SCREENING OF GERMPLASM ACCESSIONS OF SAFFLOWER FOR THEIR MORPHOLOGICAL AND BIOCHEMICAL TRAITS IN RELATION TO RESISTANCE AGAINST SAFFLOWER APHID, *Uroleucon compositae* (Theobald).

M.Sc. (Ag) Thesis

by

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INDIRA GANDHI KRISHI VISHWAVIDYALAYA
RAIPUR (Chhattisgarh).

2021

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Thesis
Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur

by

V. Sajil Kumar

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Science
In
Agriculture
(Entomology)

ROLL No. 120117143 ID No.: 20171827388

June, 2021

CERTIFICATE – I

This is to certify that the thesis entitled **"Screening of germplasm accessions of safflower for their morphological and biochemical traits in relation to resistant against Safflower aphid, *Uroleucon compositae* (Theobald)**, submitted in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture (Entomology)** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is arecord of the bonafide research work carried out by **V.Sajil Kumar** under my/our guidance and supervision. The subject of the thesis has been approved by the Students Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or hasbeen published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged byhim.

Chairman

Date: 30/06/2021

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member:	(Dr. Rajeev Shrivastav)	.....
Member:	(Dr. (Smt.) Gayatri Chandrakar)	.....

CERTIFICATE – II

This is to certify that the thesis entitled "**Screening of germplasm accessions of safflower for their morphological and biochemical traits in relation to resistant against Safflower aphid, *Uroleucon compositae*(Theobald)**" submitted by **V.Sajil Kumar** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture** in the Department of Entomology has been approved by the **external evaluator** and Students Advisory Committee after oral examination, **under the chairmanship of Head of the Department.**

Signature of Head of the Department

Date- 17/08/2021

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ACKNOWLEDGEMENT

With all my humble and whole hearted prostration before Almighty and Omnipresent "God" who always showered blessing on me to reach the acme of success and always with me for improvingthe confidence and determination in my whole life. How can I express my thanks to "God" because there is no any word to express it? So, my lord, please realize and accept my feelings.

I feel privileged to express deepest gratitude to my major advisor, ***Dr. B. P. Katlam*** *(Senior Scientist) Department of Entomology, College of Agriculture, and Raipur. I thank him for his thoughtful guidance, supervision and consistent support to my studies and research.*

I express my deep sense of gratitude and sincere thanks to my advisory committee member ***Dr. Vikas Singh*** *(Senior Scientist) Department of Entomology,* ***Dr. Rajeev Shrivastav****, (Senior Scientist), Department of Genetics and Plant Breeding and* ***Dr. (Smt.) Gayatri Chandrakar,*** *(Professor) Department of Agriculture Statistics and Social Science (L.).For providing proper guidance and encouragement throughout the research work. Without their kind cooperation, it would not have been easy for me to complete this manuscript.*

I would like to thank ***Dr. Dharmendra Khokhar*** *(Professor), Department of Plant Physiology; IGKV, Raipur for his thoughtful guidance, supervision and consistent support to my studies, research and biochemical analysis work in lab.*

I am highly obliged to Hon'ble Vice Chancellor ***Dr. S. K, Patil Sir*** *for their appreciation to all PG students for qualitative research work.*

I wish to record my sincere thanks to Dr.M.P Thakur, Dean, College of Agriculture, Dr. A.K.Sarawagi, (Professor), and Head department of Genetics and Plant Breeding, Director Research Services, Dr.R.K. Bajpai, Director of Instructions Dr G.K Das and Dr. Madhav Pandey Librarian IGKV, Raipur for their help both administrative and technical which facilitated my research work. I do express my heartiest thanks to the teachers of my department Dr S.S Shaw, Dr. D.K. Rana professor and Headof department of Entomology, Dr. H. K. Chandrakar, Dr. Sanjay Sharma, Dr. (Smt.) Jaya LaxmiGanguli,Dr Gajendra Chandrakar and Dr. (Smt.) Sonali Deole for their constant co-operative suggestion, encouragement and help during my investigation.

I am highly thankful to all the non-teaching staff of my department namely, Shri Dhinesh dhruw, Shri D. N. Chandrakar, Shri Kunjulal Sahu, Paras ram and Shri Babulal for their help and excellent co-operation.

Sincere thanks to Shrinivas Markela for help in different aspects during experimental research. With great reverence I express my warmest feeling with deep sense of gratitude to my seniors and friends Ashithosh mohanan, Beerendra, Priyanka Nagdev, Hemlata Thakur, Aalok Kumar Gupta, Harshal Chandraker and many others who helped me during my research work which leaves a memory regardful and unforgettable.I render my heartiest appreciation and gratitude to my lovely wife Smt. ***Ashitha Mohanan*** *and Son* ***Aarjav Sajil (Monu)*** *who took trouble adjusted with me and encouragerme during the course of study.*

Indeed, words are inadequate either in form or spirits to convey my deep sense of gratitude, thanks and appreciation to my parents Shri ***J.Vidhyadharan****, Smt.* ***V.Subhadra****, my brothers B. Sajit Kumar,V. Sajeesh kumar my sister in laws Somini Sajit, Swapna Sajeesh and all the family members for their love, obstinate sacrifice, sincere prayers, miraculous blessings, affectionate encouragement, love and support throughout my carrier and especially for my educational pursuits.*

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LIST OF ABBREVIATIONS

a.i	:	active ingredient
@	:	at the rate of
^{0}C	:	Degree Celsius
CD	:	Critical Differences
CG	:	Chhattisgarh
cm	:	centimeter
DAS	:	Days After Sowing
DAT	:	Days After Transplanting
et al	:	and coworkers or others
Fig.	:	Figure
g	:	gram
ha	:	hectare
hr	:	hour
1.e	:	that is
kg	:	kilogram
mg	:	milligram
mm	:	millimeter
nm	:	nano meter
NS	:	Non significant
SN	:	Serial Number
Viz.	:	Namely
SEm+	:	Standard Error of mean
t	:	tone
q	:	quintal
%	:	Per cent
/	:	Per

THESIS ABSTRACT

a)	Title of the Thesis	:	Screening of germplasm accessions of safflower for their morphological and biochemical traits in relation to resistant against Safflower aphid, *Uroleucon compositae* (Theobald).
b)	Full Name of the Student:		V.Sajil Kumar
c)	Major Subject	:	Entomology
d)	Name and Address of the major Advisor		Dr. B. P. Katlam Department of Entomology, CoA, IGKV, Raipur (C.G.)
e)	Degree to be Awarded	:	M.Sc. (Ag) Entomology

Signature of the Student

Signature of Major Advisor

Date: 30/06/2021

Signature of Head of the Department

ABSTRACT

The present investigation entitled **"Screening of germplasm accessions of safflower for their morphological and biochemical traits in relation to resistant against Safflower aphid, *Uroleucon compositae* (Theobald)"** was conducted at Instructional Cum Research farm and Laboratory of the Department of Plant Molecular Biology and Biotechnology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, C.G. during *rabi* season of 2019-20 respectively.

On the basis of foliage drying grades and Computation of Aphid Infestation Index (A.I.I.) against safflower aphid it was recorded that out of 111 safflower screened genotypes, none genotypes were categorized as highly resistant, 19 as resistant, and 39 as moderately resistant while 37 genotypes categorized as susceptible and 16 as highly susceptible against safflower aphid during *rabi* 2019- 20.

A number of insect plants interrelations have been described to be responsible for imparting plant resistant against insect pests. A plant resistant could be due to description of one or more morphological traits. Thus, the various morphological parameters *viz.* No. of spines on OIB, leaf shape, leaf margin, leaf colour, leaf texture, extent of leaf spininess and were studied.

On the basis of structural variations leaf shape were classified into lanceolate, linear, oblong. In present study Out of one hundred eleven genotypes eighty-seven showed lanceolate, fourteen oblong and thirteen genotypes as linear.

On the basis of structural variations leaf margin Safflower plant were classified into serrate and deeply serrate. Out of 111 genotype it was found that fifty-one genotypes had serrate and sixty genotype showed deeply serrate.

On the basis of structural variations No. of spines on OIB were classified into few spines, intermediate and many spines. In present study Out of one hundred eleven genotypes six genotypes showed many spines, fifty genotypes showed intermediate no. of spines in OIB and fifty genotypes had few spines. leaf shape, leaf margin, and no. of spines on OIB did not play any role in imparting resistant against aphid

In present study structural variations of leaf spininess, genotypes were classified into many spines, few spines and intermediate. Out of 111 genotypes 5 genotypes showed many spines and remaining 49 genotype had intermediate spines. Left 57 genotypes had few spines Thus, leaf spininess plays important role in the tested safflower genotypes against safflower aphid and found responsible for resistant or susceptible on the basis of mean aphid population and AII.

Total chlorophyll a content was minimum estimated of 0.138 mg/g in GMU 2424 and GMU 1894 which are resistant genotype and maximum in highly susceptible genotype GMU 1067 (0.176 mg/g) germplasm line. The overall observations indicated that higher chlorophyll content was noticed in all highly susceptible lines as compared to susceptible, Resistant and Moderate resistant lines. The germplasm containing highest quantity of chlorophyll a showed high aphid infestation. The correlation of chlorophyll a and Aphid Infestation Index was found significant highly positive (0.514**). Total chlorophyll b content was minimum estimated of 0.216 mg/g in GMU 2424 and GMU 1894 which are resistant genotype and maximum in highly susceptible genotype GMU 1067 (0.278 mg/g) germplasm line. The overall observations indicated that higher chlorophyll a content was noticed in all aphid highly susceptible lines. The germplasm containing highest quantity of

chlorophyll b showed high aphid infestation as compared to susceptible, Resistant and Moderate resistant lines germplasm. The correlation of total chlorophyll and Aphid Infestation Index was found significant highly positive (0.517**)

Total chlorophyll content was minimum estimated of 0.354 mg/g in GMU 6886 and GMU 7590 which are resistant genotype and maximum in highly susceptible genotype GMU 1360 (0.487mg/g) germplasm line. The overall observations indicated that higher total chlorophyll content was noticed in all aphid highly susceptible lines. The germplasm containing highest quantity of total chlorophyll showed high aphid infestation as compared to susceptible, Resistant and Moderate resistant lines germplasm. The correlation of total chlorophyll and Aphid Infestation Index was found significant highly positive (0.515**) total chlorophyll content. Total wax content was minimum in GMU 7618 and GMU 3965 in resistant genotype and maximum in GMU 8852 and GMU 1067 highly susceptiblegenotype (33.04 mg/g) germplasm lines. The overall observations indicated that higher waxcontent was noticed in all aphid highly susceptible lines. The germplasm containing highestquantity of wax content showed high aphid infestation as compared to susceptible, Resistant and Moderate resistant lines germplasm. The correlation of total wax content and Aphid Infestation Index was found significant highly positive (0.517**).

शोध ग्रंथ का सारांश

अ) शोध ग्रंथ का शीर्षक	:	कुसुम माहो, *यूरोलुकोन कंपोजिटी* (थोबाल्ड) के विरूद्ध प्रतिरोध के संबंध में उनके रूपात्मक और जैव रासायनिक लक्षणों के लिए कुसुम के जननद्रव्य एक्सेस की स्क्रीनिंग
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छात्र का हस्ताक्षर

मुख्य सलाहकार का हस्ताक्षर

दिनांक..30/06/2021

विभागाध्यक्ष के हस्ताक्षर

सारांश

वर्तमान प्रयोग **"कुसुम माहो, *यूरोलुकोन कंपोजिटी* (थोबाल्ड) के विरूद्ध प्रतिरोध के संबंध में उनके रूपात्मक और जैव रासायनिक लक्षणों के लिए कुसुम के जननद्रव्य एक्सेस की स्क्रीनिंग"** को इन्दिरा गाँधी कृषि विश्वविद्यालय, रायपुर (छत्तीसगढ़) के पौध आणविक जीवविज्ञान एवं जैवप्रौद्योगिकी विभाग के निर्देशात्मक सह अनुसंधान प्रक्षेत्र एवं प्रयोगशाला में रबी मौसम 2020-21 के दौरान आयोजित किया गया।

कुसुम माहो के विरूद्ध पर्ण शुष्कता के श्रेणी और माहो संक्रमण सूचकांक (ए. आई.आई.) की संगणना के आधार पर रबी 2019 - 20 के दौरान यह देखा गया कि 111 कुसुम स्क्रीन वाले जननद्रव्य में से कोई भी जननद्रव्य अत्यधिक प्रतिरोधी नहीं थे, 19 प्रतिरोधी और 39 मध्यम रूप से प्रतिरोधी जबकि 37 जननद्रव्य को संवेदनशील और 16 को अतिसंवेदनशील वाले थे।

कीटों के विरूद्ध पौधों के प्रतिरोधी पौधों को लगाने के लिए कई प्रकार के कीट पौधों के अंतर्संबंधों को कारण बताया गया है। एक या अधिक रूपात्मक लक्षणों के वर्णन के कारण कोई पौध प्रतिरोधी हो सकता है। इस प्रकार, विभिन्न रूपात्मक मापदंडों जैसे, ओ.आई.बी. पर काँटों की संख्या, पत्ती के आकार, पत्ती के किनारे, पत्ती के रंग, पत्ती की बनावट, पत्ती की कँटीलापन की सीमा पर अध्ययन किये गए।

संरचनात्मक विविधताओं के आधार पर पत्ती के आकार को भालाकार, रैखिक, लंबाकार में वर्गीकृत किया गया। वर्तमान अध्ययन में एक सौ ग्यारह जननद्रव्य में से सत्तासी भालाकार, चौदह लंबाकार और तेरह जननद्रव्य रैखिक के रूप में दिखा।

संरचनात्मक विभिन्नता के आधार पर कुसुम के पत्ती किनारे को प्लांट को दाँतेदार और गहरा दाँतेदार में वर्गीकृत किया गया। 111 जननद्रव्य में से यह पाया गया कि पचास जननद्रव्य में दाँतेदार और साठ जननद्रव्य को गहरा दाँतेदार रूप में दिखा।

संरचनात्मक विविधताओं के आधार पर ओ.आई.बी. पर काँटों की संख्या को अल्प काँटे, मध्यवर्ती और अधिक काँटों में वर्गीकृत किया गया। वर्तमान अध्ययन में एक सौ ग्यारह जननद्रव्य में से छह जननद्रव्य ने अधिक काँटे दिखे, पचास जननद्रव्य में मध्यवर्ती संख्या में काँटे ओ. आई. बी. पर और पचास जननद्रव्य में कुछ काँटे थे। पत्ती का आकार, पत्ती का किनारा, और ओ.आई.बी. पर काँटों की संख्या में माहो के विरूद्ध प्रतिरोध को लागू करने में कोई भूमिका नहीं थी.

वर्तमान अध्ययन में पत्ती के काँटों की संरचनात्मक विविधता के आधार पर, जननद्रव्य को अधिक काँटों, कुछ काँटों और मध्यवर्ती काँटों में वर्गीकृत किया गया। 111 जननद्रव्य में से 5 जननद्रव्य ने अधिक

काँटे दिखे और शेष 49 जननद्रव्य में मध्यवर्ती काँटे थे। बाकी 57 जननद्रव्य के कुछ काँटे थे, इस प्रकार, पत्ती की कंटिकापन कुसुम माहो के विरूद्ध परीक्षण किए गए कुसुम जननद्रव्य में महत्वपूर्ण भूमिका निभाते हैं और माध्य एफिड जनसंख्या और ए.आई.आई के आधार पर प्रतिरोध या संवेदनशील के लिए उत्तरदायी पाए जाते हैं।

कुल पर्णहरिम की मात्रा, जीएमयू 2424 और जीएमयू 1894 में 0.138 मिलीग्राम / ग्राम न्यूनतम मात्रा अनुमानित थी जो अतिसंवेदनशील जननद्रव्य था और अधिकतम मात्रा प्रतिरोधी जननद्रव्य जीएमयू 1067 (0.176 मिलीग्राम /ग्राम) जननद्रव्य श्रेणी में था। समग्र अवलोकन के संकेतानुसार सभी अतिसंवेदनशील जननद्रव्य श्रेणी

में प्रतिरोधी और मध्यम प्रतिरोधी जननद्रव्य श्रेणी की तुलना में उच्च पर्णहरिम की मात्रा देखी गई थी। सबसे अधिक मात्रा में पर्णहरिम युक्त जननद्रव्य एक उच्च माहो संक्रमण को दर्शाता है। पर्णहरिम ए और माहो संक्रमण सूची का सहसंबंध महत्वपूर्ण अत्यधिक सकारात्मक (0.514 **) पाया गया। कुल पर्णहरिम बी की मात्रा जीएमयू 2424 और जीएमयू 1894 में 0.216 मिलीग्राम / ग्राम न्यूनतम मात्रा अनुमानित थी जो कि प्रतिरोधी जननद्रव्य श्रेणी था एवं अधिकतम पर्णहरिम की मात्रा (0.278 मिलीग्राम / ग्राम) जीएमयू 1067 देखा गया जो अतिसंवेदनशील जननद्रव्य श्रेणी था। समग्र अवलोकन के संकेतानुसार उच्च पर्णहरिम एक की मात्रा को माहो के प्रति सभी अत्यधिक अतिसंवेदनशील जननद्रव्य श्रेणी में देखा गया। पर्णहरिम बी की सबसे अधिक मात्रा वाले जननद्रव्य श्रेणी में संवेदनशील, प्रतिरोधी और मध्यम प्रतिरोधी जननद्रव्य श्रेणी की तुलना में उच्च माहो संक्रमण दिखाई दिया। कुल पर्णहरिम और माहो संक्रमण सूची का सहसंबंध, महत्वपूर्ण अत्यधिक सकारात्मक (0.517 **) पाया गया।

जीएमयू 6886 और जीएमयू 7590 में कुल पर्णरिम की मात्रा न्यूनतम 0.354 मिलीग्राम / ग्राम अनुमानित की गई थी जो कि प्रतिरोधी जननद्रव्य था और जीएमयू 1360 (0.487 मिलीग्राम / ग्राम) अतिसंवेदनशील जननद्रव्य में अधिकतम अनुमानित की गई । समग्र अवलोकन के संकेतानुसार कुल उच्च पर्णहरिम मात्रा को माहो के प्रति अतिसंवेदनशील जननद्रव्य श्रेणियों में देखा गया । अतिसंवेदनशील, प्रतिरोधी और मध्यम प्रतिरोधी जननद्रव्य श्रेणी की तुलना में अधिक माहो संक्रमण कुल पर्णहरिम की सर्वाधिक मात्रा वाले जननद्रव्य श्रेणी देखा गया । कुल पर्णहरिम और माहो संक्रमण सूची का सहसंबंध महत्वपूर्ण अत्यधिक सकारात्मक (0.515 **) कुल पर्णहरिम मात्रा पाया गया। कुल मोम सामग्री प्रतिरोधी

जननद्रव्य श्रेणियों जीएमयू 7618 और जीएमयू 3965 में न्यूनतम थी और अतिसंवेदनशील जननद्रव्य श्रेणियों जीएमयू 8852 और जीएमयू 1067 में (33.04 मिलीग्राम / ग्राम) में अधिकतम थी । समग्र अवलोकन के संकेतानुसार उच्च मोम वाले सभी माहो अतिसंवेदनशील जननद्रव्य श्रेणी में उच्च मोम सामग्री को देखा गया था। । सबसे अधिक मात्रा में मोम सामग्री वाले जननद्रव्य में संवेदनशील, प्रतिरोधी और मध्यम प्रतिरोधी जननद्रव्य श्रेणी की तुलना में उच्च एफिड इन्फेक्शन दिखाई दिया। कुल मोम सामग्री और माहो संक्रमण सूचकांक का सहसंबंध महत्वपूर्ण अत्यधिक सकारात्मक (0.517 **) पाया गया।

CHAPTER-I
INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is one of the important Rabi oilseed crop of the country. It is well adapted to dry regions and is the member of family Asteraceae. Safflower has been grown in India since immemorial and is mentioned as kusumba inancient scriptures. Presently in India it is most commonly known as kardi in Marathi and kusum in Hindi. There are 36 species in the genus Carthamus, found in many part of world namely Asia, Africa, and mediterrian regions out of these only *Carthamus tinctorious* (L.) (2n =24) is cultivated in India. India has rich diversity of annual oilseed crops on account of diverse agro-ecological conditions. Nine annual oilseeds, which include seven edible oilseeds, viz., groundnut, rapeseed-mustard, soybean, sunflower, sesame, safflower and niger and two non-edible crops, viz., castor and linseed, are grown in country. Safflower is a multipurpose crop rich in vitamin A, iron, phosphorus and calcium. The use of this crop is as vegetable and edible oil for human being and as drying oil and dye for trade. Safflower oil which is sold as saffola, is considered to be more preferred oil due to rich poly unsaturated fatty acid (73-79% lenoleic), which help in reducing the blood cholesterol level. The oil is mainly used as edible oil. It is also used in manufacture of paints, varnishes and linoleum. India is in first place in terms of area and production in the world with an area 138 lack ha and production 41 lakh tonnes with productivity 434 kg/ha (2016-2017). Safflower is mainly grown in Maharashtra, Karnataka to some extent in Gujarat and parts of Andhra Pradesh, Madhya Pradesh, Orissa, Bihar (Akashe, 2012). In India, Maharashtra is highest producer of safflower (63%) from the largest growing area (67%) followed by Karnataka with 32% in production and 275 lakh ha in area (Jadhav et al., 2012).

