

Screening and characterization of Lentil genotypes against Aphid (*Aphis craccivora*) infestation

THESIS

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By

TIKESHWARI NAYAK

Department of Entomology

College of Agriculture, Jabalpur 482004

Jawaharlal Nehru Krishi Vishwa Vidyalaya

Jabalpur, Madhya Pradesh

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All the assistance and help received during the course of the investigation has been acknowledged by her.

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.....
Dr. A. K. Bhowmick

Date:

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THESIS APPROVED BY THE STUDENT’S ADVISORY COMMITTEE

Chairman	Dr. A. K. Bhowmick
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Member	Dr. Sunita Pandey

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.....
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Date:

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MEMBERS OF THE ADVISORY COMMITTEE

Chairman	Dr. A. K. Bhowmick
Member	Dr. A.K. Pandey
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Member	Dr. Sunita Pandey
Head of the Department	Dr. S.K. Shrivastava
Director of Instructions	Dr. S.K. Shrivastava

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Place : Jabalpur

Date :

Tikeshwari Nayak

LIST OF SYMBOLS

Symbol	Abbreviations	Stand for
/		Per
%		Percentage
°C		Celsius
	Fig.	Figure
	et.al	and other
	i.e.	that is
	Temp.	Temperature
	RH	Relative humidity
	viz.	Namely
	Max.	Maximum
	Min.	Minimum
	SW	Standard meteorological weeks
	ha	Hectare
	mt	Million Tonnes
	Hrs	Hours
	Even.	Evening
	Morn.	Morning
	NS	Non significant

INTRODUCTION

Lentil (*Lens culinaris* Medik) is the fourth most important cool season, bushy annual pulse crop. Locally it is known as “masoor” and also known by many regional names viz., adas (Arabic), masur (Hindi), Mercimek (Turkish), heramame (Japanese), lines (German), lenteja (Spanish), lentille (French) and all these names are derived from Latin word ‘Lens’ it is a self pollinated, diploid ($2n=14$) which, belongs to the family leguminosae and subfamily papilionoidae. The major lentil growing countries in South Asia are India, Nepal, Bangladesh and Pakistan. Lentil is considered to be one of the oldest food crops of mankind that researchers have traced back to 7000-8000 BC (Hawtin et al., 1980).

India leads the world in lentil production, and most of the lentil are consumed by India and its neighbor countries. Lentil is called as poor man meat because of its rich protein 28%, carbohydrates 59%, nitrogen and fiber contents, high proportion of vitamin-A, vitamin-B, potassium and iron and low sodium and fat that regulates growth and development, low level of anti nutrients and ability to grow in water stress conditions are main attributes that make lentil an important crop (Anonymous, 2003).

Lentil occupies about 14.12 million ha area in India with a production of 10.80 million tonne and productivity, 765 kg per ha. In M.P. area is 5.71 million hectare and production was 3.33 million tonne and productivity was 584 kg per ha. (Commissioner land record M.P. Gwalior 2012-13). It is mainly cultivated in Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Jharkhand, Bihar and West Bengal. In India the productivity of lentil is low, one of the major region for low productivity is colossal damage caused by various insect pests. Among the insects which damage the lentil crop aphid is most serious and damaging pests. Sometimes it can cause total failure of production, it damages the lentil crop direct through by sucking cell sap. Aphids are able to multiply quickly that a moderate infestation can become a damaging population in less than a week. Aphids damage the lentil mostly by sucking sap but are also responsible for the transmission of viruses.

Aphids heavily fed plants upon are remain stunted and produce fewer and smaller pods and seeds. Smaller plants may die from aphid through cell sap sucking. Aphids can destroy about 25-50% of developing plants.

The use of resistant genotypes in considered as simple, easy, cheap and ideal method of combating pest problem. From farmer's point of view, this can be a most acceptable form of pest control technique. Selection of resistant genotypes may be helpful in reducing pest damage. Therefore the present study was designed to screen different genotypes of lentil against the infestation of *Aphis craccivora* Koch. Totally tolerant and high yielding genotypes of lentil to aphid are not currently available for farmers use but are likely to become available in coming future.

The present study is undertaken in order to find out the tolerant genotypes among different characters and the direct and indirect contributions of these characters toward yield. The use of screening in lentil aphid is a concept, which aims to control the pest population without causing any hazards to environment and development of resistance in insect pest. To achieve such goals the present investigation **“Screening and Characterization of Lentil Genotypes against Aphid (*Aphis craccivora*) Infestation”** was conducted with following objectives.

- To study the role of biotic and abiotic factors on population fluctuation of lentil aphid.
- Screening of different genotypes of lentil for the tolerance/ susceptibility against lentil aphid.
- To study the effect of different morphological characters on tolerance/susceptibility of lentil genotypes against aphid infestation.

REVIEW OF LITERATURE

Perusal of literature reveals that little work was done on pest of lentil (*Lens culinaris*) as related to population dynamics, characterization, and screening of genotype against potential pest. However, the scattered literature was available on these aspects of different genotypes of lentil is being reviewed in this chapter.

2.1 To study the role of biotic and abiotic factors on population fluctuation of lentil aphid.

Sharma and Yadav (1993) studied 8 (*Lens culinaris*) varieties during the 1990-91 in winter season in Bihar, India. K333 had the lowest pest incidence (8.6-9.8 aphids/plant), while PL639 proved highly susceptible with a mean of 33.3-40.0 aphids/plant. Wide inter varietal variation was observed in suitability of plants for predatory coccinellids, which was influenced by crop phenology as well as seasonal changes. These observations suggest the possibility of ecologically sound aphid management in lentil by exploiting the insect-plant relationship against the pest but in favour of its natural enemies, aphidophagous coccinellids.

Karungi et al. (1999) conducted survey on cowpea aphid (*Aphis craccivora*), bud thrips (*Megalurothrips sjostedti*), legume pod borer (*Maruca vitrata*), and pod sucking bugs was studied at 3 sites in eastern Uganda. Intercropping reduced infestation of all pests, but was not as effective as the other control measures.

Rakhshani et al. (2005) reported that parasitoids (Hymenoptera, Braconidae, Aphidiinae) of the cowpea aphid (*Aphis craccivora* Koch) was investigated through out two far distant provinces, Tehran and Sistan-Baluchestan. The aphids were parasitized by an expected range of parasitoids. The species were *Aphidius colemani* Viereck, *Lysiphlebus fabarum* (Marshall), *Lysiphlebus confusus* Tremblay and Eady, *Lysiphlebus testaceipes* (Cresson), *Binodoxys acalephae* (Marshall), *Binodoxys angelicae* (Haliday), *Praon volucre* (Haliday) and *Ephedrus persicae* Froggatt. *L. testaceipes* were reported for the first time in Iran. The most common species was *L. fabarum* followed by *B. acalephae* and *L. confusus*.

Hossain et al. (2006) reported that the lentil crop sown in November received less aphid infestation and consequently produced higher yield than the crop sown in December. During 1999/2000, the avoidable yield loss due to aphid infestation was from 0.90 to 6.78%. The yield increased by 0.91 to 7.27% and 2.72 to 9.89% in 1999/2000 and 2000/01 respectively, due to protection measures taken against aphids and this was also dependent on the different dates of sowing.

Munyuli et al. (2006) tried different predator-pray ratio in the field experiments viz, uncaged plots with 100 aphids to 0 ladybeetles, caged plots with 100 aphids to 0 ladybeetles, caged plots with 100 aphids to 10 ladybeetles and caged plots with 100 aphids to 15 ladybeetles. Results showed that one ladybird beetle consumed 12 aphids per day.

Suja and Beevi (2007) studied that coccinellid predators, *H. octomaculata* had the shortest life cycle of 13.27 days followed by *C. transversalis* with 13.78 days and *M. sexmaculatus* with 18.7 days. A single grub of *C. transversalis* consumed a significantly high number of *A. craccivora* (251.8) compared to *H. octomaculata* consuming 198.22 and *M. sexmaculatus* consuming 127.6 aphids during its life time. Similarly per day consumptions of 30.77, 27.88 and 23.33 respectively.

Dalwadi et al. (2007) studied the Correlation coefficient between weather parameters and pest population revealed that minimum temperature ($r=-0.708^*$), mean temperature ($r=-0.550^*$) and vapour pressure ($r=-0.681^*$) showed significant negative association with aphids, however, its effect was not significant. Relative humidity (R. H.), sunshine hours and wind speed correlated positively with the aphid population. Bright sunshine hours exhibited significant positive ($r=-0.477^*$) correlation, whereas R. H. and vapour pressure showed negative association, however, it was non-significant.

Valerio et al. (2007) studied on the Aphids and natural enemies were quantified and identified weekly during the crop period. Predators (coccinellids) were released in order to control aphid populations. *Aphis craccivora* Koch, *Aulacorthum solani* (Kaltenbach) and *Macrosiphum euphorbiae* (Thomas) were also identified. Predator activity (anthocorids,

cecidomyiids, coccinellids, chrysopids, spiders and syrphids) was the most efficient in controlling aphid populations. Aphid population levels always reached high values in the two years of assays, especially *A. gossypii*.

Almeida-e-Silva et al. (2007) reported that the Population variations in *Acyrtosiphon* spp., *T. maculata* and *Aphis craccivora* seems to be regulated by density-dependent processes. Resistant cultivar CUF 101 had a lower abundance of *T. maculata* and *A. craccivora* and a narrower population variation than the other cultivars and may reduce their abundance in the field. Long-term studies on population dynamics including the effects of climatic conditions and density-dependent factors on plant quality will greatly contribute to pest management in lucerne fields.

Prasad et al. (2008) conducted experiments on lentil aphid revealed that during summer, maximum and minimum temperatures, morning and evening relative humidity and wind velocity showed significant negative correlation whereas, remaining parameters fail to show any significant correlation with aphid population. The coefficient of determination (R²) between weather parameters and aphid population during *rabi*, summer and *kharif* seasons was 15.47%, 44.58% and 12.70% respectively over seven years of study, suggesting the importance of these parameters in influencing the abundance of *A. craccivora*.

Chacon et al. (2008) conducted survey with factorial field experiment that measured the effect of releasing *A. colemani* and of excluding resident natural enemies using field cages on soybean aphid populations. Releasing *A. colemani* in open field plots increased soybean aphid control beyond that observed in open field plots . Molecular gut-contents analysis revealed that at least two predators, *Harmonia axyridis* (Pallas) and *Chrysoperla carnea* Stephens, engaged in intraguild predation against *A. colemani*. The prolonged effect of intraguild predation on parasitoid establishment remains to be determined.

Laamari et al. (2008) reported that the aphid infestation in a dry weight loss of only 3.09% compared with the uninfested plants. The antibiotic resistance of this landrace also significantly decreased the biological potential

of the cowpea aphid. In addition to the agronomic and heritage value, some of the landraces of the Biskra region displayed tolerance and antibiosis characteristics, suggesting that they might serve as an important genetic resource in future bean selection programmes. All the tested landraces were attractive to *A. craccivora* but only this preference was marked more for cultivars V23 and V24.

Angayarkanni and Nadarajan (2008) studies on the biology and seasonal activity of *Aphis craccivora* in cowpea ecosystem revealed that the aphid remained active throughout the year. The three predators, viz., *Menochilus sexmaculatus* [Cheilomenes sexmaculata], *Micraspis* sp. and *Coccinella transversalis*, and spiders were recorded feeding and breeding on the aphid colonies in the field conditions.

Thejaswi et al. (2008) studies on the population dynamics of field bean revealed that, during the study period 22 species of insect pests were recorded on field. Among sucking pests *Aphis craccivora* Koch, leaf hoppers, thrips, *Riptortus pedestris* F., *Riptortus strennus* Horvarth, *Coptosoma cribraria* F, *Anoplocnemis phasiana* F. and *Nezara viridula* L. were more predominant. Defoliators like *Spilactia obliqua* Walker and grass hoppers were also observed but in less numbers. The natural enemies recorded included *Campoletis chlorideae* Uchida, *Bracon* sp. nr. green, *Herpector costalis* (Str.), *Cryptopeltis tenuis* (Mirid), ladybird beetles, mirids, syrphids and carabid predators.

