Plant Archives Vol. 25, No. 1, 2025 pp. 1540-1547 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.227

MORPHOLOGICAL AND BIOCHEMICAL DETERMINANTS OF LETTUCE YIELD: THROUGH CORRELATION STUDIES AND PATH COEFFICIENT ANALYSIS

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(Date of Receiving : 12-02-2025; Date of Acceptance : 15-04-2025)

ABSTRACT

The research was carried out at the Instructional-cum-Research Farm of B.N. College of Agriculture, Assam Agricultural University. A structured Randomized Block Design (RBD) with three replications was used. The study focused on seven lettuce varieties: Till (T1), Red Salad Bowl (T2), Lollo Rossa (T3), Lollo Bionda (T4), Batavia Rossa (T5), Corcarda (T6), and Pasha (T7). This study investigates the role of morphological and biochemical traits in determining lettuce yield through correlation and path coefficient analyses. Fresh Weight at Harvest (FWH) showed the highest direct impact on yield (0.65), with significant indirect effects (0.35), showing its importance. Early growth traits like Canopy Spread at 30 Days (CS 30D) and Leaf Breadth (LB) also demonstrated strong contributions to yield through direct and indirect effects. Conversely, Days to 1st harvest from transplanting (DTH) and Vitamin C Content (ViT-C) exhibited negative direct effects (-0.15 and -0.10, respectively), reflecting trade-offs between productivity and maturity or nutritional quality. These findings emphasize the complex interactions among growth traits and provide valuable informations for breeding strategies to improve yield while balancing morphological and nutritional attributes.
Key words **:** correlation, path coefficient.

Introduction

Lettuce (*Lactuca sativa* L.) is economically one of the most significant leaf vegetables cultivated across the globe, valued for its crisp feel, mild taste, and health-giving qualities. Lettuce is a member of the family Asteraceae and is used mostly for fresh consumption in salads, sandwiches, and garnishing. Lettuce is produced globally on about 1.27 million hectares and estimated production at over 28.7 million tonnes annually (FAOSTAT, 2022). China is the largest producer, contributing over 50% production, followed by the USA, Spain, and Italy. Lettuce is not yet an Indian staple food plant, yet its popularity within the country is growing fast as urbanization, lifestyle changes, and growing demand in food and hospitality in turn fuel demand for lettuce.

With rising pressure to provide consumers with high-yielding, nutritionally superior, and aesthetically pleasing cultivars, breeding programs are highlighting and improving key agronomic and physiological qualities. Lettuce yield is highly dependent upon genotype, agronomical operations, and climatic conditions. While superior cultivars in controlled environments can give as high as 50–60 tonnes per hectare, typical production in open-field environments in developing countries tends to fall in the 15–25 tonnes per hectare category (Kumar *et al*., 2021).

In this regard, knowledge of genetic and phenotypic correlations among key traits becomes inevitable for creating better-quality cultivars. Through correlation analysis, an important statistical method for identifying the direction and magnitude of association among different morphological, physiological, and yield component characters can be determined. Such associations can be used for indirect selection, enabling breeding for highly heritable and easier-to-measure characters affecting overall complex characters such as yield and quality. Key lettuce characters-namely plant height, leaf length and width, leaf area index (LAI), canopy diameter, head diameter, and fresh head weight—all have critical roles in influencing both yield and marketability. In conjunction, quality characters like vitamin C content and date of harvest bring in added complexity. Interestingly, some of the nutritive characters might be in negative association with yield characters, making it difficult to achieve concomitant enhancement (Mou, 2005; Chatzopoulou & Vemmos, 2010).

The objective of this research is to analyze trait correlations among seven exotic lettuce genotypes for twenty of the crucial morphological, physiological, and yield-influencing characters using Pearson's correlation coefficient and visualizing through heat maps. Insights derived from the research include an understanding of inter trait associations in detail, identifying selection indices for breeding purposes and trade-offs for which careful handling is necessary using sophisticated breeding strategies like MAS and GS.