Safflower is an annual plant from the Asteraceae family (Vorpsi et al., 2010). In literature, it is referred to as cultivated (*Carthamus tinctorious L.*) and wild species (*C. lanatus L.*). several years ago in the Middle East safflower was first domesticated, cultivation of safflower spread at an early date in Indian and along the Nile valley to modern-day Sudan (Zhang, 2001). Herbaceous and branched annual safflower plant have branches which are terminated by individual

head of flowering each composed of 20-100 florets. Flower head are protected by many involucral bracts. The inner involcural bracts are fused in several layers around the head and completely cover theunopened florets.

This crop is also major aromatic and medicinal plant and also due to safflower high oil content it is cultivated as oil crop. The seed contains 15-20% protein, 30-40% oil and 45-35 hull part. The proteins from safflower seeds are of good nutritional quality (Majidi et al., 2011). It is nutritionally similar to olive oil, with high levels of linoleic or oleic acid, but much less costly (Sabzalian et al., 2010). Safflower oil is of 2 types, have 76%-79% linoleic acid and 1-2% stearic acid .one type which have high linoleic has been used in soft margarines marketed in small tubs, in salad oil, and also used in manufacture of paints and varnishes,the other standard type or polyunsaturated type have 76-79% linoleic acid and 11-17% oleic acid. Safflower oil has limited use in frying food, as heat causes to polymerize and forms tough film on cooking vessel. Second type of safflower oil called high olieic acid or monounsaturated type has 76- 79% oleic acid and 11-17% linoleic acid. Its fattyacid composition in just like olive oil, high olieic acid safflower is premium oil for frying and has been widely used in cosmetics. The meal left after oil extraction is used for animal feed (Sabzalian et al., 2008).

Safflower in India has been reported to be attacked by 36 species of pest, out of which three pest species are considered to be major pests of safflower which are Safflower aphid- *Uroleucan compositae*, capsule borer *Helicoverpa armigera* and leafeating caterpillar *Perigea capensis* among these three the most destructive is safflower aphid, which is reported to cause 35 to 75% loss in yield during infestation period. Survey results shown that intensity of *H.armigera* was more where safflower is grown as sole crop and intercropped with Bengal gram. Among the cropping pattern sole crop and safflower inter- cropped with niger harboured more aphids (58 to 60/ 5 cm twig) than compared to any other cropping pattern. Among the insect pests that attack safflower the aphid, *Uroleucon compositae* (Theobald) is considered as a major pest causing severe losses to the crop throughout the world. *U.compositae* Safflower aphidis the most destructive pests of the safflower, this pest alone can do 35-75% yield loss. Attack of aphid with high density can only be managed with chemical insecticides. Deleterious effect of

using chemical pesticides and increasing awareness and demand of pesticides free food has prompted to give emphasize on alternative management options. Identification of resistant lines and biochemical basis of resistant are important for the development of host plant resistant. The use of resistant varieties /genotypes is a way to lower the cost of crop protection as part of integrated pest management in safflower. Thus, the present study was targeted to evaluate safflower varieties for resistant against safflower aphids.

Keeping this in view and realizing the importance of safflower aphid resistance in some promising lines present investigation entitled "Screening of germplasm accessions of safflower for their morphological and biochemical traits in relation to resistance against Safflower aphid, *Uroleucon compositae* (Theobald)" was conducted during 2019-20 at Indira Gandhi krishi vishwavidyalaya, Raipur (C.G.)with following objectives: -

1. To evaluate safflower germplasm accessions for their reaction against saffloweraphid under natural conditions.
2. To study morphological characters of safflower genotypes and their associationwith resistant/preference against safflower aphid.
3. To study biochemical compounds of safflower genotypes against safflower aphidresistant/preference.

CHAPTER-II

REVIEW OF LITERATURE

Safflower is one of the major *rabi* oil-seed crops as well as important source of industrial oil in country. It has not only good oil properties but it also source for dye, paints and other medicinal purposes. Safflower aphid *Uroleucon compositae* (Theobold) is a serious pest of the safflower crop. It attacks on the tender shoots of the plants and due to its infestation, the plants fade and dry up and heavy damage is caused to the crop. Review of literature for the study entitled "Screening of germplasm accessions of safflower for their morphological and biochemical traits in relation to resistance against Safflower aphid, *Uroleucon compositae* (Theobald)" with following objectives: -

1. To evaluate safflower germplasm accessions for their reaction against safflower aphid under natural conditions.

2. To study morphological characters of safflower genotypes and their association with resistant/preference against safflower aphid.

3. To study biochemical compounds of safflower genotypes against safflower aphid resistant/preference.

2.1 To evaluate safflower germplasm accessions for their reaction against safflower aphid under natural conditions.

Naik (1987) screened seventeen genotypes of safflower for aphid resistant under irrigated conditions. He found that the aphid population ranged between 69.2 to149.7 per plant. Genotype WA300 had the lowest aphid population whereas, genotype HUS1132 recorded highest aphid populations during peak infestation period.

Akashe *et al.* (1993) screened safflower germplasm to aphid's resistant based on drying of foliage under field condition. They noted that germplasm namely GMU Nos. 181, 300, 421, 589, 632, 1183,1406 and 5-14-2B have been found to be resistant with2 grades for drying, whereas GMU-138 identified as 1 grade for drying foliage.

Ghorpade and Thakur (1996) evaluated fifteen safflower genotypes reaction to aphid and yield potential under late sown condition. They found five genotypes namelyJLSF 190, JLSF 195, JLSF 223 and JLSF 269 had exhibited as more resistant to aphid on the basis of aphid populations and degree of foliage drying, seed yield and other plant characters.

Balikai (1999) evaluated four hundred five safflower germplasm and their reaction to the aphid, *Uroleucon compositae* under irrigated condition. He reported that GMU174 genotype was found to be highly resistant, followed by GMU191, 194, 197,283, 285, 318 and 342.

Balikai (2000) screened twenty six promising safflower entries for aphid resistant and seven entries *viz.*, PI-245 7, f11- 199932, PI-306934, PI-306983, PI-220283, PI-77 and N-1536 were showing their highly tolerant reaction to aphid, whereas, rest of the entries *viz.,* PI-35, JLSF-88, JLSF-I03, SSF-3, SSF-40, SSF-17 and SSF-31 were grouped under tolerant category and eleven entries *viz.*,BLY-652, JLSF-93, JLSF-98,NS-I021-1, JSI·7, No. 16, PI-193475, B-69, Bhīma, A-I and GMU - 83 were categorized under moderately tolerant.

Bhadauria *et al.* (2000) tested nineteen safflower varieties against the aphid on thebasis of the aphid population and multiplication index. They proved that BI 11, BI 36and JSF 62 varieties were less susceptible to the safflower aphid while JSF 25, JSF 9-1 and JSF 80 proved to be highly susceptible.

Balikai *et al.* (2001) screened three hundred thirty two safflower genotype including three checks against aphid .They found that only two entries *viz.*, HUS 568 and HUS 945 were highly tolerant with aphid foliage drying grade of one, while forty eight entries recorded foliage drying grade two indicating their tolerant reactions to aphids.

Mane *et al.* (2001) reported that aphid resistant cultivar LATS –2 was exhibited with least aphid population per leaf and percent drying of leaves as compared to susceptible genotype.

Mahasi *et al*. (2002) Thirty-six exotic safflower accessions were evaluated based on 12 morphological characters in the year 2001. Considerable diversity was

observed in the accessions for all traits under study. Of greatest importance was the effective number of capitula per plant, which was responsible for high seed yield per plant. These accessions were planted in 2002 at Lanet, Naivasha Kinamba, and Katumani in a partially balanced lattice design with 3 replications. The results revealed that the effects of sites to accessions were significantly different ($P< 0.05$) while the genotype x environment (G x E) interaction was not significant. Since the interaction was not significant, this implied that the accession means which did not vary much across the test locations or the environments may be similar. From cluster analysis three major clusters were observed the largest consisting of 34 accessions. Accessions from different areas clustered together suggesting that they have genetic similarity. The clustering pattern indicated that genetic diversity might not be necessarily related to geographic diversity. At all sites, Principal Component 1 and Principal Component 2 contributed more than 80% to the total variance. In Katumani and Kinamba, effective capsules/plant showed a high positive correlation.

Neharkar *et al.* (2003) screened twenty one safflower genotypes for resistance against aphid (*Uroleucon composite*) and found that 5 genotype namely LATS-2, GMU- 1251, GMU-4609, GMU-4625 and GMU-719 showed resistant reaction, while CO -1 cultivar exhibited highly susceptible reaction against aphid. Rest of the fourteen genotype showed moderately resistant reaction against aphid.

On the basis of foliage drying Akashe *et al.* (2004) screened seventy-nine safflowergenotype and reported that due to aphid infestation 1, 3, 8, 38 and 29 entries showed atolerant reaction against aphids.

Singh (2008) screened two thousand safflower germplasm based on 1 to 5 grade of foliage drying and reported that out of 2000 safflower germplasm accessions, 18 genotype recorded foliage drying of 0-15 % with aphid population of 11-34 aphids/5 cm on the central twig/plant and they were categorized as highly tolerant against aphids while remaining six germplasm namely GMU No. 2897, 2933, 3927, 3828, 3923 and 2596 showed 15 % foliage drying with 29-34 aphids/plant.

Murumkar *et al.* (2009) studied multiple resistant sources against major diseasesand insect pests of safflower. They reported that three genotypes of safflower

namely GMU-5097, GMU-5133 and GMU-7017 exhibited moderately tolerant reaction to aphid.

In Hyderabad (Anonymous, 2009) one hundred fifty germplasm including CO-1 as susceptible check and A-1 as tolerant checks were screened against safflower aphidunder field condition. Twenty germplasm were found resistant against aphid.

One hundred fifty-four safflower genotype screened against aphid under field condition at Solapur, Maharashtra (Anonymous, 2010). Six line namely SAF-1, 835,807,901, 903,904 and 948 were found tolerant to aphid.

In Hyderabad (Anonymous, 2011) 29 GMU accession were screened against safflower aphid under field condition. Among the 29 accession 15 were found to tolerant to be aphid while 14 showed moderately resistant reaction.

At Directorate of Oil seed research, Hyderabad (Anonymous, 2012), fifty eight exotic safflower accession were screened against aphid. Among the 58, only one exoticaccession (EC 523368-2) was found resistant (1.5 score on 1-5 scales) and rest of theaccession showed either susceptible or highly susceptible reaction.

One hundred thirteen early generation breeding line ware screened for aphid resistant at Solapur, (Anonymous, 2013). Four lines namely SAF-1126, SAF-1135, SAF-1224 and SAF-1123 were categorised under resistant while 44 line under fond moderately resistant to aphid.

Rajput *et al.* (2013) Black aphid, *Uroleucon compositae* (Theobold) is a serious pest of the safflower crop. It attacks on the tender shoots of the plants and due to its drainage, the plants fade and dry up and heavy damage is caused to the crop. The study was carried out to observe the relative resistance of 5 safflower cultivars against black aphid, *Uroleucon compositae*. It was observed that the population of aphid differed significantly among the cultivars PI40/477, PI-292000 and PI-405994, while no significant difference in population of aphid was observed in case of cultivars PI-26993 and Thori-78. Cultivar PI-40/477 proved relatively resistant against aphid with low population of pest (25.47 ± 5.95 per 6 plants), while PI-405994 found to be highly susceptible with high population of pest (100.04 ± 26.11 per 6 plants). Cultivars PI-26993 (63.35 ± 14.51 per 6 plants), PI-292000

(52.87 ± 11.81 per 6 plants) and Thori-78 (50.84 ± 12.36 per 6 plants) were susceptible to aphids.

Akashe *et al.* (2014) evaluated safflower genotypes for multiple resistants to insect pests and diseases. They recorded lowest aphid population on only two genotype namely GMU- 4854 (122.5 aphids/5 cm twig and GMU-4669 (127.5 aphids/5 cm twig) as compared to tolerant check A-1 (135.0 aphids 5 cm twig) and other genotype.

At Directorate of Oilseed research, Hyderabad (Anonymous, 2014), 31 exotic safflower accessions were screened for reaction to aphid. Among the 31, only one exotic accession (EC 523368-2) found highly resistant whereas another line, EC-542441 and resistant cheek, A1 were categorized under moderately resistant group. All others were found either susceptible or highly susceptible.

Saeidi *et al.* (2015) conducted research to see the biodiversity of insects in warm and cool areas from March to April in 2009 at the Gachsaran Agricultural Research Station. A total number of 4261 specimens, which were identified into 31 families and 92 species. Out of total 31 families collected, 10 families were pests, 2 families belongs to predators and beneficial insects and 7 families belongs to parasitoids and beneficial insects and finally, 12 families of insects are saprophage and polyphagous. There was no significant difference ($P>0.05$) in the number of insects collected between months. The mean number of insects collected in the month of March, April and May was 34.7, 30.7 and 36.2 respectively. The Basht area is most susceptible host for insects (37.9), while the Gachsaran and Lishter areas is less susceptible (33.5) and (28.4) so both sites not differ significantly in the population of insects. The family Coccinellidae had more population in the Gachsaran-safflower zone (98.3) than the Basht-safflower zone (54.6) and it was significantly similar to the family cicadellidae. Similarly, different families like Aphididae (98.0), Cicadellidae (74), Thripidae (50.0), Curculionidae (26.6), Noctuidae (25.0) and Torymidae (27.3) had higher population in the Gachsaran-safflower zone than in the Basht-safflower area with means of 92.3, 63.0, 42.6, 21.0, 21.6 and 19.3 respectively. Also the families like Nymphalide, Pieridae, Lygaeidae, Papilionidae, Miridae, Pentatomidae, Reduviidae, Geometridae, Gryllotalpidae. Mantidae, Acrididae, Saturnidae and Anthocoridae had mean population of 12.6, 7.4, 12.0, 4.1, 4.4, 8.6, 1.9, 0.5, 7.5, 2.4, 11.3, 3.3 and 8.9.

Dambal and patil (2016) studied a total of 80 safflower germplasm accessions in an augmented design. The cultivars NARI-6 was included as a susceptible infester check and A-1 as a resistant check was used. It was found that out of 80 safflower germplasm accessions, eleven accessions recorded foliage drying of 21-35% with aphid population of 41-70 aphids/5 cm on the central twig/plant and A.I.I. ranging from 1.1 to 2.0. These accessions were graded as tolerant genotypes to safflower aphids. The national resistant check (A-1) recorded 23 percent of foliage drying with aphid population of 45 aphids/5 cm on the central twig/plant and seed yield of 3.2 g/plant and susceptible check NARI-6 recorded 90% of foliage drying, aphid population of 120 aphids/5 cm on the central twig/plant and zero seed yield.

Mutkule *et al.* (2018) evaluated 16 safflower germplasm for their resistance against safflower aphids on the basis of aphid infestation index (A.I.I). The cultivars CO-1 was included as a susceptible infester check and A-1 as a resistance check. It was found that out of 15 safflower germplasm lines, two germplasm SF-1506, SAF-13-40 and Bhima were found resistant whereas, six accessions were found with susceptible reaction, while rest of safflower genotypes were found highly susceptible.

2.2 To study morphological characters of safflower genotypes and their association with resistant/preference against safflower aphid.

Bhumannavar and Thontadarya (1979) based on aphid count evaluated 25 safflower varieties in the field based on aphid count and classified them into different levels of resistant. They found that infestation by the aphid was higher on spineless than on the spiny varieties.

Upadhyaya *et al.* (1980) also conducted similar studies on other species, *Oactynotus carthami* in relation to weather conditions. They found that infestation by the aphid was higher on spineless than the spiny varieties.

Rathore *et al.* (1981) studied population levels of safflower aphids *Uroleucon compositae* (Theobald) on the crop sown on different dates. They revealed that the early sown crop was less infested by the aphid and the population intensity increased with the delaying in sowing date.

Jagtap *et al.* (1985) recorded observations on incidence of *Uroleucon carthami* on 51 varieties and showed that, in general, aphid preferred varieties without spines and the variety JL28-1 was found the least susceptible (28.89 %) to aphids.

Singh (1991) studied sampling and distribution of safflower aphid *Uroleucon compositae* (Theobald) on safflower crop and reported that 5 cm of apical twig per sample was best to record aphid population.

Ghorpade and Thakur (1994) evaluated 15 safflower genotypes during 1988-91 fortheir reaction to *Uroleucon compositae* and yield potential under late sowing. On the basis of aphid populations, the degree of foliage drying, seed yield and other plant characters, five genotypes with high yield (JSLF- 190, JSLF-195, JSLF-223, and JSLF-269) were found to be more resistant to aphids. These genotypes had thin woody branches and spiny leaves.

Singh *et al.* (1996) conducted experiments on monitoring of safflower aphid population and plant infestation levels. They recorded positive correlation between different dates of sowing and pest population. The maximum number of aphids was 100 aphids plant^{-1}. They also reported that aphid population affected the crop about 55 percent in case of normal as well as late sown crops.

Akashe *et al.* (1997) conducted experiments with 9 promising safflower germplasm lines under field and caged conditions to identify genotypes with a high degree of tolerance to aphids. On the basis of aphid populations, foliage drying, yields and morphological characters displayed at different locations, SSF268. GMU3644, GMU3955, GMU4480, GMU4484 and JLSF322 were identified as tolerant to aphids and recommended for use in breeding programmes, aimed at evolving high yielding genotypes or varieties with better resistant to aphids, particularly for rainfed safflower.

Singh *et.al.* (2006) evaluated safflower germplasm accessions for resistance against safflower aphids in an augmented design. Observations were recorded during peak aphid incidence on number of aphids/5 cm on the central twig/plant and % foliage drying of whole plants due to aphid infestation from five randomly selected plants of each accessions along with checks. Grade and category were made on a

scale of 1 to 5 based up on the % foliage drying by observing visual symptoms of the whole plants. It was found that out of 2000 safflower germplasm accessions, 18 accessions recorded foliage drying of 0-15 % with aphid population of 11-34 aphids/5 cm on the central twig/plant and graded as highly tolerant to aphids. Of the 18 most promising safflower germplasm accessions, GMU No. 4474, 2902, 4585, 2866 and 3854, recorded zero per cent foliage drying with minimum aphid population of 11-15 aphids/5 cm on the central twig/plant and maximum seed yield of 3-3.3 g/plant, however, GMU2866 was non-spiny type. Seven germplasm accessions, GMU No. 3714, 3725, 3764, 3936, 4176, 2609 and 2823, recorded 10 % foliage drying with 20-24 aphids/plant and seed yield of 2.8-3 g/plant and rest six germplasm accessions, GMU No. 2897, 2933, 3927, 3828, 3923 and 2596, recorded 15 % foliage drying with 29-34 aphids/plant and seed yield of 2.4-2.6 g/plant. Plant height, number of branches and capitulum had no correlation with susceptibility of aphids. In general, spiny genotypes with thin stems, pale green leaves were observed as tolerant / resistant to aphid infestation while non-spiny, late maturing and tall genotypes with succulent stems and green leathery leaves contributed for aphid susceptibility.

