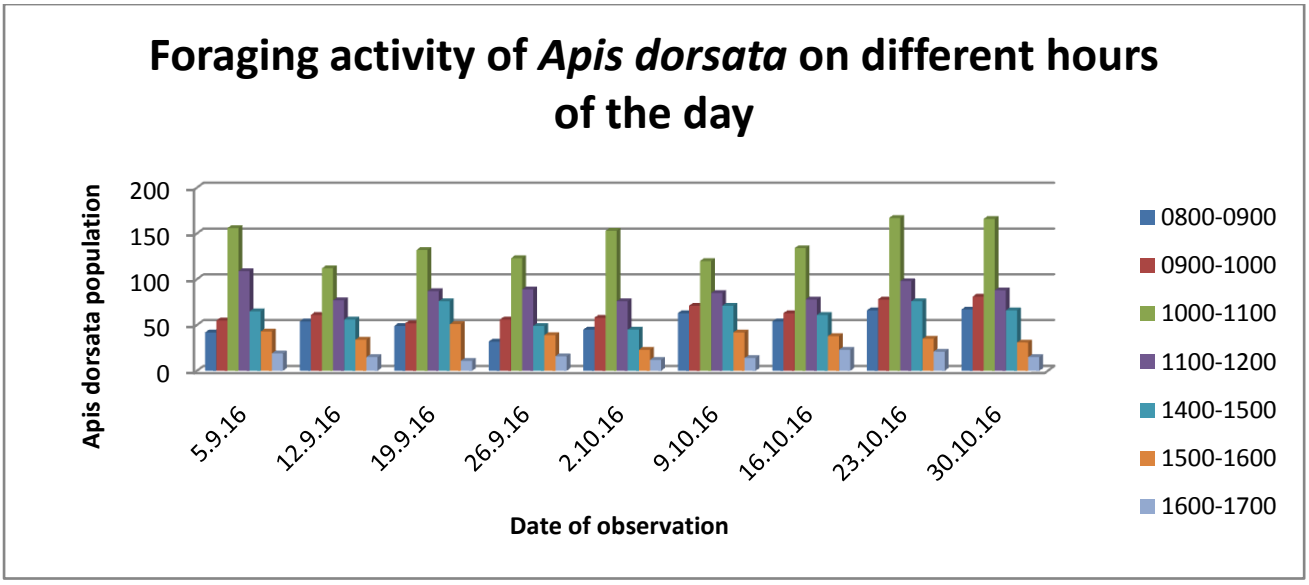

Fig:1. Foraging activity of *Apis dorsata* on different hours of the day on lajwanti grass.

During the first week of October low population was found at morning hour 0800-0900hrs (45.00bees/5min/m^2) increased and reached its peak at 1000-1100hrs (153.00bees/5min/m^2) and completely decreased its population at 1600-1700hrs(12.00 bees/5min/m^2). In Second week of October maximum population was recorded at 1000-1100hrs(120.00bees/5min/m2) and the lowest was recorded 1600-1700hrs(14.00bees/5min/m^2) with mean population 66.57bees/5min/m^2. During the third week of October maximum population was recorded at 1000-1100hrs (134.00bees/5min/m^2) however the lowest population was recorded at 1600-1700hrs (23.00bees/5min/m^2) with mean population (64.42bees/5min/m^2). After that fourth week of October the lowest population was recorded at 1600-1700hrs (21.00bees/5min/m^2) and the highest was recorded at 1000-1100hrs (167.00bees/5min/m^2) however the maximum population was found at 1000-1100hrs (166.00bees/5min/m^2) and lowest was recorded at 1600-1700hrs (15.00bees/5min/m^2) during the last week of October.

In different hours of the day low average population was recorded at 0800-0900hrs (52.44 bees/5min/m^2) and reached its peak population at 1000-1100hrs (140.33bees/5min/m^2) and slowely decreased and found lowest at 1600-1700hrs (16.22 bees/5min/m^2). Earlier workers Venkatachalapathi *et al.(*2015) on medicinal plants, Abrol (2007) on toria, Pushpalatha and Hariprasad (2015) on different bee pasturaging plants and Dalio (2013) on parthenium reported more or less similar foraging activity of honey bees.

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RESEARCH ARTICLE

IMPACT OF VARIOUS INSECTICIDES ON NATURAL ENEMIES IN COWPEA ECOSYSTEM

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Abstract: A field study was conducted to evaluate the safety of insecticides against natural enemies associated with insect pests of cowpea. The results revealed that all the treatments exerted significant impact on the populations of natural enemies (coccinellids, syrphid flies and spiders). However, thiamethoxam 30 FS was found to be relatively safe insecticide against these natural enemies. Combinations (seed treatment with thiamethoxam 70 WS + spray with imidacloprid 17.8 SL, seed treatment with thiamethoxam 30 FS + spray with imidacloprid 17.8 SL, seed treatment with imidacloprid 17.8 SL + spray with thiamethoxam 30 FS), imidacloprid 17.8 SL and spinosad 45 EC were moderate toxic while quinalphos 25 EC was the most toxic for the same. Thus, thiamethoxam, imidacloprid or their combinations as seed treatment and spray, and spinosad can be used in cowpea ecosystem for better pest management as they are less toxic for natural enemies.

Keywords: Insecticides, Natural enemies, Predators, *Vigna unguiculata*

INTRODUCTION

Cowpea, *Vigna unguiculata* (Linnaeus) is one of the important legume crop. In India cowpea is cultivated in approximately 3.9 million hectares with a production of 2.21 million tonnes and the national productivity is 683 kg per ha. Cowpea is usually preferred by farmers because of its role in maintaining soil fertility through nitrogen-fixing (Asiwe *et al.*, 2009**)** and production of nutritious fodder for livestock. More than 100 insect pests have been recorded to cause damage to the cowpea crop at different stages (Adipala *et al.*, 2000**)**. In India, several insect pests *viz.*, pod borer, *Helicoverpa armigera;* spotted pod borer, *Maruca vitrata*; spiny pod borer, *Etiella zinckenella*; pod fly, *Melanagromyza obtusa*; stem fly, *Ophiomyia phaseoli;* pea and bean weevil, *Stiona* spp.; aphids, *Aphis craccivora* and *Aphis fabae;* white fly, *Bemisia tabaci;* defoliators, *Spodoptera litura, S. exigua*, and *Amsacta* spp.; leafhoppers, *Empoasca* spp., thrips, *Megalurothrips dorsalis*, and *Caliothrips indicus*; blister beetles, *Mylabris* spp.; and the bruchids, *Callasobruchus chinensis* and *Bruchus pisorum* have been recorded which cause extensive losses (Sharma and Kaushik, 2010**)**. For the management of these pests, several management tactics have been formulated and advocated but farmers commonly rely on insecticides. Therefore, various insecticides are being used for the management of insect pests in cowpea ecosystem (Kumar *et al.*, 2014). Simultaneously, cowpea is known to have a rich natural enemy complex which plays an importance role in suppression of its insect pests. Use of insecticides in cowpea ecosystem is known to reduce populations of crop pests as well as natural enemies. Reduction in the population of natural enemies can be prevented by using such insecticides which are relatively safe for the same results in better pest management in cowpea ecosystem. Hence, present study was conducted to evaluate the safety of insecticides against natural enemies in cowpea ecosystem.

