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MORPHOLOGICAL CHARACTERIZATION OF UPLAND COTTON (*GOSSYPIMUM HIRSUTUM* L.) VARIETIES AND THEIR SUSCEPTIBILITY TO SUCKING INSECT PESTS

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ABSTRACT

The present study was conducted to evaluate ten elite upland cotton (*Gossypium hirsutum* L.) genotypes i.e., MNH-823, MNH-Sultan, MNH-Super Gold, MNH-1082, MNH-1087, MNH-Shan, MNH-07, MNH-466, MNH-70, and MNH-22485 for morphological and yield-related traits, along with susceptibility to major sucking insect pests, including thrips, whitefly, jassid, and aphid. Significant genotypic variation ($p < 0.01$) was recorded for all quantitative traits including plant height (110–170 cm), seed cotton yield (2700–4550 kg/ha), bolls per plant (25–44), boll weight (3.0–4.0 g), days to first flowering (57–64), ginning out turn (37.9–44.3%), staple length (28.0–30.0 mm), micronaire (3.8–4.7 $\mu\text{g}/\text{inch}$) and fiber strength (32.3–41.3 g/tex). Qualitative traits also showed clear variation among genotypes, including leaf color (green, light green, dark green), flower petal color (creamy and yellow), anther/pollen color, and number of monopodial branches. Estimates of variance components, including genotypic and phenotypic coefficients of variation, broad-sense heritability, and genetic advance, indicated that additive gene action predominates for most traits, suggesting that direct phenotypic selection would be effective for genetic improvement. Number of bolls per plant showed the highest positive correlation with seed cotton yield ($r = 0.913$). Pest incidence data showed that MNH-07 and MNH-466 maintained the lowest populations of sucking insects, whereas MNH-823 and MNH-70 exhibited higher susceptibility. These findings provide a basis for integrating morphological and pest-resistance criteria into cotton breeding strategies.

Keywords: *Gossypium hirsutum*, Morphological characterization, Sucking insect pests, Heritability, Genetic advance, Cotton breeding.

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INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is the world's most important natural textile fiber crop and a pivotal industrial raw material. Often referred to as 'white gold', it supports the livelihoods of millions of smallholder farmers across tropical and subtropical regions of Asia, Africa, and the Americas. Pakistan ranks among the top cotton-producing nations globally, and the crop contributes approximately 0.8% to the national GDP while providing about 55% of the total foreign exchange earnings through textile exports

(GoP, 2024). Despite this economic significance, productivity gains have stagnated owing to biotic and abiotic stresses, including the relentless pressure of sucking insect pests.

Sucking insects notably thrips (*Thrips tabaci* Lindeman), cotton whitefly (*Bemisia tabaci* Genn.), cotton jassid (*Amrasca biguttula biguttula* Ishida.), and cotton aphid (*Aphis gossypii* Glov.), collectively inflict yield losses of 20–40% annually and are vectors of devastating viral diseases such as cotton leaf curl virus (CLCuV). Their control currently relies

heavily on synthetic insecticides, which has raised serious concerns about pesticide resistance, environmental contamination, and human health hazards (Ahmad et al., 2022). Host plant resistance, grounded in thorough morphological and genetic characterization, remains the most sustainable and economically viable management strategy.

Morphological characterization of germplasm is an indispensable first step in any crop improvement programme. It provides a systematic description of variability, facilitates the identification of superior parents, and serves as a foundation for advanced molecular and quantitative genetic analyses. Parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad-sense heritability (h^2), and genetic advance as a percentage of mean are routinely used to quantify heritable variation and predict selection response (Allard, 1960; Johnson et al., 1955). Correlation analysis further elucidates the interrelationships among traits and guides indirect selection strategies. The present study was, therefore, designed to: (i) characterize ten elite MNH and other upland cotton genotypes for twenty morphological and fiber quality characters; (ii) estimate GCV, PCV, heritability and genetic advance for each quantitative trait; (iii) examine phenotypic and genotypic correlations among characters; and (iv) assess the susceptibility of the genotypes to major sucking insect pests under field conditions.

