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Determination of physio-morphic basis of resistance in different maize cultivars against insect pests

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Abstract
The present study aimed to determine physio-morphic basis of resistance in maize cultivars against insect pests at Agronomy Research Farm (ARF), The University of Agriculture, Peshawar (UAP), Pakistan during 2015. Seven maize cultivars, namely Azam, Jalal, Babar, Pahari, Iqbal, Climax 3055 and Climax 30M62 were tested. The results of physio-morphic plant characters of maize cultivars revealed that plant height ranged from 195.62–221.63 cm, stem diameter 20.16-23.84 mm, cob length 1873-24.81 cm, number of nodes plant^{-1} 12.39 - 13.83, number of leaves plant^{-1} 12.44 - 14.33, leaf trichomes density 87.01 - 102.94, leaf length 71.25-83.73 cm, leaf width 7.55-9.19 cm, thousand grains weight 192.80-282.56gm and grain yield 2644–5389 kg/ha. From the correlation matrices of physio-morphic plant characters with insect pest densities, it was noted that lower plant height, high trichomes density and more number of nodes plant^{-1} contributed for resistance in maize cultivars against the insect pest attack. On the basis of lower incidence of insect pests and physio-morphic plant characteristics, all of the seven tested maize cultivars are recommended for cultivation during spring season at Peshawar.

Keywords: Maize cultivars, Physio-morphic, Resistance, Insect Pests.

1. Introduction
Corn, usually called "maize" (*Zea mays* L.) (family Poaceae) is an annual, cross pollinated, Kharif crop. Zea, makai, corn, jovar and silk corn, etc. are other synonyms used to recognize maize. Corn provides food for humans, feed for animals particularly poultry and livestock and raw materials for various industries, hence it is a multipurpose crop [1]. Maize is worldwide distributed crop [2]. It is the fourth largest grown crop in Pakistan after wheat, cotton and rice. After wheat and rice, maize occupies third position among the world's most important cereal crops, but second after wheat in Khyber Pakhtunkhwa province [3]. In Pakistan, the total area under maize cultivation in 2013-14 was more than one million hectares and it yielded 3.5 million metric tons. The total area contribution of Khyber Pakhtunkhwa province under maize was 56 percent which contributed 63 percent of the total production [4]. Maize is mostly grown in Haripur, Swabi, Mardan, Malakand, Charsadda, Peshawar, D.I. Khan, Kohat and Bannu districts of Khyber Pakhtunkhwa [5]. In Pakistan, the most dependable, profitable and stable crop after potato is maize [6].
Maize benefits and uses are countless. Chemical proximate composition shows that maize usually contains 10 percent proteins, 3.5 percent fiber, 2 percent minerals and 80 percent carbohydrates. Vitamin B and Iron are also present in maize [7]. Culinary oil (edible oil) is also extracted from maize seeds. A chemical called Levulinc acid is an ingredient used as antifreeze is also a maize derivative. From corn stocks, fabrics and plastics are produced. Ethanol which can act as a biomass fuel is also obtained from it. There are some herbal supplements that are obtained from (corn silk) stigmas of female corn flowers. For home eating furnaces, straw of maize is commonly used as a cheap source of energy. Corn crop can also be used for forage purpose, to feed the livestock and after the fermentation of corn stocks silage can be made [8].
There are many factors which are responsible for low yield of maize [9] among which insect pests are major ones. During the initial growth phase, corn crop is more susceptible to the

insect damage particularly up to 30 percent losses can be caused by the soil insects which may necessitate the replanting of the crop. Maize germinating seeds and seedlings are damaged by other insect pests such as cutworms, wireworm, false wireworms, black field earwigs, maize stem borer and beetles such as African black beetle. Invertebrate insect pests that attack the maize crop at the development and maturity stages include corn aphid, green vegetable bug, corn earworm, red shouldered leaf beetle, common army worm, maize leaf hopper, two-spotted spider mite, maize weevil and thrips [10].