MATERIAL AND METHOD

The field trial was conducted at Breeder Seed Production Centre (BSPC), Pantnagar during the *kharif* season of 2013. The crop cv. Pant Lobia-1 was grown in a randomized block design with ten treatments *viz.*, quinalphos 25 EC @ 2 ml/lt, profenofos 40 EC @ 3 ml/lt, spinosad 45 EC @ 2 ml/lt, lambda-cyhalothrin 5 EC @ 2 ml/lt, thiamethoxam 30 FS @ 1 ml/lt, imidacloprid 17.8 SL @ 1 ml/lt, seed treatment with thiamethoxam 70 WS @ 5g/kg seed + spray with imidacloprid 17.8 SL @ 0.3 ml/lt, seed treatment with thiamethoxam 30 FS @ 2.4 ml/kg seed + spray with imidacloprid 17.8 SL @ 0.3 ml/lt, seed treatment with imidacloprid 17.8 SL @ 3 ml/kg + spray with thiamethoxam 30 FS @ 0.5 ml/lt and untreated control, replicated thrice. Plot size was 4 x 3 m^2 with spacing of 45 cm x 15 cm row to row and plant to plant, respectively. The first spray of different insecticides was made at 50% of flowering in the crop and second application was made at 25 days after the first application. The natural enemies count was taken in all treatments. The population count of coccinellids, spiders and syrphid flies were recorded on ten randomly selected plants /plot. Pre- spray count was made a day before spraying and post spray counts were made at 3,7,10 and 14 days after each insecticidal application.

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Procedure of seed treatment

One kilogram of cowpea seeds was mixed with 50g of the fine soil in a plastic container, then, 20 ml of water 3-4 drops of gum and required quantity of insecticides were added and stirred carefully. If necessary more water was added drop by drop and stirred well to get slurry. Lid of the container was tightened properly and vigorously shaken for 30 seconds to get uniform coating of the slurry on the seeds. The seeds were then air dried in shade overnight and shown on next day.

Statistical Analysis

The statistical analysis (analysis of variance) was carried out by transforming the data into square root transformed values.

Table 1. Effect of various treatments on the populations of coccinellids, syrphid flies and spiders

Treatment	Pre spray count (mean population per plant)			Mean population of coccinellids (per plant)		Mean population of syrphid flies (per plant)		Mean population of spiders (per plant)	
	Coccinellids	Syrphid flies	Spiders	After I spray	After II spray	After I spray	After II spray	After I spray	After II spray
Quinalphos 25 EC @ 2ml/lt	3.33 (1.95)*	3.33 (1.95)*	3.66 (2.03)*	1.41 (1.33) *	0.16 (0.78) *	0.91 (1.15) *	0.17 (0.79) *	1.08 (1.22) *	0.50 (0.96) *
Profenofos 40 EC @ 3ml/lt	3.33 (1.95)	3.00 (1.87)	3.00 (1.87)	1.58 (1.39)	0.41 (0.92)	1.67 (1.45)	0.58 (1.00)	1.75 (1.48)	0.83 (1.12)
Spinosad 45 EC @ 2ml/lt	2.46 (1.76)	3.33 (1.93)	4.00 (2.11)	2.08 (1.59)	0.50 (0.96)	2.08 (1.59)	0.91 (1.15)	2.00 (1.56)	1.16 (1.25)
Lambda-cyhalothrin 5 EC @2ml/lt	4.00 (2.11)	3.66 (2.03)	3.33 (1.95)	1.58 (1.38)	0.50 (1.00)	1.25 (1.30)	0.41 (0.92)	1.41 (1.36)	0.66 (1.05)
Thiamethoxam 30 FS @ 1ml/lt	3.00 (1.85)	3.00 (1.85)	3.66 (2.03)	2.83 (1.67)	1.25 (1.27)	2.58 (1.74)	1.75 (1.48)	2.83 (1.81)	2.08 (1.59)
Imidacloprid 17.8 SL @ 1ml/lt	3.33 (1.93)	3.33 (1.94)	3.00 (1.87)	2.08 (1.59)	0.91 (1.15)	1.75 (1.48)	0.91 (1.17)	2.25 (1.64)	1.50 (1.39)
Seed treatment with thiamethoxam 70 WS @ 5g/kg seed + spray with imidacloprid 17.8 SL @0.3ml/lt	3.66 (2.03)	3.66 (2.03)	3.33 (1.94)	2.25 (1.62)	0.91 (1.15)	2.00 (1.56)	0.75 (1.09)	1.83 (1.50)	1.25 (1.34)
Seed treatment with thiamethoxam 30 FS @ 2.4ml/ seed + spray with imidacloprid 17.8 SL @0.3ml/lt	3.00 (1.85)	3.00 (1.87)	4.00 (2.11)	2.33 (1.66)	0.75 (1.08)	2.25 (1.65)	1.08 (1.24)	2.50 (1.72)	1.75 (1.48)
Seed treatment with imidacloprid 17.8 SL @3 ml/kg + spray with thiamethoxam 30 FS @0.5ml/lt	3.66 (2.03)	3.33 (1.94)	3.33 (1.93)	1.83 (1.51)	0.66 (1.05)	1.75 (1.48)	0.66 (1.05)	2.25 (1.64)	1.41 (1.36)
Control	2.66 (1.76)	3.66 (2.03)	3.66 (2.03)	4.42 (2.19)	2.67 (1.94)	4.75 (2.29)	2.66 (1.75)	4.75 (2.41)	3.58 (2.00)
SEM±	0.570	0.483	0.483	0.35	0.312	0.27	0.26	0.35	0.31
CD at 5%	1.69	1.43	1.43	1.04	0.927	0.79	0.78	1.05	0.94

*Data present on parenthesis are square root transformed value

RESULT

During the course of investigation, three natural enemies' *viz.*, coccinellids, spiders and syrphid flies were recorded. The data on effect of various insecticides on the populations of these natural enemies are summarized in Table 1.