Rajput *et al.* (2013) evaluated the 5 safflower cultivars relative resistant against black aphid. They noticed that one variety PI-40/477 was comparatively resistant with lesser population of aphid 25.47 ± 5.95/ 6 plants and had different morphological characters such as higher spines on leaves which may prevents/ resists the accumulation of aphids on cultivar as a result the cultivar PI-40/477 were less infestedby the aphid attack as compare to other cultivars.

Ali *et al.* (2019) evaluated a total of 94 safflower accessions from 26 different countries for morpho agronomic performance, determine the pattern of similarity centers, and identify the best performing accessions by conducting 2 field experiments in Pakistan and Turkey using augmented design. Genetic diversity for important yield and yield traits was described including capitulum diameter (17.30 to 28.30 mm), branches per plant (5.10 to 17.30), capitula per plant (8.70 to 80.40), and seed yield per plant (4.86 to 51.02 g). These analyses showed a good level of variation in the current study. Using principal component analysis, it was observed that days to flower initiation, days to 50% flowering, days to flower completion, seed

yield per plant, capitula per plant, branches per plant, seeds per capitulum, and capitulum diameter were the major contributors to the observed genetic variability in the evaluated safflower panel. Seed yield per plant reflected a significant and positive correlation with capitula per plant, branches per plant, and capitulum diameter, and these traits can be suggested as a selection criterion in safflower breeding programs. The hierarchical clustering was in agreement with the patterns of 7 similarity centers based on seed yield per plant, capitula per plant, capitulum diameter, and branches per plant. During this study, a few promising safflower accessions were selected for future breeding programs.

Saeidi (2020) evaluated eight safflower genotypes namely, Padideh, Sina, Zarghan, Sofeh, Goldasht, Golmehr, Esfahan and Varamin, during 2016-2017, to identify antixenotic resistance against safflower aphid, *U. carthami*. Choice tests were conducted at 25 ± 1 ºC, 60 ± 5% RH and a photoperiod of 16:8 (L: D) h. After introduction of apterous adult aphids to test arena, the number of aphids on each entry was counted at 2, 4, 6 and 24 hours of release. Significant differences were found between genotypes for Total phenolic content, NPK essential elements, leaf thickness and leaf trichome density. It was found that the most antixenosis effect was observed on 'Sina'. Increase in antixenosis correlated with increase in leaf trichomes. Antixenosis can be important mode of resistance by reducing host selection and delaying aphid colonization. The identification of antixenotic resistance in several genotypes provides additional options for management of this pest. Moreover, the factors associated with this mode of resistance can be effectively used in an integrated pest management of the safflower aphid.

2.3 To study biochemical compounds of safflower genotypes against safflower aphid resistant/preference

Basavangoud *et al.* (1980) studied the biochemical basis of resistance in safflowerand reported that CTS-7403, a non-spiny variety, was the least susceptible whereas CTS-7205, a heavy spiny variety, was the most susceptible. CTS-7403 had higher levels of reducing sugar, total sugars and total phenols and lower levels of amino acidthan CTS-7205.

Malik (1988) studied role of amino acids in relation to aphid (*Lipaphis erysimi,* Kalt.) resistant in cruciferous species and reported 5 resistant, 15 tolerant and 6 susceptible crucifer species and varieties (mostly of *Brassica*) contained different amounts of free amino acids (averages of 13.7, 15.3 and 20.3 mg/g, respectively). Theloss of free amino acids due to aphid infestation was 24.0, 40.5 and 70.9%, respectively in the resistant, tolerant and susceptible genotypes and aphid fecundity was positivelycorrelated with free amino acid content.

Sachan and Sachan (1991) studied the biochemical basis of resistant in *Brasica juncea* against *Lipaphis erysimi.* They reported that protein had significantly positive correlation with aphid population on stalk and seed pod.

Westhuizen and Pretorius(1991) studied the biochemical and physiological responses of resistant and susceptible wheat to Russian wheat aphid infestation and reported that effect of Russian wheat aphid infestation on protein, free amino acid, free proline, chlorophyll and phenolic contents effect respiration rate of aphid and infestation induced changes in proline content are evidently contributing to resistant, increased phenolic content in resistant wheat after infestation may have low.

Kitroongruang *et al.* (1991) studied relationship between leaf amino acid contents and aphid resistant in muskmelons. They found there was significant variation amongresistant/susceptible lines for free amino acid contents of the leaves and aphid infestation, higher amount of amino acid accumulated in susceptible line leaf and loveramount noised in resistant line.

Neharkar and Suryawanshi (2004) investigated eight safflower genotypes Sharda, A-1, Co-I, GMU-4608, GMU-4609, GMU-4610, GMU-4625 and GMU-4627. They analysed major constituents of nitrogen, phosphorus, potassium, wax, polyphenols, total amino acids and total sugar contents. The safflower genotypes with less nitrogen,wax, (chloroform soluble matter), total amino acids and total sugars and more amount of phosphorus, potassium and polyphenols were resistant to aphids (*Uroleucon compositae*), when compared with Sharda and CO-I. It was observed that the nitrogen,wax, total amino acids and total sugars were responsible for the resistant and susceptibility in safflower genotypes. Lower contents of the above parameters were found in resistant genotypes, whereas higher content of phosphorus, potassium

and polyphenol was responsible against safflower aphid resistant and observed in genotypes GMU-4609, GMU-4625 and A-I.

Tsumuki *et al.* (2004) studied relationship between amino acid concentrations of the barley and aphid infestation. They found that total free amino acid concentrations in the leaves of the resistant barley lines tested were higher compare susceptible lines. The low value of some amino acids and the high proportion of the asparagine fraction containing glutamic acid appeared to be associated with resistant to the aphids.

Jiang *et al.* (2008) investigated mechanism of resistance to aphids in strawberry cultivars and reported the resistant of strawberry to aphids was positively related to the density of the pubescence and the content of lignose and negatively related to stomata density. The contents of hydroxybenzene, total amino acids, soluble sugar and water in the leaves did not affect the resistant of strawberry to aphids. The contents of phenylalanine, proline and valine significantly affected resistant to the pest.

Xu *et al*. (2008) investigated resistant of wheat cultivars (lines) to aphid at seedling stage and its relation with chlorophyll content. They reported was significant negative correlation between chlorophyll a content and aphids landing amount (r = 0.60*), but there was no significant correlation between chlorophyll b content and aphids landing amount (r=-0.24), indicating that the higher the chlorophyll a content, the stronger the non-preference of aphids. There was no significant correlation between chlorophyll a, b content and antibiosis to aphid.

Kumar *et al.* (2010) identified of mechanism of resistance in *Brassica juncea* against mustard aphid. They reported plants having white colored petals RWH 1 and glossy foliage, B 85 G were found resistant while, BSH 1, a susceptible check with bright yellow colored flowers was infested heavily. And higher amount of protein (Pusa Bold and DIRA 313), total soluble sugars (Pusa Bold) and oil content (Pusa Bold and RLM 619) were positively associated with average peak aphid population, while phenol (B 85 Glossy and RWH 1) and glucosinolate (B 85 and T 6342) were related with low incidence of mustard aphid and no such relationship could be established in

their F_1 and F_2 progenies.

Chiozza *et al* (2010) analysed the accumulation of amino acid in leaves of susceptible and resistant soybean plants in response to the soybean aphid. They found free amino acids in leaves at three soybean developmental stages higher in susceptible genotype and lover in resistant genotype.

Saeidi *et al.* (2011) reported that safflower fly, *Acanthiophilus helianthi* Rossi, 1794 (Diptera: Tephritidae) is one of the most important pests of safflower in Iran. Losses caused by lar- val feeding leads to disrupted plant activities, reduction in flower buds, and, ultimately, to decreased quality and quantity of crop. An investigation was made from March 2008 to August 2009 in Gachsaran and Yasooj to record the pest status of safflower and their natural enemies. A total of twenty arthropods were recorded as pests of safflower. Out of 25 farms surveyed, only seven had the incidence of pest attack. Among the pests, Safflower fly and Silver - Y- moth were found to cause considerable damage to the saf- flower plants, while others were not at economic levels. Among the natural enemies, parasitoids like Bracon hebetor, Bracon luteator, Colotrechnus viri- dis, Antistrophoplex conthurnatus, Microdontomenus annulatus, Ormyrus orientalis, Eurytoma acroptilae, Pronotalia carlinarum, Pteromalus sp. and Isocolus tinctorious were found to be associated with the pests of safflower

Gurunath and Balikai (2018) noticed variety A-1 with the foliage drying grade 3 indicating its moderately tolerant reaction to aphid infestation which was on par with the varieties A-300 (foliage drying grade 3) and A-2 (foliage drying grade 3). The varieties PBNS-12 and Nari-6 were susceptible to aphid infestation and thus recorded the foliage drying grade of 4. Under protected condition, reducing sugars were significantly and negatively correlated with aphid population. Amino acids, total phenols and total sugars showed no significant correlation with aphid population. Total phenols correlated significantly and negatively with foliage drying grade. Under unprotected condition, amino acids correlated significantly and positively with aphid population. Reducing sugars, total sugars and total phenols correlated negatively and significantly with aphid population. Amino acids correlated significantly and positively with foliage drying grade. Reducing sugars, total sugars and total phenols correlated non-significantly with foliage drying grade. The

genotypes having high concentration of amino acids viz., NARI-6, PBNS-12 recorded more infestation of aphid population. The genotypes having less concentration of reducing sugars, total phenols and total sugars viz., A-1, A-300 and A-1 recorded less aphid population and showed resistance / tolerance to aphids population.

This chapter deals with a concise description of the materials used and methods adopted in carrying out the present investigation entitled "Screening of germplasm accessions of safflower for their morphological and biochemical traits in relation to resistant against Safflower aphid, *Uroleucon compositae* (Theobald)".

3.1 Location and Experimental site

Raipur comes under the tropical region of India is situated in central part of Chhattisgarh plains. Field experiment was carried out during the year 2019-20, under All India Co-ordinated Research Project on Safflower at Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).

3.2 Geographical situation

Raipur, the place of investigation, is situated in the central part of Chhattisgarh at 21°16' N latitude, 81°36' E longitude and at altitude of 289.56 m from mean sea level.

3.3 Climate and soil

The place of investigation Raipur comes under dry, sub-humid region under seventh agro-climatic zone of the country, *i.e.* eastern plateau and hills. The annual average rainfall is 1200-1400 mm, out of which about 85 per cent is received from third week of June to mid-September and very little during October to February. May is the hottest (46°C) and December is the coolest (6°C) month of the year. The pattern of rainfall, particularly during June to September months has great variation from year to year, with occasional light showers during winter and summer season. The average maximum (42.8 ^{0}C) and minimum (10.1 ^{0}C) temperature generally has been observedin month of May and December, respectively.

3.4 Field Preparation

The preparation of field was done by tractor-drown cultivators followed by two cross-harrowing to pulverize the soil and finally the field was levelled with

planker. The layout of field was prepared as per experimental design.

3.5 To evaluate safflower germplasm accessions for their reaction against safflower aphid under natural conditions.

The experiment was conducted during 2019-20 at College of Agriculture, Raipur, Indira Gandhi Krishi Vishwavidyalaya by growing a total of 111 safflower germplasmaccessions with two checks. The date of sowing was 26/11/2019. The plots was with single rows 5 m long and spaced 45 cm apart with 20 cm between plants within rows. The cultivars PBNS-12 was included as a susceptible check and A-1 as a resistant check used. The germplasm which were used in the experiment are: GMU 2424, GMU 7573, GMU 6891, GMU 5136, GMU 1175, GMU 7590, GMU 2347, GMU 7594, GMU 2486, GMU 7316, GMU 7436, GMU 5142, GMU 7634, GMU 3944, GMU 1811, GMU 1397, GMU 7569, GMU 2775, GMU 1984, GMU 7363, GMU 3266, GMU 6915, GMU 589, GMU 5135, GMU 1731, GMU 6886, GMU 7568, GMU 1301, GMU 5133, GMU 1654, GMU 7581, GMU 590, GMU 995, GMU 7618, GMU 2644, GMU 3438, GMU 5134, GMU 2648, GMU 6037, GMU 7355, GMU 974, GMU 2687, GMU 1183, GMU 6004, GMU 4914, GMU 1360, GMU 2757, GMU 7572, GMU 4546, GMU 667, GMU 3924, GMU 2273, GMU 4983, GMU 6926, GMU 7331, GMU 1067, GMU 4814, GMU 2403, GMU 579, GMU 5149, GMU 7399, GMU 4965, GMU 6854, GMU 7579, GMU 7633, GMU 7448, GMU 7591, GMU 7456, GMU 7593, GMU 609, GMU 7359, GMU 5097, GMU 2830, GMU 753, GMU 7601, GMU 1758, GMU 7319, GMU 3206, GMU 884, GMU 880, GMU 972, GMU 1217, GMU 7599, GMU 6852, GMU 2928, GMU 2380, GMU 1798, GMU 1628, GMU 7351, GMU 184, GMU 7612, GMU 3654, GMU 1940, GMU 3926, GMU 5774, GMU 7303, GMU 5660, GMU 1437, GMU 1851, GMU 3781, GMU 1737, GMU 969, GMU 5338, GMU 849, GMU 5865, GMU 850, GMU 7542, GMU 4907, GMU 2968, GMU 3966, and GMU 3965

3.5.1 Methods of observation and Aphid Infestation Index (A.I.I.) calculation based up on foliage drying.

The observation on aphid recorded on 5 cm top twig per plant from the date of aphid appearance to the harvest of the crop. Ten plants randomly selected from each entry, Before maturity of the crop the drying of whole plant due to aphid

infestation was recorded one month after peak incidence by visual scoring in 1-5 scale. The aphid infestation index (AII) was calculated on the basis of foliage drying grades. On the basis of AII the germplasm accessions were grouped into different category. The Aphid Infestation Index (AII) was computed by using the formula followed by entomologists of the "All India Coordinated Research Project on safflower" 1990.

$$Aphid\ infestation\ index\ (A.I.I.) = \frac{1Xa + 2Xb + 3Xc + 4Xd + 5Xe}{a + b + c + d + e}$$

Where, a, b, c, d, e are the actual number of plants falling in each of the 5 corresponding foliage drying grades *i.e.* 1 to 5 scale. The mean of A.I.I. was worked out and the entrieswere classified as follows:

Table 3.1: Screening Techniques of safflower aphids based on foliage drying

Sl.No.	Categories of genotypes	A.I.I.
1	Highly Resistant (HR)	0.0-1.0
2	Resistant (R)	1.1-2.0
3	Moderately Resistant (MR)	2.1-3.0
4	Susceptible (S)	3.1-4.0
5	Highly susceptible (HS)	>4.1

Table 3.2: Safflower germplasm screened against aphids based up on Foliage drying

Sl. No.	Visual symptoms	% foliage drying	Grade	Category
1	Healthy plant with normal seed yield	0 to 20	1	Highly Resistant (HR)
2	Healthy plant but yellowing and Drying of leaves on main stem, branches and normal capitula.	21 to 40	2	Resistant (R)
3	Drying of 50 leaves on tender shoots of the plant, small to medium capitula with low seed setting	41 to 60	3	Moderately Resistant (MR)
4	Drying of leaves and tender shoots, withering of branches, Stunted growth and less number of capitula with very poor seed setting	61 to 80	4	Susceptible (S)
5	Death of plant before maturity and no seed yield	< 80	5	Highly Susceptible (HS)

3.6 To study morphological characters of safflower genotypes and their association with resistant/preference against safflower aphid.

3.6.1 Methodology: -

All morphological parameters were taken from safflower descriptors prescribed byInternational Board for Plant Genetic Resources (IBPGR), Rome (1982). Data was recorded from 5 randomly selected plants in each varietal line.

3.6.2 Study of morphological characteristics of safflower:

3.6.2.1 Leaf shape (upper stem leaves):

According to shape of leaf, the leaf of safflower was categorized as ovate, Oblong, lanceolate, linear by visual observation from 5 randomly selected plant of each germplasm.

3.6.2.2 Leaf margin:

Leaf margin were categorized as entire, serrate and deeply serrate on the basis of serration of leaf margin and it was visually observed. observation were taken in 5 randomlyselected plants of each germplasm.

3.6.2.3 Extent of leaf spininess:

Leaf spines observation were counted by visual observation at the stage of first flowering. And categorized as non-spiny, few spines, intermediate, many spines, observation were taken in 5 randomly selected plants of each germplasm.

3.6.2.4 Number of spines on OIB (outer involucral bracts):

The No. of spines on OIB were counted by visual observation at the stage of flowering and categorized as non-spiny, few spines, intermediate, many spines, observation was taken in 5 randomly selected plants of each germplasm.

3.6.2.5 Leaf texture:

The leaf texture was categorized as fleshy, normal and leathery which can be observed by pressing the leaf and by visual observation and it was taken from 5 randomlyselected plants of each germplasm.

3.6.2.6 Leaf Trichomes:

To estimate leaf trichome density in the laboratory counted the numbers of trichomes density/Cm^2 of leaf will be carried out by using one Cm^2 stopper cutter/borer to punch in a fixed area at one side of the midrib and the stopper will be used for tracing on the leaf then within the one Cm^2 the number of trichomes would be counted. The process of counting trichomes were recorded under the microscope with the aid of 10x lens. Gonzales et. al., 2008.

3.7 To study biochemical compounds of safflower genotypes against safflower aphid resistant/preference.

Biochemical factors of plants also play vital role in resistant/susceptibility of safflower crop which directly or indirectly affect the incidence of aphids. Biochemical factor such as wax content and chlorophyll a, b and total chlorophyll content of leaves were analyzed under present study at Department of Plant Molecular Biology and Biotechnology, IGKV, Raipur.

3.7.1 Determination of Wax content: -

gram leaf of each variety of Safflower had taken and immersed in 25ml chloroform in glass conical flask which was weighted initially. The solvent containing wax was filtered by centrifuging at 1000 rpm. (Freeman et. al., 1979) After centrifugation, the clear solution was again poured in same conical flask which was kept in water bath at 46◦C and finally in hot air oven at 36^0C for complete evaporation of chloroform. The flask containing total dry wax was weighted at room temperature separately. Wax content was determined by subtracting the initial weight from the finalweight of conical flask and expressed in mg/gm of leaf.

3.7.2 Determination of chlorophyll:-

The total chlorophyll as well as chlorophyll 'a' and chlorophyll 'b' content of the leaves were determined by active extraction procedure given by Yoshida *et al.* (1972). Fresh leaves (100mg) were chopped and macerated in leaf crusher flask with 80% acetone, until a homogenized mixture was obtained and extracted with 80% acetone and centrifuged at 2000 rpm for 10 minutes. The clear green supernatant was made up to 10 ml by adding 80% acetone and the total optical density was measured on spectrophotometer at 645 nm, 663 nm and similarly the blank with 80 % acetone was also measured with same wavelength.

$$Chlorophyll\,'a' = \frac{12.7XA663 - 2.69XA645}{AX1000Xw}$$

$$Chlorophyll\,'b' = \frac{22.9XA645 - 4.68XA663}{AX1000Xw}$$

$$Total\ Chlorophyll\ mg/g\ tissue = 20.2XA645 - 8.02XA633X\frac{V}{AX1000Xw}$$

Where,

A= absorbance or optical density

a= length of light path in the cell (usually 1 cm)

W= weight of sample

V= volume of solution

Fig(3.1) (a) safflower crop in field,(b) weighing leaf sample on weighing machine,(c) adding chloroform to the sample,(d) dipping leaf in chloroform (e) placing samples inside the oven (f) dried out wax content as a flim in vials

Fig (3.2) a) weighing leaf sample in weighing machine b) crushing leaf samples in morter and pestle, c) leaf extract with 80% acetone, d) using centrifuge to get clear supertant, e) taking reading in spectrophotometer

CHAPTER-IV

RESULTS AND DISCUSSION

The present investigation entitled “Screening of germplasm accessions of safflower for their morphological and biochemical traits in relation to resistant against Safflower aphid, *Uroleucon compositae* (Theobald)” was conduct Instructional cum Research farm and Laboratory of the Department of Plant Molecular Biology and Biotechnology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, C.G. during rabi season of 2019-2020 The experimental findings of the present work have been described under the following heads:

1. To evaluate safflower germplasm accessions for their reaction against safflower aphid under natural conditions.

2. To study morphological characters of safflower genotypes and their associationwith resistant/preference against safflower aphid.