An important component of Integrated Pest Management (IPM) which is environment friendly, compatible with other control methods and is packaged in seed is the Host Plant Resistance (HPR) [11]. Numbers of plant characters are involved in host plant resistance. Herbivores and their natural enemies are influenced rather positively or negatively by the structures of the plant [12]. These plant characters can be divided on biochemical and morphological basis. Most contribution towards the host plant resistance is known by the morphological characters [13]. The most important qualitative resistance factor against many insects of maize in corn crop is 2, 4-dihydroxy- 7-methoxy-(2H)-1, hydroxamic acid, 4-benzoxazin-3-(4H)-one (DIMBOA) which reduces with the maturity of the plant. Important forms of antibiosis (physical resistance) are toughness of leaf, density of trichomes and stem penetrometer resistance while stem borer feeding in cereals is promoted by the sugar contents present in stem [14, 15]. In few species of plants, silica is present in the trichomes of juvenile plant varieties that impart indigestibility to the herbivore pest [16]. An important factor due to which the feeding behavior of European corn borer influenced was leaf toughness [17]. Many irrelevant effects on grain yield due to the presence of more than one resistance mechanism would improve the pattern of plant response and will certain the resistance durability. This study aimed to find the physio-morphic basis of resistance in maize cultivars against insect pests.

2. Materials and Method

A research work under the title "Physio-morphic basis of resistance in maize cultivars against insect pests" was conducted at the ARF, UAP during 2015. RCB design was used to carry out the experiment. There were three replications and each replication had seven treatments (Climax 30M62, Climax 3055, Babar, Iqbal, Azam, Jalal and Pahari). Separate experimental units were used to sow each maize cultivar. During March 2015, these maize cultivars were sown in lines. Buffer zone of one meter was kept between the replications and a half meter between the treatments for isolation. Size of the whole experimental field was 24 m×11 m which was divided into 21 sub-plots each with an area of 3m×3m. Row to row and plant to plant distance was kept 75cm and 25cm, respectively. Standard agronomic practices were adopted in the field throughout the maize growing season. The experimental field was left open for natural infestation of insect pests. Data were recorded on weekly basis from germination till the maturity of cultivars. The details of the experiments were as following:

2.1 Insect pests data collection for maize cultivars screening

To check the comparatively resistant and susceptible responses of maize cultivars, the experimental field was observed thoroughly at weekly intervals for insect pests infestation on upper, middle and lower portion of the plant. Corn flea beetle data was recorded as number leaf^{-1} while Maize shoot fly, grass hopper, four-spotted leaf beetle, army worm and red pumpkin beetle data was recorded as number plant^{-1} on randomly selected 6 plants per treatment. The collected specimens of Grass hopper, Shoot fly, and red pumpkin beetles were killed with the help of killing jar and then properly pinned in the insect collection box. Whereas the flea beetles and four-spotted leaf beetles were mounted and army worms were preserved in 70% alcohol. All the collected insects were deposited at the Insect Museum, Department of Entomology, UAP.

2.2 Determining Physio-morphic plant characters of maize cultivars

The maize plant physical makeup was observed weekly on 6 randomly selected plants per treatment. It consisted of plant height, stem diameter, number of nodes per plant, cob length, leaf width, leaf length, number of leaves plant^{-1}, number of leaf trichomes, weight of 1000 fresh grains and grain yield in kg/hectare. The 1st node was taken as node one. With the help of a measuring tape, plant height was recorded. Stem diameter was recorded with the help of Vernier caliper from the middle of the 3rd internode. Areas of 1.5 cm^2 were randomly selected at 3 different points of a leaf for the calculation of leaf trichomes. Leaf length and leaf width were measured with the help of measuring tape. Thousand grains weight was recorded from 6 randomly selected cobs. Yield was calculated per treatment and was converted into kg/hectare.

Statistical analysis

Each parameter's recorded data was analyzed statistically by using Statistix 8.1 Software and Fisher Protected Least Significance Difference Test was used for the separation of means at 5% level of significance [18].

