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Resistant Cultivars of Safflower *Carthamus tinctorius* based on Yield Performance and Infestation against *Acanthiophilus helianthi* (Diptera: Tephritidae)

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ABSTRACT: Safflower (*Cartamous tinctorious* L.) is one of the most traditional oilseed crops and extensively cultivated in Asian countries. Thriving production of safflower is affected by several factors; one of them is insect pests. Safflower fly, *Acanthiophilus helianthi* (Rossi) is a key pest of safflower which causes substantial yield losses in every season. Using the resistant genotypes is one of the most conventional methods which reduce insect pest population, and it has been used as part of integrated pest management in safflower crop. Since host plant-resistance is the most efficient method for pest management thus, the aim of current study was subjected to evaluate the resistant genotypes against *A. helianthi.* As results, safflower varieties displayed significant variations from comparative susceptibility to comparative resistance. On the basis of results, seasonal larval and pupal population, infestation, and damage (%) caused by *A. helianthi,* PI-280-716 and PI-242-418 were found relatively susceptible; Thori-78 showed intermediate resistant, however, PI-405-992 and PI-369-848 were comparatively resistant at (*P<0.05*), respectively. Furthermore, significantly peak population of *A. helianthi* on over varieties was documented in the last two weeks of March at (*P<0.01*). In addition, the strong positive correlation between population density, dead hearts, damage percentage, and abiotic factors was recorded in susceptible PI-280-716 and PI-242-418, and negative correlation with resistant PI-405-992 and PI-369-848 cultivars, respectively. Conversely resistant varieties viz. PI-369-848 and PI-405-992 showed lesser damage and significantly higher yield at (P<0.05, P<0.01), hence forth are suggested for cultivation in order to reduce the damage of *A. helianthi.* Furthermore, resistant cultivars can reduce the yield losses and can successfullyuse as a part of integrated pest management in oilseed crops.

Keywords: *Cartamous tinctorious*, *Acanthiophilus helianthi*, Varietal resistant, Susceptibility Infestation and Yield.

I. INTRODUCTION

Safflower *Carthmus tinctorius* L. is one of the most essential and oldest oilseed crops[1]which is cultivated all over the world and ranks 8th among the major oil seed crops; however, it is extensively grown in Asian countries. Like other crops, safflower suffered and infested by several insect pests [2-3]. The safflower fly *Acanthiophilus helianthi* Rossi is one of the most economically important, and widespread pest of safflower and other crops [4-6]. Heavy infestations of *A. helianthi* occur during the reproductive phase of the plant, and significant losses in quantity and quality of the seed have been reported due to larval feeding [2, 7-9]. For the management of safflower fly, different control measures have been used, including chemical control. The majority of growers mainly depend on the synthetic insecticides for the control of *A. helianthi*in Pakistan. However,chemical control can lead to environmental pollution, poisonous food-related things, farmer's illness, and in addition to pest recurrence and resistant's [10]. To overcome these side effects, alternative control approaches are needed. One of the safe methods to avoid such a circumstance is to use the resistant varieties or genotypes as a preventive control measure, which is compatible with integrated pest management (IPM) strategy. Previous studies have been documented that, a moderate level of resistance in a crop can have a positive impact and can reduce the number of insect pests and pesticide applications [11]. Thus, the present research was made to evaluate and screening the resistant varieties of safflower genotypes against *A. helianthi* based on infestation and yield. One of the safe measures to evade pest situation is to grow resistant cotton variety and furthermore the finding out comparative resistance in conventional safflower genotypes, is a pre-requisite for the success of an Integrated Pest Management (IPM) approach for sustainable production.

II. MATERIAL AND METHODS

A. Study area, location, and experimental design

The research was conducted during 2020 at Latif Farm of Sindh Agriculture University Tandojam. To evaluate the resistance in various safflower cultivars against safflower fly *A. helianthi,* five varieties of safflower including PI-280-716, PI-405-992, PI-242-418, PI-369-

848, and Thori-78 were arranged in a randomized complete block design with five replications. The size of each plot was 1037.5 m^2 and the distance between each plot was kept as 10m. The plots were grown in single rows with spaced 45 cm apart and 20 cm between plants. All cultural and other practices (sowing time, seed rate, fertilizer, and irrigation) were applied equally in all plots.

