Asian Jr. of Microbiol. Biotech. Env. Sc. Vol. 23, No. (2) : 2021 : 258-264
© Global Science Publications
ISSN-0972-3005

EVALUATION OF BIOCHEMICAL PARAMETERS OF OKRA GERMPLASM FOR RESISTANCE AGAINST JASSIDS, *Amrasca Biguttula biguttula* (ISHIDA)

YOGESH KUMAR H D [1*], JAYARAJ PADHI [2], LADU KISHORE RATH [3], GOURI SHANKAR SAHU [4] AND MEENU KUMARI [5]

[1,2,3] Department of Entomology, [4] Department of Vegetable Science, Odisha University of Agriculture and Technology, Bhubaneswar 751 003, Odisha, India
[5] ICAR Research Complex for Eastern Region, Farming System Research Centre for Hill and Plateau Region, Ranchi 834 010, Jharkhand, India

(Received 5 February, 2021; accepted 10 April, 2021)

Key words : *Jassid, Total sugar, Reducing sugar, Phenol, Protein, Chlorophyll, Okra, Leafhopper*

Abstract–Biochemical components of okra germplasm were assessed for resistance or susceptibility to the leafhopper, *Amrasca biguttula biguttula* (Ishida) at All India Coordinated Research Project on Vegetable Crops, Odisha University of Agriculture and Technology and Central Horticultural Experiment Station, Bhubaneswar during three consecutive seasons of *kharif*, 2018, summer, 2019 and *kharif*, 2019. The results revealed that the total sugar, reducing sugar, total protein, total phenol and total chlorophyll content in different okra germplasm varied from 2.84 % to 5.51 %, 0.28 % to 0.56 %, 0.75 to 2.10 mg/g, 0.52 to 1.35 mg/g and 1.04 to 2.29 mg/g, respectively. The okra germplasm BBSR-37, BBSR-36, Pusa A-4, BBSR-57, BBSR-3 and BBSR-4 were found to be resistant to leafhopper, with BBSR-4 being moderately resistant, BBSR-09-6 susceptible besides Pusa Sawani and BBSR-53 being highly susceptible.

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is a member of Malvaceae family, is a widely grown vegetable crop, cultivated in tropical and subtropical regions of the world. It is commonly known as 'Bhendi' or 'Ladies finger' and is one of the most widespread and commercially grown vegetables in tropical countries (Singh *et al*., 2014; Sandhi *et al*., 2017). Okra cultivation covers 5.13 lakh hectares (ha) in India, with a production of 61.70 lakh metric tonnes (MT) and a productivity of 12.03 MT/ha. Okra is grown on 0.64 lakh ha in Odisha, with a yield of 5.66 lakh MT and a productivity of 8.85 MT/ha (Horticultural Statistics at a Glance, 2018).

As many as 72 pest species attacks okra crop from germination to harvest. The sucking pest complex of okra includes leafhopper (*Amrasca biguttula biguttula* Ishida), aphid (*Aphis gossypii* Glover), whitefly (*Bemisia tabaci* Gennadius) and mite (*Tetranychus cinnabarinus* Boisduval). The borer complex comprising of shoot and fruit borers *viz*., *Earias vittella* (Fabricius), *Earias insulana* (Boisdual) and *Helicoverpa armigera* (Hubner) are known to cause severe damage to the crop (Rao and Rajendran, 2003). Okra production is inhibited by a variety of insect pests, but jassid, *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae), is one of the most important insect pests on this crop, severely limiting its cultivation (Singh and Joshi, 2004).

The nymphs and adults suck the plant sap from lower surface of the leaves resulting in yellowing, browning, bronzing, cupping, withering and necrosis of leaves and ultimately the leaves shed prematurely. The phytotoxic symptoms caused due to their infestation is known as "hopper burn" (Bindra and Mahal, 1981; Mahal *et al*., 1993; Mahal *et al*., 1994). Leafhopper alone had reduced okra fruit yield by 59.79 % (Atwal and Singh, 1990). The losses in okra yield due to jassids have been reported to vary from 50.00 – 52.00 % (Rawat and Sahu, 1973), 40.00 – 56.00 % (Krishnaiah, 1980), 40.00 – 60.00 % (Narke and Suryawanshi, 1987) and 32.06 – 40.84 %

(Singh and Brar, 1994). There is a reduction of 49.80 and 45.10 % height and number of leaves respectively, due to the attack of leafhopper (Rawat and Sahu, 1973).