Table 1: Experimental Layout

R1	R2	R3
Azam (OPV)	Climax 3055 (hybrid)	Iqbal (OPV)
Babar (hybrid)	Jalal (OPV)	Pahari (OPV)
Pahari (OPV)	Climax 30M62 (hybrid)	Babar (hybrid)
Climax 3055 (hybrid)	Azam (OPV)	Jalal (OPV)
Iqbal (OPV)	Babar (hybrid)	Climax 3055 (hybrid)
Climax 30M62 (hybrid)	Pahari (OPV)	Azam (OPV)
Jalal (OPV)	Iqbal (OPV)	Climax 30M62 (hybrid)

OPV: Open Pollinated Varieties

3. Results

3.1. Plant physio-morphic characters

Table 2 shows the physio-morphic plant characters of seven maize cultivars. The results showed that Plant height of C-30M62 was significantly higher (221.63 cm) and lower of Babar cultivar (195.62 cm). Data regarding stem diameter was recorded significantly higher (23.84 mm) in C-3055 while lower (20.16 mm) in Pahari. Significantly highest cob length was observed in C-30M62 (24.81 cm) and lower (18.73 cm) in Pahari. Number of leaves plant^{-1} was obtained significantly maximum (14.33 leaves plant^{-1}) each from Jalal and C-30M62 while lower (12.44 leaves plant^{-1}) from Iqbal cultivar. Significantly maximum number of nodes plant^{-1} was recorded in C-30M62 (13.83 nodes plant^{-1}) and lower (12.39 nodes plant^{-1}) in Pahari. Leaf trichomes were counted significantly maximum (102.94 trichomes per 1.5 cm^2) on C-30M62 while lower in Pahari (87.01 trichomes per 1.5 cm^2). The result of leaf length was significantly higher in C-3055 (83.73 cm) and lower (71.25 cm) in Pahari. Leaf width existed significantly higher (9.19 cm) in Jalal and lower in Babar (7.55 cm). Thousand fresh grains weighed significantly heavier in C-30M62 (282.56 gm) while lighter in Pahari (192.80 gm). Also, significantly higher grain yield was recorded for C-3055 (5389 kg ha^{-1}) and lower (2644 kg ha^{-1}) for Pahari cultivar.

3.2. Correlation of insect pest density with morphological characters

Table 3 reveals the correlation matrix between plant physio-morphic characters with population densities of shoot fly, flea beetle, grass hopper, leaf beetle, army worm and red pumpkin beetle. Correlation of plant height was recorded negatively significant with the insect pest densities except flea beetle for which the correlation was negative and non-significant. Stem diameter was noticed non-significant and negatively correlated with the insect pest densities except red pumpkin beetle which had significant effect. The correlation matrix of cob length was found negatively significant with the densities of grass hopper, army worm, leaf beetle and red pumpkin beetle while negatively non-significant with the densities of shoot fly and flea beetle. Non-significant and negative correlation was observed for the insect pest densities with each of the leaf width and number of leaves plant^{-1}. Negative and significant correlation existed between the number of nodes plant^{-1} with the densities of flea beetle, grass hopper, leaf beetle and army worm while negatively non-significant with the shoot fly and red pumpkin beetle densities respectively. Moreover, the leaf trichomes, leaf length, thousand grains weight and grain yield was recorded significant and negatively correlated with the insect pest densities.

Table 2: Morphological plant characters of different maize cultivars during 2015.

Maize cultivars	Parameters									
	Plant height (cm)	Stem diameter (mm)	Cob length (cm)	No. of Leaves plant^{-1}	No. of Nodes plant^{-1}	Leaf trichomes per 1.5 cm^2	Leaf length (cm)	Leaf width (cm)	1000 grains weight (gm)	Grain yield (kg/ha)
Azam	204.27 de	20.92 bc	19.79 de	13.11 bc	12.89 cd	90.90 bc	77.72 bc	7.97 b	207.80 d	3037 e
Babar	195.63 f	20.54 bc	20.40 cd	14.17 a	13.16 bc	90.18 c	77.22 bc	7.55 b	194.93 e	2993 f
Pahari	202.13 e	20.16 c	18.73 e	12.94 bc	12.39 d	87.01 c	71.25 d	7.69 b	192.80 e	2644 g
C-3055	212.23 c	23.84 a	23.05 b	13.50 ab	13.27 abc	100.92 a	83.73 a	8.51 ab	279.81 a	5389 a
Iqbal	204.67 d	22.00 abc	21.44 c	12.44 c	13.22 abc	95.73 abc	75.55 cd	7.75 b	224.20 c	3559 d
C-30M62	221.63 a	21.02 bc	24.81 a	14.33 a	13.83 a	102.94 a	83.11 a	8.53 ab	282.56 a	5046 b
Jalal	216.37 b	22.14 ab	20.23 cd	14.33 a	13.78 ab	100.07 ab	80.94 ab	9.19 a	267.74 b	3722 c
LSD value	2.3604	1.9595	1.4393	0.9934	0.6216	9.2930	5.2362	0.9798	3.9609	25.597

Means followed by same letters with in each column are not significantly different at 5% probability level (LSD test).