B. Larval and pupal observation

Total 50 flower heads, were randomly collected from each plot and samples were examined under the microscope in the laboratory. Collected insects particularly (maggot and pupa of *A. helianthi*) were count and kept separately in Petridishes.

C. Infestation and damage

For the assessment of infestation and head damage percentage, 50 flower heads were randomly selected and collected from each experimental plot. From collected samples, healthy and damaged heads were inspected, and the damaged percentage was calculated by using following;

$$\text{Percentage of demaged heads} = \frac{\text{No. of damaged flower heads}}{\text{Total No. of flower heads}} \times 100$$

D. Statistical analysis

The data regarding the population of maggot and pupa, head damage percentage and correlation data with abiotic factors were subjected to statistical analysis by *Tukey's* test after one-way ANOVA; software package Statistix 8.1 and graphs were achieved by using Graph-Pad Prism software.

III. RESULTS

Seasonal larval and pupal population of *A. helianthi*on tested varieties of safflower was examined. As a result, similar population trend of *A. helianthi*was observed in all tested varieties throughout the season, and peak numbers of larvae and pupa were found in the 4th week of March (Table 1). Overall seasonal mean population of larvae and pupae/ head was considered; in order larval population,PI-280-716 > Thori-78 > PI-242-418 > PI-405-992 > PI-369-848 and pupal population PI-280-716 > PI-242-418 > Thori-78 > PI-405-992 > PI-369-848, respectively (Fig. 1).

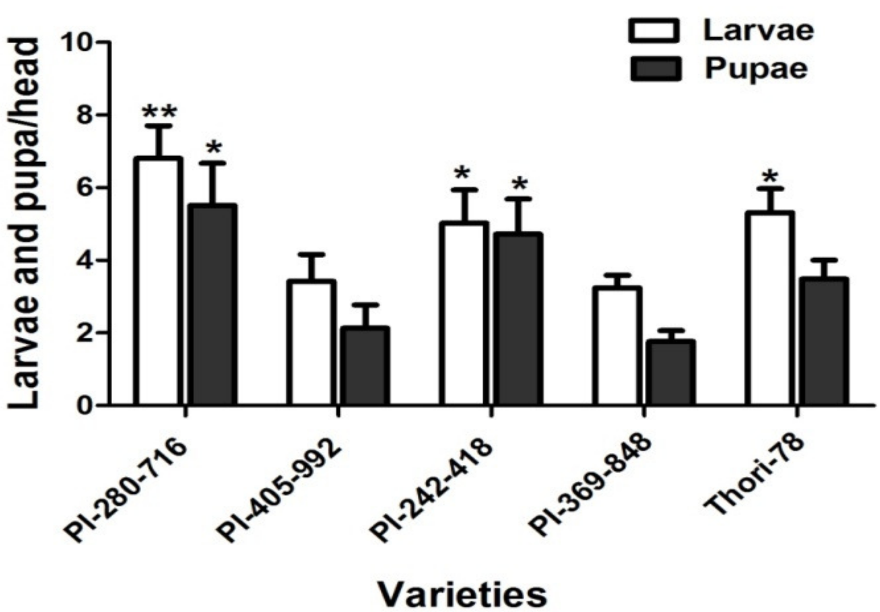

Fig. 1. Seasonal larval and pupal population of *A. helianthi* (Mean ± SE/head) on different safflower varieties at Tandojam surroundings during 2020. An asterisk (*) indicates a significant difference at (**P <0.05*, *and ** P < 0.01) LSDs* test after one- way ANOVA).

Further, the significantly maximum averaged numbers of larva and pupae of *A. helianthi* on over verities were observed on 3rd and 4th week of March at (*P<0.01*,*<0.05*) respectively (Fig. 2).

In addition, on the basis of dead hearts and damage percentage; PI-280-716 and PI-242-418 safflower verities showed significantly highly susceptible as compared PI-369-848, PI-405-992 and Thori-78 (*P < 0.05*) (Fig. 3-4).

The significantlystrong positive correlation was exhibited between the larvae and pupae population with a biotic factor such as (temperature and humidity) in the verities of PI-280-716 and PI-405-922 and the strong negative correlation was displayed with PI-405-992 and PI-242-418 at (P<0.05) as depicted in (Table 2), respectively. Further, significantly and the highly positive correlation between dead hearts and damage percentage was recorded in PI-280-716 and PI-242-418 verities and in contrast, significantly high yield was acquired from PI-405-992 and PI-369-848 varieties (*P<0.05,P<0.01*) respectively, which showed less damage percentage by *A. Helianthi* (Table 3).