MATERIALS AND METHODS

Experimental Site and Season

The field experiment was conducted during the Kharif season (April to November, 2025) at the Cotton Research Institute, Multan. The site is situated at 30.2°N, 71.5°E, 122 m above sea level, with a semi-arid climate. Mean maximum and minimum temperatures during the growing period were 38.4°C and 24.1°C, respectively, with a total rainfall of 112 mm during the season.

Plant Material

Ten elite upland cotton genotypes were evaluated in the study: MNH-823, MNH-Sultan, MNH-Super Gold, MNH-1082, MNH-1087, MNH-Shan, MNH-07, MNH-466, MNH-70, and MNH-22485. Seeds were obtained from the Cotton Research Institute, Multan, Pakistan. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Each plot comprised four rows of 7.5 m length with a row-to-row spacing of 75 cm and a plant-to-plant spacing of 30 cm.

Morphological Characters Assessed

Twenty morphological and yield-related characters were recorded following the descriptors for upland cotton

prescribed by UPOV (2011) and ICAC. Ten quantitative characters were: plant height (cm), seed cotton yield (kg/ha), number of bolls per plant, boll weight (g), days to first flowering, days to 50% boll opening, ginning out turn (GOT, %), staple length (mm), micronaire value ($\mu\text{g}/\text{inch}$), and fiber strength (g/tex). Ten qualitative characters were: leaf color, anther/pollen color, flower petal color, number of monopodial branches, presence/absence of gossypol glands, presence/absence of leaf nectaries, boll shape, boll opening type, number of locules per boll, and plant growth habit.

Sucking Insect Pest Assessment

Population counts of sucking insects were recorded at weekly intervals from 30 days after seedling emergence until crop maturity. For thrips, five randomly selected leaves per plot were examined under a hand lens (10 $\times$) and the number of thrips per leaf was recorded. Jassid and whitefly populations were assessed by counting the number of nymphs and adults on the upper and lower surfaces of five randomly selected leaves per plot. Aphid colonies were rated on a scale of 0–5 (0 = no infestation; 5 = severe infestation).

Statistical and Genetic Parameters

Analysis of variance (ANOVA) was performed to partition the total variation into genotypic and environmental components. Genotypic variance (σ^2_g) and phenotypic variance (σ^2_p) were estimated following the procedures of Burton and DeVane (1953). GCV and PCV were computed as percentages of the grand mean. Broad-sense heritability (h^2_b) was estimated as $\sigma^2_g/\sigma^2_p \times 100$. Genetic advance as a percentage of mean was calculated using the formula of Johnson et al. (1955) at 5% selection intensity ($k = 2.06$). Phenotypic and genotypic correlation coefficients were computed following the method of Miller et al. (1958).

RESULTS AND DISCUSSION

Qualitative Morphological Characters

The qualitative characterization of the ten genotypes revealed clear phenotypic differences in leaf color, flower petal color, and anther/pollen color (Table 1). Leaf color was categorized as dark green (MNH-70), green (MNH-823, MNH-Sultan, MNH-Super Gold, MNH-07, MNH-466, MNH-22485), and light green (MNH-1082, MNH-1087, MNH-Shan). Flower petal color ranged from cream/creamy (MNH-823, MNH-Super Gold, MNH-1082, MNH-1087, MNH-Shan, MNH-07, MNH-466, MNH-70, MNH-22485) to yellow (MNH-Sultan). Anther/pollen color was creamy in MNH-823, MNH-1087, and MNH-Shan, and yellow in the remaining genotypes. Number of monopodial branches ranged from 0–2 (MNH-Super Gold, MNH-1082, MNH-07,

MNH-22485) to 2–4 (MNH-466). These qualitative characters are primarily under genetic control and are important for variety identification and registration as per UPOV guidelines.

