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Screening of Different Groundnut, *Aarachis hypogaea* L. (Fabaceae: Fabales) Cultivars Against Red Hairy Caterpillar, *Amsacta albistriga* W. (Arctiidae: Lepidoptera) Population in Relation to Leaf Infestation, Physico-morphic Characters, Abiotic Factors and Yield

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Abstract.- Field screening of six groundnut cultivars (BARD-92, BARD-699, BARD-479, BARI-2000, Golden and Chakori) in randomized complete block design with three replications was conducted against red hairy caterpillar (RHC), *Amsacta albistriga* (Walker), population in relation to leaf infestation, physico-morphic characters (leaf area and plant height), abiotic factors (temperature, rainfall and humidity) and their ultimate impact on yield. Highest RHC population and leaf infestation was observed on BARD-699 and the lowest on BARD-479 throughout the season. Irrespective of plant height, leaf area seemed to effect insect infestation with minimum infestation on BARD-479 with maximum leaf area while minimum was observed on BARD-699 (maximum insect infestation). The plant height of BARD-699 was found to be maximum, whereas minimum plant height was observed on BARD-479. Maximum pod yield was recorded on Bard-479 and minimum of Bard-699. The order of cultivar resistance against RHC population during the whole crop duration was BARD-479 < BARI-2000 < Golden < BARI-92 < Chakori < BARD-699. RHC population showed significant and positive correlation with leaf infestation, and non-significant and negative correlation with leaf area. Non-significant and positive correlation was found among RHC population and plant height, and significant but negative relationship was noted between mean temperature and RHC population. Although effect of rainfall was significant and positive on RHC population, there was significant and positive correlation between relative humidity and population of RHC. A significant and negative correlation between RHC population and yield was recorded. Based on the results, high yielding cultivar Bard-479 was found resistant and low yielding Bard-699 was found susceptible against RHC.

Keywords: Groundnut, physico-morphic characters, red hairy caterpillar, abiotic factors.

INTRODUCTION

Groundnut (*Arachis hypopgaea* L.) family Leguminosae, is herbaceous, self-pollinated, annual warm-season oilseed crop (Gregory *et al.*, 1980; Javaid *et al.*, 2004; Malik *et al.*, 2015; Stansell *et al.*, 1976; Weiss, 2000). It is considered as 13th most important food crop, 4th important source of edible oil (Taru *et al.*, 2008) and 3rd substantial source of vegetable protein around the world (Entoori *et al.*, 2008). Groundnut is widely used in pharmaceuticals medicines, livestock, fuels (Ndiame *et al.*, 2004; Nigam *et al.*, 1980), confectionery, snacks etc (Atasie *et al.*, 2009; Martin and Ruberte, 1975). Groundnut oil is rich in high quantity of unsaturated fatty acids (Sabate, 2003). It contains on the average 40% fat and 25% protein (Knauft and Ozias, 1995), and is a rich source of calcium, iron and vitamin A and vitamin B complex like thiamine, riboflavin, niacin (Goplan *et al*., 1971).

Insect pests play a vital role (Ndiame *et al.*, 2004) in yield losses ranging from 23% to 31.4%, caused by various sap feeding (Nigam and Lenne, 1996) and Lepidoptera type foliage feeding insects (Amin, 1986; Ndiame *et al.*, 2004). Red hairy caterpillar (RHC) *Amsacta albistriga* Walker (Lepidoptera: Arctiidae) is the most devastating insect pest (Krishna and Prasad, 2008) in Asian

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(Muthusamy *et al*., 2012) groundnut producing countries including Pakistan (Khan, 2009). Young larvae feed in gregarious manner by scraping the underside of the leaves. A full grown larva consumes the entire leaf (Pandiarajan *et al.,* 2014) leading to yield loss ranges 25-100 % (Qaium and Sanghi, 1993; Reddy *et al.,* 2003). Chemical control is commonly practiced, but frequent use of insecticides may induce problems such as destruction of natural enemies, resurgence of insecticide resistance (Afzal *et al.,* 2015; Nadeem *et al.,* 2015), outbreaks of secondary pests (Smith and Jackson, 1975), increasing cost of cultivation, and biomagnification of pesticide residues in food (Armes *et al*., 1997).

Host plant resistance is an effective biological approach for plant protection (Iqbal *et al*., 2011) and using insect resistant varieties is an important strategy of integrated pest management (Rama, 1997). The physico-morphological features of fruits and plants are associated with egg laying, feeding and attraction of insect pests (Bhatti *et al*., 1976). The recognition of physical and morphological characteristics of resistant varieties may lead to introduction of resistance traits to favoured genotypes. Therefore, present study was conducted to evaluate the different groundnut cultivars on the basis of physico-morphic characters against population, leaf infestation of *A. albistriga* and to investigate their ultimate impact on yield under field conditions.