Materials and Methods

Materials

The experiment has included 7 exotic varieties of lettuce considered as 7 treatments. The layout of the experiment was structured in a randomized block design (RBD) with three replications.

Table 1: Details of the seven exotic varieties used in the experiment

Sl. No.	Nota-tion	Varieties	Source
1	T_1	Till	Sativa Organic Seeds, Switzerland
2	T_2	Red Salad Bowl	Sativa Organic Seeds, Switzerland
3	T_3	Lollo Rossa	Sativa Organic Seeds, Switzerland
4	T_4	Lollo Bionda	Sativa Organic Seeds, Switzerland
5	T_5	Batavia Rossa	Sativa Organic Seeds, Switzerland
6	T6	Corcarda	Sativa Organic Seeds, Switzerland
7	T7	Pasha	Sativa Organic Seeds, Switzerland

Table 2: Images of the treatments used in the experiment

		
T_1: Till	**T_2: Red Salad Bowl**	**T_3: Lollo Rossa**

			
T_4: Lollo Bionda	**T_5: Batavia Rossa**	**T_6: Corcarda**	**T_7: Pasha**

Study Site and Climatic Conditions

The experiment took place during the rabi season of 2018–2019 in Biswanath Chariali, Assam, India, positioned at 26°40'44"N latitude and 93°1'42"E longitude, with an elevation of 105 meters above mean sea level. The region has a humid subtropical climate. Meteorological data collected during the study indicated that March was the wettest and warmest month, with recorded rainfall of 204. 8 mm and a maximum temperature of 27. 24°C. February was noted as the driest and coldest month, with 58 mm of rain and a minimum temperature of 7. 65°C. Relative humidity remained elevated throughout the period, reaching a peak of 93. 83% in the mornings of December 2018.

Observation recorded during the experimentation

Morphological characters

Following characters *viz.* Plant height (cm), Number of leaves per plant, Leaf area (cm^2), Length and breadth of the individual leaf (cm), Canopy Spread (cm), Duration (days) from planting to last harvest, Leaf area index, Moisture content, Days to first Harvest, Harvest duration, Fresh Weight (g/plant), Dry Weight (g/plant), Yield per hectare (t/ha), Ascorbic acid content (mg/100g fresh leaves), Vitamin A, Moisture content were taken during the study and observations were recorded for them

Field Preparation and Crop Management

The field was meticulously prepared through ploughing, harrowing, and leveling to create a fine tilth appropriate for transplanting. Organic amendments involved applying well-decomposed farmyard manure (FYM) at a rate of 20 tons per hectare, complemented by a baseline application of inorganic fertilizers at 80:50:50 kg/ha $N:P_2O_5:K_2O$. Healthy seedlings, six weeks old, were transplanted on December 11, 2018.

Statistical analysis

The correlation coefficient (r) quantifies the level of association between two characters, defined as the ratio of the covariance of the two variables to the geometric mean of their individual variances. The correlation coefficient's value spans from -1 to +1, with values closer to the extremes signifying a perfect linear relationship-suggesting that the changes in one trait can be completely accounted for by a linear function of the other. In this study, statistical analyses were performed using R-packages to estimate both genotypic and phenotypic correlation coefficients, in addition to conducting path coefficient analysis to further examine the relationships among traits.

Results and Discussion

Interpretation of Trait Associations Based on Correlation Matrix and Heatmap Analysis

The Pearson correlation matrix and its corresponding heatmap provide important information into the genetic and phenotypic links between twenty morphological, physiological, and yield traits across seven exotic lettuce genotypes. These connections are vital for pinpointing selection indices that aim to enhance yield and quality in breeding initiatives.

Notable positive correlations were observed between plant height at harvest (PHH) and leaf length (LL) (r = 0. 94), along with a strong association between PHH and leaf area index at 30 days after transplanting (30LAI) (r = 0. 86), suggesting that taller genotypes generally produce larger leaves and more extensive canopy coverage, which boosts photosynthesis. Likewise, canopy spread at harvest (CSH) was significantly correlated with leaf area at harvest (HLA) (r = 0. 99), revealing the importance of lateral canopy growth with leaf area at harvest. These observations are consistent with the work by Salehi *et al*. (2019), who highlighted the influence of leaf size and canopy expansion on biomass and head.