3. To study biochemical compounds of safflower genotypes against saffloweraphid resistant/preference.

4.1 To evaluate safflower germplasm accessions for their reaction against Safflower aphid under natural conditions.

A field trial was conducted to study the resistance or susceptibility of safflower genotypes and accession against safflower aphid *Uroleucon compositae* (Theobald) during *rabi* 2019-20. In present study, 111 safflower genotypes were screened against the safflower aphid incidence under natural conditions. It was pertinent to mention that the germplasm had different degree of susceptibility against safflower aphid infestation and they were put under different categories as per the guidelines given by Kavitha and Reddy (2012).

Observations were recorded from the 5 cm central apical twigs from 10 randomly selected plants in each replication. The aphid population were recorded on 10 cm apical twigs but 5 cm apical twigs of effective population was considered. In this trial A-1 was maintained as resistant check whereas PBNS-12 as susceptible check.

According to the results, the different genotypes were categorized as highly resistant, resistant, moderately resistant, susceptible and highly susceptible. The aphid infestation was started in different genotypes at elongation stage of the plant nearly 40 DAS. Crop was sown NOVEMBER, 26, 2019 observations were taken during peak infestation period of aphids were January 27, February 03, February 10, February 17, February 24, and March 02, 2020 in the present study.

On the basis of foliage drying grades and Computation of Aphid Infestation Index (A.I.I.) against safflower aphid it was observed that out of 111 safflower screened genotypes, none genotypes were categorized as highly resistant, 19 as resistant, and 39 as moderately resistant while 37 genotypes categorized as susceptible and 16 as highly susceptible against safflower aphid during *rabi* 2019-20.

In present investigations extend of mean aphid population in 111 germplasm was noticed in 5 cm central apical twigs. The row of GMU 7618 had the lowest mean aphid population of 18.40 aphid count/apical twig (5 cm) followed by GMU 2424 with 20 mean aphid count/apical twig (5 cm) and variety GMU 1894 with 20.6 mean aphid population on 5 cm apical twigs. Per cent foliage drying plant^{-1} due to aphid infestation at 100% flowering stage in highly resistant genotypes was 0 to 20 % and Aphid Infestation Index (A.I.I.) was calculated less than one (<1) during the study and these entries were placed under highly resistant category on the basis of aphid infestation index whereas resistant check A-1 showed 19 aphid mean population during the present study.

None of the genotypes was designated under the highly resistant category.

19 genotypes *viz*., GMU 2424, GMU 7573, GMU 7590, GMU 2486, GMU 1811, GMU 1397, GMU 1894, GMU 6886, GMU 1310, GMU 7618, GMU 6004, GMU 2403, GMU 7456, GMU 2380, GMU 7351, GMU 5660, GMU 3781, GMU 3965 and GMU 3966 recorded aphid population ranged between 20 -30 aphid /apical twig (5 cm) and placed under the resistant category on the basis of Aphid Infestation Index (A.I.I.). The genotype GMU 7618 had the lowest aphid population with 18.4 mean aphid where as GMU 2424 and GMU 1894 recorded aphid population of 20.6 aphids. Among the resistant genotypes, the GMU 7573 had highest aphid population of 30 aphid count/apical twig (5 cm) and GMU 1811 recorded 29.6, GMU 2486 had 28.8 and GMU 7590 recorded 28.6 mean aphid in each apical twig (5 cm). The genotype GMU 2424 , GMU 7573, GMU 7590, GMU 2486, GMU 1811, GMU 1397, GMU1894, GMU 6886, GMU1310, GMU 7618, GMU 6004, GMU 2403, GMU 7456,GMU 2380, GMU 7351, GMU 5660, GMU 3781, GMU 3965 the per cent foliage drying plant due to aphid infestation was 21 to 40 % and Aphid Infestation Index (A.I.I.) was calculated between 1.1-2.0.

The 39 genotypes GMU 5136, GMU 7594,GMU 7316, GMU 7569, GMU 7363 GMU 3266, GMU 589, GMU 5135, GMU 7568,GMU 1654, GMU 7581, GMU 590, GMU 995, GMU 2644, GMU 3438, GMU 5134,GMU 2648, GMU 4546, GMU 4983, GMU 7331, GMU 579, GMU 7591, GMU 7593,GMU 7359, GMU 7319, GMU 3206 GMU 884, GMU 972, GMU 1798, GMU1628,GMU 184, GMU 3654, GMU 5774,GMU 1737, GMU 5338, GMU 5865, GMU 850,GMU 4907 and GMU 5097, showed mean aphid population of 29.4-34.8 during investigation and placed under moderately resistant category with foliage drying gradeof 41-60% with Aphid Infestation Index (A.I.I.) calculated between 2.1 to 3.0.

37 genotypes *viz*., GMU 6891, GMU 1175, GMU 2347, GMU 7436, GMU 5142, GMU3944, GMU 2775, GMU 1731, GMU 5133, GMU 6037, GMU 7355, GMU 2687, GMU 1183, GMU 4914, GMU 2757, GMU 7572, GMU 3373, GMU 6926, GMU 4814, GMU 4965, GMU 6854, GMU 7579, GMU 2830, GMU 753, GMU 7601, GMU 880, GMU 1217, GMU 7599, GMU 2928, GMU 7612,

GMU 1940, GMU 7303 GMU 1437, GMU 1851, GMU 849, GMU 7542 and GMU 2968 recorded aphid population ranged between 38-45.4 aphid /apical twig (5 cm) and placed under the susceptible category on the basis of Aphid Infestation Index (A.I.I.). The genotypeGMU 5142 had the lowest aphid population with 38.4 mean aphid, GMU 1175 with38.7 aphid, whereas GMU 7436 recorded 39.2 aphid. Among the Susceptible genotypes, the GMU 2687 had highest aphid population of 45.6 aphid count/apical twig (5 cm) and GMU 7572 recorded 45.4, GMU 2757 had 43.2 mean aphid in each apical twig (5 cm). The verities which came under susceptible category the per cent foliage drying plant due to aphid infestation was 61-80% and Aphid Infestation Index(A.I.I.) was calculated between 3.1-4.0.

16 genotypes viz GMU 7634, GMU 6919, GMU 974, GMU 1360, GMU 667, GMU 3924, GMU1067, GMU 5149, GMU 7399, GMU 7633, GMU 7448, GMU 609, GMU 1758 GMU 8852, GMU 3926, GMU 969 showed mean aphid population of 61-44 during investigation and placed under highly susceptible category. Genotype GMU 8852 had the highest aphid population with 61 mean aphid and the genotype GMU 3926 had the lowest aphid population 44 mean aphid with foliage drying grade of 81-100 with Aphid Infestation Index (A.I.I.) calculated between >4.1.

Table 4.1 Incidence of aphid on safflower genotypes during 2019-20

S.No.	Genotypes	Aphid /5 cm central apical twig/plant	Aphid Infestation Index (A.I.I.)	Category
1	GMU 2424	20	1.3	resistant
2	GMU 7573	30	1.7	resistant
3	GMU 6891	41.8	3.6	susceptible
4	GMU 5136	37.4	2.6	Moderately resistant
5	GMU 1175	37.8	3.2	susceptible
6	GMU 7590	28.6	1.4	resistant
7	GMU 2347	40	3.2	susceptible
8	GMU 7594	37.2	2.5	Moderately resistant
9	GMU 2486	28.8	2	resistant
10	GMU 7316	31.2	2.5	moderately resistant
11	GMU 7436	39.2	3.7	susceptible
12	GMU 5142	38.4	3.1	susceptible
13	GMU 7634	59.6	4.7	highly susceptible
14	GMU 3944	43.6	3.3	susceptible
15	GMU 1811	29.6	2	resistant
16	GMU 1397	27	1.9	resistant
17	GMU 7569	30	2.1	moderately resistant
18	GMU 2775	40.8	3.4	susceptible
19	GMU 1894	20.6	1.3	resistant
20	GMU 7363	36.4	2.7	moderately resistant
21	GMU 3266	34.6	2.5	moderately resistant
22	GMU 6919	54.8	4.5	highly susceptible
23	GMU 589	33	2.1	moderately resistant
24	GMU 5135	35	2.3	moderately resistant
25	GMU 1731	40	3.2	susceptible
26	GMU 6886	28.2	1.8	resistant
27	GMU 7568	33.8	2.4	Moderately resistant
28	GMU 1310	28.6	1.7	resistant
29	GMU 5133	38.2	3.2	susceptible
30	GMU 1654	34.4	2.5	moderately resistant
31	GMU 7581	37.6	2.8	moderately resistant
32	GMU 590	28.6	2.2	moderately resistant
33	GMU 995	30	2.1	moderately resistant
34	GMU 7618	18.4	1.1	resistant
35	GMU 2644	40	3	moderately resistant
36	GMU 3438	35.4	2.5	moderately resistant
37	GMU 5134	32.2	2.4	moderately resistant
38	GMU 2648	35.3	2.5	moderately resistant
39	GMU 6037	39.8	3.5	susceptible
40	GMU 7355	42.8	3.8	susceptible

S.No.	Genotypes	Aphid /5 cm central apical twig/plant	Aphid Infestation Index (A.I.I.)	Category
41	GMU 974	49.2	4.3	highly susceptible
42	GMU 2687	45.6	4	susceptible
43	GMU 1183	50.6	3.7	susceptible
44	GMU 6004	28	1.6	resistant
45	GMU 4914	39.4	3.2	susceptible
46	GMU 1360	47.2	4.1	highly susceptible
47	GMU 2757	43.2	3.3	susceptible
48	GMU 7572	45.4	3.6	susceptible
49	GMU 4546	33.8	2.5	moderately resistant
50	GMU 667	55.2	4.5	highly susceptible
51	GMU 3924	47	4.2	highly susceptible
52	GMU 3373	40	3.5	susceptible
53	GMU 4983	31.8	2.4	moderately resistant
54	GMU 6926	38.6	3.5	susceptible
55	GMU 7331	37	2.7	moderately resistant
56	GMU 1067	60.4	4.8	highly susceptible
57	GMU 4814	40.8	3.7	susceptible
58	GMU 2403	28	1.8	resistant
59	GMU 579	33	2.5	moderately resistant
60	GMU 5149	52.6	4.4	highly susceptible
61	GMU 7399	59.2	4.6	highly susceptible
62	GMU 4965	40	3.2	susceptible
63	GMU 6854	42	3.7	susceptible
64	GMU 7579	39.2	3.5	susceptible
65	GMU 7633	47.3	4.2	highly susceptible
66	GMU744 8	50	4.3	highly susceptible
67	GMU 7591	37.4	2.4	moderately resistant
68	GMU 7456	27	1.9	resistant
69	GMU 7593	36.6	2.7	moderately resistant
70	GMU 609	49.2	4.3	highly susceptible
71	GMU 7359	32	2.4	moderately resistant
72	GMU 5097	36.3	2.6	moderately resistant
73	GMU 2830	38	4	susceptible
74	GMU 753	41.2	3.7	susceptible
75	GMU 7601	39.2	3.6	susceptible
76	GMU 1758	48	4.2	highly susceptible
77	GMU 7319	37.8	2.7	moderately resistant
78	GMU 3206	37.6	2.8	moderately resistant
79	GMU 884	34.6	2.6	moderately resistant
80	GMU 880	43.2	3.8	susceptible
81	GMU 972	29	2.1	moderately resistant

S.No.	Genotypes	Aphid /5 cm central apical twig/plant	Aphid Infestation Index (A.I.I.)	Category
82	GMU 1217	41.8	3.8	susceptible
83	GMU 7599	40.4	3.7	susceptible
84	GMU 8852	61	4.8	highly susceptible
85	GMU 2928	39.3	3.8	susceptible
86	GMU 2380	28.6	1.8	resistant
87	GMU 1798	37.2	2.4	moderately resistant
88	GMU 1628	36	2.5	moderately resistant
89	GMU 7351	28	2	resistant
90	GMU 184	38	2.7	moderately resistant
91	GMU 7612	38.8	3.5	susceptible
92	GMU 3654	35.6	2.9	moderately resistant
93	GMU 1940	42.4	3.8	susceptible
94	GMU 3926	44	4.9	highly susceptible
95	GMU 5774	36.2	2.5	moderately resistant
96	GMU 7303	40.8	3.2	susceptible
97	GMU 5660	28.2	2	resistant
98	GMU 1437	39.8	3.6	susceptible
99	GMU 1851	38.8	3.5	susceptible
100	GMU 3781	27	1.5	resistant
101	GMU 1737	35.2	2.9	moderately resistant
102	GMU 969	50	4.3	highly susceptible
103	GMU 5338	34.8	2.6	moderately resistant
104	GMU 849	40.6	3.3	susceptible
105	GMU 5865	29.8	2.1	moderately resistant
106	GMU 850	71.6	2.9	moderately resistant
107	GMU 7542	38.6	3.2	susceptible
108	GMU 4907	29.2	2.1	moderately resistant
109	GMU 2968	40.6	3.2	susceptible
110	GMU 3966	24	1.2	resistant
111	GMU 3965	29	1.7	resistant
	CHECK			
	PBNS-12	28.8	2.1	highly susceptible
	A-1	19	1	highly resistant

TABLE 4.2 Genotypes grade categories based on drying of leaf

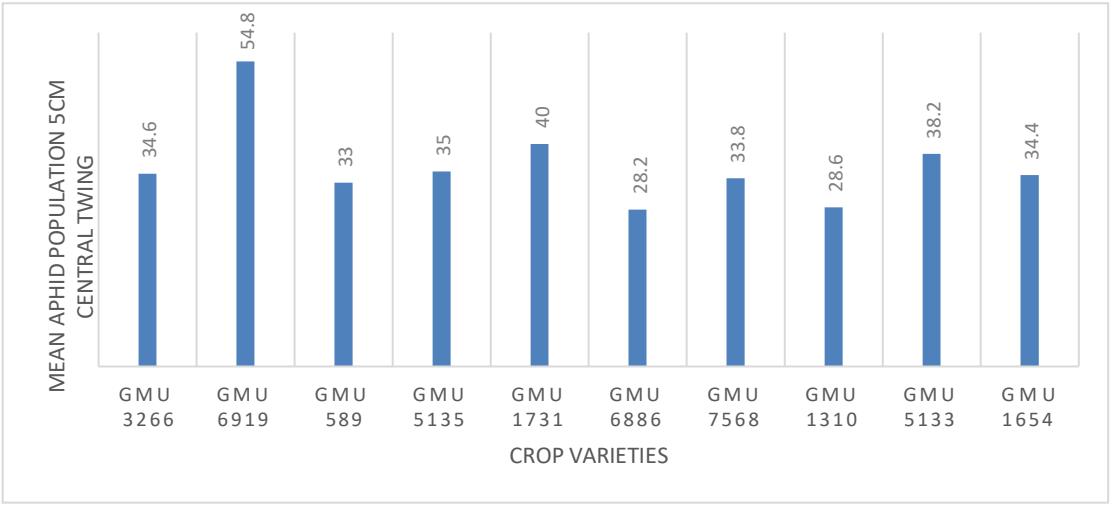
Grade	%Drying of leaves due to aphid	Name of genotype	Grade Category	Total Genotypes
1	0-20	none	Highly Resistant	0
2	20-40	GMU 2424, GMU 7573, GMU 7590, GMU 2486, GMU 1811, GMU 1397, GMU 1894, GMU 6886, GMU 1310, GMU 7618, GMU 6004, GMU 2403, GMU 7456, GMU 2380, GMU 7351, GMU 5660, GMU 3781, GMU 3965, GMU 3966	Resistant	19
3	41-60	GMU 5136, GMU 7594, GMU 7316, GMU 7569, GMU 7363, GMU 3266, GMU 589, GMU 5135, GMU 7568, GMU 1654, GMU 7581, GMU 590, GMU 995, GMU 2644, GMU 3438, GMU5134, GMU 2648, GMU 4546, GMU 4983 7331, GMU 579 , GMU 7591, GMU 7593, GMU 7359, GMU 7319, GMU 3206 , GMU 884, GMU 972, GMU 1798, GMU 1628, GMU 184, GMU 3654, GMU 5774, GMU 1737, GMU 5338, GMU 5865, GMU 850, GMU 4907, GMU 5097	Moderately resistant	39
4	61-80	GMU 6891, GMU 1175, GMU 2347, GMU 7436, GMU 5142, GMU 3944, GMU 2775, GMU 1731, GMU 5133, GMU 6037, GMU 7355, GMU 2687, GMU 1183, GMU 4914, GMU 2757, GMU 7572, GMU 3373, GMU 6926, GMU 4814, GMU 4965, GMU 6854, GMU 7579, GMU 2830, GMU 753, GMU 7601, GMU 880, GMU 1217, GMU 7599, GMU 2928, GMU 7612, GMU 1940, GMU 7303, GMU 1437, GMU 1851, GMU 849, GMU 7542, GMU 2968	Susceptible	37
5	81-100	GMU 7634, GMU 6919, GMU 974, GMU 1360, GMU 667, GMU 3924, GMU1067, GMU 5149, GMU 7399, GMU 7633, GMU 7448, GMU 609, GMU 1758 GMU 8852, GMU 3926, GMU 969	Highly susceptible	16

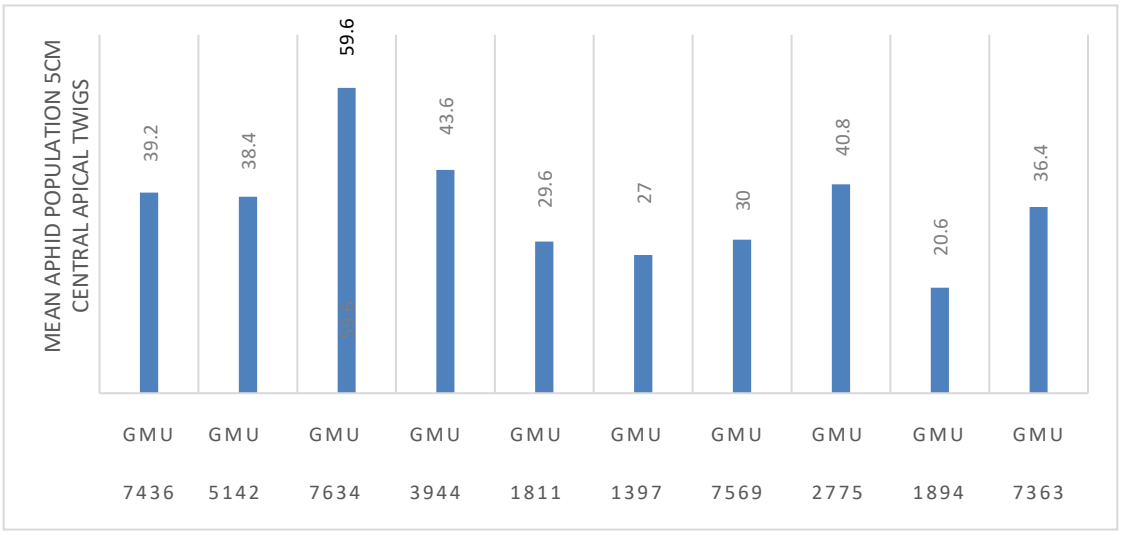
Present findings are in agreement with the earlier findings of Basavangoud *et al*., (1980),Balikai (2002), Reddy *et al.*(1983) and other workers, who reported that safflower plants showed highly resistant to susceptible response against Aphid. This pest is active from January to April as the fall in temperature and increased relative humidity favour the population build-up. It is expected that genetic characteristics of the safflower crop be explored with regard to tolerance against aphid. Several germplasm lines showing stable tolerance to aphid have been identified by safflower management unit of the safflower research project at various centers in the country. Genotype screening work is the most prerequisite step for identification of resistant donor.