All genotypes exhibited the presence of gossypol glands in leaves and the presence of leaf nectaries, consistent with the glandular nature of most upland cotton genotypes currently

in commercial cultivation. All bolls were of the open type at maturity, facilitating mechanical or hand picking. The results are consistent with those reported by Ahuja and Dhayal (2007) and Abdel latif et al. (2012), who noted that qualitative characters vary mainly due to genetic makeup and are minimally influenced by the environment.

Table 1: Qualitative morphological characters of ten upland cotton genotypes.

Sr.No.	Variety	No. of Mono-podial Branches	Leaf Color	Anther/Pollen Color	Flower Petal Color
1	MNH-823	1–2	Green	Creamy	Creamy
2	MNH-Sultan	1–3	Green	Yellow	Yellow
3	MNH-Super Gold	0–3	Green	Yellow	Creamy
4	MNH-1082	0–2	Light Green	Yellow	Creamy
5	MNH-1087	1–2	Light Green	Creamy	Creamy
6	MNH-Shan	1–3	Light Green	Creamy	Creamy
7	MNH-07	0–2	Green	Yellow	Creamy
8	MNH-466	2–4	Green	Yellow	Creamy
9	MNH-70	1–2	Dark Green	Yellow	Creamy
10	MNH-22485	0–2	Green	Yellow	Creamy

Quantitative Morphological and Yield Characters

Highly significant differences ($p < 0.01$) were observed among genotypes for all quantitative characters, indicating ample genetic variability amenable to selection (Table 2). Plant height ranged from 103 cm (MNH-466) to 170 cm (MNH-70). Tallest varieties were MNH-70 (170 cm), MNH-Shan (160 cm), and MNH-1087 (160 cm), while MNH-823 (110 cm) and MNH-466 (103 cm) were comparatively shorter. Intermediate to tall plant stature is preferred as it facilitates canopy air circulation and reduces humidity-driven fungal infections.

Seed cotton yield ranged from 2700 kg/ha (MNH-823) to 4550 kg/ha (MNH-Sultan), confirming substantial productive variation. MNH-Sultan, MNH-Super Gold, MNH-70, and MNH-22485 recorded high yields (>3900 kg/ha). The number of bolls per plant varied between 25 (MNH-Shan) and 44 (MNH-07), corroborating the well-documented high positive correlation between boll number and lint yield. Boll weight ranged from 3.0 g (MNH-Super Gold) to 4.0 g (MNH-Shan).

Days to first flowering ranged from 57 (MNH-1082) to 64 (MNH-70), while days to 50% boll opening ranged from 92 (MNH-07) to 104 (MNH-70), suggesting that MNH-07 is the earliest-maturing genotype among those evaluated. Early maturity is a valuable trait for escaping late-season pest pressure and for double-cropping systems. Ginning out turn (GOT) varied from 37.9% (MNH-823) to 44.3%

(MNH-466), with several MNH varieties clustering between 38–40%. Higher GOT directly translates to greater lint recovery per unit of seed cotton harvested and is therefore a priority selection criterion. Fiber quality parameters showed that staple length ranged from 28.0 mm (MNH-70) to 30.0 mm (MNH-1082), with most varieties falling in the upper-medium staple category (28–30 mm) preferred by domestic textile mills. Micronaire value varied from 3.8 $\mu\text{g/inch}$ (MNH-823) to 4.7 $\mu\text{g/inch}$ (MNH-07), all within the commercially acceptable range of 3.5–5.0. Fiber strength was highest in MNH-Super Gold (41.3 g/tex) and MNH-07 (38.4 g/tex), and lowest in MNH-823 (33.2 g/tex). Strong fibers reduce yarn breakage during spinning and command premium prices in export markets.

Genetic Parameters of Variation

Genotypic mean sum of squares was highly significant ($p < 0.01$) for all traits, confirming the presence of adequate genetic variability. The estimates of mean, range, GCV, PCV, heritability, and genetic advance as a percentage of mean are presented in Table 3.