Impact on coccinellid beetles

A perusal of the data present in Table 1 indicate that coccinellids population before spray was ranged between 2.46 and 4.00 /plant. After first spray, thiamethoxam 30 FS was recorded relatively safe treatment with the highest population of coccinellids (2.83/plant). Next safe treatments were seed treatment with thiamethoxam 30 FS + spray with imidacloprid 17.8 SL (2.33/plant), seed treatment with thiamethoxam 70 WS + spray with imidacloprid 17.8 SL (2.25/plant), spinosad 45 EC (2.08/plant), imidacloprid 17.8 SL (2.08/plant) and seed treatment with imidacloprid 17.8 SL + spray with thiamethoxam 30 FS (1.83/plant) which were at par with one another. Quinalphos 25 EC was recorded highly toxic to coccinellids with lowest population (1.41/plant) in comparison to control (4.42/plant). After second spray also, thiamethoxam 30 FS was found superior in safety against natural enemies as it gave highest population of coccinellids (1.25/plant) followed by imidacloprid 17.8 SL and seed treatment with thiamethoxam 70 WS + spray with imidacloprid 17.8 SL with 0.91 coccinellids/ plant whereas, quinalphos 25 EC was recorded with least number (0.16/plant).

Impact on syrphid flies

The data computed in Table 1 reveal that the population of syrphid flies before spray was ranged from 3.00 to 3.66 /plant. After first spray, thiamethoxam 30 FS was found to be the safest treatment as it gave highest population of syrphid flies (2.58/plant) followed by seed treatment with thiamethoxam 30 FS + spray with imidacloprid 17.8 SL (2.25/plant) and spinosad 45 EC (2.08/plant). However, quinalphos 25 EC found to be toxic to syrphid flies as it recorded with least number (0.91/plant). After second spray, population of syrphid flies ranged from 0.17 to 2.66/plant with highest number (1.75/plant) in thiamethoxam 30 FS and least number (0.17/plant) in quinalphos 25 EC.

Impact on spiders

The same effect was found for spiders also. The population of spiders before spray ranged from 3.00 to 4.00 /plant in all treatments which was gradually decreased after each spray (Table 1). After first spray, maximum number of spiders was recorded in thiamethoxam 30 FS (2.83/plant) which was at par with seed treatment with thiamethoxam 30 FS + spray with imidacloprid 17.8 SL (2.50/plant), imidacloprid 17.8 SL (2.25/plant), seed treatment with imidacloprid 17.8 SL + spray with thiamethoxam 30 FS (2.25/plant) and spinosad 45 EC (2.00/plant) whereas, least number was recorded in quinalphos (1.08/plant). After second spray, same trend of toxicity was observed. The population of spiders was ranged from 0.50 to 3.58/plant. Maximum number of spiders was recorded in thiamethoxam 30 FS (2.08/plant) while minimum number was found in quinalphos 25 EC (0.50/plant).

DISCUSSION

Neonicotinoid insecticides are comparatively new molecule, effective against sucking insect pests and relatively safe for natural enemies (Misra, 2009). Thiamethoxam was found to be relatively safe insecticide for coccinellids. This finding is in agreement with Bharani *et al.* (2015) in tomato ecosystem who reported that neonicotinoids (thiamethoxam and imidacloprid) can be used in compatible manner in IPM programmes for controlling thrips and reducing effect on predatory coccinellids. Imidacloprid can be used for the management of mustard insect pests because of their higher efficacy against aphids and leaf miners and less toxicity to beneficial insects' *viz.*, lady beetle (*Coccinella septumpunctata* L.) and syrphid fly larvae (Amin *et al.*, 2014). Safety of neonicotinoids (thiamethoxam and imidacloprid) as seed treatment against coccinellid predator (*Coccinella septempunctata* L.) is in agreement with Suhail *et al*., 2013. Kannan *et al.* (2004) reported that the seed treatment of transgenic cotton with imidacloprid was not only safe but also attracted predators *viz.*, coccinellid beetles, *Coccinella septumpunctata* (Linnaeus) and *Cheilomenes sexmaculatus* (Fabricius); green lace wing, *Chrysoperla carnea* (Stephens) and Lynx spider, *Oxyopes javanus* (Thorell); orb spider, *Argiope minuta* (Karsh); wolf spider, *Lycosa pseudoannulata* (Boesenberg and Strand); long-javed spider, *Tetragnatha javana* (Thorell); *Neoscona theisi* (Walcknear) and *Peucetia viridana* (Stoliczka) in transgenic cotton. Patil *et al*. (2015) demonstrated that the treatments with imidacloprid 70 WS @ 10 g/kg seed was relatively safe to natural enemies. Thakare *et al.* (2009) also reported that seed treatments of thiamethoxam @ 4 g/kg and imidacloprid @ 10 g/kg were proved safer to lady bird beetle, Chrysopa, Syrphid fly, Spiders on Bt cotton. On the contrary, Singh *et al.* (2008) reported that the synthetic insecticides, e.g. cartap hydrochloride 4 G and imidacloprid 17.8 SL adversely affected to the spider's fauna in Basmati rice ecosystem. Safety of spinosad for coccinellid beetles is in agreement with Galvan *et al.* (2005) in sweet corn who reported that densities of *Harmonia axyridis* larvae in plots treated with spinosad were generally higher than in plots treated with chlorpyrifos, carbaryl, bifenthrin, and λ-cyhalothrin. Dhanalakshmi and Mallapur (2008) also

reported that among different newer molecules, spinosad 45 SC @ 0.1 ml/l was found as safe as untreated control to natural enemies of sucking pests of okra. Generally, conventional insecticides prove to be more toxic to the natural enemies due to high doses required and high persistency (Samanta *et al.*, 2005). Gogoi *et al.* (2013) reported that quinalphos 25 EC was found to be most toxic to parasitoids. Ningthoujam and Kumar (2012) also reported that organophosphate insecticides are highly toxic to spider in mango ecosystem.

From the present investigation, it can be concluded that newer molecules (neonicotinoids and spinosad) are relatively safe for natural enemies in comparison to conventional insecticides. Therefore, thiamethoxam, imidacloprid or their combinations as seed treatment and spray, and spinosad can be incorporated in IPM programmes and enhanced biodiversity in cowpea ecosystem for better pest management as they are less toxic for natural enemies.

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RESEARCH ARTICLE

EFFECT OF TOP-DRESSING OF NITROGEN ON SORGHUM FORAGE YIELD AND QUALITY UNDER DIFFERENT AGRONOMIC PRACTICES

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Abstracts: A field experiment was conducted during summer season. The effect of various agronomic factors on the growth, forage yield, quality and economics of summer sown forage sorghum at IGKV, Raipur. A Field experiment was laid out in randomized block design with 12 treatments. The treatment T_{11} was found better with regards to plant height, dry mater production, No. of leaves and crop growth rate as campared to other treatments.The crop irrigated at an interval of 10 days and top-dressing of nitrogen @ 30kg ha^{-1} given at 30 DAS recorded maximum green and dry forage yield, protein yield and net returns as compared to rest of the treatments. The sorghum yielded more fodder during first cutting.Treatment T_{11} was found to be more remunerative and economical as compared to other treatments under study.