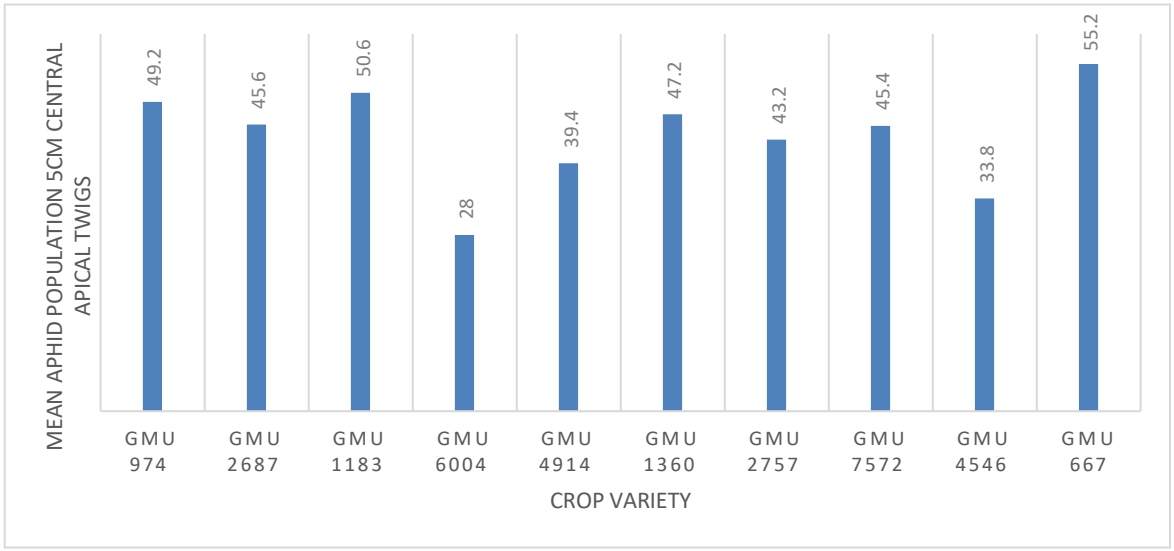
Reddy *et al.*(1983) evaluated 2457 safflower lines for resistant to aphid and concluded that 117 lines were found moderately resistant to aphids. The only different method was in planting or layout of this experiment, because standard resistant checkand susceptible check was planted after every 10 lines.

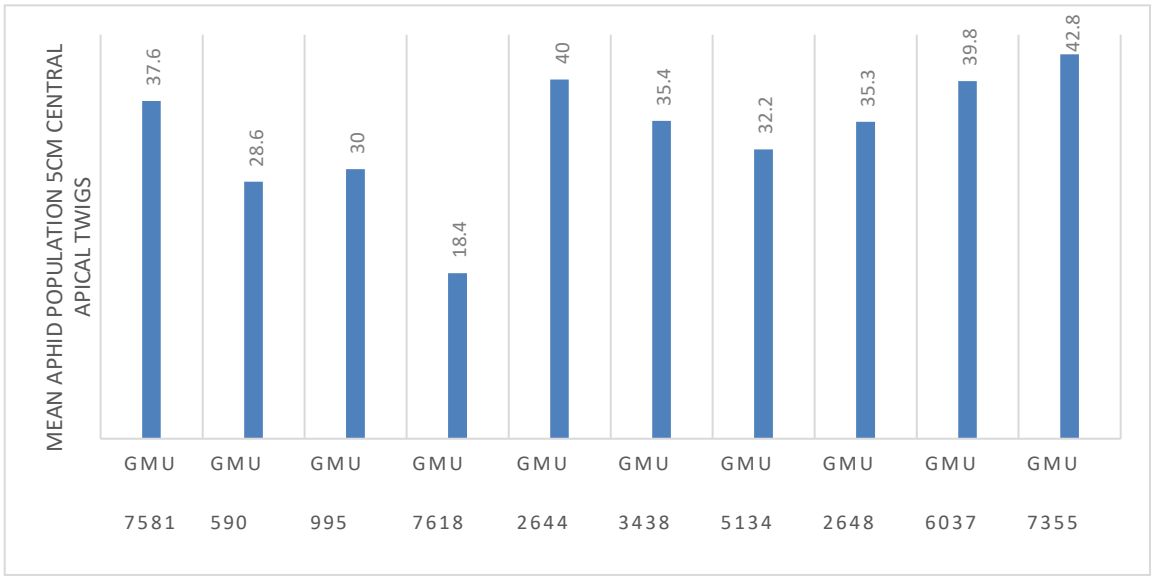
Basavangoud *et al.*(1980) also carried out similar studies on aphid resistant to safflower and concluded that heavy spine variety, CTS-705 was highly susceptible to aphids. Similarly, less spiny variety, CTS-7403 was found least susceptible to safflower aphid.

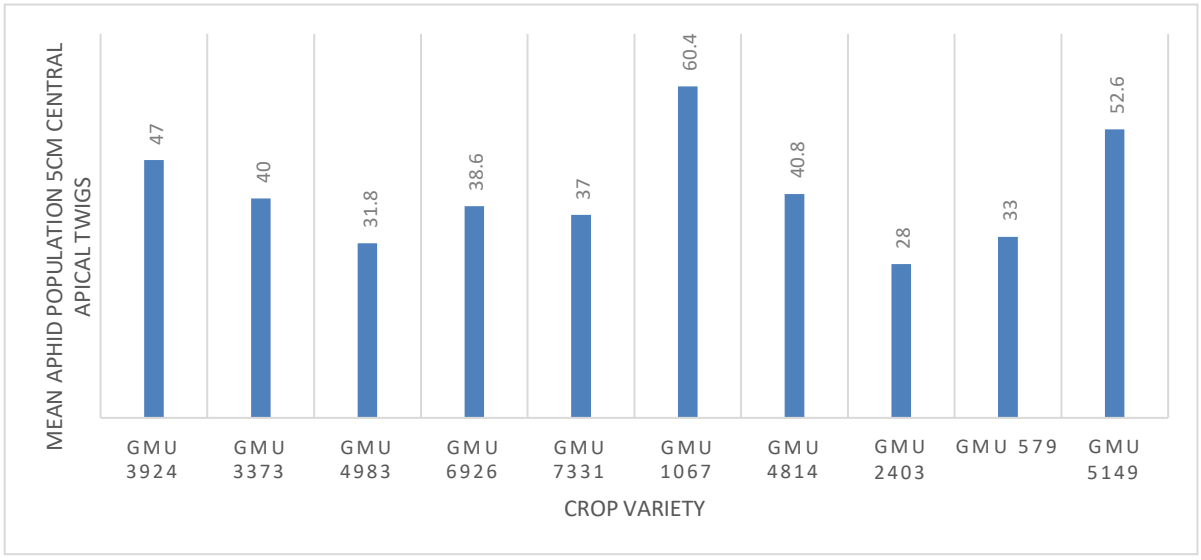
fig 4.1 Bar graph showing crop varieties with corresponding mean aphid population on 5cm central apical twigs

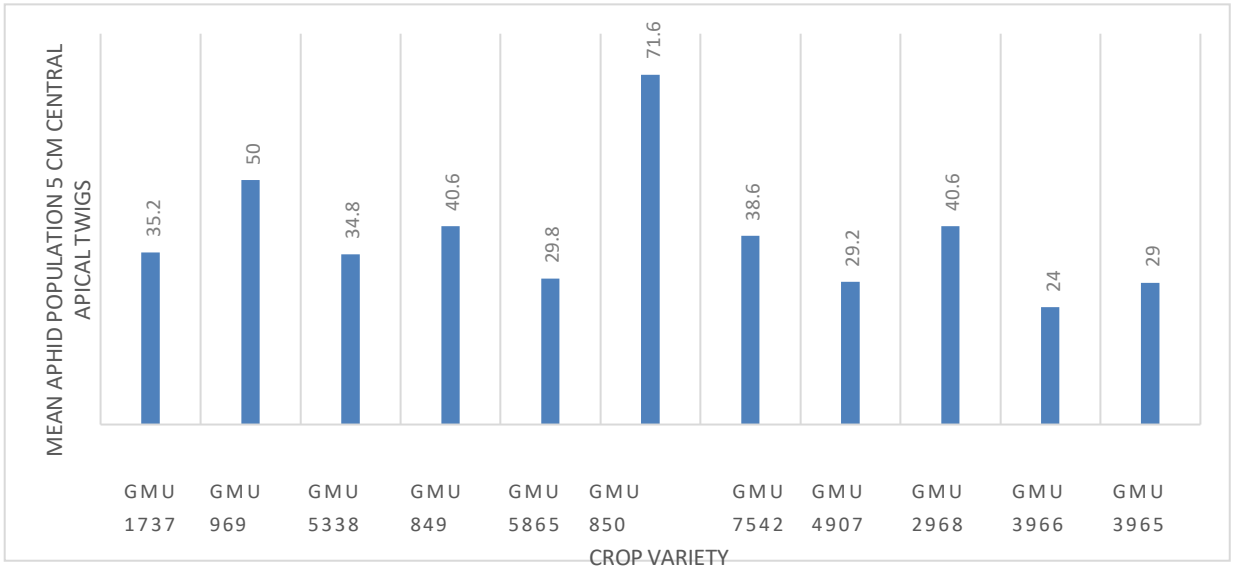


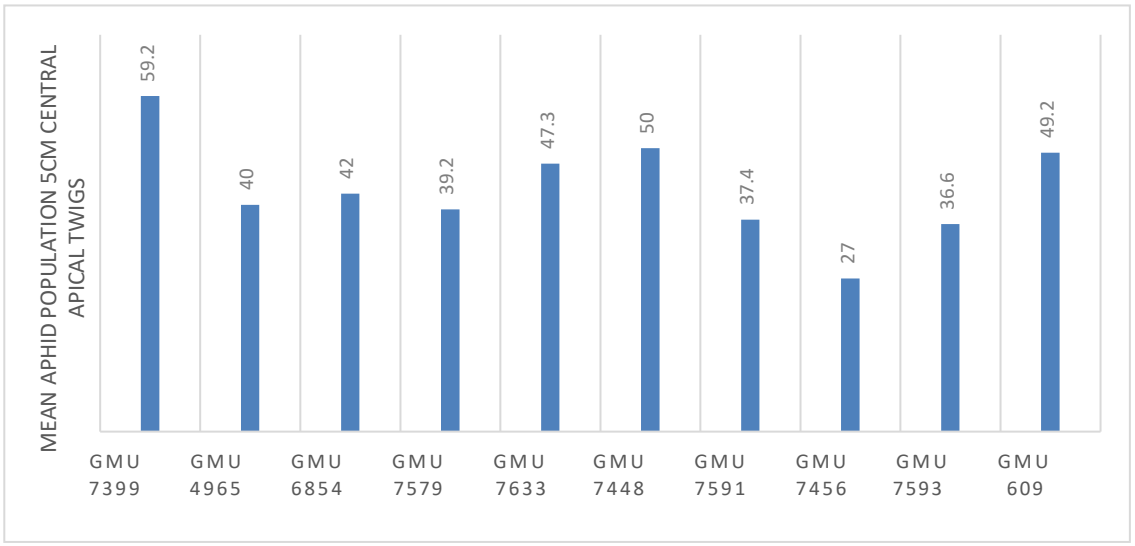


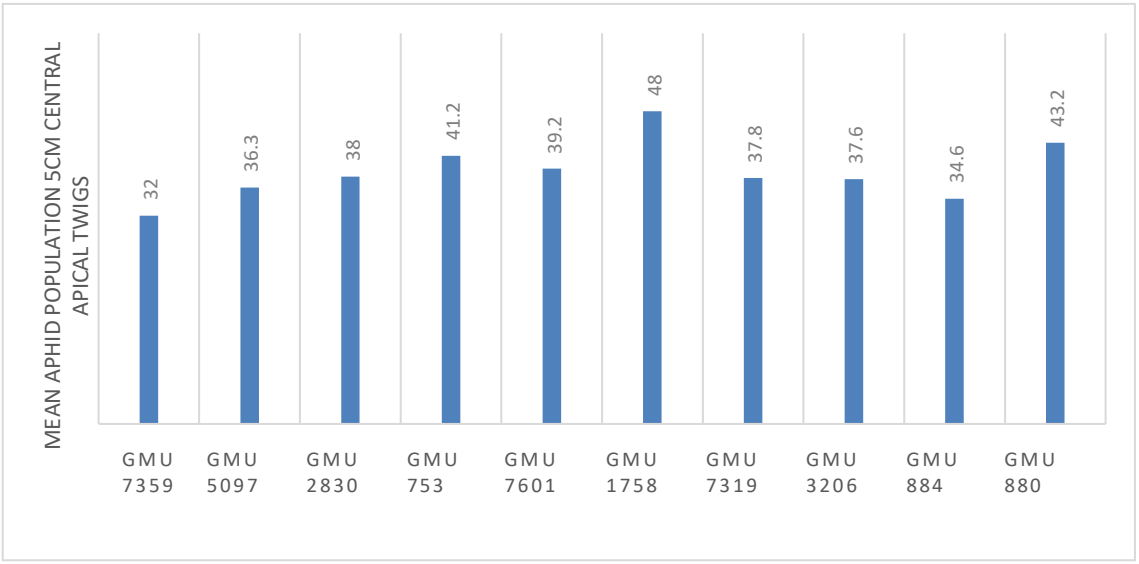

MEAN APHID POPULATION 5CM CENTRAL APICAL TWIGS
49.2
45.6
50.6
28
39.4
47.2
43.2
45.4
33.8
55.2
GMU 974
GMU 2687
GMU 1183
GMU 6004
GMU 4914
GMU 1360
GMU 2757
GMU 7572
GMU 4546
GMU 667
CROP VARIETY

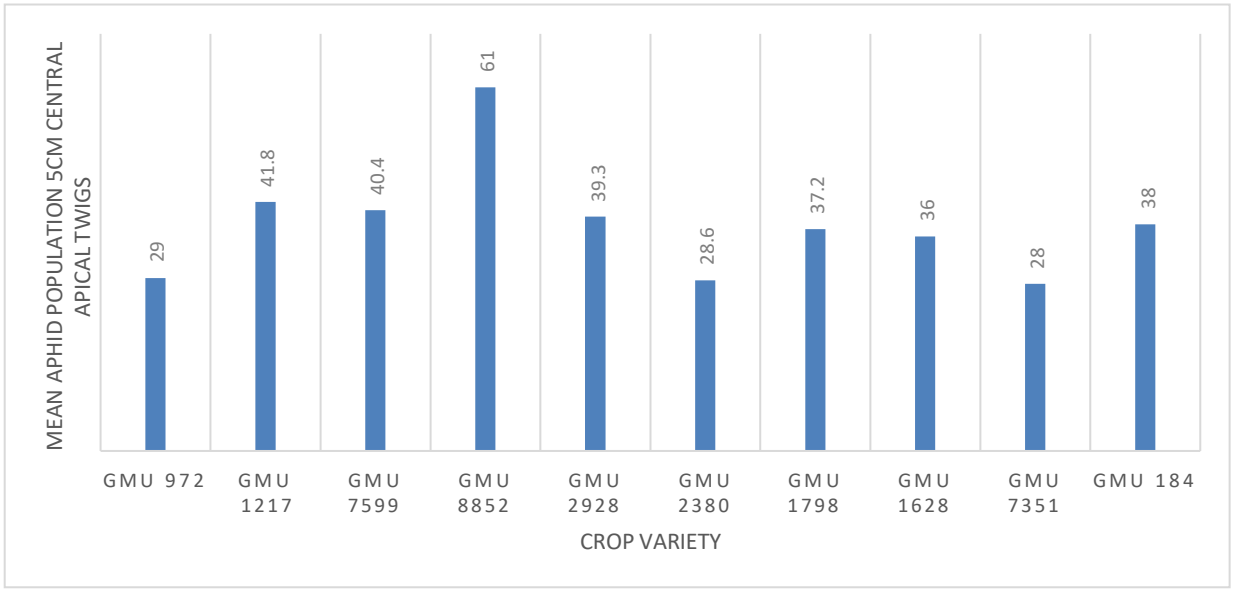

MEAN APHID POPULATION 5CM CENTRAL APICAL TWIGS
37.6
28.6
30
18.4
40
35.4
32.2
35.3
39.8
42.8
GMU 7581
GMU 590
GMU 995
GMU 7618
GMU 2644
GMU 3438
GMU 5134
GMU 2648
GMU 6037
GMU 7355

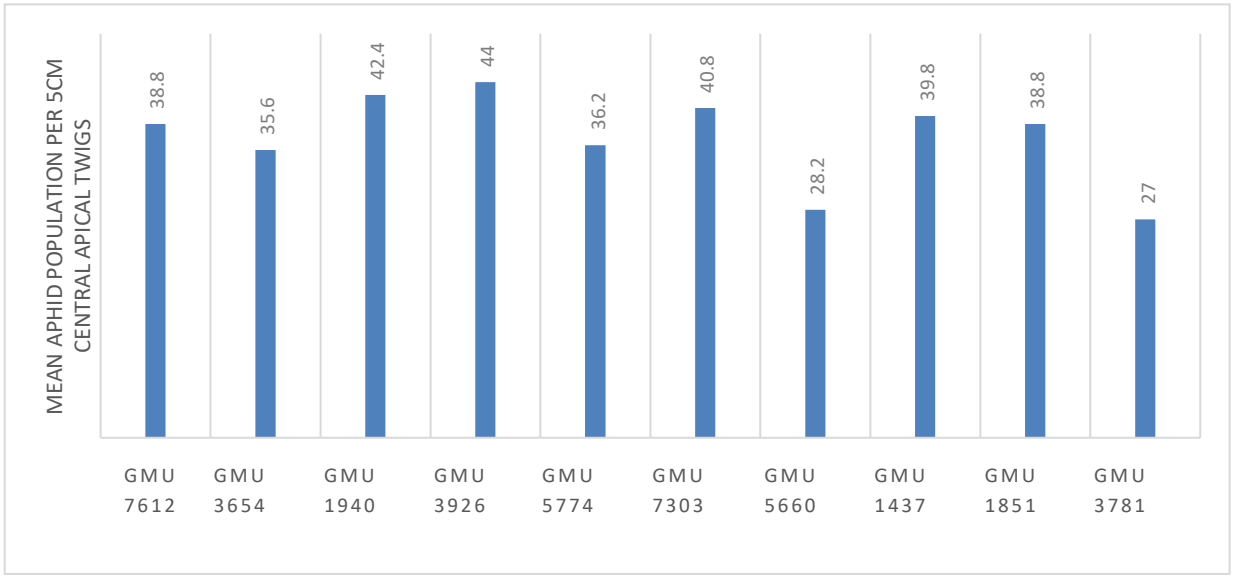

MEAN APHID POPULATION 5CM CENTRAL APICAL TWIGS
47
40
31.8
38.6
37
60.4
40.8
28
33
52.6
GMU 3924
GMU 3373
GMU 4983
GMU 6926
GMU 7331
GMU 1067
GMU 4814
GMU 2403
GMU 579
GMU 5149
CROP VARIETY

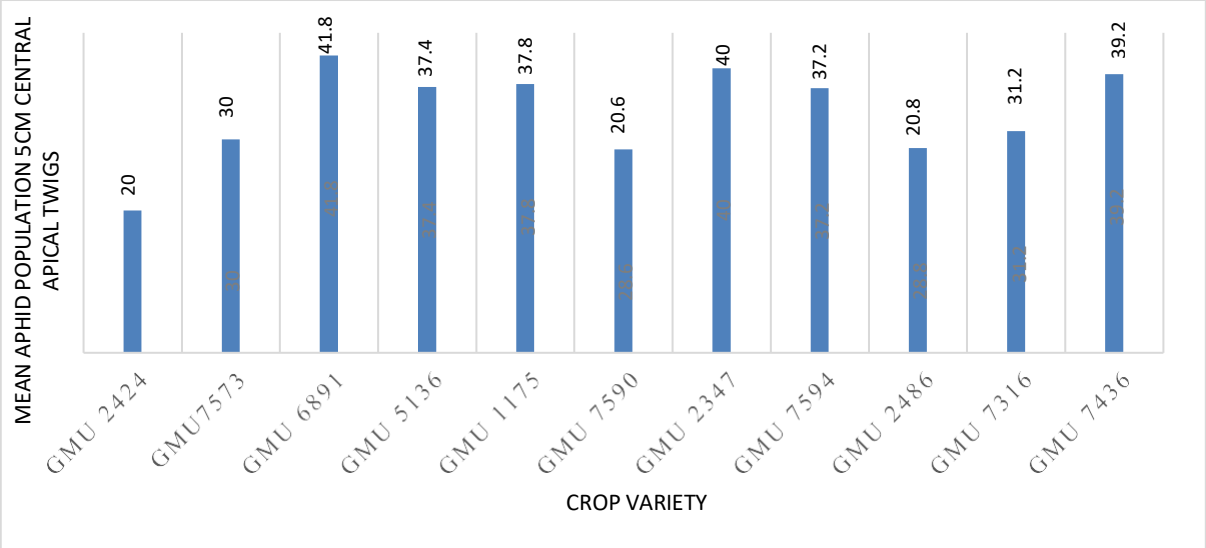

MEAN APHID POPULATION 5 CM CENTRAL APICAL TWIGS
35.2
50
34.8
40.6
29.8
71.6
38.6
29.2
40.6
24
29
GMU 1737
GMU 969
GMU 5338
GMU 849
GMU 5865
GMU 850
GMU 7542
GMU 4907
GMU 2968
GMU 3966
GMU 3965
CROP VARIETY


MEAN APHID POPULATION 5CM CENTRAL APICAL TWIGS
59.2
40
42
39.2
47.3
50
37.4
27
36.6
49.2
GMU 7399
GMU 4965
GMU 6854
GMU 7579
GMU 7633
GMU 7448
GMU 7591
GMU 7456
GMU 7593
GMU 609


MEAN APHID POPULATION 5CM CENTRAL APICAL TWIGS
32
36.3
38
41.2
39.2
48
37.8
37.6
34.6
43.2
GMU 7359
GMU 5097
GMU 2830
GMU 753
GMU 7601
GMU 1758
GMU 7319
GMU 3206
GMU 884
GMU 880


MEAN APHID POPULATION 5CM CENTRAL APICAL TWIGS
29
41.8
40.4
61
39.3
28.6
37.2
36
28
38
GMU 972
GMU 1217
GMU 7599
GMU 8852
GMU 2928
GMU 2380
GMU 1798
GMU 1628
GMU 7351
GMU 184
CROP VARIETY


MEAN APHID POPULATION PER 5CM CENTRAL APICAL TWIGS
38.8
35.6
42.4
44
36.2
40.8
28.2
39.8
38.8
27
GMU 7612
GMU 3654
GMU 1940
GMU 3926
GMU 5774
GMU 7303
GMU 5660
GMU 1437
GMU 1851
GMU 3781



4.2 To study morphological characters of safflower genotypes and their association with resistant/preference against safflower aphid.