MATERIALS AND METHODS

The study was conducted at University Research Farm of PMAS Arid Agriculture University, Rawalpindi, Pakistan, during the year 2010. Six potential groundnut cultivars (BARD-92, BARD-699, BARD-479, BARI-2000, Golden and Chakori) were sown in Randomized Complete Block Design (RCBD) with three replications. Seeds of (BARD-92, BARD-699 and BARD-479) were arranged from Oil Seed Department, National Agriculture Research Centre, Islamabad, Pakistan and seeds of (BARI-2000, Golden and Chakori) were obtained from Barani Agriculture Research Institute, Chakwal, Pakistan.

The seed was sown @ 80 kg ha^{-1} per cultivar maintaining plot size of 3.6 m × 5.5 m (Baig, 2012). Each plot contained 6 rows of 3.6 m with row to row spacing of 60 cm and plant to plant distance of 10 cm. All agronomical practices (weeding, fertilizer application and irrigation) were strictly followed throughout the growing season in all test plots but insecticides were not applied throughout the season to avoid any ill effect on population density of RHC.

Meteorological observations

The meteorological data were obtained from Barani Agriculture Research Institute, Chakwal, Rawalpindi, Pakistan. The data of environmental factors (temperature, relative humidity and rainfall) correlated with population and infestation of the RHC.

Data collection

Although, RHC appeared but the population did not reach economic injury level (EIL) until 58 and 65 days after sowing (DAS). This may be attributed to the unfavourable temperature conditions that are necessary for growth and development of RHC. Population density of RHC was recorded by randomly selecting ten plants per plot at weekly interval 58 DAS onward. Leaf infestation of RHC was recorded after emergence of plant *i.e.* 60 DAS by selecting two leaves from lower, two leaves from middle and one leaf from upper plant part using randomly selected five plants from each plot (Javed *et al.,* 2014). Percent infestation of RHC was calculated according to the following formula

$$\text{Percent Infestation} = \frac{\text{No. of infested plants}}{\text{No. of sampled plants}} \times 100$$

Leaf area and plant height were recorded at 55, 110 and 165 DAS as described earlier by Baig (2012). Leaf area was measured by randomly selecting five leaves from lower, middle and upper part of randomly selected plant by using digital leaf area meter (*LI-3000C* Portable Leaf Area Meter ®) while the plant height was taken with the help of meter rod.

The physico-morphic characteristics (leaf area and plant height), environmental factors

Table I.- **Metrological data from 3rd week of May to 4th week of August during 2010.**

Meteorological observation period	Days after sowing	Minimum temperature (°C)	Maximum temperature (°C)	Average temperate (°C)	Relative humidity (%)	Precipitation (mm)
May						
3rd week	007	20.8	38.9	29.8	43.7	0.6
4th week	014	21.3	37.4	29.3	43.2	1.2
June						
1st week	021	19.8	36.5	28.1	45.0	0.5
2nd week	028	23.2	40.0	31.6	33.7	1.1
3rd week	035	24.0	39.5	31.7	41.1	0.5
4th week	042	23.5	36.2	29.9	56.8	4.3
July						
1st week	049	24.5	37.3	30.9	54.6	0.4
2nd week	056	25.7	38.6	32.1	56.5	6.9
3rd week	063	22.8	32.3	27.6	77.1	9.8
4th week	070	23.2	31.9	27.6	86.1	15.9
August						
1st week	077	23.7	31.2	27.5	88.9	2.8
2nd week	084	23.8	31.9	27.8	84.2	11.2
3rd week	096	24.5	33.8	29.1	80.8	9.5
4th week	108	20.8	30.9	25.9	75.8	5.1

(temperature, relative humidity and rainfall) and yield were correlated with population of RHC.

Statistical analysis

The data were statistically analysed by using Statistix 8.1 software program (Minja *et al*., 2002), (means for population were compared by using least significance difference test (LSD) (Steel *et al*., 1990) while means comparison for leaf infection was calculated by using Duncan's Multiple Range Test (DMRT) at 5% level of probability (Subramanian and Krishnamurthy, 2002).