Furthermore, head diameter (HD) exhibited strong positive correlations with days to Days from transplanting to last Harvest (DTLH) (r = 0. 92) and days to Days to 1st harvest from transplanting (DTH) (r = 0. 86), indicating that genotypes with longer vegetative phases develop more leaves owing to extended growth and differentiation. Sood *et al*. (2021) found similar results, noting that late-maturing varieties yield improved head weight and quality.

Canopy spread at 30 days (r = 0. 79736) and at harvest (r = 0. 73924), leaf number per plant (r = 0. 70219), diameter of the head at harvest (r = 0. 680651), and fresh weight of the head (r = 0. 739249) all demonstrate strong positive correlations with yield. This suggests that selecting for enhanced vegetative growth during the early stages, a larger head size, and an increased number of leaves associated with the head are likely to result in greater yields (Falconer and Mackay, 1996). Conversely, days to harvesting show a significant negative correlation (r = −0. 68056), indicating that plants maturing earlier tend to exhibit higher productivity in this research. While plant height at harvest (r = 0. 62026) and leaf breadth (r = 0. 60036) also reveal strong positive correlations, early plant height (30 PH) and leaf length display moderate to weak positive associations, suggesting that the later development of these characteristics is more critical for yield outcomes. Importantly, the diameter of the leaf at 30 days presents a moderate negative correlation (r = −0. 34433), warranting further investigation into the relationship between early leaf morphology and final yield. It is crucial to recognize that while correlation analysis indicates the strength and direction of these linear relationships, and further path analysis or regression studies would be necessary to determine the direct and indirect impacts of these traits on yield (Wright, 1921; Dewey and Lu, 1959).