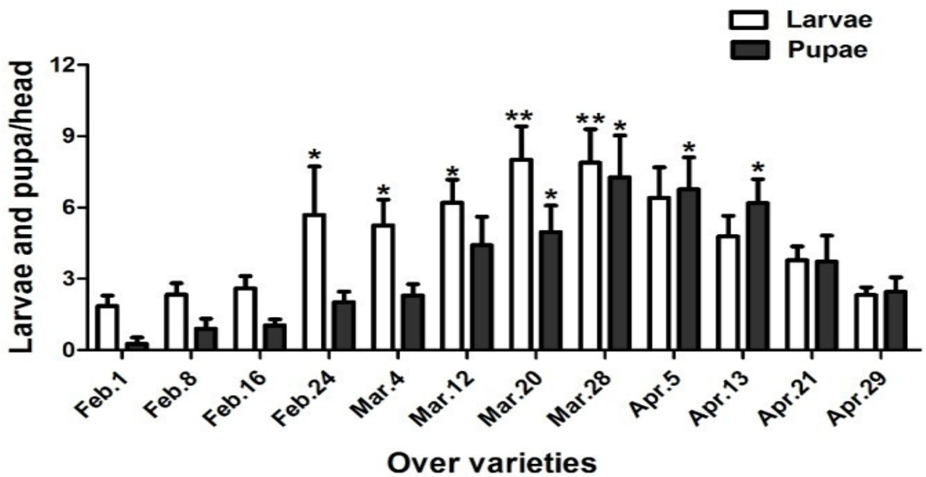

Fig. 2. Averaged larval and pupal population of *A. helianthi* (Mean ± SE/head) over varieties at Tandojam surroundings during 2020. An asterisk (*) indicates a significant difference at (**P <0.05*, *and ** P < 0.01) LSDs* test after one- way ANOVA).

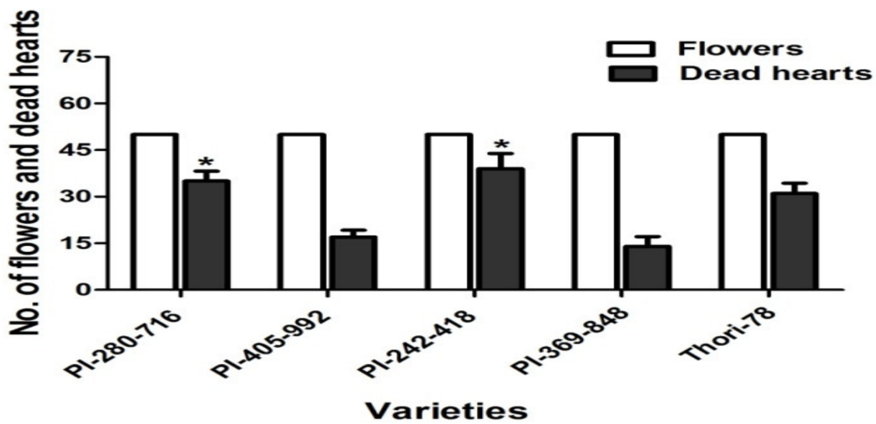

Fig. 3. Total numbers (mean ± SE) of flowers and damaged heads (dead hearts) was recorded in different varieties of safflower due to the infestation of *A. helianthi* at Tandojam during 2020. An asterisk (*) indicates a significant difference at (*P <0.05) LSDs* test after one- way ANOVA).

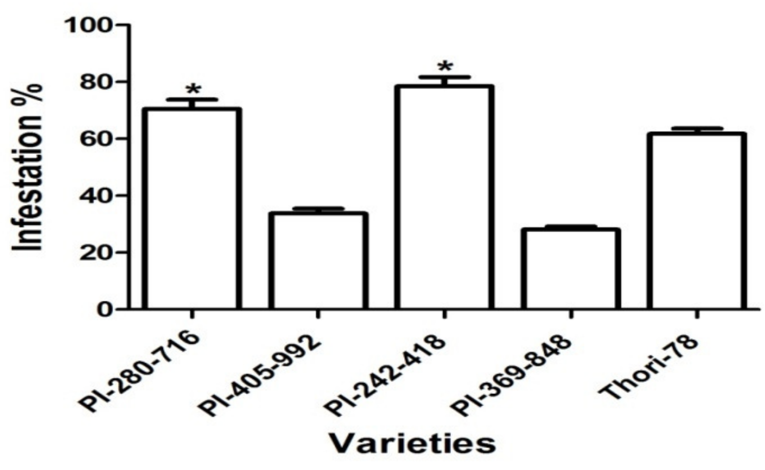

Fig. 4. Infestation (%) of *A. helianthi* on different safflower varieties at Tandojam surroundings during 2020. An asterisk (*) indicates a significant difference at (*P <0.05) LSDs* test after one- way ANOVA).