RESULTS AND DISCUSSION

Meteorological Observations

Minimum temperature ranged 19.8 to 25.7 °C (Table I). Lowest and highest minimum temperature was noted during 1st week of June and 2nd week of July, respectively. Maximum temperature ranged 30.9 to 40°C. Lowest and highest maximum temperature was noted during 4th week of August and 2nd week of June, respectively. Average temperature ranged 25.9 to 31.7°C. Lowest and highest average temperature was noted during 4th week of August and 3rd week of June, respectively. A period starting from 3rd week of May to 2nd week of July received maximum average temperature (+28°C). The 2nd July and August were the peak months of relative humidity and maximum relative humidity (+70 %) occurred during these weeks. Relative humidity ranged 33.7 to 88.89%. Lowest and highest relative humidity was noted during 2nd week June and 1st week of August respectively. Precipitation ranged 0.6 mm to 15.9 mm. Lowest and highest precipitation was noted during 1st week of July and 4th week of July respectively. The 2nd, 3rd, 4th week of July, while 2nd, 3rd and 4th week of August were the peak weeks of precipitation receiving + 6 mm rainfall (Table I).

Population density of RHC

Significant differences were found among the cultivars related to larval population of RHC. Observation was taken at weekly intervals until 108 DAS. Mean comparison of RHC population among six tested groundnut cultivar is shown in Table II. Bard-479 cultivar was found relatively resistant among all six tested cultivars with minimum RHC population, while Bard-699 cultivar was highly susceptible recorded with maximum RHC population on the crop. The descending order of

Table II.- Comparison of average *A. albistriga* population on groundnut cultivars during 2010.

Cultivar	Mean of *A. albistriga* population													
	58 DAS	**65 DAS**	**72 DAS**	**79 DAS**	**86 DAS**	**93 DAS**	**100 DAS**	**107 DAS**	**114 DAS**	**121 DAS**	**128 DAS**	**135 DAS**	**142 DAS**	**149 DAS**
Bard-699	0.22 a	0.025 a	0.41 a	0.45 a	0.53 a	0.60 a	0.63 a	0.76 a	0.99 a	2.06 a	2.43 a	**3.66 a**	3.63 a	3.46 a
Chakori	0.18 b	0.21 b	0.35 b	0.39 b	0.46 b	0.51 b	0.57 b	0.73 b	0.90 b	1.53 b	2.80 b	3.00 b	2.90 b	2.70 b
Bard-92	0.14 c	0.17 c	0.33 c	0.37 c	0.43 c	0.50 b	0.53 c	0.66 b	0.85 c	1.35 bc	2.40 bc	2.53 bc	2.66 b	2.40 b
Golden	0.11 cd	0.14 d	0.25 d	0.29 d	0.35 d	0.41 c	0.47 d	0.62 c	0.75 d	0.98 cd	1.79 c	1.80 c	1.93 c	1.63 c
Bari-2000	0.08 d	0.11 d	0.23 e	0.27 e	0.34 d	0.39 c	0.45 d	0.55 d	0.68 e	0.84 de	1.11 d	1.38 d	1.56 c	1.46 c
Bard-479	0.04 e	0.06 e	0.12 f	0.16 f	0.18 e	0.20 d	0.23 e	0.32 e	0.44 f	0.47 e	0.49 e	**0.50 e**	0.52 d	0.50 d
LSD at 0.05	0.03	0.02	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.45	0.03	0.45	0.44	0.46

Means sharing the same letters in each column are statistically non-significant at P □ 0.05. DAS: days after sowing

resistance for groundnut cultivars against RHC population was BARD-479 < BARI-2000 < Golden < BARI-92 < Chakori < BARD-699 respectively.

Population of RHC on groundnut cultivars varied significantly during different weeks (Table II). Although, RHC appeared but its population did not reach economic injury level (EIL) until 56 and 63 DAS. These are attributed to significant increase in relative humidity (RH) and precipitation that also favoured development of RHC during 56 to 63 DAS. The results show RH and precipitation in relationship with temperature was conducive for multiplication and infestation of insects. These findings are in confirmation to results of Kharub *et al*. (1993), who found temperature as conducive parameter for the infestation of Lepidoptera type insects on groundnut. However, with the passage of time the pest population increased gradually after 72-79 DAS. A tremendous increase in population of RHC was recorded after 77 -108 DAS. Increase in population of RHC was considered due to high rainfall, increased RH and temperature (AICRPAM 1997; Padmavathamma *et al*. 2000). The highest population of RHC was recorded on BARD-699 (3.66 per leaf), followed by Chakori which was statistically similar to the infestation recorded on BARD-92 with 3.00 and 2.53 RHC insect per leaf while minimum pest population (0.50 per leaf) was recorded in BARD-479 at 135 DAS. Weather directly influenced yield and quality by occurrence and development of diseases and pests (Kolte, 1985). These results are not in agreement with Rakesh *et al*. (2007) who reported that tobacco caterpillar have non-significant correlation with maximum and minimum temperatures regarding pest infestation; whereas, Malik and Parihar (1996) reported that temperature was positively correlated, while RH was negative correlated with population build-up of the *Spodoptera litura* and *Spilarctia obliqua.*