Keywords: Forage yield, Quality of forage, Sorghum

INTRODUCTION

Sorghum forage is the basic feed for live stock and especially valuable for feeding in all regions of the world. Cured sorghum fodder, with a little protein supplement, maintains cattle in good condition throughout the winter with little or no gain supplement. Sorghum fodder contains 70% carbohydrates, minerals, crude fat and nitrogen free extract (Chaudhry, 1994). Green forage demands for rapidly expanding livestock industry is increasing day by day in India. Cutting of sorghum is capable of producing high-quality forage in mid to late summer when cool-season perennials have low production (Undersander *et al*., 1990). Forage sorghum grass is an important livestock feed, often used to produced silage, hay or pasture during summer when adequate supply of moisture is available for the production of other crops (Fribourg, 1995). Timing and placement of N fertilizer have a major effect on the efficiency of N management systems. Nitrogen is the key element of plant growth and is the most liminting nutrient. It promotes shoot elongation, tillering and regeneration after defoliation. The present study was therefore planned with the object to determine the effects of different agronomic practices for obtaining maximum fodder yield of sorghum.

To manage the sorghum crop for achievement of maximum forage production, the farmer should be concerned about nitrogen requirement (Vanderlip, 2012). Although sorghum is a C4 crop and uses nitrogen in a more efficient way compared to most C3 crops, nitrogen is the most essential nutrient for sorghum growth, which is still one of the major factors limiting its yield (Young and Long, 2000). On the other hand, while nitrogen fertilization increases growth of sorghum and its yield, inappropriate amount of fertilizer during cultivation leads to lower plant performance and reduction in efficiency of the applied fertilizer compared to the actual potential of fertilizer use efficiency (Zhao et al., 2005).

MATERIAL AND METHOD

The research was carried out at the Research cum Instructional Farm, IGKV, Raipur (C.G.) during *Summer* season. Raipur is situated in mid-eastern part of Chhattisgarh state and lies at 210 16' North Latitude and 810 36' East Longitude with an altitude of 314.15 above the mean sea level. The soil of experimental field was sandy loam in texture and neutral in reactions. It is deep and hence, has good water holding capacity. It was neutral in reaction, low in nitrogen, medium in available phosphorus and medium exchangeable potassium.The crop received about 90 mm rains during the growth periods. The experiment was laid out in Randomized Block Design with 3 replications. The treatment compare of 12 combination T_1(cut at 8$\pm$2cm, CH+Inter.+Irri. At 15 DI), T_2(cut at 8$\pm$2cm, CH+Inter.+Irri. At 15 DI), T_3(cut at 8$\pm$2cm, CH+2,4-D +Irr. At 15 DI), T_4(cut at 8$\pm$2cm, CH+2,4-D +Irri. At 15 DI), T_5(cut at 8$\pm$2cm, CH+Inter.+N_{30} +Irri. At 15 DI), T_6(cut at 8$\pm$2cm, CH+2,4-D +Irri. At 15 DI), T_7(cut at 8$\pm$2cm, CH+Inter +Irri. At 10 DI), T_8(cut at 8$\pm$2cm, CH+Inter +Irri. At 10 DI), T_9(cut at 8$\pm$2cm, CH+2,4-D +Irri. At 10 DI), T_{10}(cut at 8$\pm$2cm, CH+2,4-D +Irri. At 10 DI), T_{11}(cut at 8$\pm$2cm, CH+Inter+N_{30} +Irri. At 10 DI), T_{12}(cut at 8$\pm$2cm, CH+Inter +N_{30}+Irri. At10 DI).

RESULT AND DISCUSSION

Growth and yield attributes

Plant height plays an important role in the final yield of fodder crops. Plant height indicated that T_{11} affect

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the plant height significantly.The treatment T_{11} produced the tallest plants followed by others.

The plant height recorded during initial stage of the growth did not differ significantaly but there was progressive increase in the height of sorghum plant during 90 DAS due to various treatments specialy T_{11} was better as compared to other treatment. This indicated that top-dressing of nitrogen was better as compared to basal application. This may be due to the fact that nitrogen enhanced the vegetative growth of the plant, accelerated the elongation of internode by the increased supply of nitrogen to cell sap.The minimum (107.23cm) plant height was observed in T_2. The results indicated that different agronomic practices with top-dressing of nitrogen application has pronounced effect in increasing vegetative growth of crop plants. Significant increase in plant height with nitrogenous fertilizers has also been observed in maize by Desai and Dore (1980), Bajwa *et al.* (1983), Abbas and Al-Younis (1980) Abdel-Gawad (1983), Safdar (1997) and Ahmad (1999).

Table 1. Effect of nitrogen on different growth parameters and yield attributes.

Treatment	Plant ht.(cm) 90 DAS	CGR,(g plant^{-1} day^{-1}) 90 DAS	Total Dry matter yield (q ha^{-1})	Total Green forage yield, (q ha^{-1})	Nitrogen uptake, kg ha^{-1} (100 DAS)	Protein yield (q ha^{-1})	B:C Ratio
T_1	109.31	0.506	164.99	661.72	73.25	4.47	1.70
T_2	107.23	0.505	161.18	655.42	68.62	4.28	1.67
T_3	110.18	0.494	160.10	647.05	67.04	4.18	1.66
T_4	107.32	0.488	158.08	636.94	67.91	4.24	1.62
T_5	118.19	0.530	173.63	671.45	79.26	4.95	1.70
T_6	113.17	0.524	165.81	663.22	73.28	4.57	1.66
T_7	112.12	0.513	170.11	680.54	74.39	4.71	1.47
T_8	108.30	0.510	166.33	661.89	74.08	4.62	1.40
T_9	110.23	0.496	168.40	662.93	74.72	4.66	1.42
T_{10}	108.17	0.494	166.18	653.94	73.00	4.56	1.39
T_{11}	128.26	0.562	184.48	725.41	83.58	5.21	1.57
T_{12}	121.27	0.534	179.12	709.08	80.05	4.99	1.51
SEm±	2.11	0.022	1.77	6.31	1.03	0.04	
CD (0.05)	6.17	0.066	5.18	13.09	3.02	0.20	

The top-dressing of nitrogen in conjunction with increased frequently of irrigation applied at 10 days interval resulted in higher values of CGR and Dry matter during all the stage of crop growth. Dry matter accumulation was directly related with the growth pattern of the crop, which linearly influences the biological yield and increased with the advancement of crop age. The result showed that treatment T_{11} was better than the rest of the treatment.