Table 1: The seasonal population of *Acanthiophilus helianthi* (larvae and pupal/head) on different varieties of safflower at Tandojam during 2020.

Sampling dates	Varieties									
	PI-280-716		PI-405-992		PI-242-418		PI-369-848		Thori-78	
	Larvae	Pupa	Larvae	Pupa	Larvae	Pupa	Larvae	Pupa	Larvae	Pupa
Feb. 1	3.15±0.56	0.00±0.00	0.74±0.16	0.00±0.00	1.75±0.88	0.00±0.00	1.15±0.23	0.00±0.00	2.59±0.48	1.34±0.47
Feb. 8	3.75±0.78	0.66±0.33	0.92±0.33	0.00±0.00	1.92±0.92	1.11±0.39	2.10±0.56	0.33±0.33	3.09±0.67	2.42±0.93
Feb. 16	4.31±0.93	1.19±0.39	1.35±0.45	0.33±0.33	2.15±0.78	1.20±0.56	2.34±0.49	0.66±0.33	3.27±0.83	1.83±0.82
Feb. 24	5.15±1.03	2.45±0.78	2.67±0.94	0.66±0.33	2.75±0.43	2.84±0.84	3.28±0.73	1.32±0.78	3.85±1.04	2.85±0.92
Mar. 4	8.66±0.94	3.69±0.92	3.08±0.73	1.00±021	4.68±1.13	2.25±0.93	3.67±0.75	1.64±0.39	6.66±1.67	2.94±0.73
Mar. 12	8.74±1.1.2	7.53±1.93	3.75±1.08	1.34±045	7.65±1.45	6.83±0.67	4.29±1.19	2.53±0.74	6.67±1.43	3.85±1.13
Mar. 20	12.43±1.19	7.63±2.42	5.81±1.23	3.45±1.45	9.41±1.84	7.25±0.25	4.72±0.96	1.78±0.78	8.15±1.93	4.73±1.37
Mar. 28	10.33±0.85	12.35±2.93	8.78±1.62	5.34±1.89	10.35±1.42	10.23±2.67	5.39±0.82	2.64±0.39	9.75±1.35	5.83±1.96
Apr. 5	9.75±1.35	10.39±1.39	5.95±1.96	6.38±1.92	8.65±1.17	8.34±1.45	4.12±1.21	2.19±0.75	6.48±1.25	6.52±2.35
Apr. 13	7.45±0.53	9.35±2.34	2.33±0.53	4.72±1.21	5.21±0.74	7.46±1.83	3.61±0.94	3.67±1.10	5.36±0.94	5.72±1.79
Apr. 21	4.75±0.47	6.34±1.25	2.00±0.62	1.27±0.93	4.32±0.67	6.35±1.27	3.23±0.56	2.43±0.81	5.21±1.56	2.23±0.64
Apr. 29	3.26±0.64	4.62±1.25	1.50±0.75	1.12±0.62	1.80±0.83	2.89±0.62	2.12±0.82	1.93±0.67	2.95±1.10	1.72±0.84

Table 2: Correlation analysis between larvae and pupae population and some weather factors in safflower agro-ecosystem.

Varieties	Temperature				Relative humidity (%)			
	Larvae		Pupae		Larvae		Pupae	
	Correl. (r)	P-value	Correl.(r)	P-value	Correl.(r)	P-value	Correl.(r)	P-value
PI-280-716	0.431*	0.048	0.654**	0.00146	0.616**	0.0017	0.787**	0.0456
PI-405-992	-0.478*	0.035	-0.436*	0.0118	-0.528*	0.0278	-0.435*	0.0382
PI-242-418	0.597**	0.118	0.496*	0.125	0.557*	0.227	0.453*	0.157
PI-369-848	-0.628**	0.220	-0.438*	0.0194	-0.449*	0.083	0.303ns	0.0835
Thori-78	0.457*	0.137	0.407	0.0491	0.353ns	0.159	0.402ns	0.0331

ns, non-significant (*P>0.05*); *, significant at (*P<0.05*); **, highly significant at (*P<0.01*)

Table 3: Correlation analysis between dead hearts and damage percentage and averaged yield of different varieties of safflower crop at Tandojam surroundings during 2020.