Leaf infestation of RHC

Leaves infestation of RHC also varied significantly ($P \leq 0.001$) and positive correlation (0.9706**) was found among tested groundnut cultivars during different weeks of study (Table IV). Leaf infestation was observed at weekly intervals until 108 DAS. It was observed that BARD 479 was

Table III.- Comparison of percent leaf infestation of *A. albistriga* at various intervals on groundnut cultivar.

Cultivars	Percent leaf infestation of *A. albistriga*													
	60 DAS	67 DAS	74 DAS	81 DAS	88 DAS	95 DAS	102 DAS	109 DAS	116 DAS	123 DAS	130 DAS	137 DAS	144 DAS	151 DAS
Bard-699	14.00 a	14.00 a	15.00 a	16.00 a	17.00 a	19.00 a	20.00 a	22.00 a	25.00 a	28.00 a	33.00 a	37.00 a	42.00 a	**44.00 a**
Chakori	11.00 b	12.00 b	13.00 b	14.00 b	14.00 b	17.00 b	18.00 b	20.00 b	22.00 b	25.00 b	30.00 b	32.00 b	37.00 b	38.00 b
Bard-92	9.00 c	11.00 bc	12.00 c	13.00 c	13.00 b	15.00 c	17.00 c	19.00 b	21.00 b	24.00 b	28.00 c	30.00 c	36.00 b	36.00 bc
Golden	8.00 c	10.00 c	10.00 d	11.00 d	11.00 c	12.00 d	14.00 d	15.00 c	18.00 c	20.00 c	25.00 d	28.00 d	33.00 c	34.00 c
Bari-2000	5.00 d	7.00 d	8.00 e	8.00 e	9.00 d	10.00 c	11.00 e	13.00 d	15.00 d	18.00 d	22.00 e	26.00 d	29.00 d	31.00 d
Bard-479	2.00 e	4.00 e	5.00 f	6.00 f	6.00 e	8.00 f	9.00 f	10.00 e	10.00 e	13.00 f	14.00 f	15.00 e	16.00 e	**17.00 e**
LSD@0.05	0.01	0.014	0.01	0.09	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02

Means sharing the same letters in each column are statistically non-significant at P□0.05 DAS: days after sowing.

comparatively resistant among all six tested cultivars with minimum percentage of leaf infestation while, BARD 699 was highly susceptible with maximum leaf infestation throughout the experiment (Table III). The descending order percentage leaf infestation by RHC was BARD-479 < BARD 2000 < Golden < BARI 92 < Chakori < Bard-699, respectively.

Leaf infestation of RHC was minimum in 67-81 DAS that may be due to the high RH and precipitation in relation to temperature that helped in growth and development of RHC. The results are confirmatory to AICRPAM (1997) and Padmavathamma *et al*. (2000) reported that emergence of RHC was found to be closely related to heavy rainfall events. Leaf infestation started to increase gradually from 88 DAS onward. Maximum leaves infestation of RHC was found on BARD-699 (0.44) at 151 DAS on the fourth week of August, which was followed by Chakori (0.38), BARD-92 (0.36), Golden (0.34), Bari-2000 (0.31) with mean values. Minimum leaf infestation of RHC was observed on the cultivar BARD-479 with mean value of 0.17. The findings are in agreement with Prasad and Gowda (2006) who found strong relation between leaf infestation and larval population of *Spodoptera litura* in groundnut. Leaf infestation has strong co-relation with larval population per unit area (Parasad and Gowda, 2006).

Comparison of physico-morphic characters of groundnut

Leaf area

Observation for leaf area was recorded at three intervals is given in Table IV. Leaf area of BARD-479 was maximum (4.56, 9.47 and 15.33 cm^2), while minimum leaf area was observed on BARD-699 (2.50, 4.43 and 6.80) after 55, 110 and 165 DAS, respectively. The descending order of average leaf area comparison was BARD-479 < BARD 2000 < Golden < BARI 92 < Chakori < Bard-699, respectively. There was non-significant ($p \leq 0.001$) and negative correlation (-0.6861^{ns}) found between leaf area of different groundnut cultivars and population of RHC (Table IV). Some insects did not prefer old leaves rather they prefer middle age leaves so negative co-relation was

Table IV.- Means of physico-morphic characters of different groundnut cultivars.