Prasad et al. (2008) conducted a field experiment during 2001/02-2005/06 on the population dynamics of sucking pests infesting cotton in Guntur, Andhra Pradesh, India. The incidence of aphids had significant negative association with maximum temperature, minimum temperature, evening relative humidity and rainfall and positive association with morning relative humidity. The total influence of all the weather parameters was high and significant on the leafhoppers (51.78%) and whiteflies (60.26%) population, while it was low and non-significant on the aphids and thrips population.

Hasan et al. (2009) reported that the highest number of aphid was observed in the vegetative parts of the mustard plant in the morning. High cloudiness, relative humidity and dew point favoured the aphid population and slight rainfall quickly declined the aphid population. Among the different environmental factors maximum temperature, dew point and sun shine hours were positively correlated with aphid population and minimum temperature, relative humidity and wind speed were negatively correlated with aphid population.

2.2 Screening of different genotypes of lentil for the tolerance/susceptibility against lentil aphid.

Hariri and Tahhan (1983) studies on the insects affecting faba bean (*Vicia faba*), lentil and chickpea (*Cicer arietinum*). The main insect pests were aphids, *Lixus algirus* (L.) and *Bruchus dentipes* Baudi on *V. faba*, *Sitona spp.* on lentil, and *Liriomyza cicerina* (Rond.), *Heliothis spp.* and *Callosobruchus chinensis* (L.) on chickpea. Screening tests were made for varietal tolerance to these pests, and the effect of cultural practices on infestation rates was also studied.

Owain (2003) observed positive correlations in performance of green peach aphid clones on faba bean and lentil, and of cowpea aphid clones on faba bean and lentil. Bluegreen aphid clones showed a negative correlation in performance on field pea and faba bean.

Salem (2005) reported that the results obtained with regard to the index values indicated that Giza blanca and Giza-3 were more susceptible cultivars to aphid infestation. However, Giza blanca was suggested to possess a tolerant factor because of its high yield in comparison to other tested cultivars. The relative growth rate and the degree of distribution and settlement of the aphid on different cultivars after 24 and 48 hours clarified that the population of aphid on Giza blanca and Giza-3 were more and above the equilibrium position and represented by positive departure. The local bean proved to be the least susceptible cultivar to aphid infestation.

Abdel-Samad and Ahmed (2006) reported susceptibility of the faba bean cultivars could be arranged (in both moths) ascendingly according to the

mean of infestation by the aphid per plant as follows: Misr1 (40.6) and Misr2 (42.6), Giza 40 (54.2) and Giza 429 (58.7). For the leafminer, the arrangement was Misr2 (18.2), Giza 429 (19.8%), Misr1 (23.9%) and Giza 40 (26.1%). Three species of hymenopterous parasitoids were found attacking the aphid: *Lysiphlebus fabarum*, *Aphidius matricariae* and *Trioxys* sp. Three species of parasitoids associated with the leafminer also were found: *Diglyphus isaea*, *Prigalio* sp. and *Opius* sp. These parasitoids reached their maximum during February and March; 21.1% in February and 17.2% in March for the aphid and 12.8% in February and 13.1% in March for the leafminer.

Kumari et al. (2007) screened for the identification of highly tolerant genotypes and their resistant sources, following pedigree analysis. Visual scoring of aphid infestation was performed on a 0-9 scale. Two accessions on 3-year and 23 accessions on 2-year basis of screening were found tolerant to the aphids. Pedigree analysis, all the 26 genotypes showing high degree of tolerance were classified into 5 groups. 'Precoz' was found to be the major source of resistance for 20 entries, followed by 'LG 171' for 3 entries.

Salman et al. (2007) the results showed that the broad bean plants which were irrigated at 56 and 63 days as a first irrigation harboured highly significant numbers of *A. craccivora* compared with the plants irrigated at 14, 21 and 28 days. These results also showed significant negative correlation between the infestation of *A. craccivora* and the yield of broad bean plants. [1 feddan = 0.42 ha].

Moraes and Bleicher (2007) conducted experiment with the intention of evaluating the response of different cowpea, *Vigna unguiculata* (L.) Walp, cultivars to the black aphid (*Aphis craccivora* Koch). Plants were infested twelve days after planting with five adult females per plant. Evaluations were performed three and five days after infestation by visual counting of the adults and nymph forms present on the plants. A variance and Turkey analysis were done with the obtained data at a 5% level of probability. The Epace 10 and Patativa cultivars were less preferred by *A. craccivora*.

Elanchezhyan et al. (2008) reported that the hybrid, Sweta was the best in reducing the shoot and fruit damage by *Leucinodes orbonalis*,

recording a mean shoot and fruit damage of 8.0% and 8.7% (number basis), and populations of spotted leaf beetle, *Henosepilachna vigintioctopunctata*, ash weevil, *Myloccerus spp.*, mealybug, *Coccidohystrix insolitus*, *C. insolita*, aphid, *Aphis gossypii*, leafhopper, *A. biguttula biguttula* and whitefly, *Bemisia tabaci*, recording 8.0, 0.0, 6.5, 6.3, 0.0 and 0.0 numbers/3 leaves, respectively. Hybrids Bejo Sheetal and Pusa hybrid-6 recorded high population of coccinellids, syrphids and spiders.

Kumari et al. (2009) screened One hundred and twelve accessions of lentil (*Lens culinaris* Medik) for tolerance to black aphids (*Aphis craccivora* Koch) and some morphological attributes were recorded to find the association with aphid incidence. Growth habit and days to flowering had shown significant association but with lesser degree while there was no significant role of biomass. Low infestation of aphids was observed on genotypes with green or yellowish green foliage and slightly pubescent leaves. Moderate infestation was recorded in genotypes with dark green foliage while genotypes with ash green foliage and densely pubescent leaves were highly susceptible to aphids.

Souleymane et al (2013) reported that the results revealed among the cowpea cultivar IT97K-556-6 showed some level of tolerance, as 40 % of the seedlings survived until 21 days after infestation even with a high aphid population. The cultivar TVu 1659 had the highest number of aphids per seedling with 59.0 and 268.0 at 9 and 13 days respectively after infestation, respectively while the wild cowpea accession TVNu 1158 had the lowest number of aphids per seedling with 3.2, 11.0 and 25.0 at 5, 9 and 13 days after infestation respectively. A part from having the lowest number of aphids 80% of the seedlings of this wild cowpea line survived to 21 days after infestation. The wild cowpea line TVNu 1158 was consistently aphid resistant and should be a good source of resistance genes for incorporation into cultivated cowpea.

Humyun et al. (2014) observed that the peak population of *A. craccivora* was recorded 110 DAS (May-June). Aphid had significant positive correlation with relative humidity for BARD-479 and Golden cultivars. Whereas, rainfall had negative correlation with aphids on BARD-479, BARI-

2000, BARD-92 and BARD-699 cultivars. Consequently, based on the aphid density and leaf injuries on plant, BARD-699 was more resistant and BRD-479 highly susceptible cultivar.

2.3. To study the effect of different morphological characters on tolerance/susceptibility of lentil genotypes against aphid infestation.

Tickoo et al. (2005) conducted experiment on the cultivated varieties***** and losses due to the biotic and abiotic factors remain the main causes of concern. Direct selection for grain yield. through important yield components like pods/plant, seed weight, plant height and branches, increasing harvest index, increasing biomass, breeding early-maturing varieties, development of bold seeded varieties for export purposes for better seed quality have been recommended. Value-addition to the crop produce in its various parameters will help in creating demand anti enhancing exports.

Lesly (2005) reported that the genotypes revealed high significant variability for the traits; germination percentage, plant height, days to flower initiation, days to flower termination, days to physiological maturity, branches/plant, clusters/plant, number of pods/plant, pod length, seeds/pod, hundred seed weight, harvest index and seed yield per plant. High PCV and GCV values were recorded by seed yield/plant, hundred seed weight, harvest index, number of pods/plant and germination percentage. All the characters showed high heritability except seeds /pod, pod length and number of branches /plant. Genotypes were grouped into 51 and 46 clusters, among them the most divergent clusters were 12:47 and 11:42 in both the seasons respectively.

Savitha. (2008) studied the correlation association that days to 50% flowering, number green pods per plant, test weight, number of racemes per plant and shelling percentage (fresh), showed significant positive association with green pod and seed yield. In pendal types only the pod number recorded the significant positive association with green pod yield per plant. genotype were used for morphological and molecular diversity analysis. On the other hand, limited molecular diversity was observed among every genotypes. Further, the molecular diversity was not concurrent with morphological diversity.

Gupta et al. (2012) studied the variation among the genotypes for the characters plant height, days to maturity, number of primary branches plant-1, number of secondary branches plant-1, height of the lowest pod and 100-seed weight. Yield plant-1 was positively correlated with pods plant-1, seeds pod-1, seeds plant-1 and 100-seed weight. Days to flowering, days of maturity and 100-seed weight showed high heritability. Study of selection indices through discriminate functions observed that LM-123-7 ranked as the best followed by LM-132-7, LM-21-6, LM-24-3 and LM-14-2 and suggests that the highest scoring genotypes might be recommended for farmer's cultivation for better yield.

Ufuk and Zuhail (2013) observed the general similarities between the species in their trait correlation structure and level of integration among traits, but characteristic differences were observed in the patterns of change. The interactions were significant between year and characters in all characters except number of branches/plant. The similar pattern of genetic variation and phenotypic integration observed in these genotypes. This may be due to their close phylogenetic relation and to their ecological distributions. We further examined phenotypic and genotypic correlation for lentil genotypes. Many of the traits measured had significant genotype effects.

Bakhsh et al. (2013) reported that the Inheritance of testa colour, testa pattern, cotyledon color and stem color was studied in crosses of lentil involving parents with brown, grey, green testa color, red and yellow cotyledon color, and with green and coloured seedling stem. These segregating patterns revealed involvement of two genes and a recessive inhibitor in the regulation of testa colour.

MATERIAL AND METHODS

This chapter include details of the material used and methodology followed during the course of present investigations. According to the objectives, the studies were divided into three sections as detailed below.

- To study the role of biotic and abiotic factors on population fluctuation of lentil aphid.
- Screening of different genotypes of lentil for the tolerance/ susceptibility against lentil aphid.
- To study the effect of different morphological characters on tolerance/susceptibility of lentil genotypes against aphid infestation.

3.1 Location:

The experiments were conducted on the Experimental field at Seed Breeding Farm, Department of Plant Breeding and Genetics, College of Agriculture, J.N.K.V.V. Jabalpur during the *rabi* season of the year 2013-2014.

3.2 Climatic Condition

Jabalpur is situated between 22⁰49' and 24⁰8' North latitude and 78⁰2' and 80⁰58' East longitude, at an altitude of 411.78 m above the mean sea level. The climate of the region is typically semi-humid and sub tropical. Jabalpur comes under the agro climatic region of Kymore plateau and Satapura hills and lies in rice-wheat crop zone of the state. The mean annual rainfall is nearly 1423 mm which is received mostly between mid-June to mid-September. The mean maximum temperature during the hottest month of May and June varies from 45.5⁰C to 46.4⁰C. January is the coldest month with mean maximum and minimum temperatures of 24.4⁰C and 7.3⁰C, respectively.

Experimental no.1. To study the role of biotic and abiotic factors on population fluctuation of lentil aphid.

Experimental Details:

1. Variety	:	JL1
2. Replication	:	3
3. Plot size	:	4.5 m ²
4. Spacing (row-row)	:	0.25 m
5. Row length	:	3m
6. Number of row/plot	:	6
7. Date of sowing	:	11-12-2013

Method of observation:

In order to study the Observation on population dynamics of *A. craccivara* on lentil Jabalpur local variety were carried out during *rabi* season of the year 2013-14. The crop was sown in 2nd week of November, observations were taken by counting the no. of aphid from randomly selected 10 plant / plot at weekly interval starting one week of germination till harvesting of crop. Data thus, obtained were correlated with abiotic factors to determine its effect on the population of *A. craccivora*. Population of Aphid, *Coccinella septempunctata* and spider were recorded at the various stages of crop the activity of crop them and the natural enemies found during the branching, flowering, podding stage of crop.