Insecticides have become the most common choice of pest control among the various pest management strategies. However, they are detrimental to the environment and financially uneconomical, leading to environmental pollution. Plants contain a variety of compounds that are primarily used to defend themselves against natural enemies. Developing jassid resistance varieties is the most logical solution to the jassid problem. Host plant resistance is an efficient, cost-effective, and safe way to protect plants from jassid (Devi *et al*., 2018). In integrated pest management, varietal tolerance is a key technique. A resistant variety assists in insect species suppression thus having the least amount of damage to the crop ecosystem. It also eliminates the need for toxic pesticides that cause environmental pollution (Sandhi *et al*., 2017). Plants with a variety of biophysical and biochemical characteristics play an important role in providing resistance to a variety of insect pests (Halder *et al*., 2016; Halder and Srinivasan, 2011). Even a low level of tolerance in plants has a dramatic effect, which in fact reduces the need of insecticides. Based on the facts mentioned above, the present research was carried out to evaluate the chemical components of okra germplasm having different degrees of resistance and susceptibility with the population of jassids.

MATERIALS AND METHODS

The research was conducted at the All India Coordinated Research Project on Vegetable Crops, Odisha University of Agriculture and Technology and the Central Horticultural Experiment Station, Bhubaneswar, during *kharif*, 2019. The experiment was conducted in randomized block design with ten treatments and three replications. The treatments comprised of ten okra germplasm containing five resistant (BBSR-37, BBSR-36, BBSR-57, BBSR-47 and BBSR-3), one moderately resistant (BBSR-4), one moderately susceptible (BBSR-09-6) and one susceptible (BBSR-53) genotype, selected based on two year field trial with a resistant and a susceptible check (Pusa A-4 and Pusa Sawani, respectively).

The polybags of 1′ diameter were used for the study and they were filled with 6 kg mixture of soil and FYM in the ratio of 3:1. Recommended dose of fertilizers were applied at the time of sowing. Sowing was done on last week of September during *kharif*, 2019. Two seeds per polythene bag were sown and the bags were labelled properly. The crop was kept free from any insecticide application. The number of jassid nymph and adult were counted from top, middle and bottom canopy of the each germplasm. Total number of jassids present on the lower as well as upper surfaces of the leaf was noted down. The observations were recorded during early morning hours throughout the crop season at weekly intervals. At peak jassid infestation period (49 – 63 DAS) the biochemical attributes *viz*., total sugars, reducing sugars, total phenol, total protein and total chlorophyll were estimated according to the standard procedures. The amount of total sugars present in the okra leaf sample was estimated by Anthrone method (Hedge and Hofreiter, 1962; Sadasivam and Manickam, 1992). The reducing sugar content was determined by following Nelson-Somogyi method (Somogyi, 1952). The protein content of the okra leaf sample was quantified as per the protocol given by Lowry *et al.* (1951). The quantity of phenol present in the okra leaf sample was estimated by following the method of Bray and Thorpe (1954). The chlorophyll content in leaf sample was estimated as per the procedure given by Arnon (1941).

The data obtained on jassid population and various biochemical attributes of okra germplasm during *kharif*, 2019 were subjected to square root transformations wherever required and were analysed by randomized block design procedure using OPSTAT software. F test was conducted to test the significance of variations in the treatments. The standard error mean [SE (m) ±] and critical difference (CD) at 5 % level of significance were also calculated following the procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Jassid population

The mean jassid population of okra germplasm at weekly intervals during *kharif*, 2019 was presented in Table 1. Jassid activity peaks between 49 and 63 DAS and steadily declines by the end of the crop season. At 56 DAS, the least jassid population was recorded on okra germplasm BBSR-37 (5.78 jassids/ leaf), which was *at par* with Pusa A-4 (6.00 jassids/

leaf), followed by BBSR-36 (6.33 jassids/leaf) and BBSR-57 (6.56 jassids/leaf). At 56 DAS, the highest jassid population was recorded on okra germplasm Pusa Sawani (17.89 jassids/leaf), which was *at par* with BBSR-53 (17.67 jassids/leaf) and differed significantly with BBSR-09-6 (14.11 jassids/leaf). The okra germplasm BBSR-47, BBSR-3 and BBSR-4 were observed with moderate number of jassids with 6.89, 7.11 and 10.00 jassids per leaf, respectively.