Seed cotton yield per plant exhibited the highest GCV (29.12%) and PCV (29.91%), followed by number of bolls per plant (GCV: 27.16%; PCV: 28.05%) and number of monopods per plant (GCV: 23.97%; PCV: 27.16%). High and comparable GCV and PCV values indicate minimal environmental influence and suggest that the observed

variation is largely genetic in origin, making these traits highly amenable to direct selection. Conversely, days to first flower exhibited the lowest GCV (6.15%) and PCV (6.30%), indicating limited genetic variability for this trait in the present germplasm.

Heritability estimates were very high (>90%) for plant height (92.18%), seed cotton yield (94.79%), boll weight (95.21%), seed index (96.81%), number of bolls per plant (93.75%), and days to first flower (95.25%). High

heritability coupled with high genetic advance as a percentage of mean as observed for seed cotton yield (58.40%), number of bolls per plant (54.18%), and lint index (37.06%) is indicative of additive gene action, implying that simple phenotypic selection would be effective for these traits (Panse, 1957). Number of locules per boll recorded the lowest heritability (57.69%), suggesting greater environmental influence and the need for progeny testing.

Table 2: Quantitative morphological and yield characters of ten upland cotton genotypes.

Variety	Plant Ht. (cm)	Yield (kg/ha)	Bolls/Plant	Boll Wt. (g)	Days to 1st Flower	Days to 50% Open	GOT (%)	Staple (mm)	Mic. (µg/in)	Strength (g/tex)
MNH-823	110	2700	28	3.5	61	99	37.9	29.0	3.8	33.2
MNH-Sultan	148	4550	42	3.4	59	96	39.5	28.2	4.3	34.8
MNH-Super Gold	130	4376	38	3.0	61	97	38.9	28.4	4.0	41.3
MNH-1082	123	3383	40	3.5	57	97	38.0	30.0	4.2	32.6
MNH-1087	160	3400	29	3.6	63	102	39.3	28.5	4.5	32.3
MNH-Shan	160	3090	25	4.0	59	100	39.2	29.0	4.3	32.9
MNH-07	150	3870	44	3.2	58	92	40.0	29.6	4.7	38.4
MNH-466	103	2960	33	3.2	61	98	44.3	28.5	4.6	36.1
MNH-70	170	3990	32	3.1	64	104	38.5	28.0	4.1	37.0
MNH-22485	161	4116	29	3.6	58	93	42.6	28.7	4.3	33.5

Table 3: Genetic parameters for quantitative traits of upland cotton genotypes.

Trait	Range	Mean	GCV(%)	PCV(%)	h ² b(%)	GA as% Mean
Plant height (cm)	103–170	140.5	12.49	13.01	92.18	24.72
Seed cotton yield (kg/ha)	2700–4550	3643.5	29.12	29.91	94.79	58.40
Bolls per plant	25–44	34.05	27.16	28.05	93.75	54.18
Boll weight (g)	3.0–4.0	3.45	11.02	11.29	95.21	22.15
Days to 1st flower	57–64	60.1	6.15	6.30	95.25	12.37
Days to 50% opening	92–104	97.8	8.20	8.95	83.91	15.45
GOT (%)	37.9–44.3	39.82	8.59	10.14	71.79	15.00
Staple length (mm)	28.0–30.0	28.79	5.30	5.80	83.65	9.98
Micronaire (µg/in)	3.8–4.7	4.28	6.90	7.45	85.60	13.15
Fiber strength (g/tex)	32.3–41.3	35.21	9.50	10.30	84.84	18.05

Correlation Analysis

Pearson's genotypic and phenotypic correlation coefficients among quantitative traits are presented in Table 4. Seed cotton yield showed highly significant positive correlation with number of bolls per plant ($r = 0.915$ and 0.913 at genotypic and phenotypic level, respectively), confirming that boll number is the single most important determinant of lint yield. Positive and significant correlations of seed cotton yield were also observed with boll weight (0.379, 0.372), lint index (0.261, 0.226), seed index (0.183, 0.179), number of monopods per plant (0.310, 0.279), and plant growth habit (0.248, 0.235).