Experimental no. 2. Screening of different genotypes of lentil for the tolerance/ susceptibility against lentil aphid.

Details of experiment:

1. Number of genotype	:	41
2. Design	:	RBD
3. Replications	:	3
4. Plot size	:	4.5 m ²
5. Date of sowing	:	11/12/2013

Table 1: Treatment details (genotypes/variety of Lentil)

Treatment	Genotypes code	Decode	Treatment	Genotypes code	Decode
T1	GP1	DKL 37	T22	GP22	RKL 1003-15 B
T2	GP2	IPL 316 Ch.	T23	GP23	KLS 9-5
T3	GP3	IPL 330	T24	GP24	L 4076 Ch.
T4	GP4	PL 164	T25	GP25	IPL 534
T5	GP5	RKL 603-1	T26	GP26	RKL 1017
T6	GP6	RVL 12-5	T27	GP27	L 4717-1
T7	GP7	LL 1318	T28	GP28	L 4710
T8	GP8	PL 157	T29	GP29	RKL 407-1
T9	GP9	L 4715	T30	GP30	RKL 1003-42E
T10	GP10	IPL 331	T31	GP31	JL 3 Ch.
T11	GP11	PL 160	T32	GP32	L 4716
T12	GP12	JL 3 Ch.	T33	GP33	L 4709
T13	GP13	DPL 62 Ch.	T34	GP34	RL 3
T14	GP14	IPL 329	T35	GP35	JL 3 Ch.
T15	GP15	KLB 13-6	T36	GP36	IPL 327
T16	GP16	IPL 332	T37	GP37	DPL 62 Ch.
T17	GP17	IPL 81 Ch.	T38	GP38	IPL 81 Ch.
T18	GP18	RKL 1003 216	T39	GP39	RKL 604-05
T19	GP19	LL 1242	T40	GP40	RVL 11-6
T20	GP20	L 4714	T41	GP41	IPL 316 Ch.
T21	GP21	VL 523			



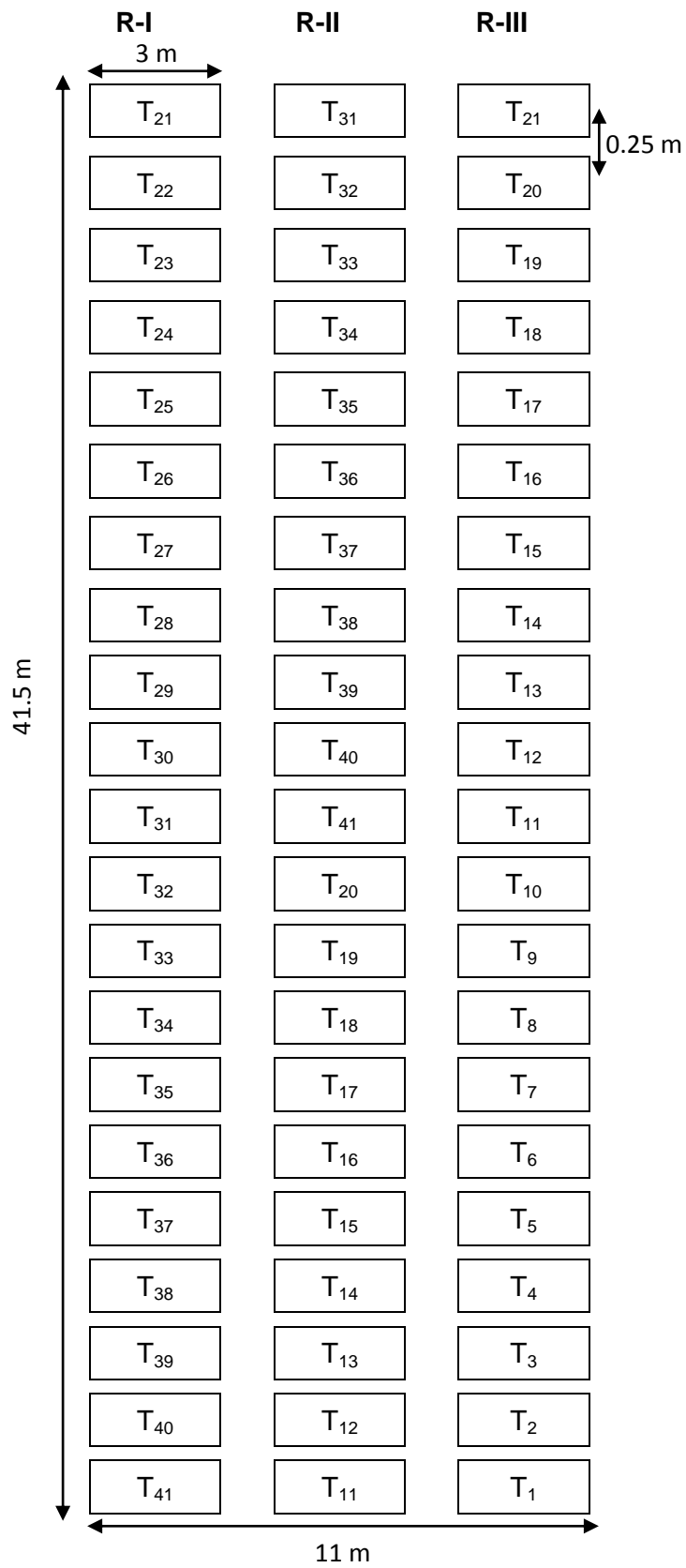


Fig. 1: Layout plan of experimental trial.

Method of observation:-

Screening of different genotypes of lentil for the resistant against lentil aphid. The observations was started from one week after germination and continued till maturity of the crop. From each entries randomly ten plants were selected and recorded the observations. Aphid population was recorded from 10 cm apical twigs per plant. At harvest yield of individual genotype was recorded. Data, so obtained were subjected to appropriate Factorial and transformation analysed for interpretation. The yield of each variety was also recorded separately from net plot area.

Experimental no.3 To study the effect of different morphological characters on tolerance / susceptibility of lentil genotypes against aphid infestation.

Method of observation:-

From each entries randomly 5 plants were selected and observations were recorded on following parameters. Plant height (cm), Primary branch, Secondary branch, Leaflet size, Seed yield / plant (g) and aphid infestation

Analysis of data

Statistical analysis: Correlation studies:

Correlation of the biotic and abiotic factors on population fluctuation were worked out by using the formula as

$$\text{Correlation } r = \frac{\sum xy - \frac{\sum x \cdot \sum y}{n}}{\sqrt{\frac{\{\sum x^2 - (\sum x)^2\}}{n} \cdot \frac{\{\sum y^2 - (\sum y)^2\}}{n}}}$$

Test of significance of correlation coefficient

$$t = \frac{r}{\sqrt{\frac{1-r^2}{n-2}}}$$

Where,

'n' is the number of sets of observations and 'r' is the correlation coefficient, the value of 't' is based on (n-2) degree of freedom.

Data recorded on various aspects were tabulated and subjected to statistical analysis by using the techniques of the analysis of variance. Treatments significance was tested by 'F' test. When 'F' test showed significant difference between the treatments mean values, was further tested for critical difference (CD) at 5% level of significance.

Analysis of variance

The data were subjected to statistical analysis after tabulation in to transformed values. The population data of aphid were transformed to $\sqrt{x + 0.5}$ while data in percentages were transformed to their root square. The data so obtained were analyzed by using the analysis of variance techniques as given below.

Following analysis of variance table was used:

The skeleton of "Analysis of Variance" is given below:-

Source of variation	D.F.	SS	MSS	F
Replication	r-1	SS _R	MSS _R	$\frac{MSS_R}{MSS_E}$
Treatment	(ab-1)	SST	MSS _T	$\frac{MSST}{MSSE}$
A	(a-1)	SS _A	MSS _A	$\frac{MSS_A}{MSS_E}$
B	(b-1)	SS _B	MSS _B	$\frac{MSS_B}{MSS_E}$
AB	(a-1)(b-1)	SS _{AB}	MSS _{AB}	$\frac{MSS_{AB}}{MSS_E}$
Error	(r-1)(ab-1)	SS _E	MSS _E	$\frac{MSS_E}{MSS_E}$
Total	(abr-1)	SS _T		

Where,

A= first factor of level

B= second factor of level

C= correction factor

r = number of replications

t = number of treatments

ai= sum of ith level of factor A

bi= sum of jth level of factor B

trts= Treatment sum of square

MSS_R= replication mean sum of square

MSS_T=treatment mean sum of square

MSS_E= error mean sum of square

The significance among different treatment means was judged by critical difference (C.D) at 5% level of significance for comparison among the treatments, for which the marginal means of each treatment was considered. The following formula was used for various estimations.

(1) Standard error of mean = $S.E.m_{\pm} = \sqrt{\frac{E.ms}{r}}$

(2) Critical difference (C.D.) = $S.E.m \times \sqrt{2} \times t_{0.05}$

Where,

Ems = error mean sum of square

t = 't' value at 5 % level at error d.f.

r = number of replications

$S.E.m_{\pm}$ = standard error of any treatment mean

CD = Critical Difference

RESULTS

The experimental results of present investigations to study the role of biotic and abiotic factors on population fluctuation of lentil aphid, screening of different genotypes of lentil for the tolerance susceptibility against lentil aphid and study the effect of different morphological characters on resistance or susceptibility of lentil genotypes against aphid infestation. The experiment was conducted during *rabi* season of the year 2013-14 at experimental field of Seed Breeding farm, Department of Plant Breeding and Genetics, College of Agriculture, J.N.K.V.V. Jabalpur.

4.1 To study the population dynamics of Aphid (*Aphis craccivora*), Lady bird beetle (*C. septempunctata*) and spider on lentil.

During *rabi* season of the year 2013-14 Aphid (*Aphis craccivora*) infesting lentil crop and their natural enemies lady bird beetle (*C. septempunctata*) and spider activities was observed on the crop. The population of aphid and their natural enemies was correlated with meteorological parameters which is given in table no. 6 and 7.

Table2: Seasonal incidence of Aphid (*Aphis craccivora*), *C. septempunctata* and spider on lentil in relation to Meteorological factors during *rabi* season 2013-14 Jabalpur.

Sr. no	Month	Standard Week	<i>Aphis craccivora</i> /plant 10 cm of apical twigs	<i>C.septempunctata</i> /plant 10 cm of apical twigs	Spider /plant 10 cm of apical twigs
1	January	1	24.0	0.0	0.0
		2	28.7	0.0	0.0
		3	53.3	1.0	1.0
		4	80.3	2.0	0.7
2	February	5	99.0	2.0	2.0
		6	101.0	4.0	1.0
		7	51.0	4.7	1.0
		8	18.3	2.3	1.0
3	March	9	7.0	1.7	0.3
		10	6.3	1.0	0.7

Table 3: Correlation co-efficient between of aphid (*A. craccivora*), *C. septempunctata* and spider on lentil in relation with Meteorological factors during Rabi season 2013-14.

	Rainfall (mm)	Temperature (°C)		Relative humidity%	
		Maximum	Minimum	Maximum	Minimum
Aphid/plant 10 cm apical twigs	-0.53	-0.01	-0.71*	0.23	-0.4
Coccinellids/plant 10 cm apical twigs	-0.04	0.44	-0.25	-0.31	-0.55
Spider/plant 10 cm apical twigs	-0.32	0.16	-0.63*	0.15	-0.58

* Significant at 5 % level of significance

** Significant at 1 % level of significance

4.1.1 Aphid

The incidence of aphid was started from 1st standard week (24.00 aphid/plant/10 cm apical twigs). Initially the population was low. The aphid population gradually increased and reached to its peak on (101.0 Aphid/plant 10cm apical twigs) 6th standard meteorological week (8th February). The aphid population gradually decreased from 7th standard week (51.00 aphid/plant/10 cm apical twigs) to 10th standard meteorological week (6.3 Aphid/plant 10cm apical twigs).