Fodder yield

Fodder yield is a function of genetic as well as environmental factors which plays a vital role in plant growth and development. All the treatments differed significantly from one another except T_{11}which were statistically at par with each other (Table 1).Green and dry fodder yield of forage sorghum was affected significantaly due to various treatments with regards to green and dry fodder

yields optimum supply of irrigation and top-dressing of nitrogen.The maximum green dry forage yield under the treatment T_{11} might be responsible for handsome net return per hectare.The economics and net returns per hectare showed spectacular variation due to different treatments under study.Maximum net returns per hectare was found under the treatment T_{11}. The benefit:cost ratio was, however greater in the treatment which received irrigation at fortnightly interval because of less cost of cultivation involved in the said treatment. The higher net returns due to adequate supply of irrigation and top dressing of nitrogen was also reported by Patel *et al*.1992.

Dry matter yield

The effect of top-dressing of nitrogen, result was recorded significant on total dry weight(Table 1). Nitrogen application increased total dry weight so that T_{11} treatments resulted in the higher total dry weight.Total dry weight was the second most sensitive trait to nitrogen application along with different agronomic practices, which showed a 184.48 qha^{-1} highest increase as a result of nitrogen application along with irrigation. Accoring to result T_{11} (cut at 8$\pm$2cm, CH+Inter+N_{30} +Irri. At 10 DI) was better as compared to other treatment. Higher nitrogen can cause delay in leaf senescence leading to a larger biomass accumulation. According to Borrell and Hammer (2000).

Qualitative parameters

The nitrogen uptake was also influenced by various treatment, maximum being found under the treatment T_{11}. Sorghum crop draws maximum quantity of nitrogen during its initial stage of growth followed by steady reduction in nitrogen uptake with the advancement of crop age. With regards to protein yield, treatment (T_{11}) again proved significantaly better during 100 DAS resulting maximum protein yield of 5.21 qha^{-1}.Treatment T_{11}(cut at 8$\pm$2cm, CH+Inter+N_{30} +Irri. At 10 DI) was found to be superior with regards to nitrogen uptake and protein yield.

CONCLUSION

In the present study, it was shown that nitrogen could affect most sorghum measured growth and forage parameters. The highest plant height, crop growth rate, dry matter accumulation, total dry weight as well as biological yield were achieved from top-dressing of nitrogen application treatment. Nitrogen could increase physiological indices such as plant height, CGR and Dry matter yield. Overall, the results of this experiment demonstrated that nitrogen could have a positive effect on sorghum growth and yield.It was concluded that although green fodder yield was increased with the application of top-dressing of nitrogen fertilizer, however, green fodder yield obtained with a combination of T_{11}, was as good as compared to other treatment.

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RESEARCH ARTICLE

GROWING STOCK ESTIMATION AND SOIL PHYSIO-CHEMICAL PROPERTIES UNDER TEAK AND SHISHAM PLANTATION OF DEHRADUN, UTTRAKHAND, INDIA

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Abstract: The soils under two Plantations i.e Teak (*Tectona grandis*) and Shisham (*Dalbergia sissoo*) were analysed for physio-chemical properties and growing stock. Soil samples were analyzed for texture, water holding capacity, pH, available potassium, available phosphorus, total nitrogen, organic carbon, electrical conductivity, calcium and magnesium. Average available potassium was maximum (102 ppm) in *Tectona grandis* plantation, whereas it was (32.00ppm) in shisham plantation. Similarly available phosphorus was highest in Teak (18.17ppm) whereas in shisham it was (2.75ppm). Organic carbon and total nitrogen were also maximum under teak plantation. The soil pH under eucalyptus was near neutral, whereas it was slightly acidic in shisham. The average available calcium and magnesium were also higher in teak plantation. The average electrical conductivity in both the plantations was 0.03dsm^{-1}. The maximum growing stock was recorded under Teak. A positive correlation was found between G.S and soil organic matter and organic carbon.

Keywords: Organic matter, Growing stock, Teak, Shisham

INTRODUCTION

The growth and reproduction of forest cannot be under-stood without the knowledge of soil. The soil and vegetation have a complex interrelation because they develop together over a long period of time. The vegetation influences the chemical properties of soil to a great extent. The selective absorption of nutrient elements by different tree species and their capacity to return them to the soil brings about changes in soil properties (Singh *et al*.1986). Concentration of elements in the soils is a good indicator of their availability to plants. Their presence in soil would give good information towards the knowledge of nutrient cycling and bio-chemical cycle in the soil–plant ecosystem.

MATERIAL AND METHOD

This study was carried out in two different vegetation types at Dehradun of Uttarakhand, which lies between 77 20'4"- 78 18'30" E longitude, 29 58'40"-30 20'4" N latitude at an elevation of 620 m (a.m.s.l).The study was conducted at two different sites (Site 1-Lechiwalla for Teak, Site 2-Sidduwalafor shisham) of Dehradun Forest Division. Soil samples were collected at three different places, randomly selected in each selected site and thus nine pits were dug out (3 pits at each site) Soil samples were collected from three predetermined depths i.e. 0-10, 10-30 and 30-60cm by opening pits. The water holding capacity (WHC) was determined as per Mishra (1968), whereas the bulk density was estimated by the method of Wilde *et al*. (1964). Total nitrogen was determined by the colorimetric technique (Jackson 1993).

The volume of individual tree species in various sample plots were calculated on the basis of existing volume tables or volume equations based on the Indian Forest records (FSI 1985 I & II) publications for the respective species. Following were the main standard volume equations used in the present study:-

Tecktona grandis $V = 0.0645 + 0.2322\ D^2H$ (Chaturvadi 1973)

Shorea robusta $V = 0.08940 * 2650\ D^2H$ (Chaturvadi1973).

RESULT

The soil texture in *Tectona grandis* plantation was silty loam at 0-10cm depth and silty clay loam at the 10-30cm and 30-60cm depth respectively. The percentage of clay was found higher (40.0%) at 30-60cm depth. Thus this shows that there was the movement of clay from upper to lower horizons. The percent water holding capacity was fond higher (54.02%) at 0-10cm depth. The soil colour varied from dark yellowish brown to yellowish brown. The dark colour is usually related with higher content of organic carbon in the soil. The bulk density usually increase with increase in depth, but it showed a reverse trend in *Tectona grandis* plantation and was thus found higher (0.95%) at 0-10cm depth. The frequent forest fires would have been the reason for it. The soil porosity was found higher (68.84%) at 10-30cm depth (Table 1.1).

In *Tectona grandis* (Teak) plantation the soil pH was neutral and ranged from 7.06 to 7.17. The total nitrogen found, higher (0.30%) at 0-10cm depth. The available phosphorus was found maximum (22.5ppm) at 30-60cm depth and lower (18.0ppm) at 0-10cm depth. The available potassium was found

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maximum (153ppm) at 0-10cm depth (Table 1.2). The electrical conductivity ranged from 0.03dsm-1 to 0.24dsm-1. The exchangeable calcium was found higher 0.26% at 10-30cm depth. The ex. Magnesium was found higher 0.09% at 30-60cm depth. The growing stock under teak was found 227.56m^3/ha (Table 1.2).