The mean jassid population during *kharif*, 2019 was ranged between 3.08 and 9.24 jassids per leaf. The least jassid population was observed on okra germplasm BBSR-37 (3.08 jassids/leaf), which was followed by Pusa A-4 (3.39 jassids/leaf), BBSR-36 (3.42 jassids/leaf), BBSR-57 (3.56 jassids/leaf) and BBSR-47 (3.81 jassids/leaf). The moderate level of jassid population were noticed on okra germplasm BBSR-3 (4.06 jassids/leaf) and BBSR-4 (5.11 jassids/leaf). The highest mean jassid population was recorded on okra germplasm BBSR-53 (9.24 jassids/leaf), which was followed by Pusa Sawani (9.20 jassids/leaf) and BBSR-09-6 (6.85 jassids/leaf). These results are in confirmation with the findings of Ramachandra (2018), who reported 3.75 to 10.33 jassids per leaf. Similar results were observed by Srasvan (2017), who observed 4.34 jassids per leaf on resistant genotype IC-282280 and 12.36 jassids per leaf on susceptible genotype Pusa Sawani.

Biochemical parameters

The data of biochemical parameters in different okra germplasm during *kharif*, 2019 was presented in Table 1.

Total sugars

The total sugar content in selected okra germplasm during *kharif*, 2019 was ranged from 2.84 % to 5.51 %. The lowest total sugar content was observed on okra germplasm BBSR-53 with sugar content of 2.84 %, which was *at par* with BBSR-09-6 (2.93 %).

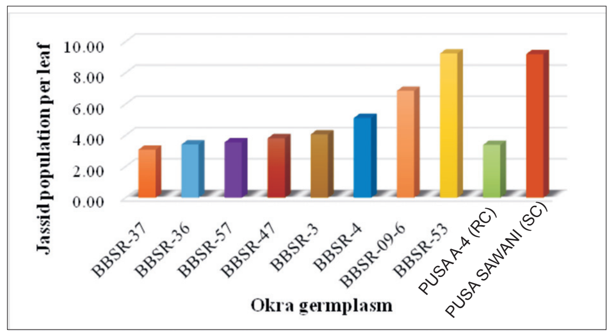

Fig. 1. Mean jassid population of different okra germplasm during kharif, 2019

Table 1. Mean jassid population on okra germplasm at weekly intervals during *kharif*, 2019