A number of insect plants interrelations have been described to be responsible for imparting plant resistant against insect pests. A plant resistant could be due to description of one or more morphological traits. Thus, the various morphological parameters *viz.* No. of spines on OIB, leaf shape, leaf margin, leaf texture, extent of leaf spininess, trichome density were studied.

4.2.1 Leaf shape

On the basis of structural variations leaf shape were classified into lanceolate, linear, oblong. In present study Out of 111 genotypes 84 showed lanceolate, 14 oblong and genotypes as linear type leaf shape as given in Table 4.3. Thus leaf shape did not play role in the tested safflower genotype against safflower aphid and making the plant resistant or susceptible.

4.2.2 leaf margin

On the basis of structural variations leaf margin Safflower plant were classified into serrate and deeply serrate. In this experiment 111 germplasm were analysed for resistant involve morphological parameters like leaf margin. out of 111 genotype it was found that 51 genotypes had serrate and 60 genotypes showed deeply serrate (Table 4.3). Thus, leaf margin did not play role in the safflower genotypes against safflower aphid and making the plant resistant/ susceptible.

4.2.3 leaf spininess

In present study structural variations of leaf spininess, genotypes were classified into many spines, few spines and intermediate. Out of one hundred and eleven genotypes 5 genotypes showed many spines and remaining 48 genotype had intermediate spines. Left 58 genotypes had few spines Thus, leaf spininess plays

important role in the tested safflower genotypes against safflower aphid and found responsible for resistant or susceptible on the basis of mean aphid population and AII.

4.2.4 No. of spines on OIB

on the basis of structural variations No. of spines on OIB were classified into few spines, intermediate and many spines. In present study Out of 111, 5 genotypes showed many spines, 48 genotypes showed intermediate no. of spines in OIB and 58 genotypes had few spines. Thus, No. of spines on OIB did not play role in the tested safflower genotype against safflower aphid and making the plant resistant or susceptible.

4.2.5 leaf texture

On the basis of structural variations leaf texture of Safflower plant were classified into normal, fleshy and leathery. In this experiment 111 germplasm were analyzed resistant involve morphological parameters like leaf texture. out of one hundred eleven genotype it was found that 60 genotypes had normal leaves and 46 genotypes showed fleshy leaves, remaining genotypes showed leathery texture.

4.2.6 Leaf trichome

In present study trichomes present in leaves of different genotype are countedin per cm^2 of leaf. The mean of trichomes are calculated and are mentioned in the table, out of 111 genotypes highest 61.2 No. of trichome per cm^2 is seen in genotypes which are categorized under resistant category *i.e.* GMU 3966. Whereas 26 No. of trichomes per cm^2 is lowest in variety which comes under susceptible category i.e. GMU 7634.

Table 4.3 Morphological characters of safflower genotypes

S.no	Variety	Leaf shape	Leaf margin	Leaf spininess	No. Of spines on oib	Leaf texture	Trichome Density/ cm^2
1	GMU 2424	Lanceolate	Serrate	Many spines	Many spines	Leathery	54.6
2	GMU 7573	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	44.2
3	GMU 6891	Lanceolate	Serrate	Few spines	Few spines	Fleshy	31.4
4	GMU 5136	Lanceolate	Serrate	Intermediate	Intermediate	Normal	37.4
5	GMU 1175	Linear	Serrate	Few spines	Few spines	Fleshy	33.4
6	GMU 7590	Lanceolate	Deeply serrate	Many spines	Many spines	Leathery	51.6
7	GMU 2347	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	34.2
8	GMU 7594	Lanceolate	Serrate	Intermediate	Intermediate	Normal	38
9	GMU 2486	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	43
10	GMU 7316	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	39.2
11	GMU 7436	Lanceolate	Serrate	Few spines	Few spines	Fleshy	30.6
12	GMU 5142	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	34.4
13	GMU 7634	Linear	Serrate	Few spines	Few spines	Fleshy	26
14	GMU 3944	Lanceolate	Deeply serrate	Few spines	Few spines	Normal	33.6
15	GMU 1811	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	43.6
16	GMU 1397	Lanceolate	Serrate	Intermediate	Intermediate	Normal	43.6
17	GMU 7569	Lanceolate	Serrate	Intermediate	Intermediate	Normal	40
18	GMU 2775	Lanceolate	Deeply serrate	Few spines	Few spines	Normal	32.6
19	GMU 1894	Lanceolate	Deeply serrate	Many spines	Many spines	Leathery	55
20	GMU 7363	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	37.2
21	GMU 3266	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	38.4

S.no	Variety	Leaf shape	Leaf margin	Leaf spininess	No. Of spines on oib	Leaf texture	Trichome Density/ cm^2
22	GMU 6915	Oblong	Deeply serrate	Few spines	Few spines	Fleshy	27.4
23	GMU 589	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	41.6
24	GMU 5135	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	40
25	GMU 1731`	Lanceolate	Serrate	Few spines	Few spines	Normal	33.6
26	GMU 6886	Linear	Deeply serrate	Intermediate	Intermediate	Normal	43.4
27	GMU 7568	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	39
28	GMU 1301	Lanceolate	Serrate	Intermediate	Intermediate	Normal	46.2
29	GMU 5133	Linear	Deeply serrate	Few spines	Few spines	Normal	33.8
30	GMU 1654	Oblong	Serrate	Intermediate	Intermediate	Normal	39.4
31	GMU 7581	Lanceolate	Serrate	Few spines	Intermediate	Normal	36.4
32	GMU 590	Lanceolate	Serrate	Intermediate	Intermediate	Normal	41
33	GMU 995	Oblong	Deeply serrate	Intermediate	Intermediate	Normal	41.8
34	GMU 7618	Lanceolate	Serrate	Many spines	Many spines	Leathery	65
35	GMU 2644	Linear	Serrate	Few spines	Few spines	Normal	35.2
36	GMU 3438	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	38.6
37	GMU 5134	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	39
38	GMU 2648	Lanceolate	Serrate	Intermediate	Intermediate	Normal	37.8
39	GMU 6037	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	32
40	GMU 7355	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	29.8
41	GMU 974	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	29
42	GMU 2687	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	29.4
43	GMU 1183	Linear	Deeply serrate	Few spines	Few spines	Fleshy	31

S.no	Variety	Leaf shape	Leaf margin	Leaf spininess	No. Of spines on oib	Leaf texture	Trichome Density/ cm^2
44	GMU 6004	Lanceolate	Serrate	Intermediate	Intermediate	Normal	45
45	GMU 4914	Lanceolate	Serrate	Few spines	Few spines	Normal	34.2
46	GMU 1360	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	29.4
47	GMU 2757	Oblong	Serrate	Few spines	Few spines	Fleshy	33.2
48	GMU 7572	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	31.6
49	GMU 4546	Lanceolate	Serrate	Intermediate	Intermediate	Normal	38.4
50	GMU 667	Oblong	Deeply serrate	Few spines	Few spines	Fleshy	27
51	GMU 3924	Linear	Serrate	Few spines	Few spines	Fleshy	29
52	GMU 2273	Lanceolate	Serrate	Few spines	Few spines	Fleshy	31.6
53	GMU 4983	Linear	Serrate	Intermediate	Intermediate	Normal	39.2
54	GMU 6926	Lanceolate	Serrate	Few spines	Few spines	Fleshy	32
55	GMU 7331	Linear	Serrate	Intermediate	Intermediate	Normal	37.6
56	GMU 1067	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	25.2
57	GMU 4814	Linear	Serrate	Few spines	Few spines	Fleshy	30.4
58	GMU 2403	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	44
59	GMU 579	Linear	Deeply serrate	Intermediate	Intermediate	Normal	39
60	GMU 5149	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	28.2
61	GMU 7399	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	26
62	GMU 4965	Oblong	Serrate	Few spines	Few spines	Fleshy	33.4
63	GMU 6854	Lanceolate	Serrate	Few spines	Few spines	Fleshy	30.6
64	GMU 7579	Linear	Deeply serrate	Few spines	Few spines	Fleshy	32
65	GMU 7633	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	29.6

S.no	Variety	Leaf shape	Leaf margin	Leaf spininess	No. Of spines on oib	Leaf texture	Trichome Density/ cm^2
66	GMU 7448	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	28.6
67	GMU 7591	Lanceolate	Serrate	Intermediate	Intermediate	Normal	39.6
68	GMU 7456	Oblong	Deeply serrate	Intermediate	Intermediate	Normal	44
69	GMU 7593	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	37.2
70	GMU 609	Lanceolate	Serrate	Few spines	Few spines	Fleshy	29.6
71	GMU 7359	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	39.6
72	GMU 5097	Lanceolate	Serrate	Intermediate	Intermediate	Normal	37.6
73	GMU 2830	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	29
74	GMU 753	Lanceolate	Entire	Few spines	Few spines	Fleshy	30
75	GMU 7601	Oblong	Deeply serrate	Few spines	Few spines	Fleshy	31.6
76	GMU 1758	Lanceolate	Serrate	Few spines	Few spines	Fleshy	28.6
77	GMU 7319	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	37.6
78	GMU 3206	Oblong	Deeply serrate	Few spines	Few spines	Normal	36.8
79	GMU 884	Lanceolate	Serrate	Intermediate	Intermediate	Normal	37
80	GMU 880	Lanceolate	Serrate	Few spines	Few spines	Fleshy	29.4
81	GMU 972	Lanceolate	Serrate	Intermediate	Intermediate	Normal	42.6
82	GMU 1217	Oblong	Serrate	Few spines	Few spines	Fleshy	30
83	GMU 7599	Lanceolate	Serrate	Few spines	Few spines	Fleshy	30.4
84	GMU 6852	Lanceolate	Serrate	Few spines	Few spines	Fleshy	25.8
85	GMU 2928	Lanceolate	Deeply serrate	Few spines	Few spines	Normal	29.2
86	GMU 2380	Oblong	Deeply serrate	Intermediate	Intermediate	Normal	44.4
87	GMU 1798	Lanceolate	Deeply serrate	Intermediate	Intermediate	Fleshy	40

S.no	Variety	Leaf shape	Leaf margin	Leaf spininess	No. Of spines on oib	Leaf texture	Trichome Density/ cm^2
88	GMU 1628	Lanceolate	Deeply serrate	Intermediate	Intermediate	Fleshy	38.8
89	GMU 7351	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	44
90	GMU 184	Lanceolate	Deeply serrate	Intermediate	Intermediate	Fleshy	37.8
91	GMU 7612	Lanceolate	Serrate	Few spines	Few spines	Normal	31.6
92	GMU 3654	Linear	Serrate	Few spines	Few spines	Fleshy	36
93	GMU 1940	Lanceolate	Serrate	Few spines	Few spines	Normal	29
94	GMU 3926	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	28.2
95	GMU 5774	Lanceolate	Serrate	Intermediate	Intermediate	Normal	38.4
96	GMU 7303	Lanceolate	Serrate	Few spines	Few spines	Normal	33.8
97	GMU 5660	Oblong	Deeply serrate	Intermediate	Intermediate	Normal	43.4
98	GMU 1437	Lanceolate	Deeply serrate	Few spines	Few spines	Normal	31.6
99	GMU 1881	Lanceolate	Serrate	Few spines	Few spines	Fleshy	31.2
100	GMU 3781	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	50.6
101	GMU 1737	Lanceolate	Serrate	Few spines	Few spines	Normal	35.8
102	GMU 969	Lanceolate	Serrate	Few spines	Few spines	Fleshy	28.8
103	GMU 5338	Lanceolate	Serrate	Intermediate	Intermediate	Normal	37
104	GMU 849	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	33.6
105	GMU 5865	Oblong	Deeply serrate	Intermediate	Intermediate	Normal	41.8
106	GMU 850	Lanceolate	Serrate	Few spines	Few spines	Fleshy	22.4
107	GMU 7542	Lanceolate	Deeply serrate	Few spines	Few spines	Fleshy	33.8
108	GMU 4907	Lanceolate	Deeply serrate	Intermediate	Intermediate	Normal	41.2
109	GMU 2968	Lanceolate	Serrate	Few spines	Few spines	Normal	34

S.no	Variety	Leaf shape	Leaf margin	Leaf spininess	No. Of spines on oib	Leaf texture	Trichome Density/ cm^2
110	GMU 3966	Lanceolate	Serrate	Many spines	Many spines	Leathery	61.2
111	GMU 3965	Oblong	Serrate	Intermediate	Intermediate	Normal	44
	CHECK						
	PBNS 12(SC)	Lanceolate	Serrate	Intermediate	Intermediate	Normal	42
	A.1 (RC)	Lanceolate	Serrate	Many spines	Many spines	Leathery	70

Host plant resistant is one of the most effective methods for reducing insect damage and an important component of integrated pest management. Each plant species possesses unique defense mechanism involving various morphological characters which have deep effect on the reproduction and survival of insect pest of that particular plant species. The results obtained from the present studies of resistant involve various morphological parameters discussed below.

Similar findings were reported by Singh (2008) who evaluated 2000 safflower germplasm at Directorate of Oilseeds Research, Rajendranagar, Hyderabad and foundthat spiny genotypes with thin stems, pale green leaves were observed as tolerant/resistant to aphid infestation while non-spiny, late maturing and tall appearance with succulent stem and green leathery leaves of plants contributed for aphid susceptibility.

Rajput *et al.* (2009) who observed similar finding relative resistant of 5 safflower cultivars against black aphid. These differences in the population buildup ofaphid were attributed due to change in the morphological characters of cultivars evaluated. They observed that PI-40/477 has different morphological characters such as spines on leaves which may prevents/ resists the accumulation of aphids on cultivaras a result the cultivar PI-40/477 were less infested by the aphid attack as compare to other cultivars.

Kadam and Thakur (2002) conducted experiment to determine the relative resistant of safflower cultivars against safflower aphid, *Uroleucon compositae*. The mechanisms of resistant were also studied. Safflower cultivars GMU-1251, PI-306983, JLSF-213, JLSF-217, JLSF-291, A-1 and Bhima showed resistant to *Uroleucon compositae*, while Co-1 was highly susceptible.

Similar findings were reported by Jagtap *et al.* (1985) who studied on incidenceof Safflower Aphid, *Uroleucon carthami* on 51 varieties and they noted that, in general, aphids preferred those varieties without spines on their branches. Most susceptible to infestation was T6S (170.8% relative to control variety Tara), whileJL28-1 was least susceptible (28.89%).