The soil texture in *Shorea robusta* (Sal) was silty clay loam at 0-10 and 30-60 cm depths respectively and silty loam at 10-30cm depth. The soil colour varied from pale brown to brownish yellow. The bulk density increase with the increase in depth. Moreover, due to the increase of bulk density with depth the porosity thus showed the reverse trend and decrease with the depth. The moisture content and water holding capacity was found higher (13.38%) and (52.77%) at 30-60cm depth respectively (Table1.3).

The soil pH was slightly acidic and ranged from 6.97 to 6.30. The organic carbon content was found higher in the surface horizon and decrease with the increase in depth that was 1.60% at 0-10cm depth, 0.34% at 10-30cm depth and 0.78% at 30-60cm depth respectively. The electrical conductivity ranged from 0.02dsm-1 to 0.57 dsm-1. The ex. Calcium was found higher 0.11% at 10-30cm depth.The exchangeable Mg was found higher 0.04% at 30-60cm depth. The growing stock for shisham plantation was 121.30m^3/ha (Table1.4).

A positive correlation was found between organic carbon and total nitrogen; growing stock and organic carbon; total nitrogen and Growing stock in all forest types (Table 1.5 &1.6).

DISCUSSION

The average pH (7.12) was found higher in case of Teak forest. The pH was negatively correlated to organic carbon, organic matter, were as it was positively correlated with phosphorus. Paudel and Sah (2003) also found out the same results while working on the Physiochemical characteristics of soil in tropical sal (*Shorea robusta* Gaertn.) forests in eastern Nepal.

Potassium performs very vital processes like regulating transpiration and respiration, influencing enzyme action, synthesis of carbohydrates and proteins etc. (Brady, 1966). Potassium is not much influenced by soil organic matter because it is not the direct supplier of potassium (Gupta and Sharma, 2008). The maximum potassium was reported under Sal fores*t*. The phosphorus was also found higher in the lower horizons of the *Teak* forest, which may be due to the leaching properties of the soils.

In the present study a positive correlation was found between organic carbon, total nitrogen, organic matter and available phosphorus in all the vegetation types. Gupta and Sharma (2008) also showed that nitrogen, organic carbon and phosphorus were positively correlated chiefly because all these attributes are intimately linked with soil humus.

Table 1. Physical properties of soil under (Site 1) *Tectona grandis* plantation

Teak	WHC %	Soil porosity %	Bulk Density %	Moisture Content %	Soil Texture %	Soil Colour		
						Hue	Value Chroma	Colour
0-10	54.02	63.46	0.95	4.4	Silty Loam	10/YR	4/4	Dark Yellowish Brown
10-30	52.47	68.84	0.81	10.1	Silty Clayey Loam	10/YR	5/4	Yellowish Brown
30-60	51.98	65	0.91	9.57	Silty Clayey Loam	10/YR	5/4	Dark Yellowish Brown
Mean	52.82	65.76	0.89	8.02				

Table 2. Chemical properties of soil under (Site 1) *Tectona grandis* plantation

Teak	Total Nitrogen %	Organic Carbon %	C/N Ratio	Available Phosphorus (ppm)	Available Potassium (ppm)	pH	EC dSm^{-1} (1:5)	Ca%	Mg%
0-10	0.308	2.021	6.56	18.0	153	7.06	0.24	0.25	0.04
10-30	0.266	1.603	6.02	17.5	84	7.17	0.06	0.26	0.03
30-60	0.238	1.186	4.98	22.5	69	7.14	0.03	0.19	0.09
Mean	0.27	1.60	5.85	19.33	102	7.12	0.11	0.23	0.05

Table 3. Physical properties of soil under (Site 2) *Dalbergia sissoo* plantation

Depths	WHC %	Soil porosity %	Bulk Density %	Moisture Content %	Soil Texture %	Soil Colour		
						Hue	Value Chroma	Colour
0-10	46.66	63.70	0.85	1.42	Silty Loam	10/YR	7/4	Very Pale Brown
10-30	38.45	66.15	0.88	1.72	Loam	10/YR	7/4	Very Pale Brown
30-60	23.38	56.15	1.14	1.52	Silty Loam	10/YR	6/4	Light Yellowish Brown
Mean	36.16	62	0.95	1.56				

Table 4. Chemical properties of soil under (Site 2) *Dalbergia sissoo* plantation

Depths	Total Nitrogen %	Organic Carbon %	C/N Ratio	Available Phosphorus (ppm)	Available Potassium (ppm)	pH	EC dSm^{-1} (1:5)	Ca%	Mg%
0-10	0.098	0.722	7.36	3.75	51	5.66	0.05	0.15	0.03
10-30	0.064	0.290	4.53	2.50	25	5.71	0.03	0.09	0.02
30-60	0.042	0.132	3.14	2.00	20	6.36	0.03	0.08	0.002
Mean	0.068	0.38	5.01	2.75	32	5.91			

Table 5. Statistical correlation between various parameters in *Tectona grandis* plantation

	T.N%	*OC%*	*C/N R*	*AV.P*	*AV.K*	*pH*	*WHC%*	*Soil.P%*	*SOM*	*B.D*	*M. C %G.S*
T.N%	1										
OC%	0.94**	1.00									
C/N R	0.87	0.98**	1.00								
AV.P	-0.58	-0.82	-0.91	1.00							
AV.K	1.00	0.94	0.86*	-0.57	1.00						
pH	-0.90	-0.70	-0.56	0.16	-0.91	1.00					
WHC%	1.00	0.96**	0.89*	-0.62	1.00	-0.88	1.00				
Soil.P%	-0.58	-0.28	-0.10	-0.33	-0.59	0.88*	-0.54	1.00			
SOM	0.94**	1.00	0.98**	-0.82	0.94	-0.70	0.96	-0.28	1.00		
B.D	0.58	0.28	0.10	0.33	0.59	-0.88	0.54	-1.00	0.28	1.00	
M. C %	-0.96	-0.82	-0.70	0.34	-0.97	0.98	-0.95	0.78	-0.82	-0.78	1.00
G.S	0.88	0.95	0.77	0.33	0.44	0.77	0.77	0.77	0.92	0.87	1.00

Table 6. Statistical Correlation between various parameters in *Shorea robustra* forest.