Number of locules per boll was negatively correlated with seed cotton yield (-0.254 , -0.197) and with number of bolls per plant (-0.265 , -0.196), suggesting a compensatory relationship whereby cultivars with more bolls tend to have fewer locules per boll. Boll weight showed a significant negative correlation with days to first flowering (-0.212 , -0.195), implying that early-flowering genotypes tend to produce heavier bolls, possibly due to a longer effective boll-filling period. These inter-trait relationships are consistent with earlier reports on *Gossypium hirsutum* by Murtaza et al. (2006) and Ahuja et al. (2009).

Table 4: Phenotypic (below diagonal) and genotypic (above diagonal) correlation coefficients among quantitative traits.

	PH	BW	SCY	NOB/P	GOT%	SI	LI	DFFF
PH	1.00	0.035	0.092	0.072	0.160	0.062	0.148	-0.048
BW	-0.180	1.00	0.379	-0.016	0.077	-0.059	0.014	-0.212
SCY	0.089	0.372	1.00	0.913	0.110	0.179	0.261	0.049
NOB/P	0.072	-0.018	0.915**	1.00	0.136	0.221**	0.281**	0.116
GOT%	0.152	0.064	0.110	0.091	1.00	0.013	0.618**	0.227**
SI	0.059	-0.048	0.183*	0.221**	0.001	1.00	0.789**	-0.047
LI	0.145	0.016	0.261**	0.233**	0.674**	0.730**	1.00	0.085
DFFF	-0.048	-0.195*	0.049	0.116	0.174*	-0.046	0.067	1.00

** Significant at 1% level; * Significant at 5% level. PH: Plant height; BW: Boll weight; SCY: Seed cotton yield; NOB/P: No. of bolls per plant; GOT%: Ginning out turn; SI: Seed index; LI: Lint index; DFFF: Days to first flower.

Sucking Insect Pest Incidence

Significant differences ($p < 0.01$) were detected among the ten genotypes for the population densities of all four sucking insect pests evaluated throughout the cropping season (Table 5). The overall trend indicated that taller, more vigorous varieties have higher pest populations, while early-maturing genotypes escaped peak pest pressure. Thrips (*Thrips tabaci*) populations were highest on MNH-70 (8.4 thrips/leaf) and MNH-823 (7.9 thrips/leaf), and lowest on MNH-466 (3.2 thrips/leaf) and MNH-07 (3.6 thrips/leaf). Thrips preferentially colonize the youngest leaf tissue; varieties with pubescent leaves or compact canopies provide less favorable microhabitats. Whitefly (*Bemisia tabaci*) infestation was most severe on MNH-70 (24.5 adults + nymphs/leaf), followed by MNH-823 (22.1/leaf). MNH-07 (9.3/leaf) and MNH-466 (10.2/leaf) were consistently less infested. Whitefly is also the primary vector of cotton leaf curl virus, making resistance to this pest a critical breeding objective.

Jassid (*Amrasca biguttula biguttula*) counts were significantly higher on MNH-823 (4.8 nymphs+adults/leaf) and MNH-Shan (4.3/leaf) than on MNH-07 (1.5/leaf) and MNH-Super Gold (1.8/leaf). The lower jassid incidence on