Treat-ments	Germplasm	Jassid population per leaf at different days after sowing												Mean
		7	14	21	28	35	42	49	56	63	70	77	84	
T_1	BBSR-37	0.00	0.22	0.44	1.22	2.11	3.89	5.33	5.78	5.56	4.89	4.11	3.44	3.08
		(1.00)	(1.11)	(1.20)	(1.49)	(1.76)	(2.21)	(2.52)	(2.60)	(2.56)	(2.43)	(2.26)	(2.11)	(2.02)
T_2	BBSR-36	0.00	0.22	0.56	1.33	2.44	4.44	5.89	6.33	5.89	5.33	4.56	4.00	3.42
		(1.00)	(1.11)	(1.25)	(1.53)	(1.86)	(2.33)	(2.62)	(2.71)	(2.62)	(2.52)	(2.36)	(2.24)	(2.10)
T_3	BBSR-57	0.00	0.33	0.78	1.33	3.00	4.56	6.00	6.56	6.00	5.11	4.78	4.22	3.56
		(1.00)	(1.15)	(1.33)	(1.53)	(2.00)	(2.36)	(2.65)	(2.75)	(2.65)	(2.47)	(2.40)	(2.29)	(2.13)
T_4	BBSR-47	0.00	0.33	0.78	1.56	3.44	4.78	6.33	6.89	6.56	5.56	5.11	4.44	3.81
		(1.00)	(1.15)	(1.33)	(1.60)	(2.11)	(2.40)	(2.71)	(2.81)	(2.75)	(2.56)	(2.47)	(2.33)	(2.19)
T_5	BBSR-3	0.00	0.44	0.89	1.67	3.56	5.22	6.78	7.11	7.00	6.11	5.44	4.56	4.06
		(1.00)	(1.20)	(1.37)	(1.63)	(2.13)	(2.49)	(2.79)	(2.85)	(2.83)	(2.67)	(2.54)	(2.36)	(2.25)
T_6	BBSR-4	0.00	0.44	1.22	1.78	4.33	6.56	8.89	10.00	9.00	7.33	6.56	5.22	5.11
		(1.00)	(1.20)	(1.49)	(1.67)	(2.31)	(2.75)	(3.14)	(3.32)	(3.16)	(2.89)	(2.75)	(2.49)	(2.47)
T_7	BBSR-09-6	0.00	0.67	1.44	2.22	5.11	8.44	12.00	14.11	12.22	10.11	8.89	7.00	6.85
		(1.00)	(1.29)	(1.56)	(1.80)	(2.47)	(3.07)	(3.61)	(3.89)	(3.64)	(3.33)	(3.14)	(2.83)	(2.80)
T_8	BBSR-53	0.00	1.56	2.56	3.78	7.22	10.22	14.11	17.67	16.11	15.00	13.11	9.56	9.24
		(1.00)	(1.60)	(1.89)	(2.19)	(2.87)	(3.35)	(3.89)	(4.32)	(4.14)	(4.00)	(3.76)	(3.25)	(3.20)
T_9	PUSA-A4	0.00	0.22	0.56	1.33	2.67	4.33	5.89	6.00	5.78	5.33	4.44	4.11	3.39
	(RC)	(1.00)	(1.11)	(1.25)	(1.53)	(1.91)	(2.31)	(2.62)	(2.65)	(2.60)	(2.52)	(2.33)	(2.26)	(2.09)
T_{10}	PUSA	0.00	1.67	2.44	3.67	7.00	9.11	15.11	17.89	16.22	15.33	12.78	9.22	9.20
	SAWANI (SC)	(1.00)	(1.63)	(1.86)	(2.16)	(2.83)	(3.18)	(4.01)	(4.35)	(4.15)	(4.04)	(3.71)	(3.20)	(3.19)
	SE(m) ±	0.000	0.048	0.084	0.060	0.052	0.048	0.080	0.069	0.066	0.070	0.077	0.080	
	CD (5 %)	NS	0.14	0.25	0.18	0.16	0.14	0.24	0.21	0.20	0.21	0.23	0.24	

Figures in parentheses are square root transformed values $\sqrt{(x+1)}$, RC – Resistant check, SC – Susceptible check

The highest total sugar content was noticed on okra germplasm BBSR-37 (5.51 %), which was *at par* with Pusa A-4 (5.40 %) and differed significantly with BBSR-36 (4.82 %). The moderate level of total sugar content was recorded on Pusa Sawani (3.02 %), BBSR-4 (3.11 %), BBSR-47 (3.30 %), BBSR-3 (3.38 %) and BBSR-57 (4.01 %). These results are similar to the findings of previous researchers. The total sugar content in okra genotypes ranged from 2.47 % in AKOV-107-04 to 3.82 % in AKOV-106 (Mudgalkar *et al.*, 2015); 2.31 % in GAO-5 to 2.90 % in Glory (Ranmalbhai, 2014); 3.00 % in ST-2 to 4.60 % in HRB-128-1-1 (Lokesh, 2002); 1.93 mg/g in IC-45800 to 4.06 mg/g in OK-9 (Kadu, 2018). Nain and Rathee (2017) revealed that total sugar content was observed to be less in the highly susceptible okra variety HBT-6-15-3-7 (1.93 %) and higher in the least susceptible variety HB-02-14-1-1 (3.30 %). Higher the sugar content in the genotype, lower the jassid attack as high total sugars acts as phagodeterrent.