4.3 To study biochemical compounds of safflower genotypes against safflower aphid resistant / preference

Table 4.4 Reaction of aphid population with safflower genotypes morphological and biochemical parameters

S. No.	Genotypes	Aphid /5 cm central apical twig/plant	Aphid Infestation Index (A.I.I.)	chlorophyll a mg/g	chlorophyll b mg/g	total chlorophyll mg/g	wax content mg/g	Trichome density/ cm^2	seed yield / plant/g	seed yield/ variety/g	Category
1	GMU 2424	20	1.3	0.138	0.216	0.36	15.12	54.6	16.8	420	resistant
2	GMU 7573	30	1.7	0.142	0.222	0.367	15.72	44.2	14.4	360	resistant
3	GMU 6891	41.8	3.6	0.16	0.25	0.404	22.48	31.4	6.8	170	susceptible
4	GMU 5136	37.4	2.6	0.149	0.24	0.39	17.98	37.4	9.6	240	Moderately resistant
5	GMU 1175	37.8	3.2	0.156	0.244	0.397	20.14	33.4	8	200	susceptible
6	GMU 7590	28.6	1.4	0.139	0.244	0.354	15.18	51.6	16	400	resistant
7	GMU 2347	40	3.2	0.156	0.248	0.402	19.36	34.2	8	200	susceptible
8	GMU 7594	37.2	2.5	0.148	0.23	0.377	17.64	38	10	250	Moderately resistant
9	GMU 2486	28.8	2	0.143	0.225	0.369	15.88	43	12	300	resistant
10	GMU 7316	31.2	2.5	0.148	0.23	0.378	17.64	39.2	10	250	moderately resistant
11	GMU 7436	39.2	3.7	0.161	0.248	0.405	23.8	30.6	6.4	160	susceptible
12	GMU 5142	38.4	3.1	0.155	0.243	0.395	19.62	34.4	8.08	2.2	susceptible
13	GMU 7634	59.6	4.7	0.175	0.273	0.445	32.71	26	3.4	85	highly susceptible
14	GMU 3944	43.6	3.3	0.157	0.245	0.402	20.42	33.6	7.6	190	susceptible
15	GMU 1811	29.6	2	0.143	0.227	0.371	15.88	43.6	12	300	resistant
16	GMU 1397	27	1.9	0.143	0.225	0.371	15.88	43.6	13.2	330	resistant
17	GMU 7569	30	2.1	0.147	0.233	0.38	16.44	40	10.4	260	moderately resistant
18	GMU 2775	40.8	3.4	0.158	0.247	0.4	20.78	32.6	7.4	185	susceptible
19	GMU 1894	20.6	1.3	0.138	0.216	0.36	15.12	55	16.8	420	resistant

S. No.	Genotypes	Aphid /5 cm central apical twig/plant	Aphid Infestation Index (A.I.I.)	chlorophyll a mg/g	chlorophyll b mg/g	total chlorophyll mg/g	wax content mg/g	Trichome density/ cm^2	seed yield / plant/g	seed yield/ variety/g	Category
20	GMU 7363	36.4	2.7	0.151	0.239	0.384	18.38	37.2	9.2	230	moderately resistant
21	GMU 3266	34.6	2.5	0.148	0.23	0.377	17.64	38.4	10	250	moderately resistant
22	GMU 6919	54.8	4.5	0.173	0.276	0.444	32.16	27.4	4	100	highly susceptible
23	GMU 589	33	2.1	0.144	0.227	0.371	16	41.6	11.2	280	moderately resistant
24	GMU 5135	35	2.3	0.146	0.23	0.373	16.3	40	10.6	265	moderately resistant
25	GMU 1731	40	3.2	0.156	0.243	0.395	20.14	33.6	8	200	susceptible
26	GMU 6886	28.2	1.8	0.142	0.222	0.347	15.72	43.4	13.6	340	resistant
27	GMU 7568	33.8	2.4	0.147	0.235	0.376	16.44	39	10.4	260	Moderately resistant
28	GMU 1310	28.6	1.7	0.142	0.223	0.364	15.72	46.2	14.4	360	resistant
29	GMU 5133	38.2	3.2	0.156	0.244	0.396	20.14	33.8	8	200	susceptible
30	GMU 1654	34.4	2.5	0.148	0.231	0.378	17.64	39.4	10	250	moderately resistant
31	GMU 7581	37.6	2.8	0.152	0.25	0.4	18.75	36.4	8.8	220	moderately resistant
32	GMU 590	28.6	2.2	0.148	0.288	0.372	16.16	41	10.8	270	moderately resistant
33	GMU 995	30	2.1	0.144	0.232	0.374	16	41.8	11.2	280	moderately resistant
34	GMU 7618	18.4	1.1	0.134	0.211	0.348	14.84	65	21	575	resistant
35	GMU 2644	40	3	0.154	0.24	0.391	19.36	35.2	8.4	210	moderately resistant
36	GMU 3438	35.4	2.5	0.148	0.23	0.376	17.64	38.6	10	250	moderately resistant
37	GMU 5134	32.2	2.4	0.147	0.233	0.38	16.44	39	10.4	260	moderately resistant
38	GMU 2648	35.3	2.5	0.148	0.231	0.378	17.64	37.8	10	250	moderately resistant
39	GMU 6037	39.8	3.5	0.159	0.245	0.403	22	32	7.2	180	susceptible
40	GMU 7355	42.8	3.8	0.162	0.245	0.403	24.86	29.8	6	150	susceptible
41	GMU 974	49.2	4.3	0.169	0.272	0.44	31.88	29	5	125	highly susceptible
42	GMU 2687	45.6	4	0.166	0.266	0.434	28.66	29.4	5.6	140	susceptible

S. No.	Genotypes	Aphid /5 cm central apical twig/plant	Aphid Infestation Index (A.I.I.)	chlorophyll a mg/g	chlorophyll b mg/g	total chlorophyll mg/g	wax content mg/g	Trichome density/ cm^2	seed yield / plant/g	seed yield/ variety/g	Category
43	GMU 1183	50.6	3.7	0.161	0.248	0.405	23.8	31	6.4	160	susceptible
44	GMU 6004	28	1.6	0.141	0.219	0.361	15.52	45	14.8	370	resistant
45	GMU 4914	39.4	3.2	0.156	0.244	0.397	20.14	34.2	8	200	susceptible
46	GMU 1360	47.2	4.1	0.167	0.269	0.487	29.9	29.4	5.4	135	highly susceptible
47	GMU 2757	43.2	3.3	0.157	0.245	0.402	20.42	33.2	7.6	190	susceptible
48	GMU 7572	45.4	3.6	0.16	0.25	0.404	22.48	31.6	6.8	170	susceptible
49	GMU 4546	33.8	2.5	0.148	0.23	0.377	17.64	38.4	10	250	moderately resistant
50	GMU 667	55.2	4.5	0.173	0.276	0.444	32.16	27	4	100	highly susceptible
51	GMU 3924	47	4.2	0.168	0.274	0.443	30.54	29	5.2	130	highly susceptible
52	GMU 3373	40	3.5	0.159	0.243	0.402	22.2	31.6	7.2	180	susceptible
53	GMU 4983	31.8	2.4	0.147	0.235	0.376	16.44	39.2	10.4	260	moderately resistant
54	GMU 6926	38.6	3.5	0.159	0.254	0.412	22.2	32	7.2	180	susceptible
55	GMU 7331	37	2.7	0.151	0.239	0.384	20.78	37.6	9.2	230	moderately resistant
56	GMU 1067	60.4	4.8	0.176	0.277	0.447	33.04	25.2	3.2	80	highly susceptible
57	GMU 4814	40.8	3.7	0.161	0.248	0.405	23.8	30.4	6.4	160	susceptible
58	GMU 2403	28	1.8	0.142	0.223	0.364	15.72	44	13.6	340	resistant
59	GMU 579	33	2.5	0.148	0.23	0.377	17.64	39	10	250	moderately resistant
60	GMU 5149	52.6	4.4	0.17	0.272	0.441	32	28.2	4.4	110	highly susceptible
61	GMU 7399	59.2	4.6	0.174	0.278	0.445	32.32	26	3.9	90	highly susceptible
62	GMU 4965	40	3.2	0.156	0.243	0.395	20.14	33.4	8	200	susceptible
63	GMU 6854	42	3.7	0.161	0.259	0.412	23.8	30.6	6.4	160	susceptible
64	GMU 7579	39.2	3.5	0.159	0.254	0.402	22.2	32	7.2	180	susceptible
65	GMU 7633	47.3	4.2	0.168	0.274	0.449	30.54	29.6	5.2	130	highly susceptible

S. No.	Genotypes	Aphid /5 cm central apical twig/plant	Aphid Infestation Index (A.I.I.)	chlorophyll a mg/g	chlorophyll b mg/g	total chlorophyll mg/g	wax content mg/g	Trichome density/ cm^2	seed yield / plant/g	seed yield/ variety/g	Category
66	GMU744 8	50	4.3	0.168	0.272	0.44	30.56	28.6	5	125	highly susceptible
67	GMU 7591	37.4	2.4	0.147	0.233	0.38	16.44	39.6	10.4	260	moderately resistant
68	GMU 7456	27	1.9	0.149	0.24	0.39	17.98	44	9.4	240	resistant
69	GMU 7593	36.6	2.7	0.166	0.266	0.343	20.66	37.2	5.6	140	moderately resistant
70	GMU 609	49.2	4.3	0.161	0.248	0.405	23.8	29.6	6.4	160	highly susceptible
71	GMU 7359	32	2.4	0.16	0.25	0.404	22.48	39.6	6.8	170	moderately resistant
72	GMU 5097	36.3	2.6	0.168	0.267	0.436	30.54	37.6	5.2	130	moderately resistant
73	GMU 2830	38	4	0.151	0.239	0.384	18.38	29	9.2	230	susceptible
74	GMU 753	41.2	3.7	0.152	0.25	0.4	18.74	30	8.8	220	susceptible
75	GMU 7601	39.2	3.6	0.149	0.24	0.39	17.98	31.6	9.6	240	susceptible
76	GMU 1758	48	4.2	0.168	0.267	0.436	30.54	28.6	6.4	150	highly susceptible
77	GMU 7319	37.8	2.7	0.151	0.239	0.384	18.38	37.6	11.6	290	moderately resistant
78	GMU 3206	37.6	2.8	0.152	0.25	0.4	18.74	36.8	6	150	moderately resistant
79	GMU 884	34.6	2.6	0.149	0.24	0.39	17.98	37	6.4	160	moderately resistant
80	GMU 880	43.2	3.8	0.162	0.245	0.409	24.86	29.4	3.2	80	susceptible
81	GMU 972	29	2.1	0.144	0.227	0.371	16	42.6	6	150	moderately resistant
82	GMU 1217	41.8	3.8	0.162	0.245	0.409	24.86	30	13.6	340	susceptible
83	GMU 7599	40.4	3.7	0.161	0.248	0.405	23.8	30.4	10.4	260	susceptible
84	GMU 8852	61	4.8	0.176	0.277	0.447	33.04	25.8	10	250	highly susceptible
85	GMU 2928	39.3	3.8	0.162	0.245	0.409	24.86	29.2	12	300	susceptible
86	GMU 2380	28.6	1.8	0.142	0.223	0.38	16.44	44.4	9.2	230	resistant
87	GMU 1798	37.2	2.4	0.147	0.233	0.38	16.44	40	7.2	180	moderately resistant
88	GMU 1628	36	2.5	0.148	0.23	0.377	17.64	38.8	8.6	215	moderately resistant

S. No.	Genotypes	Aphid /5 cm central apical twig/plant	Aphid Infestation Index (A.I.I.)	chlorophyll a mg/g	chlorophyll b mg/g	total chlorophyll mg/g	wax content mg/g	Trichome density/ cm^2	seed yield / plant/g	seed yield/ variety/g	Category
89	GMU 7351	28	2	0.143	0.325	0.369	15.88	44	6	150	resistant
90	GMU 184	38	2.7	0.151	0.239	0.39	19.1	37.8	5.8	135	moderately resistant
91	GMU 7612	38.8	3.5	0.159	0.254	0.412	22.2	31.6	10	250	susceptible
92	GMU 3654	35.6	2.9	0.153	0.239	0.39	19.1	36	8	200	moderately resistant
93	GMU 1940	42.4	3.8	0.162	0.245	0.409	24.86	29	12	300	susceptible
94	GMU 3926	44	4.9	0.165	0.263	0.426	27.4	28.2	6.8	170	highly susceptible
95	GMU 5774	36.2	2.5	0.148	0.23	0.377	17.64	38.4	7.2	180	moderately resistant
96	GMU 7303	40.8	3.2	0.156	0.244	0.397	20.14	33.8	15.2	380	susceptible
97	GMU 5660	28.2	2	0.143	0.227	0.371	15.88	43.4	8.6	215	resistant
98	GMU 1437	39.8	3.6	0.16	0.23	0.404	22.48	31.6	5	125	susceptible
99	GMU 1851	38.8	3.5	0.159	0.254	0.412	22.2	31.2	9.6	240	susceptible
100	GMU 3781	27	1.5	0.14	0.219	0.363	15.38	50.6	8	200	resistant
101	GMU 1737	35.2	2.9	0.153	0.239	0.39	19.1	35.8	11.2	280	moderately resistant
102	GMU 969	50	4.3	0.169	0.272	0.44	31.88	28.8	2	50	highly susceptible
103	GMU 5338	34.8	2.6	0.149	0.24	0.39	17.98	37	8	200	moderately resistant
104	GMU 849	40.6	3.3	0.156	0.244	0.397	20.14	33.6	11.2	280	susceptible
105	GMU 5865	29.8	2.1	0.144	0.227	0.371	16	41.8	8	200	moderately resistant
106	GMU 850	71.6	2.9	0.188	0.314	0.477	34.9	22.4	20	500	moderately resistant
107	GMU 7542	38.6	3.2	0.156	0.244	0.397	20.14	33.8	14.4	360	susceptible
108	GMU 4907	29.2	2.1	0.144	0.227	0.371	16	41.2	9	210	moderately resistant
109	GMU 2968	40.6	3.2	0.156	0.246	0.402	20.14	34	14.4	360	susceptible
110	GMU 3966	24	1.2	0.142	0.223	0.364	15.72	61.2	9	230	resistant
111	GMU 3965	29	1.7	0.136	0.205	0.356	14.98	44	7.5	160	resistant

S. No.	Genotypes	Aphid /5 cm central apical twig/plant	Aphid Infestation Index (A.I.I.)	chlorophyll a mg/g	chlorophyll b mg/g	total chlorophyll mg/g	wax content mg/g	Trichome density/ cm^2	seed yield / plant/g	seed yield/ variety/g	Category
	CHECK										
	PBNS-12	28.8	2.1	0.144	0.227	0.371	0.16	42	11.6	290	highly susceptible
	A-1	19	1	0.122	0.182	0.321	13.25	70	28	700	highly susceptible

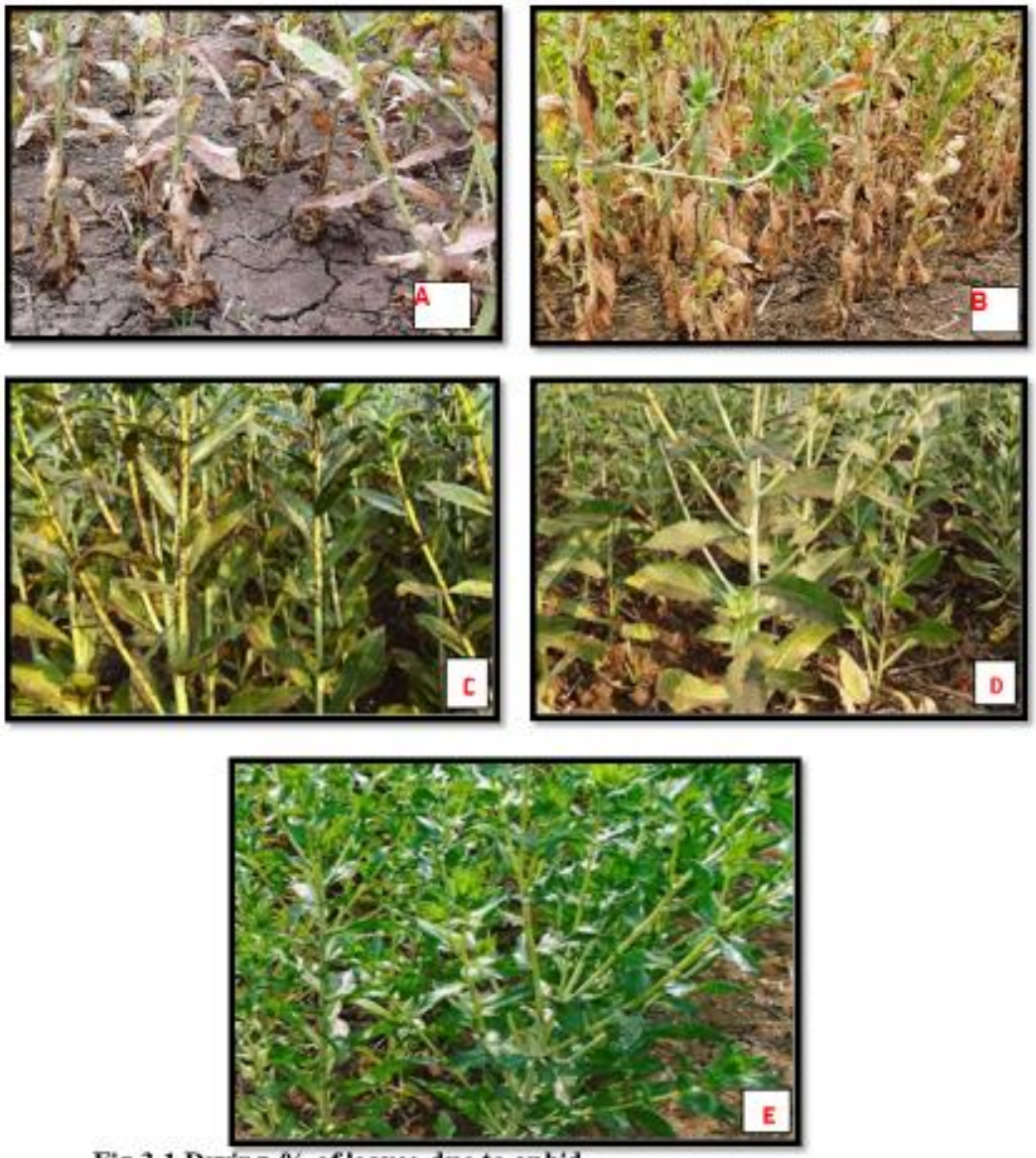


Fig 3.1 Drying % of leaves due to aphid.

- ✓ **A** –GMU 7634 **Highly Susceptible Genotype > 80 % drying..**
- ✓ **B** -GMU 6891)**Susceptible Genotype 61 to 80 % drying.**
- ✓ **C** -GMU 7316 **Moderately Resistance Genotype < 60 % drying.**
- ✓ **D**-GMU 2424)**Resistance Genotype < 40 % drying.**
- ✓ **E- A1 Highly Resistance < 20% drying.**

4.3.1 Chlorophyll a content

Total chlorophyll a content was minimum estimated of 0.138 mg/g in GMU 2424 and GMU 1894 which are resistant genotype and maximum in highly susceptible genotype GMU 1067 (0.176 mg/g) germplasm line. The overall observations indicated that higher chlorophyll content was noticed in all 3 aphid highly susceptible lines as compared to susceptible, Resistant and Moderate resistant lines. The germplasm containing highest quantity of chlorophyll a showed high aphid infestation as compared to susceptible, Resistant and Moderate resistant lines germplasm. The correlation of total chlorophyll and Aphid Infestation Index was found significant highly positive (0.514**).

4.3.2 Chlorophyll b content

Total chlorophyll b content was minimum estimated of 0.216 mg/g in GMU 2424 and GMU 1894 which are resistant genotype and maximum in highly susceptible genotype GMU 1067 (0.278 mg/g) germplasm line. The overall observations indicated that higher chlorophyll a content was noticed in all 3 aphid highly susceptible lines as compared to susceptible, Resistant and Moderate resistant lines. The germplasm containing highest quantity of chlorophyll a showed high aphid infestation as compared to susceptible, Resistant and Moderate resistant lines germplasm. The correlation of total chlorophyll and Aphid Infestation Index was found significant highly positive (0.517**) (Table 4.5 and 4.6).

4.3.3 Total chlorophyll content

Total chlorophyll content was minimum, estimated in 0.354 mg/g in GMU 6886 and GMU 7590 which are resistant genotype and maximum in highly susceptible genotype GMU 1360 (0.487mg/g) germplasm line. The overall observations indicated that higher total chlorophyll content was noticed in all 3 aphid highly susceptible lines as compared to susceptible, Resistant and Moderate resistant lines. The germplasm containing highest quantity of chlorophyll a showed high aphid infestation as compared to susceptible, Resistant and Moderate resistant lines germplasm. The correlation of total chlorophyll and Aphid Infestation Index was found significant highly positive (0.515**)

4.3.4 Wax content

Total wax content was minimum in GMU 7618 and GMU 3965 in resistant genotype and maximum in GMU 8852 and GMU 1067 highly susceptible genotype (33.04 mg/g) germplasm lines (Table 4.6).The overall observations indicated that higher wax content was noticed in all 3 aphid highly susceptible lines as compared to susceptible, Resistant and Moderate resistant lines. The germplasm containing highest quantity of wax content showed high aphid infestation as compared to susceptible, Resistant and Moderate resistant lines germplasm. The correlation of total wax content and Aphid Infestation Index was found significant highly positive (0.517**).