The correlation coefficient of aphid population with meteorological factors showed that the aphid population had significant negative correlation with minimum temperature ($r = -0.71$) while the maximum temperature showed non significant negative correlation ($r = -0.01$). The morning relative humidity had non significant positive correlation ($r = 0.23$) while the evening relative humidity showed non significant negative correlation ($r = -0.4$) with aphid population. The rainfall had non significant negative impact ($r = -0.53$) on aphid population.

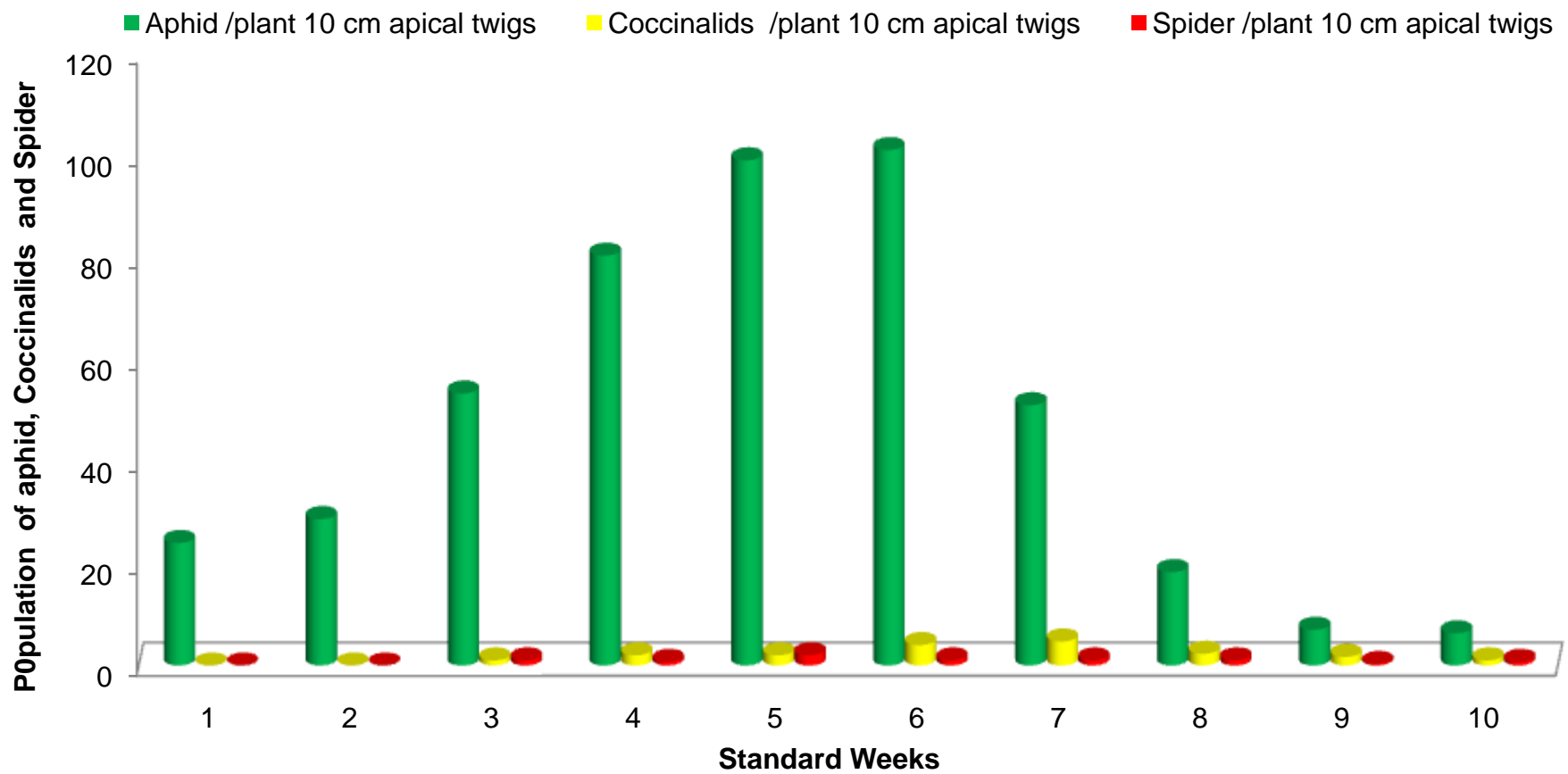


Fig. 2. Seasonal incidence of Aphid (*Aphis craccivora*), Coccinellids and spider on lentil at Jabalpur during rabi 2013-14

4.1.2 Spider

Initially the spider population was nil and its activity was started from 3rd standard week (1.0 spider/plant/10 cm apical twigs) after that the population gradually increased. The peak period for spider activity (2.0 spider/plant10 cm apical twigs) was recorded on 5th standard meteorological week. The spider activity was again decreased from 6th standard meteorological week (1.0 spider to 0.3 spider/plant10 cm apical twigs) to 9th standard meteorological week. However, the lowest spider activity was recorded on 9th standard meteorological week (0.3 spider/plant10 cm apical twigs).

The minimum temperature showed significant negative correlation ($r = -0.63$) while maximum temperature ($r = 0.16$) and maximum relative humidity showed non significant positive correlation ($r = 0.15$) with spider activity. The minimum relative humidity ($r = -0.58$) and rainfall ($r = -0.32$) showed non significant negative correlation with spider population.

4.1.3 *C. septempunctata*

Initially at 1st and 2nd standard week the *C. septempunctata* population was nil (0.00) and its activity was started slowly from 3rd standard week (1.0 *C. septempunctata* /plant/10 cm apical twigs) after that the population gradually increased. The peak period for *C. septempunctata* activity (4.7 *C. septempunctata* /plant10 cm apical twigs) was recorded on 7th standard meteorological week. The *C. septempunctata* activity was again decreased from 8th standard meteorological week (2.3 Lady bird beetle /plant10 cm apical twigs) to 10th standard meteorological week. However, the lowest spider activity was recorded on 10th standard meteorological week (1.0 *C. septempunctata* /plant10 cm apical twigs).

The *C. septempunctata* population had non significant negative correlation with minimum temperature ($r = -0.25$) while the maximum temperature showed non significant positive correlation ($r = 0.44$) with Lady bird beetle population. Both maximum ($r = -0.31$) and minimum (-0.55) relative humidity had non significant negative impact on Lady bird beetle population.

The graph showed that the aphid population (*A. craccivora*) first appeared (24.0 aphid/plant 10 cm of twigs) on 1st standard meteorological week (4th to 10th January). The pest activity slightly increased from 2nd standard meteorological week (11th to 17th January) and gradually reached to its peak (101.0 aphid/plant 10 cm of twigs) in 6th standard meteorological week (8th to 14th February). The predators (spider and Lady bird beetle) population were increased with increased the population of aphid. The graph clearly showed that when the population of aphid was decreased the population of predators were also decreased. The maximum and minimum temperature, relative humidity of morning and evening, rainfall during peak activity period were 28 °C & 10°C, 91 % & 39 %, 0.00 mm respectively. The graph showed that the population fluctuation of aphid (*A. craccivora*) was higher during January and February at the same time the population of predators was also high.

4.2 Screening of different genotypes of lentil for the tolerance / susceptibility against lentil aphid.

Forty one genotypes of lentil were screened against the infestation of aphid, the aphid population on different genotypes were recorded as per the methodologies explained in “Material and Methods” and result are presented in tables 4 and figures 3.

Table 4. Response of different genotypes of lentil against the infestation of aphid (*Aphis craccivora*).

Genotypes	Aphid (<i>Aphis craccivora</i>) population 10 cm apical twigs/plant										
	Periods of observations										
	4 th Jan.	11 th Jan	18 th Jan.	25 th Jan.	1 st Feb.	8 th Feb.	15 th Feb.	22 th Feb.	1 st Mar.	8 th Mar.	Mean
GP1	1.10 (1.26)	1.07 (1.25)	1.57 (1.44)	0.50 (1.00)	0.43 (0.97)	0.90 (1.18)	0.87 (1.17)	0.30 (0.89)	0.27 (0.88)	0.20 (0.89)	0.72 (1.09)
GP2	1.13 (1.28)	0.80 (1.14)	0.87 (1.17)	0.87 (1.17)	0.80 (1.14)	1.00 (1.22)	0.73 (1.11)	1.40 (1.38)	0.47 (0.98)	0.30 (0.89)	0.84 (1.15)
GP3	1.60 (1.45)	0.50 (1.00)	0.57 (1.03)	0.70 (1.09)	0.57 (1.03)	2.00 (1.58)	1.53 (1.43)	0.47 (0.98)	0.27 (0.88)	0.23 (0.86)	0.84 (1.13)
GP4	2.10 (1.61)	0.60 (1.05)	0.63 (1.06)	0.47 (0.98)	0.67 (1.08)	1.00 (1.22)	1.00 (1.22)	0.37 (0.93)	0.23 (0.86)	0.30 (0.89)	0.74 (1.09)
GP5	2.90 (1.84)	0.73 (1.11)	0.23 (0.86)	0.83 (1.15)	0.83 (1.15)	1.30 (1.34)	1.13 (1.28)	0.80 (1.14)	0.57 (1.03)	0.50 (1.00)	0.98 (1.09)
GP6	4.73 (2.29)	0.20 (0.84)	0.37 (0.93)	1.33 (1.35)	1.10 (1.26)	1.20 (1.30)	1.13 (1.28)	0.77 (1.13)	0.47 (0.98)	0.50 (1.00)	1.18 (1.24)
GP7	2.10 (1.61)	0.60 (1.05)	0.57 (1.03)	1.13 (1.28)	1.07 (1.25)	1.20 (1.30)	1.17 (1.29)	0.67 (1.08)	0.50 (1.00)	0.60 (1.05)	0.96 (1.19)
GP8	1.50 (1.41)	0.53 (1.02)	0.87 (1.17)	1.17 (1.29)	0.73 (1.11)	1.07 (1.25)	1.17 (1.29)	0.53 (1.02)	0.60 (1.05)	0.50 (1.00)	0.87 (1.16)
GP9	3.20 (1.92)	0.80 (1.14)	3.90 (2.10)	1.70 (1.48)	1.63 (1.46)	2.40 (1.70)	2.43 (1.71)	1.57 (1.44)	1.20 (1.30)	0.70 (1.10)	1.95 (1.54)
GP10	0.87 (1.17)	0.33 (0.91)	1.90 (1.55)	0.30 (0.89)	0.37 (0.93)	0.50 (1.00)	0.60 (1.05)	0.40 (0.95)	0.37 (0.93)	0.20 (0.84)	0.58 (1.02)
GP11	0.87 (1.17)	0.90 (1.18)	3.27 (1.94)	1.43 (1.39)	1.50 (1.41)	1.30 (1.34)	1.67 (1.47)	1.00 (1.22)	0.83 (1.15)	0.50 (1.00)	1.33 (1.33)
GP12	0.33 (0.91)	4.20 (2.17)	5.60 (2.47)	5.20 (2.39)	2.40 (1.70)	4.07 (2.14)	2.07 (1.60)	2.10 (1.61)	1.20 (1.30)	0.80 (1.14)	2.80 (1.74)
GP13	0.50 (1.00)	0.20 (0.84)	1.40 (1.38)	0.33 (0.91)	1.07 (1.25)	0.53 (1.02)	1.07 (1.25)	0.40 (0.95)	0.37 (0.93)	0.30 (0.89)	0.62 (1.04)
GP14	2.30 (1.67)	0.83 (1.15)	1.40 (1.38)	0.63 (1.06)	1.50 (1.41)	0.77 (1.13)	0.77 (1.13)	0.70 (1.09)	0.50 (1.00)	0.50 (1.00)	0.99 (1.20)
GP15	0.10 (0.77)	1.70 (1.48)	0.60 (1.05)	0.13 (0.80)	0.63 (1.06)	0.77 (1.13)	0.77 (1.13)	0.17 (0.81)	0.13 (0.80)	0.43 (0.95)	0.54 (1.00)
GP16	0.33 (0.91)	0.33 (0.91)	0.30 (0.89)	0.33 (0.91)	0.83 (1.15)	0.37 (0.93)	1.00 (1.22)	0.37 (0.93)	0.33 (0.91)	0.37 (0.93)	0.46 (0.97)
GP17	0.60 (1.05)	0.57 (1.03)	1.20 (1.30)	0.90 (1.18)	1.30 (1.34)	0.83 (1.15)	1.20 (1.30)	0.57 (1.03)	0.50 (1.00)	0.40 (0.95)	0.81 (1.13)
GP18	3.27 (1.94)	0.17 (0.82)	1.53 (1.43)	0.50 (1.00)	1.40 (1.38)	0.83 (1.15)	0.77 (1.13)	0.47 (0.98)	0.40 (0.95)	0.40 (0.95)	0.97 (1.17)
GP19	2.87 (1.83)	0.80 (1.14)	1.03 (1.24)	2.87 (1.83)	1.37 (1.37)	1.90 (1.55)	1.80 (1.52)	1.80 (1.52)	1.10 (1.26)	0.53 (1.02)	1.61 (1.43)
GP20	2.43 (1.71)	2.40 (1.70)	1.47 (1.40)	0.47 (0.98)	1.00 (1.22)	1.27 (1.33)	1.10 (1.26)	0.57 (1.03)	0.40 (0.95)	0.47 (0.98)	1.16 (1.26)
GP21	1.20 (1.30)	0.40 (0.95)	0.90 (1.18)	0.43 (0.97)	1.00 (1.22)	0.67 (1.08)	0.80 (1.14)	0.60 (1.05)	0.30 (0.89)	0.20 (0.84)	0.65 (1.06)