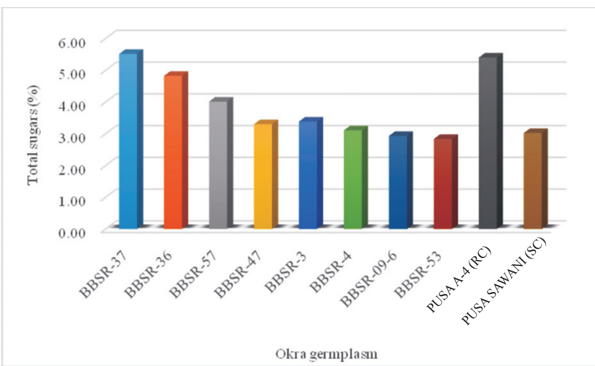

Fig. 2. Total sugar content in different okra germplasm during *kharif*, 2019

Reducing sugars

The reducing sugar content in selected okra germplasm during *kharif*, 2019 was ranged between 0.28 % and 0.87 % in pot culture experiment. The lowest reducing sugar content was noticed on okra germplasm BBSR-36 (0.28 %), which differ significantly with BBSR-37 (0.33 %), Pusa A-4 (0.34 %), BBSR-57 (0.35 %) and BBSR-47 (0.38 %). The moderate level of reducing sugar content was registered on okra germplasm BBSR-3 (0.43 %) and BBSR-4 (0.51 %). The highest reducing sugar content was observed on okra germplasm Pusa Sawani with reducing sugar content of 0.87 %, which was *at par* with BBSR-53 (0.86 %), differed significantly with BBSR-09-6 (0.64 %). The results are in agreement with those of Ranmalbhai (2014), who observed the reducing sugar content between 0.44 % in GAO-5 and 0.55 % in both Glory and Arka Anamika. Similarly 0.56 mg/g in OK-7 to 2.00 mg/g in IC-282288 (Kadu, 2018). The susceptible genotypes observed maximum reducing sugar content as compared to resistant genotypes. The reducing sugars act as phagostimulant for the leafhopper population (Kadu, 2018; Sandhi *et al*, 2017).

Total protein

The data revealed that the protein content of selected okra germplasm during *kharif*, 2019 was ranged between 0.75 and 2.10 mg/g sample. The lowest protein content was recorded on okra germplasm BBSR-37 with 0.75 mg/g sample, which differed significantly with Pusa A-4 (0.80 mg/g), followed by BBSR-36 (0.86 mg/g), BBSR-57 (0.93 mg/

Table 2. Biochemical basis of resistance in okra against jassids during *kharif*, 2019

Treatments	Germplasm	Total sugars (%)	Reducing sugars (%)	Total protein (mg/g)	Total phenol (mg/g)	Total chlorophyll (mg/g)
T_1	BBSR-37	5.51	0.33	0.75	1.35	1.13
T_2	BBSR-36	4.82	0.28	0.86	1.27	1.04
T_3	BBSR-57	4.01	0.35	0.93	1.11	1.16
T_4	BBSR-47	3.30	0.38	0.98	1.01	1.22
T_5	BBSR-3	3.38	0.43	0.94	1.00	1.24
T_6	BBSR-4	3.11	0.51	1.25	0.88	1.41
T_7	BBSR-09-6	2.93	0.64	1.56	0.71	1.89
T_8	BBSR-53	2.84	0.86	2.06	0.52	2.22
T_9	PUSA-A4 (RC)	5.40	0.34	0.80	1.09	1.15
T_{10}	PUSA SAWANI (SC)	3.02	0.87	2.10	0.59	2.29
	SE(m) ±	0.035	0.005	0.010	0.017	0.027
	CD (5 %)	0.11	0.02	0.03	0.05	0.08

RC – Resistant check, SC – Susceptible check

g) and BBSR-3 (0.94 mg/g). The highest protein content was recorded on okra germplasm Pusa Sawani with 2.10 mg/g sample, which differed significantly with BBSR-53 (2.06 mg/g), followed by BBSR-09-6 (1.56 mg/g). The moderate level of protein content was observed on okra germplasm BBSR-47 (0.98 mg/g) and BBSR-4 (1.25 mg/g). Similar findings were obtained by Kadu (2018), who reported that the protein content of 0.50 mg/g in OK-7 to 2.25 mg/g in IC-140906 in the leaves of okra germplasm. Ranmalbhai (2014) reported that the protein content of 1.64 % in Ankur-40 to 1.97 % in Nirmala-303. The susceptible genotypes observed with higher amount of protein content as compared to resistant genotypes (Lokesh, 2002; Sreedevi, 2011; Kadu, 2018).