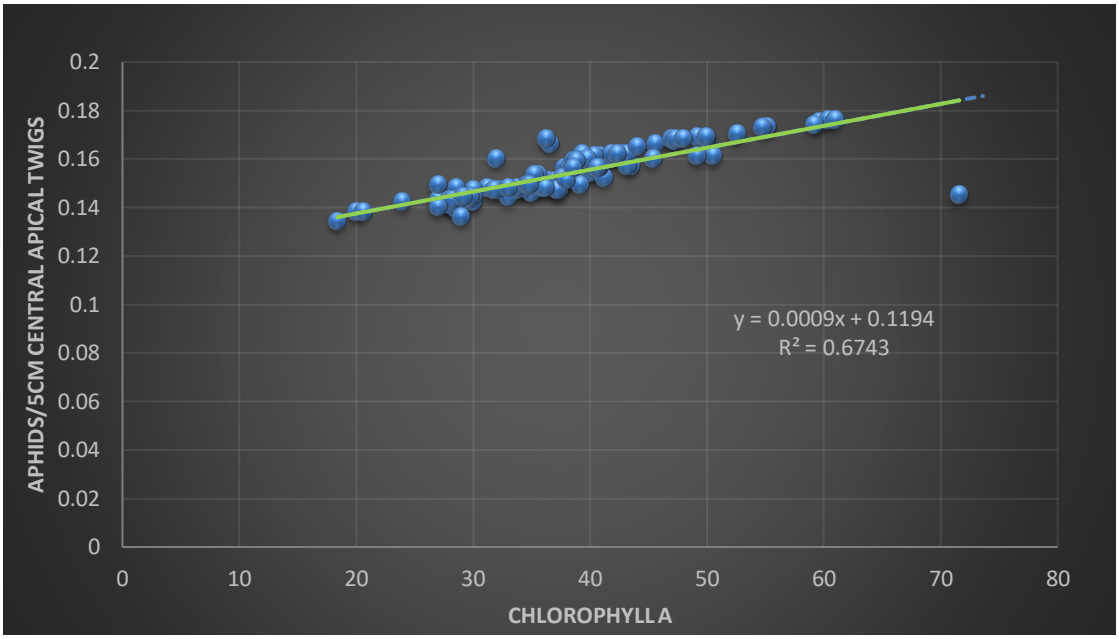
Table 4.5 Correlation coefficient between biochemicals and aphid population/5cmcentral twig/plant

	Values of correlation coefficient			
	Chlorophyll a	**Chlorophyll b**	**Total chlorophyll**	**Wax content**
Aphid population/5cm central twig	**0.514****	**0.517****	**0.515****	**0.517****

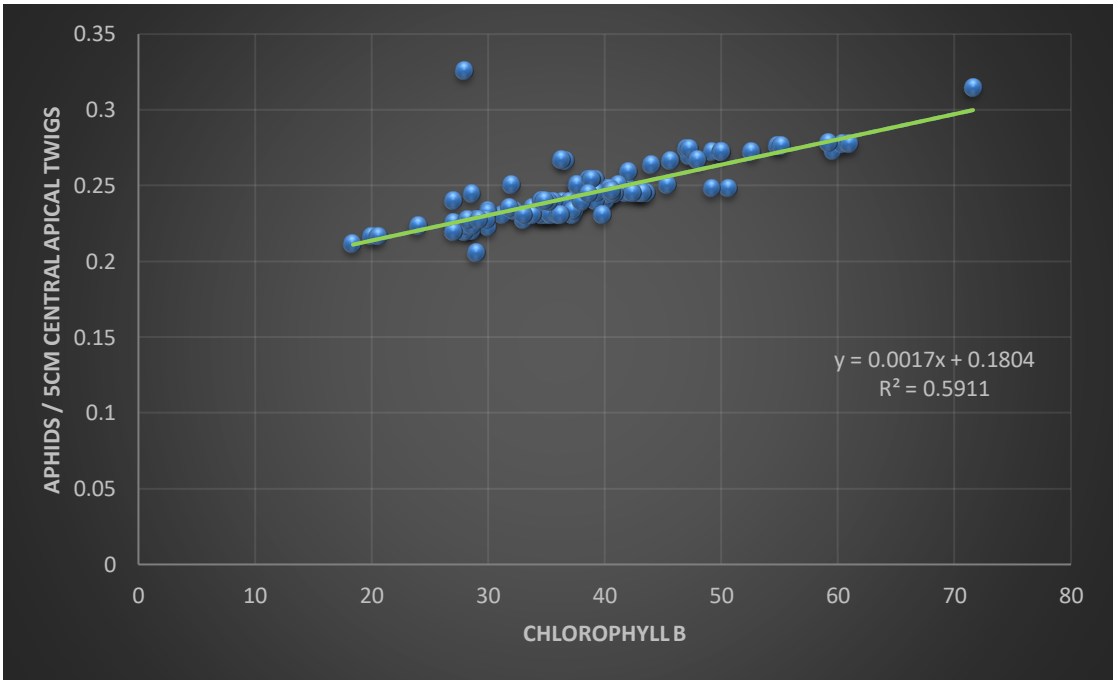
As par the above finding, it can be concluded that lower level chlorophyll are responsible for imparting resistant. To explain this, the lowest total chlorophyll and wax content in two genotypes i.e. A-1 (RC) and GMU 7618 is very resistant to aphid and genotype *i.e*. GMU 1067 is very low in Chlorophyll and wax content is very susceptible to aphid.

Similarly, Neharkar and Suryawanshi (2004) also observed eight safflower genotypes Sharda, A-1, Co-I, GMU-4608, GMU-4609, GMU-4610, GMU-4625 and GMU-4627, were analyzed for their major constituents of nitrogen, phosphorus,potassium, wax, polyphenols, total amino acids and total sugar contents. The safflowergenotypes with less nitrogen, wax, (chloroform soluble matter), total amino acids and total sugars and more amount of phosphorus, potassium and polyphenols were resistant to aphids (*Uroleucon compositae*), when compared with Sharda and CO-I. Itwas observed that the nitrogen, wax, total amino acids and total sugars were responsible for the resistant and susceptibility in safflower genotypes. Lower contents of the above parameters were found in resistant genotypes, whereas higher content of phosphorus, potassium and polyphenol was responsible against safflower aphid resistant and observed in genotypes GMU-4609, GMU-4625 and A-I.

Elanchezhya, *et al.* (2008), also confirm that maximum contents of total phenol were recorded in resistant cultivar, Sweta (7.61 mg/ g) and minimum in highly susceptible cultivar, Bejo and Sheetal (1.95 mg/ g) in his experiment indicating that it plays an important role in imparting resistant against the pest. A strong negative correlation was observed between the pest infestation and total phenol content (r = - 0.88**).

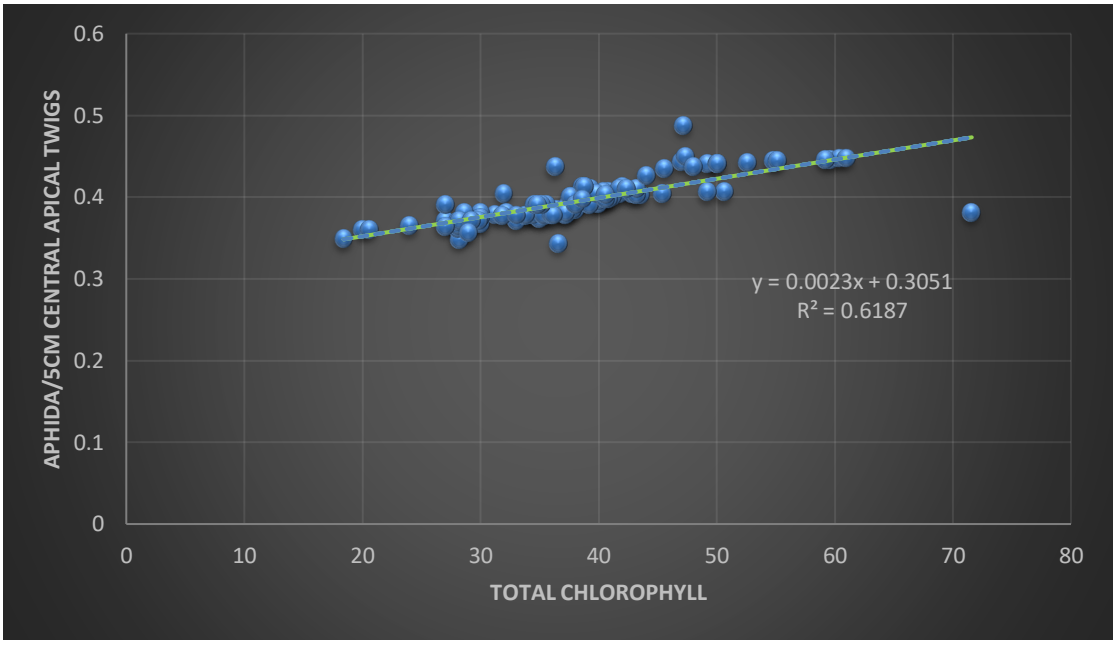


(a)

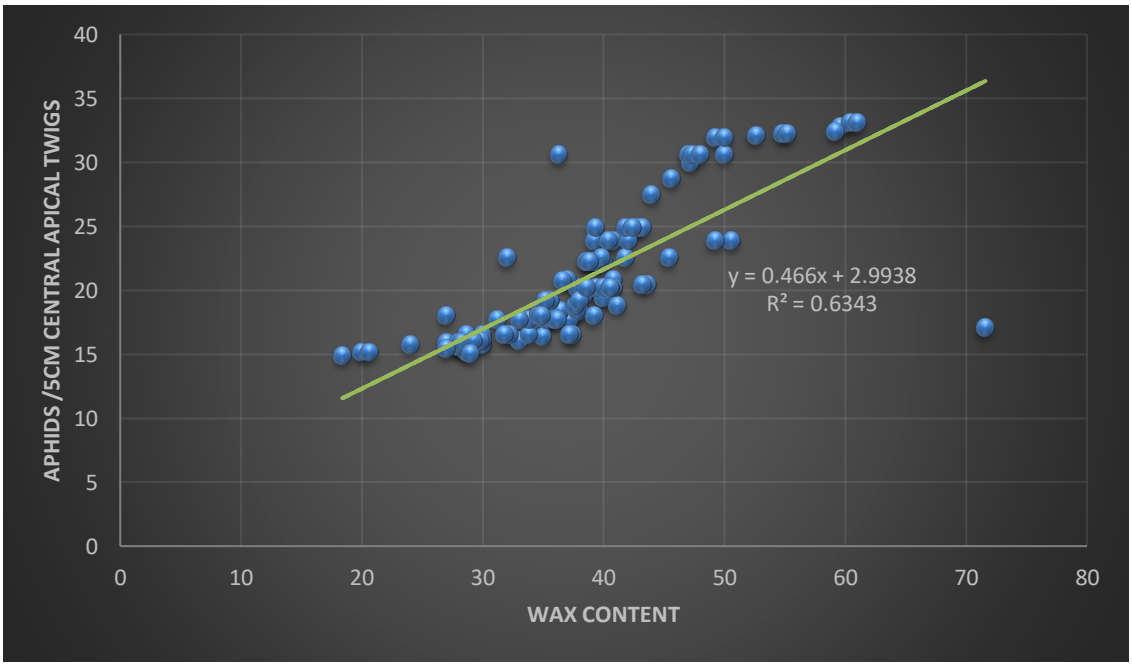


(b)

fig-4.2 (a) correlation between aphid population 5cm central apical twigs and chlorophyll a content in leaves. (b) correlation between aphid population 5cm central apical twigs and chlorophyll b content in leaves



(a)



(b)

fig-4.3 (a) correlation between aphid population 5cm central apical twigs and total chlorophyll a content in leaves. (b) correlation between aphid population 5cm central apical twigs and wax content in leaves

CHAPTER-V
SUMMARY AND CONCLUSIONS

The present investigation entitled "Screening of germplasm accessions of safflower for their morphological and biochemical traits in relation to resistant against Safflower aphid, *Uroleucon compositae* (Theobald)" was conducted at Instructional cum Research Farm and Laboratory of the Department of Plant Molecular Biology and Biotechnology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, C.G. during *rabi* season of 2019-20 respectively. The summary and conclusion of present works is given below:

The objective of the present study are -

1. To evaluate safflower germplasm accessions for their reaction against safflower aphid under natural conditions.
2. To study morphological characters of safflower genotypes and their association with resistant/preference against safflower aphid.
3. To study biochemical compounds of safflower genotypes against safflower aphid resistant/preference.

1. To evaluate safflower germplasm accessions for their reaction againstsafflower aphid under natural conditions.

In the present investigations safflower genotypes population, the mean incidence of aphids and foliage drying grade of leaves was recorded to find out the Aphid Infestation Index (AII).

From the result achieved it can be summarized that there were 18 genotypes namely GMU 2424,GMU 7573, GMU 7590, GMU 2486, GMU 1811, GMU 1397, GMU 1894, GMU 6886, GMU 1310, GMU 7618, GMU 6004, GMU 2403, GMU 7456, GMU 2380, GMU 7351, GMU 5660 GMU 3781, GMU 3965 showed minimum aphid population below 30 with Aphid Infestation Index (AII) between 1.1-2.1 and registered under resistant category during the present study. There were none genotypes which were highly resistant, A.I.I was not less than <1.1 in any genotype studied.

It was also noticed that there were genotypes namely GMU 5136, GMU 7594, GMU 7316, GMU 7569, GMU 7363, GMU 3266, GMU 589, GMU 5135,GMU 7568, GMU GMU 654, GMU 7581, GMU 590, GMU 995, GMU 2644, GMU3438, GMU 5134, GMU 2648, GMU 4546, GMU 4983, GMU 7331, GMU 579, GMU7591, GMU 7593, GMU 7359 GMU 7319, GMU 3206, GMU 884, GMU 972,GMU1798, GMU 1628, GMU184, GMU 3654, GMU 5774, GMU 1737, GMU 5338,GMU 5865, GMU 850, GMU 4907 which were under category moderately resistant showed aphid population in range 30-40 and aphid infestation index A.I.I was ranged between 2.1-3.0, similarly it was observed that there were genotypes which were categorised into susceptible the genotypes were GMU 6891, GMU 1175, GMU 2347,GMU 7436, GMU 5142, GMU 3944, GMU 2775, GMU 1731, GMU 5133 GMU6037, GMU 7355, GMU 2687, GMU 1183, GMU 4914, GMU 2757, GMU 7572,GMU 3373, GMU 6926, GMU 4814, GMU 4965, GMU 6854, GMU 7579, GMU2830, GMU 753, GMU 7601, GMU 880, GMU 1217, GMU 7599, GMU 2928, GMU7612, GMU 1940, GMU 7303, GMU 1851, GMU 849, GMU 7542, GMU 2968 these genotypes showed aphid population between 40-45 with aphid infestation index A.I.I ranged between 3.1- 4.0. There were also some genotypes which were highly susceptible these were GMU 6919 974 1360 GMU 667 3924 1067 5149 7399 7633 7448 609 1758 8852 3926 GMU 969 this genotype showed aphid population above 50 and aphid infestation index A.I.I was always > 4.1.

2. To study morphological characters of safflower genotypes and their associationwith resistant/preference against safflower aphid.

A number of insect plants interrelations have been described to be responsible for imparting plant resistant against insect pests. A plant resistant could be due to description of one or more morphological traits. Thus, the various morphological parameters *viz.* No. of spines on OIB, leaf shape, leaf margin, leaf colour, leaf texture, extent of leaf spininess were studied

On the basis of structural variations leaf shape were classified into lanceolate, linear, oblong. In present study Out of one hundred eleven genotypes eighty-seven showed lanceolate, fourteen oblong and thirteen genotypes as linear type leaf shape. Thus, leaf shape did not play role in the tested safflower genotype against safflower aphid and making the plant resistant or susceptible.

On the basis of structural variations leaf margin Safflower plant were classified into serrate and deeply serrate. Out of 111 genotype it was found that fifty one genotypes had serrate and sixty genotype showed deeply serrate. leaf margin did not play role in the safflower genotypes against safflower aphid and making the plant resistant/ susceptible.

In present study structural variations of leaf spininess, genotypes were classified into many spines, few spines and intermediate. Out of one hundred and eleven genotypes 5 genotypes showed many spines and remaining 49 genotype had intermediate spines. Left 57 genotypes had few spines. leaf spininess plays important role in the tested safflower genotypes against safflower aphid and found responsible for resistant or susceptible on the basis of mean aphid population and AII.

On the basis of structural variations No. of spines on OIB were classified into few spines, intermediate and many spines. In present study Out of one hundred eleven genotypes six genotypes showed many spines, fifty genotypes showed intermediate no. of spines in OIB and fifty genotypes had few spines. Thus, No. of spines on OIB did not play role in the tested safflower genotype against safflower aphid making the plant resistant or susceptible.

On the basis of structural variations leaf texture of Safflower plant were classified into normal, fleshy and leathery. In this experiment 111 germplasm were analyzed resistant involve morphological parameters like leaf texture. out of one hundred eleven genotype it was found that fifty-nine genotypes had normal leaves and 46 genotypes showed fleshy leaves, remaining genotypes showed leathery texture.

Safflower plant leaf shape was classified into Ovate, Oblong, Lanceolate and Linear. Among the fifty genotypes 21genotypes had Ovate, 17 genotypes oblong and 12 genotypes were lanceolate type leaf shape was observed. Against safflower aphid and making the plant resistant or susceptible. In genotype morphological parameter aphid resistant on basis of leaf shape out 10 genotype thee line of genotype highly susceptible, 21 moderately resistant, three genotypes were highly resistant, and 9 genotype line resistant and 6 genotype lines were susceptible to safflower aphid. Thus, Leaf shape did not play role in the tested safflower genotype.

On the basis of structural variations types of leaf margin classified into Entire, Serrate or dentate and deeply serrate. Out of fifty genotype 30 line of genotype had deeply serrate and 20 genotype line had serrate type leaf margin. Thus, leaf margin did not play role in the tested safflower genotype against safflower aphid and making the plant resistant or susceptible.

In present study structural variations of leaf colour genotypes were classified into Light green (yellowish tinge), Dark green (bluish tinge) and Grayish colour. Out of fifty genotypes 38 genotypes showed light green and remaining 18 genotypes as dark green leaf colour. leaf colour play important role in the tested safflower genotypes against safflower aphid and found responsible for resistant or susceptible on the basisof mean aphid population and AII.

3. To study biochemical compounds of safflower genotypes against safflower aphid resistant/preference.

Biochemical basis of resistant of safflower germplasm against aphid, various biochemical constituents *viz*. total chlorophyll, chlorophyll a, chlorophyll b were estimated and correlated with aphid mean population 5cm central apical twigs/plant chlorophyll a content was minimum estimated of 0.138 mg/g in GMU 2424 and GMU 1894 which are resistant genotype and maximum in highly susceptible genotype GMU 1067 (0.176 mg/g) germplasm line. The overall observations indicated that higher chlorophyll content was noticed in all 3 aphid highly susceptible lines as compared to susceptible, Resistant and Moderate resistant lines. The germplasm containing highest quantity of chlorophyll a showed high aphid infestation as compared to susceptible, Resistant and Moderate resistant lines germplasm. The correlation of total chlorophyll and aphid mean population 5cm central apical twigs/plant was found significant highly positive (0.514**)

chlorophyll b content was minimum estimated of 0.216 mg/g in GMU 2424 and GMU 1894 which are resistant genotype and maximum in highly susceptible genotype GMU 1067 (0.278 mg/g) germplasm line. The overall observations indicated that higher chlorophyll b content was noticed in all 3 aphid highly susceptible lines as compared to susceptible, Resistant and Moderate resistant lines. The germplasm containing highest quantity of chlorophyll a showed high aphid infestation as

compared to susceptible, Resistant and Moderate resistant lines germplasm. The correlation of total chlorophyll and aphid mean population 5cm central apical twigs/plant was found significant highly positive (0.517**).

Total chlorophyll content was minimum estimated of 0.354 mg/g in GMU 6886 and GMU 7590 which are resistant genotype and maximum in highly susceptible genotype GMU 1360 (0.487mg/g) germplasm line. The overall observations indicated that higher total chlorophyll content was noticed in all 3 aphid highly susceptible lines as compared to susceptible, Resistant and Moderate resistant lines. The germplasm containing highest quantity of total chlorophyll showed high aphid infestation as compared to susceptible, Resistant and Moderate resistant lines germplasm. The correlation of total chlorophyll and aphid mean population 5cm central apical twigs found significant highly positive (0.515**).

Total wax content was minimum in GMU 7618 and GMU 3965 in resistant genotype and maximum in GMU 8852 and GMU 1067 highly susceptible genotype (33.04 mg/g) germplasm lines. The overall observations indicated that higher wax content was noticed in all 3 aphid highly susceptible lines as compared to susceptible, Resistant and Moderate resistant lines. The germplasm containing highest quantityof wax content showed high aphid infestation as compared to susceptible, resistant and Moderate resistant lines germplasm. The correlation of total wax content and aphid mean population 5cm central apical twigs was found significant highly positive (0.517**)

Suggestion for future works

In future, further following studies should be done-

1. For evaluating resistant varieties on safflower aphid genetic study and identification of histological and more physio - chemical factors such as total nitrogen, moisture content, ash content conferring resistant against sucking insect pest to be done.
2. Anatomical characters in relation to resistant against aphid should be identified.
3. To find out antibiosis effect in resistant safflower genotype against aphid.
4. Hybridization programme to evolve varies for aphid resistant should be taken up.

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