	Dead hearts and damage %		Yield	
Varieties	**Correlation (r)**	**P-value**	**Yield**	**P-value**
PI-280-716	0.450*	0.021	881.72ns	0.0852
PI-405-992	0.555ns	0.0753	1288.19*	0.0402
PI-242-418	0.711**	0.0014	771.38ns	0.193
PI-369-848	0.474ns	0.225	1342.92**	0.001
Thori-78	0.593ns	0.352	791.35ns	0.185

ns, non-significant (*P>0.05)*; *,significant at (*P<0.05*); **,significant at (*P<0.01*)

IV. DISCUSSION

Safflower is an important oilseed crop and globally cultivated in warm temperate and cool subtropical regions [12-14]. Significantly, contribute in medicinal field s also medicinal value [15, 16]. However, the successful production of safflower in Asian countries affected by a number of insect pests, among these safflower fly considered as a key and noxious pest and 30-70 % yield losses in different safflower cultivars have been reported [13, 14]. To minimize the yield losses by insect pests can also be used resistant verities along with other control method [17, 18]. Due to the lack of information relating to the safflower resistant verities, therefore the present study was objected to screening out the resistant cultivars among the available commercial verities. As a result, the larval and pupal population of *A. helianthi*was recorded throughout the season from February to April in all tested safflower cultivars. However, the density (population of larvae and pupae) and severity damage of was observed late March and April. The same population trend of *A. helianthi*was documented in over verities and such practice of *A. helianthi*in safflower agro-system have been evidenced [19]. On the other hand, significant highly seasonal larval and pupal population was recorded in PI-280-716, PI-242-418 and Thori-78 only in the larva, respectively. Thus, these findings suggesting that, tested safflower verities showed comparatively susceptible to resistant. Agreed with the population trend in verities; the significantly maximum number of damaged flowers and infestation percentage was exhibited in PI-280-716, PI-242-418 safflower verities at (P<0.05). Hence, the consistence with increasing trend in population, flower damaged and highest infestation percentage in PI-280-716, PI-242-418 safflower cultivars proved their susceptibilities, similar as reported in locally developed varieties [4, 19]. However, rest verities of safflower i.e, Thori-78 showed comparatively moderate and PI-369-848 and PI-405-992 demonstrate highly resistant cultivars, respectively, agreed with the previous studies [1, 20], that resistant in safflower have been evidenced. Further, data revealed significantly more flower dead hearts and damage percentage (70.23% and 78.67%) and huge yield losses in PI-280-716 and PI-242-418 were recorded, respectively. These results regarding, damage percentage of safflower verities is conformity with [21, 22], they evidenced that *A. helianthis* in central Italy causing (79%, 37.3-73.2 % and 14-38) damage to large, medium, and small sized flower heads, respectively. Targeting to the resistant verities, that PI-369-484, PI405-992, and Thori-78 showed lesser damage, infestation % and proved as a resistant verity.

Consequently, significantly high yield was received from resistant verities such as PI-369-484, PI405-992, respectively. On the other hand, environmental factors had a great influence in the increasing or decreasing insect pest population in safflower agro-ecosystem. In the present study, the population of safflower fly (Larvae and pupa) and damage infestation % was positively correlated with temperature and humidity in susceptible verities and negatively correlated with comparatively resistant verities.

V. CONCLUSION

Resistant cultivars can reduce the yield losses and can successfullyuse as a part of integrated pest management in oilseed crops. As a conclusion from this work suggested that, among the tested safflower varieties PI-280-716 and PI-242-418 showed extensively infestation and damage % by *A. helianthis,* which lead to direct effect on the yield of safflower. Two cultivarsPI-369-848 and PI-405-992 appeared as a resistant and suffered less damage and high production, therefore, to recommend for cultivation. Ecological factors also played stronger and positive role on population dynamics of *A. helianthis,* to susceptible safflower varieties.

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