Total phenol

The total phenol content of selected okra germplasm during *kharif,* 2019 was ranged between 0.52 and 1.35 mg/g sample. The lowest phenol content was noticed on okra germplasm BBSR-53 with 0.52 mg/g sample, which was *at par* with Pusa Sawani (0.59 mg/g) and differed significantly with BBSR-09-6 (0.71 mg/g). The highest phenol content was observed on okra germplasm BBSR-37 with 1.35 mg/g sample, which differed significantly with BBSR-36 (1.27 mg/g), followed by BBSR-57 (1.11 mg/g). The moderate level of phenol content was observed on okra germplasm BBSR-4 (0.88 mg/g), BBSR-3 (1.00 mg/g), BBSR-47 (1.01 mg/g) and Pusa A-4 (1.09 mg/g). The phenol content in the leaves of okra genotypes varied between 1.36 mg/g in IC-140906 and 5.78 mg/g in OK-9 (Kadu, 2018); 1.33 mg/g in Pusa Sawani to 1.58 mg/g in *Abelmoschus moschatus* (Sandhi *et al*., 2017); 0.75 mg/g in IIVR-11 to 1.78 mg/g in VRO-3 (Srasvan, 2017); 0.42 mg/g in SB-6 to 0.75 mg/g in VROB-181 (Halder *et al*., 2016). Resistant okra varieties had the highest phenol content, whereas the susceptible varieties recorded least phenol content. This might be due to phenols act as antifeedant to insect herbivores (Kadu, 2018, Srasvan, 2017 and Sreedevi, 2011). Phenolics in a very large quantity could have direct toxicity to the insect (Halder *et al*., 2016).

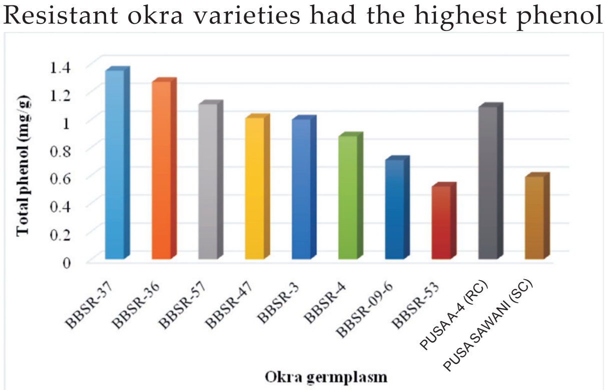

Fig. 3. Total phenol content in different okra germplasm during *kharif*, 2019

Total chlorophyll

The total chlorophyll content on selected okra germplasm during *kharif,* 2019 was ranged between 1.04 and 2.29 mg/g sample. The data showed that the maximum chlorophyll content was observed on okra germplasm Pusa Sawani (2.29 mg/g sample), which was *at par* with BBSR-53 (2.22 mg/g), differed significantly with germplasm BBSR-09-6 (1.89 mg/g) and BBSR-4 (1.41 mg/g). The minimum chlorophyll content was observed on okra germplasm BBSR-36 with 1.04 mg/g sample, which was *at par* with BBSR-37 (1.13 mg/g) and differed significantly with Pusa A-4 (1.15 mg/g). The moderate level of total chlorophyll was observed on okra germplasm BBSR-57 (1.16 mg/g), followed by BBSR-47 (1.22 mg/g) and BBSR-3 (1.24 mg/g). The present results are in confirmation with the findings of Srasvan (2017), who revealed that the total chlorophyll content varied between 0.70 mg/g in VRO-3 and 1.15 mg/g in IC-282280 in the leaves of okra genotypes. Ranmalbhai (2014) also reported that the total chlorophyll content ranged from 0.17 mg/g in IC-48948 to 0.54 mg/g in Narendra and 1.17 mg/g in Glory to 1.51 mg/g in GAO-5.