Cultivars	Leaf Area (cm^2)			Plant Height (cm^2)			Yield
	55 DAS	110 DAS	165 DAS	55 DAS	110 DAS	165 DAS	(Kg/plot)
BARD-479	4.56 a	9.47 a	15.33 a	5.80 f	10.66 f	17.70 e	7.10 a
BARI-2000	3.33 b	6.21 b	9.07 b	8.73 d	17.60 d	27.93 c	5.67 c
Golden	3.15 c	6.01 b	9.00 c	10.56 c	21.83 c	33.13 b	6.00 b
BARD-92	3.04 d	5.76 c	8.51 d	6.70 e	13.50 e	20.33 d	4.24 d
Chakori	2.28 e	5.25 d	7.51 e	11.63 b	22.60 b	33.83 b	4.18 d
BARD-699	2.05 f	4.43 e	6.80 f	13.43 a	27.90 a	38.30 a	3.87 e
LSD	0.09	0.24	0.01	0.36	0.48	0.86	0.2

observed between insect population and leaf area (Khanam *et al*., 2003; Mabbaett *et al.*, 1984).

Table V.- Correlation of *A. albistriga* population on different groundnut cultivars.

Population of *A. albistriga*	Factors
0.9706**	Leaf Infestation
-0.6861^{ns}	Leaf area
0.2954^{ns}	Plant height
-0.4115**	Temperature
0.6693**	Relative humidity
0.4651**	Rainfall
-0.7757**	Yield

The asterisk indicates the significance level (*=Significant at P ≤0.05 **= high significant
P ≤ 0.01 ns= non-significant DAS: days after sowing)

Plant height

Plant height of BARD-699 was found to be maximum 13.43, 27.90 and 38.30 (cm per plant), while minimum plant height was observed on BARD-479 cultivar 5.80, 10.60 and 17.70 (cm per plant) after 55, and 108 DAS, respectively (Table IV). The descending order of average leaf area comparison was BARD-479 < BARD 2000 < Golden < BARI 92 < Chakori < Bard-699 respectively. Non-significant (p ≤ 0.001) and positive correlation (0.2954^{ns}) was found between the RHC population and plant height of tested cultivars (Table IV). The plant height and number of branches per plants results in increase of plant metabolism which promotes photosynthesis ultimately favours higher population of insect pests (Khanam *et al*., 2003; Suenaga and Tanaka 1997).

Yield of different groundnut cultivars

The data regarding the yield (Kg per 0.0019 ha^{-1}) of different groundnut cultivars are given in Table IV. Maximum pod yield was found in Bard-479 *i.e.* 3600 kg ha^{-1} and minimum of Bard-699 *i.e,.* 1956 kg ha^{-1}. The yield of Bard-92 and Chakori was statistically at par with each other having yields of 2141 kg ha^{-1} and 2111 kg ha^{-1} respectively. There was significant (*p*≤0.001) difference between cultivars regarding yield. There was negative correlation between the RHC population and yield viz., yield was decreased with increase in pest population (Bardner and Fletcher, 1974).

Abiotic factors and population of RHC

Correlation of RHC population with abiotic factors showed negative but highly significant (p ≤ 0.001) correlation between mean temperature and the population of RHC. There was significant (p ≤ 0.001) and positive correlation with RH and population RHC (Kharub *et al*., 1993; Malik and Parihar, 1996). However, Rakesh *et al*. (2007) found non-significant correlation of insect infestations with RH. The emergence of RHC is rainfall event (AICRPAM, 1997; Kharub *et al*., 1993; Padmavathamma *et al*., 2000). Whereas, in some cases significant correlation could not be found with rainfall/humidity (Rakesh *et al*., 2007).

CONCLUSION

It was concluded that Bard-479 cultivar was resistant while Bard-699 showed high susceptibility to leaf infestation of RHC. In physico-morphic characters, leaf area was found to be maximum in Bard-479 and minimum of Bard-699, while Plant height was maximum of Bard-699 and minimum of Bard-479. Yield was found to be maximum of Bard-479 and minimum of Bard-699. Consequently, based on RHC population and leaf infestation, Physico-morphical characters (like leaf area, plant height) and yield, Bard-479 was found resistant and high yielding cultivar, while Bard-699 was susceptible. Though, Bard-479 has more leaf area and is a high yielding cultivar, but low infestation of RHC was observed, might be due to the presence of some resistant gene. In future, studies should be conducted on genotype and genes expression of this cultivar.

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Conflict of interest statement

The author declare no conflict of interest.

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