	T.N%	*OC%*	*C/N R*	*AV.P*	*AV.K*	*pH*	*WHC%*	*Soil.P%*	*SOM*	*B.D*	*M. C %*
T.N%	1.00										
OC%	1.00	1.00									
C/N R	0.99**	1.00	1.00								
AV.P	0.69	0.75*	0.76	1.00							
AV.K	0.96**	0.93	0.92	0.45	1.00						
pH	0.39	0.48	0.49	0.94**	0.11	1.00					
WHC%	0.42	0.33	0.31	-0.37	0.66	-0.67	1.00				
Soil.P%	0.42	0.50	0.51	0.95	0.14	1.00	-0.65	1.00			
SOM	0.99**	1.00	1.00	0.76*	0.93	0.48	0.32	0.51	1.00		
B.D	-0.42	-0.50	-0.51	-0.95	-0.14	-1.00	0.65	-1.00	-0.51	1.00	
M. C %	-0.53	-0.61	-0.62	-0.98	-0.27	-0.99	0.55	-0.99	-0.62	0.99	1.00
G.S	0.88	0.77	0.88	0.22	0.33	0.65	0.88	0.89	0.55	0.66	100

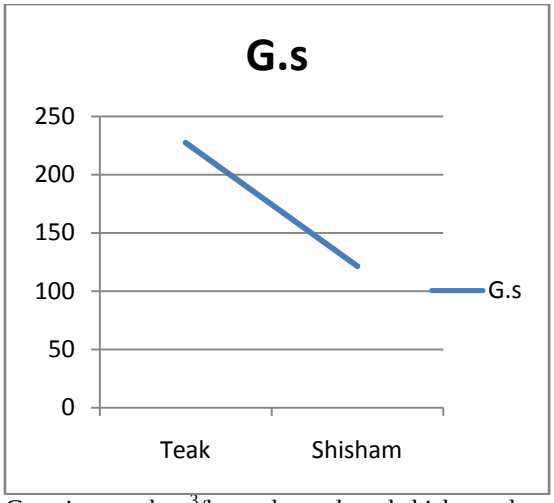

Fig.1. Growing stock m^3/ha under teak and shisham plantations.

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RESEARCH ARTICLE

STUDIES ON SEASONAL INCIDENCE AND EXTENT OF DAMAGE CAUSED BY DIAMONDBACK MOTH, *PLUTELLA XYLOSTELLA* (L.) IN CAULIFLOWER

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Abstract: Survey of seasonal incidence and extent of damage caused by DBM (*Plutella xylostella* Linn.) was conducted at three locations having appreciable areas under cauliflower cultivation during the first fortnight of December to second fortnight of March. It was found that the pest infestation started on cauliflower crop from the first fortnight of January and the activity continued until second fortnight of March. The peak period of infestation was recorded in the second fortnight of February with an average of 7.1 larvae/plant leading to 32.9 per cent plant infestation. In general the incidence of DBM remained low to moderate from the first fortnight of January to the second fortnight of January. The maximum activity of *P. xylostella* confined in the second fortnight of January to the second fortnight of February. Hence, maximum plant protection measures should be taken up against the pest during this period. The plant infestation by the DBM on the cauliflower crop was observed from the first fortnight of January to the second fortnight of March. The maximum infestation of 32.9 per cent, out of which 12.5, 10.3 and 10.1 per cent plants were observed having less, moderate and high degree of damage, respectively. In the first and second fortnights of March the per cent plant infestation was suddenly decreased.

Keywords: Cauliflower, Diamondback moth damage, Population, Seasonal Incidence

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) is one of the most important cole crop of India. It occupies an important place in human diet. Cauliflower has high quality protein and is peculiar in stability of vitamin "C" after cooking. It is rich in minerals such as potassium, sodium, iron, phosphorus, calcium and magnesium. Cauliflower requires a cool and moist growing season and does not endure as much as cabbage does as it is more seriously affected by unfavorable conditions. Rich, heavy loam soils with good drainage and liberal supplies of moisture are ideal for cauliflower growing.

India is the world's second largest producer of vegetables, next to China. The total production of vegetable in India is 98.50 million tones and the total area is about 6.2 million/ha (Anonymous, 2002). In India, cauliflower is more widely grown as compared with cabbage. It is generally grown throughout India during winter season. In summer season it is grown in parts of Bihar, Madhya Pradesh, Himachal Pradesh, Maharashtra and Nilgiri Hills in Chennai.

Diamondback moth (DBM), *Plutella xylostella* (L) (Lepidoptera: Yponomeutidae), is an important pest of cruciferous crops and enjoys worldwide distribution (CIE 1967). Hardy (1938) stated that the pest could breed and develop between 10°C and 40°C and that the adults were active at up to 50°C. Young pupae and the adults survived for several months and the eggs and pupae for two and six weeks, respectively, at 0°C. In India, DBM was first recorded in 1914 (Fletcher 1914) on cruciferous vegetables and a perusal of literature reveals that this species is distributed all over India wherever crucifers are grown. It is one of the more thoroughly studied pests in India. DBM in India infests important crucifers viz: cabbage, cauliflower, radish, khol rabi (knol khol), turnip, beetroot, mustard, *Brassica campestris* var *toria*, and *B. campestris* var *sarson* (Chand and Choudhary 1977, Dube and Chand 1977, Jayarathnam 1977; Singh and Singh 1982). Non-cruciferous crop like *Amaranthus virdis* L has also been reported to be the host of this species (Vishakantaiah and Visweswara Gowda 1975).

Studies on the food plant preference of DBM have revealed that among several crucifers, the pest exhibits a marked preference for cauliflower and cabbage. This is probably due to the fact that both plants possess fleshy and succulent leaves compared to rest of the crucifers tested, and this probably provides olfactory and gustatory stimuli for successful host selection and development (Chand and Choudhary 1977, Dube and Chand 1977, Singh and Singh 1982).

Economic significance and remunerative nature of the cole crops in short span have compelled the growers to adopt intensive vegetable cultivation. It has been estimated that the insect pests are responsible for reducing more than 40 per cent yield in vegetables. Among these the diamondback moth is the most devastating and cosmopolitan pest of crucifer vegetables (CIE, 1967).

The incidence and the damage of DBM is causing 50 to 80 per cent loss in marketable yield and has the pest status of national importance (Srinivasan and Krishnakumar, 1982). The pest is found to be active from July to April with two peak periods, one during September when up to 38 per cent cauliflower plants

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are infested and the other during December to February when 23 to 36.9 per cent cauliflower, 27 to 49 per cent cabbage and 27 to 29 per cent radish plants are infested (Choudhary and Rawat, 1967). The yponomeutid , *Plutella xylostella* was abundant in December- March with a population peak in February, as reported by Lee (1986) and Vishwakarma and Pachori (2002).

MATERIAL AND METHOD

The present investigation was conducted during rabi season. The variety Madhuri was used for investigation. The experiments were conducted at three locations, namely, Amkhera, Maharajpur and Panagar of district Jabalpur (M.P.).