CONCLUSION

The research concluded that highest total sugars and maximum phenol content imparts resistance into the okra germplasm, whereas highest reducing sugars, maximum protein content and excess chlorophyll content were responsible for susceptibility. The okra germplasm BBSR-37, BBSR-36, Pusa A-4, BBSR-57, BBSR-3 and BBSR-4 were found to be resistant to leafhopper, with BBSR-4 being moderately resistant, BBSR-09-6 susceptible besides Pusa Sawani and BBSR-53 being highly susceptible. These germplasm were identified to be a source of leafhopper resistance and could be used in breeding programmes and IPM strategies. Resistance cultivars provide a better control of insect pests, but do not give complete protection to the crops from the pests. Therefore, resistance cultivars should be used in combination with other methods of pest control to achieve sustainable pest management. Resistant variety is a safe, economical and long lasting alternative method of pest control.

ACKNOWLEDGEMENTS

The authors acknowledge All India Coordinate Research Project on Vegetable Crops, Odisha University of Agriculture and Technology and the Central Horticultural Experiment Station, Bhubaneswar, for their assistance, encouragement and cooperation during the research.

AUTHOR'S CONTRIBUTION

Yogesh Kumar, H.D. Data collection, biochemical analysis and manuscript preparation; Jayaraj Padhi: Drafting the manuscript and critical review of the article; Meenu Kumari: Biochemical analysis; Gouri Shankar Sahu: Providing okra germplasm; Ladu Kishore Rath: Critical revision of the article.

REFERENCES

Arnon, D.I. 1949. Copper enzymes in isolated chloroplasts phenol oxidase in *Beta vulgaris*. *Plant Physiology*. 24 : 1.

Atwal, A.S. and Singh B. 1990. Pest population and assessment of crop losses. ICAR Publication, Indian council of Agricultural Research, New Delhi. p. 265.

Bindra, O.S. and Mahal, M.S. 1981. Varietal resistance in eggplant (brinjal), *Solanum melongena* to the cotton jassid, *Amrasca biguttula biguttula* (Ishida). *Phytoparasitica.* 9 : 119-131.

Bray, H.G. and Thorpe, W.V. 1954. Analysis of phenolic compounds of interest in metabolism. *Methods of Biochemical Analysis*. 1 : 27-52.

Devi, Y.K., Pal, S. and Seram, D. 2018. Okra jassid, *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae) biology, ecology and management in okra cultivation. *Journal of Emerging Technologies and Innovative Research*. 5(10) : 333-343.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research, Edn-2. John Wiley and Sons, New York. p. 680.

Halder, J. and Srinivasan, S. 2011. Varietal screening and role of morphological factors on distribution and abundance on spotted pod borer, *Maruca vitrata* (Geyer) on cowpea. *Annals of Plant Protection Sciences*. 19(1): 71-74.

Halder, J., Sanwal, S.K., Deb, D., Rai, A.B. and Singh, B. 2016. Mechanisms of physical and biochemical basis of resistance against leafhopper, *(Amrasca biguttula biguttula* Ishida) in different okra [*Abelmoschus esculentus* (L.) Moench] genotypes. *Indian Journal of Agricultural Sciences*. 86(4) : 481-484.

Hedge, J.E. and Hofreiter, B.T. 1962. Carbohydrates chemistry. (Eds. Whistler RL and Be Miller JN), Academic press, New York. p. 17.

Horticultural Statistics at a Glance. 2018. Department of Agriculture, Cooperation & Farmers Welfare. p. 458.

Kadu, R.V. 2018. Resistance mechanism in okra genotypes against leafhopper (*Amrasca biguttula biguttula* Ishida) and whitefly (*Bemisia tabaci* Gennadius) and their management. Ph.D. thesis submitted to MPKV, Rahuri (Maharashtra), India. p. 171.

Krishnaiah, K. 1980. Methodology for assessing crop losses due to pests of vegetable and assessment of crop losses due to pests and diseases. In: Proceedings of workshop held at University of Agricultural Sciences, Bengaluru, September 19-30, p. 259-267.

Lokesh, 2002. Evaluation of okra genotypes for resistance to cotton leafhopper, *Amrasca biguttula biguttula* (Ishida). M.Sc. thesis submitted to the CCSHAU, Hisar (Haryana), India. p. 64.