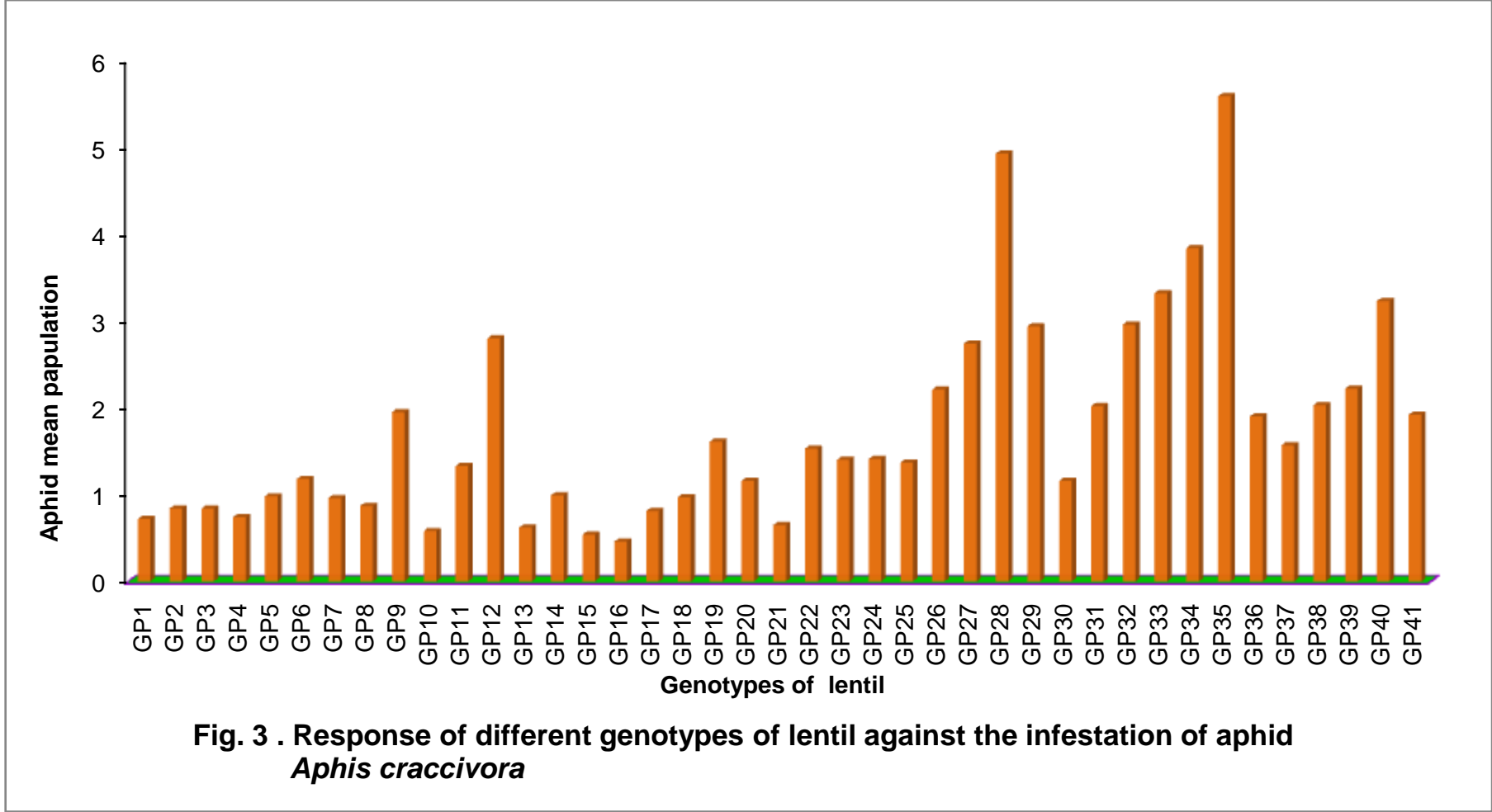
Genotypes	Aphid (<i>Aphis craccivora</i>) population 10 cm apical twigs/plant										
	Periods of observations										
	4 th Jan.	11 th Jan	18 th Jan.	25 th Jan.	1 st Feb.	8 th Feb.	15 th Feb.	22 th Feb.	1 st Mar.	8 th Mar.	Mean
GP22	10.30 (3.29)	0.30 (0.89)	0.77 (1.13)	0.37 (0.93)	1.00 (1.22)	0.37 (0.93)	0.57 (1.03)	0.77 (1.13)	0.57 (1.03)	0.30 (0.89)	1.53 (1.25)
GP23	7.70 (2.88)	1.30 (1.34)	0.30 (0.89)	1.10 (1.26)	0.37 (0.93)	0.67 (1.08)	0.83 (1.15)	0.80 (1.14)	0.60 (1.05)	0.30 (0.89)	1.40 (1.26)
GP24	8.10 (2.93)	0.77 (1.13)	2.53 (1.74)	0.27 (0.88)	0.77 (1.13)	0.27 (0.88)	0.47 (0.98)	0.37 (0.93)	0.40 (0.95)	0.20 (0.84)	1.41 (1.24)
GP25	9.43 (3.15)	1.03 (1.24)	0.37 (0.93)	0.37 (0.93)	0.57 (1.03)	0.37 (0.93)	0.60 (1.05)	0.37 (0.93)	0.40 (0.95)	0.17 (0.82)	1.37 (1.20)
GP26	18.70 (4.38)	0.47 (0.98)	0.23 (0.86)	0.37 (0.93)	0.47 (0.98)	0.40 (0.95)	0.40 (0.95)	0.50 (1.00)	0.40 (0.95)	0.17 (0.82)	2.21 (1.28)
GP27	12.20 (3.56)	3.07 (1.89)	2.13 (1.62)	2.20 (1.64)	0.57 (1.03)	1.80 (1.52)	1.87 (1.54)	2.17 (1.63)	1.00 (1.22)	0.40 (0.95)	2.74 (1.66)
GP28	8.50 (3.00)	3.70 (2.05)	6.07 (2.56)	8.80 (3.05)	0.60 (1.05)	7.30 (2.79)	6.67 (2.68)	5.80 (2.51)	1.20 (1.30)	0.70 (1.09)	4.93 (2.21)
GP29	12.23 (3.57)	0.80 (1.14)	7.43 (2.82)	1.10 (1.26)	4.03 (2.13)	0.83 (1.15)	0.77 (1.13)	1.30 (1.34)	0.50 (1.00)	0.40 (0.95)	2.94 (1.65)
GP30	5.70 (2.49)	0.60 (1.05)	1.40 (1.38)	0.33 (0.91)	1.00 (1.22)	0.60 (1.05)	0.60 (1.05)	0.60 (1.05)	0.50 (1.00)	0.30 (0.89)	1.16 (1.21)
GP31	8.10 (2.93)	0.60 (1.05)	4.80 (2.30)	0.43 (0.97)	0.57 (1.03)	0.87 (1.17)	0.50 (1.00)	0.57 (1.03)	0.60 (1.05)	3.20 (1.92)	2.02 (1.45)
GP32	8.80 (3.05)	4.30 (2.19)	2.10 (1.61)	4.80 (2.30)	0.50 (1.00)	0.80 (1.14)	3.30 (1.95)	3.90 (2.10)	0.70 (1.09)	0.40 (0.95)	2.96 (1.74)
GP33	10.60 (3.33)	10.70 (3.35)	2.13 (1.62)	2.20 (1.64)	1.50 (1.41)	1.30 (1.34)	1.30 (1.34)	2.37 (1.69)	0.70 (1.09)	0.37 (0.93)	3.32 (1.78)
GP34	3.67 (2.04)	0.30 (0.89)	6.03 (2.56)	7.47 (2.82)	1.63 (1.46)	7.83 (2.89)	4.30 (2.19)	5.20 (2.39)	1.50 (1.41)	0.50 (1.00)	3.84 (1.97)
GP35	14.03 (3.81)	5.90 (2.53)	7.60 (2.83)	6.50 (2.65)	4.73 (2.29)	7.33 (2.80)	5.10 (2.37)	3.43 (1.98)	0.80 (1.14)	0.47 (0.98)	5.59 (2.34)
GP36	8.53 (3.01)	1.00 (1.22)	2.90 (1.84)	0.67 (1.08)	3.07 (1.89)	0.43 (0.97)	0.70 (1.09)	0.60 (1.05)	0.60 (1.05)	0.47 (0.98)	1.90 (1.42)
GP37	8.10 (2.93)	0.63 (1.06)	0.63 (1.06)	0.80 (1.14)	1.63 (1.46)	0.87 (1.17)	0.93 (1.20)	1.00 (1.22)	0.50 (1.00)	0.57 (1.03)	1.57 (1.33)
GP38	10.20 (3.27)	1.13 (1.28)	1.80 (1.52)	0.83 (1.15)	2.80 (1.82)	0.73 (1.11)	1.00 (1.22)	0.63 (1.06)	0.70 (1.09)	0.47 (0.98)	2.03 (1.45)
GP39	5.00 (2.35)	2.53 (1.74)	1.20 (1.30)	3.33 (1.96)	0.70 (1.09)	2.70 (1.79)	2.00 (1.58)	3.10 (1.90)	1.10 (1.26)	0.50 (1.00)	2.22 (1.60)
GP40	25.30 (5.08)	0.93 (1.20)	0.17 (0.82)	1.03 (1.24)	1.80 (1.52)	0.70 (1.09)	0.70 (1.09)	0.57 (1.03)	0.60 (1.05)	0.47 (0.98)	3.23 (1.51)
GP41	11.90 (3.52)	0.53 (1.02)	3.43 (1.98)	0.37 (0.93)	0.80 (1.14)	0.47 (0.98)	0.50 (1.00)	0.40 (0.95)	0.50 (1.00)	0.27 (0.88)	1.92 (1.34)

* Figures in parenthesis are square root transformed value

Difference between Treatments C. D. (P = 0.05) = 0.02

Difference between Periods of observation C. D. (P = 0.05) = 0.01

Difference between Treatments x Periods of observation C. D. (P = 0.05) = 0.05



4.2.1 Over all mean of aphid population

Considering the economic importance of *A. craccivora* infesting lentil, forty one promising genotype were screened against this pest under field condition. The incidence of *A. craccivora* was recorded at an interval of 7 days started from second week after germination to maturity of crop during *rabi* season. The mean data thus obtained were presented in Table 4 and depicted in Fig.3. The results showed that all the genotypes differed significantly in respect the aphid population per plant/10cm apical twigs. Among the screened genotypes the genotype, GP16 (0.46 aphid/plant10cm apical twigs) was recorded as the least susceptibility genotype followed by GP15 (0.54 aphid/plant10cm apical twigs), GP10 (0.58 aphid/plant10cm apical twigs) and GP13 (0.62 aphid/plant10cm apical twigs). The genotypes GP-2 and GP-3 were found at par to each other with 0.84 aphid/plant10cm apical twigs. The genotype GP-35 (5.59 aphid/plant/10 cm apical twigs) was recorded as the most susceptible genotype followed by GP-28 (4.93 aphid/plant/10 cm apical twigs), GP-34 (3.84 aphid/plant/10 cm apical twigs) and GP-33 (3.32 aphid/plant/10 cm apical twigs). Considering the aphid population, the genotype under screening can be placed in increasing order of susceptibility as GP16<GP15<GP10<GP13<GP21<GP1<GP4<GP17<GP3<GP2<GP8<GP7<GP18<GP5<GP14<GP30<GP20<GP6<GP11<GP25<GP23<GP24<GP22<GP37<GP19<GP36<GP41<GP9<GP31<GP38<GP26<GP39<GP27<GP12<GP29<GP32<GP40<GP33<GP34<GP28<35 .