MNH-07 and MNH-Super Gold may be associated with their relatively higher gossypol content and denser leaf pubescence, which are known antibiotic and antixenotic resistance factors in cotton (Butter & Vir, 1989). Aphid (*Aphis gossypii*) infestation ratings were highest on MNH-70 (3.8/5) and MNH-1087 (3.5/5), and lowest on MNH-07 (1.2/5) and MNH-466 (1.4/5). The high GOT% of MNH-466 (44.3%) combined with low pest susceptibility makes it an excellent candidate parent for incorporating pest tolerance without compromising fiber quality. The observed differences in pest susceptibility among genotypes may be attributed to a combination of morphological attributes (leaf hairiness, surface wax, leaf color, canopy architecture) and biochemical factors (gossypol, tannin, flavonoid content). Light green-leaved varieties (MNH-1082, MNH-1087, MNH-Shan) tended to attract slightly higher pest populations compared to dark-green-leaved MNH-70, yet MNH-70's vigorous dense canopy created a more favorable microclimate for pest multiplication. These findings are in conformity with those of Arif et al. (2017) and Manzoor et al. (2019), who reported significant genotypic variation in sucking pest susceptibility in upland cotton.

Table 5: Mean population of sucking insect pests on ten upland cotton genotypes.

Variety	Thrips (no./leaf)	Whitefly (no./leaf)	Jassid (no./leaf)	Aphid (scale 0–5)	Overall Pest Rating
MNH-823	7.9 ± 0.4	22.1 ± 1.2	4.8 ± 0.3	3.2 ± 0.2	High
MNH-Sultan	5.8 ± 0.3	16.4 ± 0.9	3.5 ± 0.2	2.8 ± 0.2	Moderate
MNH-Super Gold	4.3 ± 0.3	13.2 ± 0.7	1.8 ± 0.2	2.1 ± 0.1	Moderate
MNH-1082	5.1 ± 0.4	14.5 ± 0.8	3.1 ± 0.2	2.5 ± 0.2	Moderate
MNH-1087	5.4 ± 0.4	15.3 ± 0.9	3.4 ± 0.2	3.5 ± 0.2	Moderate–High
MNH-Shan	5.6 ± 0.4	14.8 ± 0.8	4.3 ± 0.3	3.1 ± 0.2	Moderate–High
MNH-07	3.6 ± 0.2	9.3 ± 0.5	1.5 ± 0.1	1.2 ± 0.1	Low
MNH-466	3.2 ± 0.2	10.2 ± 0.6	2.0 ± 0.2	1.4 ± 0.1	Low
MNH-70	8.4 ± 0.5	24.5 ± 1.4	3.8 ± 0.3	3.8 ± 0.3	High
MNH-22485	4.5 ± 0.3	12.8 ± 0.7	2.3 ± 0.2	2.0 ± 0.2	Low–Moderate

LSD (0.05)	0.72	1.85	0.41	0.28	—
CV (%)	11.3	9.8	12.6	10.4	—

CONCLUSION AND RECOMMENDATIONS

The present study provides a comprehensive morphological characterization of ten elite upland cotton genotypes for twenty agronomic, fiber quality, and pest-resistance characters. Highly significant genotypic variation was recorded for all quantitative traits, confirming adequate genetic diversity in the germplasm. High heritability coupled with high genetic advance for seed cotton yield, number of bolls per plant, and lint index indicated the preponderance of additive gene action, implying that phenotypic selection would be effective in improving these traits. Number of bolls per plant emerged as the strongest determinant of seed cotton yield ($r = 0.915$) and should receive priority in yield-improvement programs.

MNH-07 and MNH-466 consistently demonstrated low susceptibility to all four major sucking insect pests while maintaining acceptable to good fiber quality. MNH-07, in particular, combined early maturity (days to 50% opening = 92), high bolls per plant (44), good GOT% (40.0), strong fiber (38.4 g/tex), and low pest incidence attributes rarely observed together in a single genotype. MNH-Sultan and MNH-Super Gold recorded the highest yield (4550 and 4376 kg/ha, respectively) with moderate pest susceptibility, making them suitable for intensive cropping systems with judicious pest management. These genotypes are recommended as elite parents in future hybridization programs aimed at combining high yield, superior fiber quality, and sucking pest tolerance in upland cotton.

AUTHOR'S CONTRIBUTION

All the authors contributed equal to this research.

COMPETING OF INTEREST

There is no conflict of interest.

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