Table 3: Correlation of insect pests density with various morphological plant characters of maize cultivars during 2015.

Insect pests	Parameters									
	Plant height	Stem diameter	Cob length	No. of Leaves plant^{-1}	No. of Nodes plant^{-1}	Leaf trichomes	Leaf length	Leaf width	1000 grains weight	Grain yield
Flea beetle	-0.7081 ns	-0.4693 ns	-0.6702 ns	-0.7157 ns	-0.7542	-0.7742	-0.9629	-0.7302 ns	-0.7985	-0.7568
Shoot fly	-0.8939	-0.5693 ns	-0.6215 ns	-0.6245 ns	-0.7132 ns	-0.8531	-0.8817	-0.9118	-0.9303	-0.8074
Grasshopper	-0.8128	-0.6971 ns	-0.8731	-0.3789 ns	-0.7678	-0.9531	-0.8057	-0.6614 ns	-0.9439	-0.9425
Armyworm	-0.8254	-0.6980 ns	-0.9158	-0.2728 ns	-0.7545	-0.9561	-0.8528	-0.6248 ns	-0.9326	-0.9560
Leaf beetle	-0.8139	-0.7317 ns	-0.8337	-0.4735 ns	-0.7956	-0.9604	-0.8680	-0.7336 ns	-0.9645	-0.9433
Red pumpkin beetle	-0.7951	-0.7662	-0.8780	-0.2202 ns	-0.7108 ns	-0.9392	-0.8589	-0.6271 ns	-0.9245	-0.9566

Correlation is significant at 5% level.
ns = Non-significant correlation.

4. Discussion

Results of physio-morphic plant characters are in conformity with that of some earlier researchers like those of Parvez *et al.* [19]. They investigated some physio-morphic plant characters and proved that low plant height, greater hair density on leaf lamina, comparatively longer tassel length and lesser the

number of internodes had contributed for resistance against stem borers in maize cultivars. No. of nodes plant^{-1}, cob height, plant height, length of central spike, cob length, leaf width, leaf length, stem diameter, leaf trichomes and thousand grains weight were found negatively correlated with the insect pests by Afzal *et al.* [20] which support our findings. Songa *et al.* [21] showed the key factors affecting the grain yield of maize by focusing on principle component analysis which included stem diameter and plant height. Negative and significant correlation of the infestation with leaf trichomes, leaf length, cob length, 1000 grains weight and grain yield was noted by Ullah [22] which is comparable to the present research study. The minor and major variations in the results of present study and earlier studies might be due to the variations in soil texture variation, climatic conditions, method of planting, irrigation, fertilization, management techniques, cropping pattern and hedge grasses, etc.

5. Conclusion and Recommendations

The Physio-morphic plant characters of maize cultivars revealed that plant height ranged from 195.62–221.63 cm, stem diameter 20.16-23.84 mm, cob length 1873-24.81cm, number of nodes plant^{-1} 12.39 - 13.83, number of leaves plant^{-1} 12.44-14.33, leaf trichomes density 87.01 - 102.94, leaf length 71.25-83.73 cm, leaf width 7.55-9.19cm, thousand grains weight 192.80-282.56gm and grain yield 2644–5389 kg/ha. From the correlation matrices of physio-morphic plant characters with insect pest densities, it was noted that lower plant height, high trichomes density and more number of nodes plant^{-1} contributed for resistance in maize cultivars against the insect pest attack. On the basis of above stated information, all of the seven tested maize cultivars are recommended for cultivation during spring season. Maize should be cultivated earlier in spring for lower incidence of insect pests. It is necessary to diversify new resistance basis in maize. Further parameters at different locations need to be studied.

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