The period of observations for aphid infestation was also differed significantly to each other. The highest incidence of aphid was recorded on at initial stage of crop growth at 1st week of January (5.93 aphid/plant/10 cm apical twigs). However, the lowest incidence of aphid population was recorded on crop maturity at 8th march (0.48 aphid/plant/10 cm apical twigs). The moderate aphid population was recorded from 25th January to 22nd February, during this period the population was in the range of (1.60 to 1.23 aphid/plant/10 cm apical twigs).

Table 5 : Response of different genotypes of lentil against infestation of *Aphis craccivora* population month wise during crop season .

Genotypes	Aphid <i>Aphis craccivora</i> population 10cm apical twigs/plant												
	Periods of observations												
	4 th Jan.	11 th Jan.	18 th Jan.	25 th Jan.	Mean	1 st Feb.	8 th Feb.	15 th Feb.	22 th Feb.	Mean	1 st Mar.	8 th Mar.	Mean
GP1	1.10	1.07	1.57	0.50	1.06	0.43	0.90	0.87	0.30	0.63	0.27	0.20	0.23
GP2	1.13	0.80	0.87	0.87	0.92	0.80	1.00	0.73	1.40	0.98	0.47	0.30	0.38
GP3	1.60	0.50	0.57	0.70	0.84	0.57	2.00	1.53	0.47	1.14	0.27	0.23	0.25
GP4	2.10	0.60	0.63	0.47	0.95	0.67	1.00	1.00	0.37	0.76	0.23	0.30	0.27
GP5	2.90	0.73	0.23	0.83	1.18	0.83	1.30	1.13	0.80	1.02	0.57	0.50	0.53
GP6	4.73	0.20	0.37	1.33	1.66	1.10	1.20	1.13	0.77	1.05	0.47	0.50	0.48
GP7	2.10	0.60	0.57	1.13	1.10	1.07	1.20	1.17	0.67	1.03	0.50	0.60	0.55
GP8	1.50	0.53	0.87	1.17	1.02	0.73	1.07	1.17	0.53	0.88	0.60	0.50	0.55
GP9	3.20	0.80	3.90	1.70	2.40	1.63	2.40	2.43	1.57	2.01	1.20	0.70	0.95
GP10	0.87	0.33	1.90	0.30	0.85	0.37	0.50	0.60	0.40	0.47	0.37	0.20	0.28
GP11	0.87	0.90	3.27	1.43	1.62	1.50	1.30	1.67	1.00	1.37	0.83	0.50	0.67
GP12	0.33	4.20	5.60	5.20	3.83	2.40	4.07	2.07	2.10	2.66	1.20	0.80	1.00
GP13	0.50	0.20	1.40	0.33	0.61	1.07	0.53	1.07	0.40	0.77	0.37	0.30	0.33
GP14	2.30	0.83	1.40	0.63	1.29	1.50	0.77	0.77	0.70	0.93	0.50	0.50	0.50
GP15	0.10	1.70	0.60	0.13	0.63	0.63	0.77	0.77	0.17	0.58	0.13	0.43	0.28
GP16	0.33	0.33	0.30	0.33	0.33	0.83	0.37	1.00	0.37	0.64	0.33	0.37	0.35
GP17	0.60	0.57	1.20	0.90	0.82	1.30	0.83	1.20	0.57	0.98	0.50	0.40	0.45
GP18	3.27	0.17	1.53	0.50	1.37	1.40	0.83	0.77	0.47	0.87	0.40	0.40	0.40
GP19	2.87	0.80	1.03	2.87	1.89	1.37	1.90	1.80	1.80	1.72	1.10	0.53	0.82
GP20	2.43	2.40	1.47	0.47	1.69	1.00	1.27	1.10	0.57	0.98	0.40	0.47	0.43
GP21	1.20	0.40	0.90	0.43	0.73	1.00	0.67	0.80	0.60	0.77	0.30	0.20	0.25

Genotypes	Aphid <i>Aphis craccivora</i> population 10cm apical twigs/plant												
	Periods of observations												
	4 th Jan.	11 th Jan.	18 th Jan.	25 th Jan.	Mean	1 st Feb.	8 th Feb.	15 th Feb.	22 th Feb.	Mean	1 st Mar.	8 th Mar.	Mean
GP22	10.30	0.30	0.77	0.37	2.93	1.00	0.37	0.57	0.77	0.68	0.57	0.30	0.43
GP23	7.77	1.30	0.30	1.10	2.62	0.37	0.67	0.83	0.80	0.67	0.60	0.30	0.45
GP24	8.10	0.77	2.53	0.27	2.92	0.77	0.27	0.47	0.37	0.47	0.40	0.20	0.30
GP25	8.10	0.77	2.53	0.27	2.92	0.77	0.27	0.47	0.37	0.47	0.40	0.20	0.30
GP26	9.43	1.03	0.37	0.37	2.80	0.57	0.37	0.60	0.37	0.48	0.40	0.17	0.28
GP27	18.70	0.47	0.23	0.37	4.94	0.47	0.40	0.40	0.50	0.44	0.40	0.17	0.28
GP28	12.20	3.07	2.13	2.20	4.90	0.57	1.80	1.87	2.17	1.60	1.00	0.40	0.70
GP29	8.50	3.70	6.07	8.80	6.77	0.60	7.30	6.67	5.80	5.09	1.20	0.70	0.95
GP30	12.23	0.80	7.43	1.10	5.39	4.03	0.83	0.77	1.30	1.73	0.50	0.40	0.45
GP31	5.70	0.60	1.40	0.33	2.01	1.00	0.60	0.60	0.60	0.70	0.50	0.30	0.40
GP32	8.10	0.60	4.80	0.43	3.48	0.57	0.87	0.50	0.57	0.63	0.60	3.20	1.90
GP33	8.80	4.30	2.10	4.80	5.00	0.50	0.80	3.30	3.90	2.13	0.70	0.40	0.55
GP34	10.60	10.70	2.13	2.20	6.41	1.50	1.30	1.30	2.37	1.62	0.70	0.37	0.53
GP35	3.67	0.30	6.03	7.47	4.37	1.63	7.83	4.30	5.20	4.74	1.50	0.50	1.00
GP36	14.03	5.90	7.60	6.50	8.51	4.73	7.33	5.10	3.43	5.15	0.80	0.47	0.63
GP37	8.53	1.00	2.90	0.67	3.28	3.07	0.43	0.70	0.60	1.20	0.60	0.47	0.53
GP38	8.10	0.63	0.63	0.80	2.54	1.63	0.87	0.93	1.00	1.11	0.50	0.57	0.53
GP39	10.20	1.13	1.80	0.83	3.49	2.80	0.73	1.00	0.63	1.29	0.70	0.47	0.58
GP40	5.00	2.53	1.20	3.33	3.02	0.70	2.70	2.00	3.10	2.13	1.10	0.50	0.80
GP41	25.30	0.93	0.17	1.03	6.86	1.80	0.70	0.70	0.57	0.94	0.60	0.47	0.53
	11.90	0.53	3.43	0.37	4.06	0.80	0.47	0.50	0.40	0.54	0.50	0.27	0.38

4.3 To study the effect of different morphological characters on tolerance/susceptibility of lentil genotypes against aphid infestation.

Table 6 : Effect of different Morphological factors of lentil on the incidence of lentil Aphid.

S.N.	Genotypes	Primary branch /plant	Secondary branch /plant	Leaflet size (mm)	Plant height (cm)	Seed yield/plant (g)	Aphid/plant 10 cm apical twigs
1	GP1	1.90	5.30	1.30	38.10	7.00	0.72
2	GP2	2.00	6.20	1.20	40.90	14.70	0.84
3	GP3	2.10	6.20	1.50	39.60	12.30	0.84
4	GP4	1.70	8.80	1.20	35.80	10.70	0.74
5	GP5	2.10	5.10	1.00	35.20	12.00	0.98
6	GP6	1.70	6.20	1.40	35.30	3.60	1.18
7	GP7	1.70	6.50	0.90	39.90	10.40	0.96
8	GP8	2.00	7.30	1.00	39.10	11.70	0.87
9	GP9	1.80	6.80	1.10	38.50	11.00	1.95
10	GP10	2.20	7.40	0.90	52.10	13.50	0.58
11	GP11	2.10	6.90	1.10	34.90	5.50	1.33
12	GP12	2.00	7.10	1.00	31.90	7.70	2.80
13	GP13	2.10	8.70	1.10	37.00	14.00	0.62
14	GP14	2.00	5.60	1.00	44.80	14.00	0.99
15	GP15	2.50	8.00	1.20	40.40	12.20	0.54
16	GP16	2.10	7.70	1.10	39.70	17.20	0.46
17	GP17	1.70	6.10	1.10	43.00	9.50	0.81
18	GP18	1.90	6.20	1.10	42.90	13.00	0.97
19	GP19	2.00	7.00	0.90	41.30	11.40	1.61
20	GP20	2.10	7.10	1.00	33.40	3.50	1.16
21	GP21	1.90	7.20	1.10	40.30	7.90	0.65
22	GP22	1.90	3.90	0.70	31.20	6.40	1.53
23	GP23	1.70	3.60	0.90	40.30	5.30	1.40
24	GP24	2.60	6.20	1.10	39.50	7.70	1.41
25	GP25	2.10	4.60	1.20	32.30	2.50	1.37
26	GP26	2.00	4.40	1.00	35.80	5.80	2.21
27	GP27	2.30	4.50	0.90	37.30	4.80	2.74
28	GP28	2.10	4.90	0.90	33.70	3.50	4.93
29	GP29	2.30	5.20	1.00	37.60	7.30	2.94
30	GP30	2.30	4.00	1.30	35.70	5.70	1.16
31	GP31	2.10	4.30	0.90	35.10	4.90	2.02
32	GP32	2.00	4.10	1.00	37.50	3.60	2.96
33	GP33	1.70	5.10	1.00	36.90	12.20	3.32
34	GP34	2.00	4.60	1.00	33.80	4.80	3.84
35	GP35	1.80	4.90	1.10	31.00	14.70	5.59
36	GP36	1.60	4.90	1.10	38.50	16.20	1.90
37	GP37	1.80	6.50	1.10	37.70	12.10	1.57
38	GP38	1.90	5.30	1.00	38.50	7.90	2.03
39	GP39	1.90	5.30	1.00	34.30	3.50	2.22
40	GP40	1.20	2.70	1.10	37.40	11.80	3.23
41	GP41	1.80	4.10	1.30	36.90	9.70	1.92

Table 7: The Correlation coefficients of the lentil genotype damage with different morphological factors.