Survey of *Plutella xylostella* L. was carried at three distant locations, namely, Amkhera, Maharajpur and Panagar, where cauliflower and cabbage were grown in large areas. The observations were recorded on two different dates of transplantation of cauliflower till its harvest at fortnightly interval.

For recording the pest incidence at each location, five samples of 20 sq m each were selected, within which five plants were selected randomly and tagged. The plants were observed for recording the incidence of DBM and the total larval population per tagged plant was recorded. Besides recording the pest incidence, the degree of infestation as seen visually was categorized as less, moderate and high, by randomly selecting 10 plants from each plot. Five such samples were recorded from each location. Sampling was carried out by random selection method. The samples were kept free from any insecticidal treatment during the study.

RESULT

Observations recorded at three locations in Jabalpur district from December, soon after the transplantation of cauliflower seedlings, for the seasonal incidence of the pest and per cent plant infestation caused by the DBM larvae are presented in Table 1 and 2.

Table 1. Seasonal incidence of DBM

Locations	Larval population per plant*							
	December		January		February		March	
	1st fortnight	2nd fortnight	1st fortnight	2nd fortnight	1st fortnight	2nd fortnight	1st fortnight	2nd fortnight
Amkhera	0.0	0.0	3.2	4.1	5.5	6.9	6.2	3.3
Maharajpur	0.0	0.0	2.7	4.3	6.4	7.3	6.1	2.9
Panagar	0.0	0.0	2.8	3.9	5.6	7.1	5.8	3.4
Average	0.0	0.0	2.9	4.1	5.8	7.1	6.0	3.2

*Mean of 25 plants

The pest did not appear during the first and second fortnights of December. It appeared in the first fortnight of January at all location and remained in the field until the second fortnight of March. The average larval population range of 2.9 larvae/plant was recorded during the first fortnight of January. The larval population increased in the second fortnight of January to 4.1 larvae/plant. At initial stage 7.2 per cent plants were infested during the first fortnight of January and the per cent plant infestation also increased in the second fortnight of January to 15.6 per cent. The larval population remained low but suddenly increased, because of changes in weather factors and rainfall of 37.0 mm, with an average of 5.8 larvae/plant and per cent plant infestation during the first fortnight of February. The larval population after rainy day suddenly increased in the second fortnight of February with an average of 7.1 larvae/plant and maximum of 32.9 per cent plant infestation.

The larval activity suddenly decreased at the increased maximum temperature of 36.4◦C and relative humidity of 66 per cent with an average of 6.0 and 3.2 larvae/plant with 26.7 and 20.1 per cent plant infestation during the first and second fortnight of March, respectively.

Extent of damage due to DBM

The extent of crop damage due to *P. xylostella* (grading as less, moderate and high) is presented in Table 2.

Table 2. Extent of damage due to DBM

Infestation intensity	Per cent plant infestation*							
	December		January		February		March	
	1st fortnight	2nd fortnight	1st fortnight	2nd fortnight	1st fortnight	2nd fortnight	1st fortnight	2nd fortnight

Less	0.0	0.0	4.1	7.8	10.2	12.5	9.9	6.1
Moderate	0.0	0.0	2.0	4.7	8.3	10.3	9.2	8.9
High	0.0	0.0	1.1	3.1	6.3	10.1	7.6	5.1
Total	0.0	0.0	7.2	15.6	24.8	32.9	26.7	20.1

*Mean of 50 plants

Infestation of *P. xylostella* started in the first fortnight of January. Visual observations led to the determination of 7.2 per cent plant infestation during that period, out of which 4.1 per cent plants were less damaged, 2.0 per cent were moderately damaged and 1.1 per cent were highly damaged, when the maximum temperature was 23.1◦C and relative humidity was 63.5 per cent. In the second fortnight of January the plant infestation increased to 15.6 per cent, out of which 7.8 per cent plants were placed under less damaged category, 4.7 per cent were moderately damaged and 3.1 per cent were highly damaged. The first fortnight of February witnessed further increase in per cent plant infestation which was 24.8, out of which 10.2, 8.3 and 6.3 per cent plants were observed with less, moderate and high degree of damage. During the second fortnight of February a maximum of 32.9 per cent plant infestation was recorded, out of which 12.5, 10.3 and 10.1 per cent plants were observed with less, moderate and high degree of damage respectively, when the maximum temperature was 27.7◦C and relative humidity was 62.0 per cent. In the first fortnight of March the per cent plant infestation decreased abruptly to 26.7 per cent with 9.9, 9.2 and 7.6 per cent of less, moderate and high degree of damaged plants. The second fortnight of March witnessed a further decline trend with 20.1 per cent infestation of cauliflower plants, out of which 6.1, 8.9 and 5.1 per cent plants showed less, moderate and high degree of damage, respectively.

DISCUSSION

Diamond back moth, *Plutella xylostella* (Linn.) is a major pest of cruciferous vegetables crop like cauliflower, cabbage and rapeseed and enjoys worldwide distribution (CIE, 1967; Choudhary and Rawat, 1967; Chelliah and Srinivasan, 1986 and Talekar, 1990). The larvae feed on the crop foliage from the seedling stage up to harvest, ultimately reducing the yield and quality. The pest poses a serious problem due to high reproductive potential, rapid turnover of generations and ability to withstand the diversified conditions of environment.

In Madhya Pradesh no systematic information on the seasonal incidence of DBM is available, though it is of common occurrence. The pest was not observed during the first and second fortnights of December at all three locations. The incidence of the pest on cauliflower was noticed during the first fortnight of January. At the peak period of insect activity, on an average the population was 7.1 larvae/plant with an average of 32.9 per cent plant infestation was recorded during the second fortnight of February at all the three locations. These findings revealed that the second fortnight of February was congenial for the development of *P. xylostella* under the agro-climatic condition of Jabalpur district. This necessitated the plant protection measures to be adopted during the aforesaid period.

This finding was in accordance with the earlier worker Vishwakarma and Pachori (2002), who observed the *P. xylostella* activity on cabbage crop at Jabalpur during the second fortnight of December to second fortnight of March, with peak period during the second fortnight of February. Similarly, Lee (1986) had also reported that *P. xylostella* was abundant from December to March with peak population in February.

Devjam and Singh (1999) noted the density of *P. xylostella* on cauliflower over a period of two cropping seasons from January to April during 1994 and 1995 in Manipur, India. In the present study also the DBM appeared in the first fortnight of January until second fortnight of March.

However, Khaire *et al.* (1987) in Maharashtra found that *P. xylostella* reached at peak during the first fortnight of November, which contradicted the current findings.

In the present investigation, it was observed that the cool temperature and comparatively high relative humidity favored quick multiplication of *P. xylostella*, while the high temperature along with high relative humidity reduced its population considerably, which was in accordance with the findings of Lee (1986) and Vishwakarma and Pachori (2002).

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