Lowry, O.H., Rosebrough, N.J., Farr, A.L., Randall, R.J. 1951. Protein measurement with the Folin phenol reagent. *Journal of Biological Chemistry*. 193(1) : 265-275.

Mahal, M.S., Brar, L.S., Singh, R. and Singh, B. 1994. Influence of varying magnitude of jassid injury on seed yield of okra and economics of its control. *Journal of Insect Science*. 7(2) : 129-132.

Mahal, M.S., Lal, H., Singh, R. and Singh, B. 1993. Field resistance in okra to the cotton jassid, *Amrasca biguttula biguttula* (Ishida) in relation to crop age. *Journal of Insect Science*. 6(1) : 60-63.

Mudgalkar, A.B., Sonalkar, V.U. and Gaikwad, B.B. 2015. Correlation between leafhopper and whitefly population with phenol and sugar contents of okra leaf. *Journal of Entomological Research*. 39(2): 131-134.

Nain, J. and Rathee, M. 2017. Effect of leaf morphology and phytochemistry of okra on development and survival of two spotted spider mite. *Tetranychus urticae* Koch. *Indian Journal of Entomology*. 79(1): 32-36.

Narke, C.G. and Suryawanshi, D.S. 1987. Chemical control of major pests of okra. *Pesticides*. 21(1) : 37-42.

Ranmalbhai, J.A. 2014. Morphological, biochemical and molecular characterization of okra cultivars [*Abelmoschus esculentus* (L.) Moench]. M.Sc. thesis submitted to Anand Agricultural University, Anand (Gujarat), India. p. 114.

Rao, N.S. and Rajendran, R. 2003. Joint action potential of neem with other plant extracts against the leafhopper, *Amrasca devastans* (Distant) on okra. *Pest Management and Economic Zoology*. 10(2): 131-136.

Rawat, R.B. and Sahu, H.R. 1973. Estimation of losses in growth and yield of okra due to *Empoasca devastans* (Distant) and *Earias spp*. *Indian Journal of Entomology*. 35 : 252-254.

Ramachandra, D.S. 2018. Morphological and biochemical basis of resistance, ecology and bio-efficacy of insecticides against pest complex in summer okra. Ph.D. thesis submitted to Junagadh Agricultural University, Junagadh (Gujarat), India. p. 115.

Sadasivam, S. and Manickam, A. 1992. Biochemical methods for agricultural sciences. Wiley Eastern Limited, New Delhi. p. 11-12.

Sandhi, R.K., Sidhu, S.K., Sharma, A., Chawla, N. and Pathak, M. 2017. Morphological and biochemical basis of resistance in okra to cotton jassid, *Amrasca biguttula biguttula* (Ishida). *Phytoparasitica*. 45 : 381-394.

Singh, G. and Brar, K.S. 1994. Effect of dates of sowing on the incidence of *Amrasca biguttula biguttula* (Ishida) and *Earias spp*. on okra. *Indian Journal of Ecology*. 21(2) : 140-144.

Singh, P., Chauhan, V., Brahmkumar, B.T., Chauhan, S.S., Simon, S., Bilal, S. and Abidi, A.B. 2014. An overview on okra [*Abelmoschus esculentus* (L.) Moench] and its importance as a nutritive vegetable in the world. *International Journal of Pharmacy and Biological Sciences*. 4 : 227-233.

Singh, R. and Joshi, A.K. 2004. Pests of okra [*Abelmoschus esculentus* (L.) Moench] in Paonta Valley, Himachal Pradesh. *Insect Environment*. 9 : 173-174.

Somogyi, M. 1952. Notes on sugar determination. *Journal of Biological Chemistry*. 195 : 19-23.

Srasvan, K.G. 2017. Evaluation of resistance mechanism in certain okra [*Abelmoschus esculentus* (L.) Moench] genotypes against sucking pests and fruit borer (*Earias vittella* Fabricius), Ph.D. thesis submitted to BHU, Varanasi (Uttar Pradesh), India. p. 186.

Sreedevi, K.V. 2011. Studies on insect pests of okra, [*Abelmoschus esculentus* (L.) Moench] with special reference to fruit borers and their management. M.Sc. thesis submitted to UAS, Bengaluru (Karnataka), India. p. 104.