S.N.	Morphological character	Primary branch /plant	Secondary branch /plant	Leaflet size (mm)	Plant height (cm)	Seed yield (g)	Aphid/plant 10cm apical twigs
1	Primary branch /plant	1					
2	Secondary branch /plant	0.24					
3	Leaflet Size (mm)	-0.02	0.16				
4	Plant Height (cm)	0.06	0.30	0.01			
5	Seed Yield (g)	-0.18	0.39*	0.14	0.48**		
6	Aphid /plant 10 cm apical twigs	0.16	-0.51**	-0.27	-0.49**	-0.23	1

4.3.1 The Correlation coefficients of the lentil genotype damage and different morphological factors.

Influence of different plant characteristics of lentil genotypes against the infestation of aphid (*A. craccivora*) were recorded and correlated with aphid infestation to know the response of different morphological factors on tolerance/ susceptibility of lentil genotypes. Different morphological characteristics namely primary branch, secondary branch, leaflet size, plant height seed yield were recorded on different genotypes. All the genotype differed significantly in respect to the morphological characters. The highest number of primary branch was recorded in the genotype GP24 (2.60 branch /plant) and lowest primary branches was recorded in the genotype GP40 (1.20 branch /plant). The highest number of secondary branch was recorded in the genotype GP4 (8.80 branch /plant) while lowest secondary branches was recorded in the genotype GP40 (2.70 branch /plant). The longest leaflet size was recorded in the genotype GP3 (1.50 mm) and shortest leaflet size was found in the genotype GP22 (0.77 mm).The maximum seed yield was recorded in the genotype GP16 (17.20 g/plant) while minimum seed yield was recorded in the genotype GP25 (2.50 g/plant). All the genotype differed significantly in respect to plant height. The longest plant height was recorded in the genotype GP10 (52.10 cm) and lowest in genotype GP35 (31.00 cm)

Maximum aphid incidence was recorded in the genotype GP35 (5.59 aphid/plant10cm apical twigs) while minimum aphid incidence was recorded in the genotype GP16 (0.46 aphid /plant10cm apical twigs).

The role of morphological factors on the incidence of aphid showed that the secondary branch had significant negative correlation ($r = -0.51^{**}$) with aphid population while the primary branch had non significant positive correlation (0.16) with aphid population. The plant height showed significant negative correlation ($r = -0.49^{**}$ cm) with aphid population, while leaflet size showed non significant negative correlation ($r = -0.27$ mm) with aphid population. The seed yield had non significant negative correlation ($r = -0.23$ g) with aphid population.

DISCUSSION

Present study '**Screening and Characterization of Lentil Genotypes against Aphid (*Aphis craccivora*) Infestation**' was conducted with following objectives, to study the role of biotic and abiotic factors on population fluctuation of lentil aphid (*Aphis craccivora*), screening of different genotypes of lentil for the tolerance / susceptibility against lentil aphid and to study the effect of different morphological characters on tolerance / susceptibility of lentil genotypes against aphid infestation. The results obtained are discussed in the light of available literature.

5.1 To study the role of biotic and abiotic factors on population fluctuation of lentil aphid (*Aphis craccivora*).

In the present study the population dynamics of aphid (*A. craccivora*) infesting lentil crop showed that the incidence of aphid was started from 1st standard week (24.00 aphid/plant/10 cm apical twigs). Initially the population was low. The aphid population gradually increased and reached to its peak on (101.0 Aphid/plant 10cm apical twigs) 6th standard meteorological week (8th to 14th to 20th February). Our results was in conformity with the results of Sharma and Yadav (1993) they reported the genotype K-333 had the lowest incidence (8.6-9.8 aphids/plant) of aphid while PL639 proved as highly susceptible variety with a mean of 33.3-40.0 aphids/plant. The aphid population gradually decreased from 7th standard week (51.00 aphid/plant/10 cm apical twigs) to 10th standard meteorological week (6.3 Aphid/plant 10cm apical twigs). Present results was also supported by the results of Hossain et al. (2006) reported that the lentil crop sown in November received less aphid infestation and consequently produced higher yield than the crop sown in December.

Wide inter varietal variation was observed in suitability of plants for predators, (coccinellids and spiders) which was influenced by aphid population. The predators (spider and coccinellids) population were increased with increased the population of aphid. The graph clearly showed that when the population of aphid was decreased the population of predators were also decreased. Present findings was supported by the

findings of Valerio et al. (2007) who quantified the Aphids and natural enemies at weekly during the crop period. Predators (coccinellids) were released in order to control aphid populations. *Aphis craccivora* Koch, *Aulacorthum solani* (Kaltenbach) and *Macrosiphum euphorbiae* (Thomas) were also identified. Predator activity (anthocorids, cecidomyiids, coccinellids, chrysopids, spiders and syrphids) was the most efficient in controlling aphid populations.

5.2 Correlation Coefficient.

In present finding the incidence of aphid (*A. craccivora*) and their natural enemies (spider and coccinellids) activity were correlated with weather data revealed that minimum temperature showed significant negative correlation with aphid and spider population. While maximum temperature and relative humidity of morning and evening showed negative correlation with aphid, lady bird beetle and spider activity. The present findings was supported by the reports of the Dalwadi et al. (2007) who worked out the correlation coefficient between weather parameters and pest population and reported that minimum temperature, high significant negative correlated association with aphids population. Whereas relative humidity showed negative association. Prasad et al. (2008) reported that aphid population had significant negative association with maximum temperature, minimum temperature, evening relative humidity and rainfall and positive association with morning relative humidity. Our result the rainfall, maximum temperature, evening relative humidity and aphid population had negative correlation but non significant. In the earlier work Hasan et al. (2009) reported that among the different environmental factors maximum temperature positively correlated with aphid population while minimum temperature and relative humidity negatively correlated with aphid population. These reports are in agreement with the present conclusion. In the present finding correlation coefficient

5.3 Screening of different genotypes of lentil for the tolerance/susceptibility against lentil aphid.

In the present investigation, Forty one promising genotype were screened against this pest under field condition. The incidence of *A.*

craccivora was recorded at an interval of 7 days started from second week after germination to maturity of crop during *rabi* season. Among the screened genotypes the genotype, GP16 (0.46 aphid/plant10cm apical twigs) was recorded as the least susceptibility genotype followed by GP15 (0.54 aphid/plant10cm apical twigs), GP10 (0.58 aphid/plant10cm apical twigs) and GP13 (0.62 aphid/plant10cm apical twigs). The genotypes GP-2 and GP-3 were found at par to each other with 0.84 aphid/plant10cm apical twigs. The genotype GP-35 (5.59 aphid/plant/10 cm apical twigs) was recorded as the most susceptible genotype followed by GP-28 (4.93 aphid/plant/10 cm apical twigs), GP-34 (3.84 aphid/plant/10 cm apical twigs) and GP-33 (3.32 aphid/plant/10 cm apical twigs). The present results was in conformity with the results of Moraes and Bleicher (2007) who conducted an experiment with the intention of evaluating the response of different cowpea, *Vigna unguiculata* (L.) Walp, cultivars to the black aphid (*Aphis craccivora* Koch). Plants were infested twelve days after planting with five adult females per plant. Evaluations were performed three and five days after infestation by visual counting of the adults and nymph forms present on the plants. Salman et al. (2007) also reported that the faba bean cultivars showed varying susceptibility to infestation, and they were divided into the following groups: Giza 674 and Giza Blanka (susceptible); Giza 843, Giza 2 and Giza 40 (low tolerant); and Giza 429 (moderately tolerant). Considering the aphid population, the genotype under screening can be placed in increasing order of susceptibility as GP16<GP15<GP10<GP13<GP21< GP1<GP4<GP17<GP3<GP2<GP8<GP7<GP18<GP5<GP14<GP30<GP20<GP6<GP11<GP25<GP23 <GP24<GP22<GP37<GP19<GP36<GP41<GP9<GP31<GP38<GP26<GP39<GP27<GP12<GP29<GP32<GP40<GP33<GP34<GP28<35 (Fig.3)

Present work was similar to the Abdel-Samad and Ahmed (2006) reported susceptibility of the faba bean cultivars could be arranged (in both moths) ascending according to the mean of infestation by the aphid per plant as follows: Misr1 (40.6) and Misr2 (42.6), Giza 40 (54.2) and Giza 429 (58.7). For the leafminer, the arrangement was Misr2 (18.2), Giza 429 (19.8%), Misr1 (23.9%) and Giza 40 (26.1%).

The period of observations for aphid infestation was also differed significantly to each other. The highest incidence of aphid was recorded on at initial stage of crop growth at 1st week of January (5.93 aphid/plant/10 cm apical twigs). However, the lowest incidence of aphid population was recorded on crop maturity at 8th march (0.48 aphid/plant/10 cm apical twigs). The moderate aphid population was recorded from 25th January to 22nd February, during this period the population was in the range of (1.60 to 1.23 aphid/plant/10 cm apical twigs). This result was similar to Humyun et al. (2014) who screened five cultivars of groundnut against aphid. The peak population of *A. craccivora* was recorded after 110 DAS (May-June).

5.4 To study the effect of different morphological characters on resistance or susceptibility of lentil genotypes against aphid infestation.

In the present experiment result was recorded on the genotype characters, secondary branch and plant height was significant negatively correlated with aphid population. Primary branch and aphid population was positively correlated with them but the correlation was not significant. Seed yield showed significance positive correlation with plant height and also significant with secondary branch . These reports are in agreement with the conclusion of Gupta et al. (2012) who reported that the characters, plant height, days to maturity, number of primary branches plant-1, number of secondary branches plant-1, height of the lowest pod and 100-seed weight. Yield plant-1 was positively correlated with pods plant-1, seeds pod-1, seeds plant-1 and 100-seed weight. The present findings supported by the findings of the Tickoo et al. (2005) who reported that the important yield components like pods/plant, seed weight, plant height and branches, increasing harvest index, increasing biomass, breeding early-maturing varieties, development of bold seeded varieties for export purposes for better seed quality have been recommended.

The plant height showed significant negative correlation ($r = -0.49^{**}$ cm) with aphid population, while leaflet size showed non significant negative correlation ($r = -0.27$ mm) with aphid population. The seed yield had non significant negative correlation ($r = -0.23$ g) with aphid population. Present

findings was strongly supported by the findings of Kumari et al. (2009) who screened one hundred and twelve accessions of lentil (*Lens culinaris* Medik) for tolerance to black aphids (*Aphis craccivora* Koch) and some morphological attributes were recorded to find the association with aphid incidence. Growth habit and days to flowering had shown significant association but with lesser degree while there was no significant role of biomass. Low infestation of aphids was observed on genotypes with green or yellowish green foliage and slightly pubescent leaves. Moderate infestation was recorded in genotypes with dark green foliage while genotypes with ash green foliage and densely pubescent leaves were highly susceptible to aphids.

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

6.1 SUMMARY

Lentil (*Lens culinaris*) is one of the most important pulse crop of India. Insect pests are one of the major constraints for low productivity of the crop. The homopterous sucking pest Aphid (*Aphis craccivora*) and their natural enemies lady bird beetle (*C. septempunctata*) and spider are major insect present on the crop. Screening measures are most common to avoid the ill effect of insecticides, Present investigation on screening of different genotype of lentil against aphid infestation with the objectives *viz.* To study the role of biotic and abiotic factors on population fluctuation of lentil aphid (*Aphis craccivora*), screening of different genotypes of lentil for the tolerance/ susceptibility against lentil aphid. to study the effect of different morphological characters on tolerance susceptibility of lentil genotypes against aphid infestation. The results obtained were summarized in this chapter are:

6.1.1 To study the role of biotic and abiotic factors on population fluctuation of lentil aphid (*Aphis craccivora*).

During *rabi* season of 2013-14 aphid (*Aphis craccivora*) infesting lentil and their natural enemies lady bird beetle (*C. septempunctata*) and spider were observed of the crop.

6.1.2 Aphid

The peak period for aphid infestation (101.0 Aphid/plant 10cm apical twigs) was recorded in 6th standard meteorological week (8th to 14 February) while lowest incidence (6.3 Aphid/plant 10cm apical twigs) was recorded in 10th standard meteorological week (8th to 14 march). The correlation coefficient of aphid population with meteorological factors showed that the aphid population had significant negative correlation with minimum temperature ($r = -0.71$) while the maximum temperature showed non significant negative correlation ($r = -0.01$). The morning relative humidity had non significant positive correlation ($r = 0.23$) while the evening relative humidity showed non significant negative correlation ($r = -0.40$) with aphid population. The rainfall had non significant negative impact ($r = -0.53$) with aphid population.

6.1.3 Spider

The peak period for spider activity (2.0 spider/plant 10 cm apical twigs) was recorded in 5th standard meteorological week (1st to 7 February) while lowest period for spider activity (0.3) was recorded in 9th standard meteorological week (1st to 7th March). The minimum temperature showed significant negative correlation ($r = -0.63$) while maximum temperature ($r = 0.16$) and morning relative humidity showed non significant positive correlation ($r = 0.15$) with spider activity.

6.1.4 *C. septempunctata*

The peak period for Coccinellids (4.7 Coccinellids/plant 10cm apical twigs) activity was recorded in 7th standard meteorological week (15th to 21st February) while lowest activity of coccinellids (1.0 Coccinellids/plant 10cm apical twigs) was recorded in 3rd and 10th standard meteorological week (18th to 24th January and 8th March.). The Coccinellids population had non significant negative correlation with minimum temperature ($r = -0.25$) while the maximum temperature showed non significant positive correlation ($r = 0.44$) with Coccinellids both maximum ($r = -0.31$) and minimum (-0.55) relative humidity had non significance negative impact on coccinellids population.

6.1.5 Screening of different genotypes of lentil for the tolerance / susceptibility against lentil aphid.

On the basis of overall mean of aphid population recorded different genotype of lentil crop. The genotype forty one promising genotype of lentil were screened against *A. craccivora* in field condition. Among all these genotype GP16 (0.46 aphid/plant 10cm apical twigs) followed by GP15 (0.54 aphid/plant 10cm apical twigs), GP10 (0.58 aphid/plant 10cm apical twigs), GP13 (0.62 aphid/plant 10cm apical twigs), GP21 (0.65 aphid/plant 10cm apical twigs), GP1 (0.72 aphid/plant 10cm apical twigs), were found less susceptible to this pest., GP24 (1.41 aphid/plant 10cm apical twigs), GP23 (1.40 aphid/plant 10cm apical twigs), GP25 (1.37 aphid/plant 10cm apical twigs), GP11 (1.33 aphid/plant 10cm apical twigs) genotype were found moderately susceptible and the genotype GP35 (5.59 aphid/plant 10cm apical twigs) was highly susceptible to the attack of aphid and the genotype highest aphid population was recorded 1st standard week (4th January).

6.1.6 To study the effect of different morphological characters tolerance / susceptibility of lentil genotypes against aphid infestation.

The highest number of primary branch was recorded in the genotype GP24 (2.60 branch /plant) and lowest primary branches was recorded in the genotype GP40 (1.20 branch /plant). The highest number of secondary branch was recorded in the genotype GP4 (8.80 branch /plant) while lowest secondary branches was recorded in the genotype GP40 (2.70 branch /plant) The longest leaflet size was recorded in the genotype GP3 (1.50 mm) and shortest leaflet size was found in the genotype GP22 (0.77 mm)The maximum seed yield was recorded in the genotype GP16 (17.20 g/plant) while minimum seed yield was recorded in the genotype GP25 (2.50 g/plant) All the genotype differed significantly in respect to plant height. The longest plant height was recorded in the genotype GP10 (52.10 cm) and shortest in genotype GP35 (31.00 cm) Maximum aphid incidence was recorded in the genotype GP35 (5.59 aphid/plant10cm apical twigs) while minimum aphid incidence was recorded in the genotype GP16 (0.46 aphid /plant10cm apical twigs)

The role of morphological factors on the incidence of aphid showed that the secondary branch had significant negative correlation ($r = -0.51$) with aphid population while the primary branch had non significant positive correlation (0.16) with aphid population. The plant height showed significant negative correlation ($r = -0.49$ cm) with aphid population while leaflet size showed non significant negative correlation ($r = -0.27$ mm) with aphid population. The seed yield had significant negative correlation ($r = -0.23$ g) with aphid population.

6.2 Conclusion

During *rabi* season of 2013-14 Aphid (*Aphis craccivora*) infesting lentil and their natural enemies lady bird beetle (*C. septempunctata*) and spider were recorded on the crop.

The peak period for aphid infestation (101.0 Aphid/plant 10cm apical twigs) was recorded in 6th standard meteorological week (8th to 14th February)

while lowest incidence (6.3 Aphid/plant 10cm apical twigs) was recorded in 10th standard meteorological week (8th to 14th March). The correlation coefficient of aphid population with meteorological factors showed that the aphid population had significantly negative correlation with minimum temperature ($r = -0.71$) while the maximum temperature showed non significant negative correlation ($r = -0.01$). The morning relative humidity had non significant positive correlation ($r = 0.23$) while the evening relative humidity showed non significant negative correlation ($r = -0.40$) with aphid population. The rainfall had non significant negative impact ($r = -0.53$) with aphid population.

The peak period for spider activity (2.0 spider/plant 10 cm apical twigs) was recorded in 5th standard meteorological week (1st February) while lowest period for spider activity (0.3) was recorded in 9th standard meteorological week (1st to 7th March). The minimum temperature showed significant negative correlation ($r = -0.63$) while maximum temperature ($r = 0.16$) and morning relative humidity showed non significant positive correlation ($r = 0.15$) with spider activity.

The peak period for *C. septempunctata* (4.7 *C. septempunctata* /plant 10cm apical twigs) activity was recorded in 7th standard meteorological week (15th to 21th February) while lowest activity of *C. septempunctata* (1.0 *C. septempunctata* /plant 10cm apical twigs) was recorded in 3rd and 10th standard meteorological week (18th to 24th January and 8th to 14th March). The *C. septempunctata* population had non significant negative correlation with minimum temperature ($r = -0.25$) while the maximum temperature showed non significant positive correlation ($r = 0.44$) with *C. septempunctata* both maximum ($r = -0.31$) and minimum ($r = -0.55$) relative humidity had non significance negative impact on *C. septempunctata* population.

On the basis of overall mean of aphid population recorded on different genotype of lentil crop. The genotype forty one promising genotype of lentil were screened against *A. craccivora* in field condition. Among all these genotype, GP16 (0.46 aphid/plant 10cm apical twigs) followed by GP15 (0.54 aphid/plant 10cm apical twigs), GP10 (0.58 aphid/plant 10cm apical twigs), GP13 (0.62 aphid/plant 10cm apical twigs), GP21 (0.65 aphid/plant 10cm apical

twigs), GP1 (0.72 aphid/plant10cm apical twigs), were found less susceptible to this pest., GP24 (1.41 aphid/plant10cm apical twigs), GP23 (1.40 aphid/plant10cm apical twigs), GP25 (1.37 aphid/plant10cm apical twigs), GP11 (1.33 aphid/plant10cm apical twigs) genotype were found moderately susceptible and highly susceptible genotype GP35 (5.59 aphid/plant10cm apical twigs) to the attack of aphid and highest aphid population was recorded in 1st standard week (4th to 10th January).

The highest number of primary branch was recorded in the genotype GP24 (2.60 branch /plant) and lowest primary branches was recorded in the genotype GP40 (1.20 branch /plant) The highest number of secondary branch was recorded in the genotype GP4 (8.80 branch /plant) while lowest secondary branches was recorded in the genotype GP40 (2.70 branch /plant) The longest leaflet size was recorded in the genotype GP3 (1.50 mm) and shortest leaflet size was found in the genotype GP22 (0.77 mm) The maximum seed yield was recorded in the genotype GP16 (17.20 g/plant) while minimum seed yield was recorded in the genotype GP25 (2.50 g/plant) All the genotype differed significantly in respect to plant height. The longest plant height was recorded in the genotype GP10 (52.10 cm) and shortest in genotype GP35 (31.00 cm) Maximum aphid incidence was recorded in the genotype GP35 (5.59 aphid/plant10cm apical twigs) while minimum aphid incidence was recorded in the genotype GP16 (0.46 aphid /plant10cm apical twigs)

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6.3 SUGGESTIONS FOR FURTHER WORK

- Studies the different natural enemies associated with lentil aphid and their role for regulating the population of aphid.
- Non chemical methods for the management of aphid should be conducted.
- Results of present investigations, effect different morphological characters on resistance or susceptibility of lentil genotype against aphid infestation was not fulfil the requirement of breeder to breed the varieties having such type of characters. Further there is a need to evaluate such type of character under artificial pest load condition.
- The trial should be repeated to confirm these results.
- The varieties showing poor performance *by A.craccivora* may be further tested and their Antixenotic characteristics may be identified.
- Development of BIPM modules and its validation in large scale.

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APPENDICES

**Appendix 1: Weekly meteorological parameters during the crop season
December to April (2013-14)**

Month	Meteo. Week	Temp. max. (C)	Temp. min.	Relative humidity (%) Morning	Relative humidity (%) Evening	Rainfall (mm)
Dec	49	27.8	8.5	91	33	0.0
	50	25.9	7.1	89	30	0.0
	51	26.0	7.5	91	34	0.0
	52	24.5	11.0	90	44	0.0
Jan	1	23.5	11.1	90	57	0
	2	22.3	10.2	94	59	18.0
	3	22.2	12.3	95	68	6.8
	4	22.3	10.6	91	61	0
	5	23.7	5.6	93	34	0
Feb	6	28	10	91	39	0
	7	23.9	9.5	88	41	12.0
	8	25.5	11.9	93	55	17.0
	9	24.8	14.3	91	60	58.2
March	10	26.6	11.9	87	42	1.8
	11	30.5	12.6	84	45	2.6
	12	34	13.4	79	27	0
April	13	36.4	17.6	77	20	0
	14	37.4	18.5	55	16	0
	15	37.4	17.9	58	17	0
	16	37.7	20.6	61	-	0

Screening of genotypes of lentil against aphid

ANOVA for aphid population

Source	DF	SS	MSS	F cal	F tab 5%	F tab 1%	SEm	CD 5%
Replication	2	0.22	0.11	109.00	3.01	4.63		
W	9	147.06	16.34	15846.72	1.89	2.43	0.0029	0.0080
GP	40	119.19	2.98	2889.93	1.41	1.62	0.0059	0.0163
WxGP	360	209.51	0.58	564.42	1.16	1.23	0.0185	0.515
Error	820	0.85	0.01					
Total	1229	476.83						

SEm=0.0029

CD5%=0.0080



Plate 1. Lentil plant infested by *Aphis craccivora*



Plate 2. *Coccinella septempunctata* feeding on aphids



Plate 3. Flowers of *Lens culinaris* infested by *Aphis craccivora*



Plate 4. Aphids infested pod of *Lens culinaris* Medik

CURRICULUM VITAE

The author of this thesis **Tikeshwari Nayak** D/o **Agrahij Prasad Nayak** was born on 3rd September 1986 at Pawan Vihar Colony H.No.-B/15 New Rajendra Nagar Raipur (CG)



After graduation, for further study, she got admission in M.Sc. (Ag.) for specialization in Entomology at the College of Agriculture, JNKVV, Jabalpur (M.P), where successfully completed the entire course requirement for Master's degree with an OGPA 6.7 out of 10 point scale in the year 2014.

For the partial fulfilment of the Master's degree carried out thesis work on "Screening and characterization of lentil Genotypes against aphid (*Aphis craccivora*) infestation". It was successfully conducted by her and being submitted in the form of this thesis.

She took admission for B.Sc. (Ag.) in the College of Agriculture, JNKVV, Jabalpur (M.P.) in the year 2008. she has successfully completed her graduation with 6.76 OGPA in the year 2012.

She passed her Higher Secondary School (12th) in the year 2004 from P.J. Umathe Govt. girls Higher Secondary School, Raipur (C.G.) and High School (10th) in the year 2002 from P.J. Umathe Govt. girls Higher Secondary School, Raipur (C.G.)