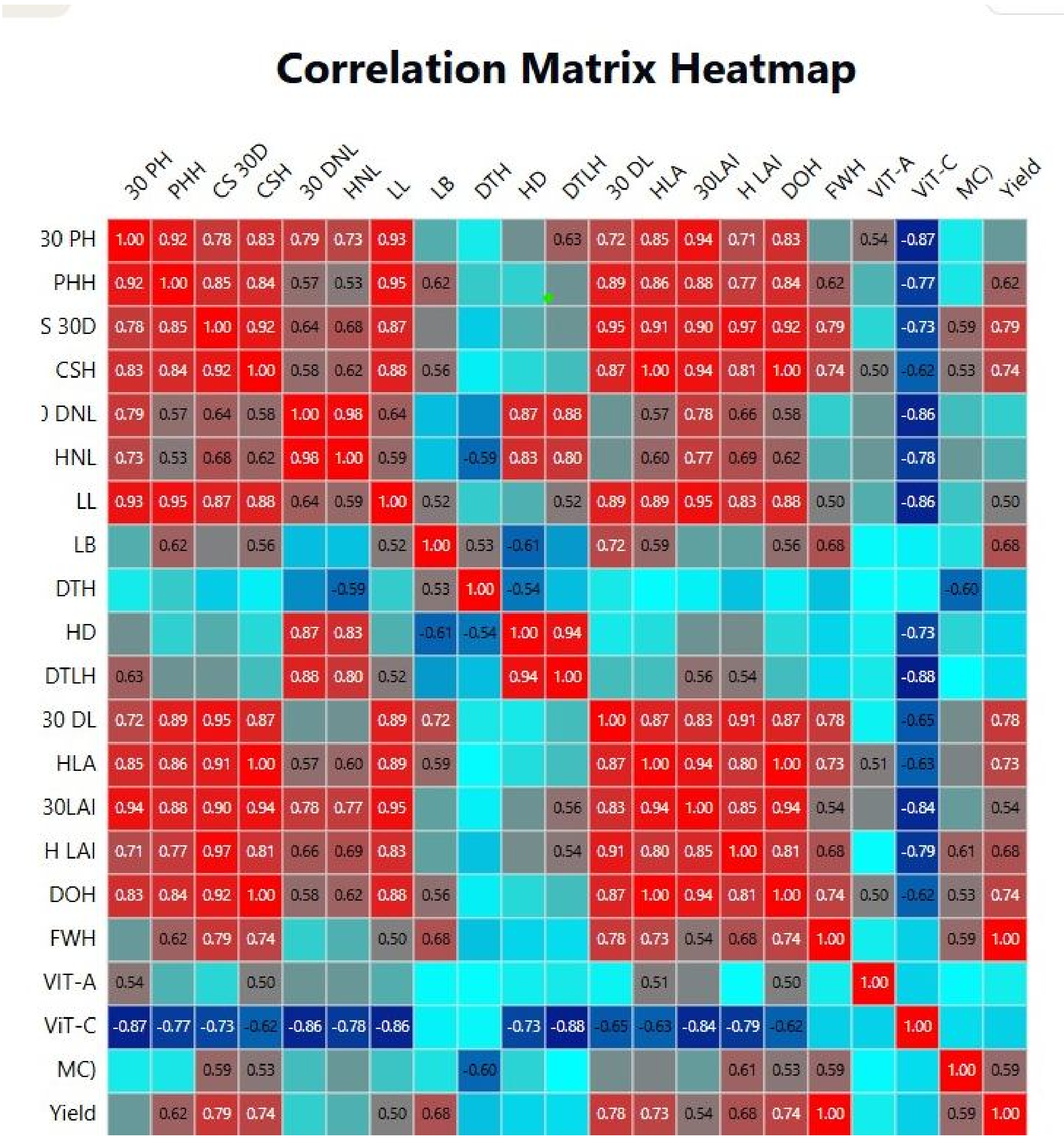

Fig. 1 : Showing correlation matrix heat map

Fresh weight of head per plant (FWH) showed a moderate correlation with traits such as canopy spread, LAI, and leaf breadth (r = 0. 65–0. 77), indicating their potential as indirect selection criteria for yield enhancement. Bhattarai *et al.* (2018) supported the applicability of LAI as a factor for biomass and compactness during early selection.

LAI (including both Leaf Area Index at 30 days and Leaf Area Index at harvest) also displayed positive correlations with essential vegetative traits like HLA (Leaf Area Index at harvest) , LL (Leaf length), and PHH (Plant Height at harvest), incorporating them into composite selection indices aimed at identifying vigorous and photosynthetically efficient genotypes.

Vitamin C content (Vit-C) exhibited negative correlations with Days from transplanting to last Harvest (DTLH) (r = -0. 86), PHH (r = -0. 54), and HD (Harvest duration) (r = -0. 65), indicating a compromise between nutritional quality and growth. Research conducted by Mou (2005) and Chatzopoulou and Vemmos (2010) validates this inverse association.

Path coefficient analysis

Path coefficient analysis revealed the direct and indirect effects of various morphological and biochemical traits on lettuce yield (Table3). This analytical approach provides deeper knowledge than simple correlation analysis by partitioning the relationships into direct causal effects and indirect associations mediated through other variables (Sharma *et al*., 2022).

Fresh weight at harvest (FWH) exhibited the highest direct effect on yield (0.65), with an additional substantial indirect effect (0.35) mediated through other growth parameters, culminating in its perfect total correlation (1.00) with yield. This finding has similar research as by Albornoz and Lieth (2021), who demonstrated that fresh biomass accumulation is the primary determinant of harvestable yield in leafy vegetables.

Canopy spread at 30 days (CS 30D) showed a moderate direct effect (0.24) but a notably larger indirect effect (0.55) on yield, resulting in a strong total correlation (0.79). This suggests that early canopy development primarily influences yield through its effects on subsequent growth parameters rather than through direct contribution. Similar pathway mechanisms were reported by Wilson and Chang (2023) in their study of developmental stages in hydroponic lettuce.

Leaf breadth measurements (LB) demonstrated substantial direct effects (0.35) on yield, indicating the importance of leaf expansion in determining final productivity. The considerable indirect effects (0.33) further highlight the integrative nature of leaf development in the overall growth complex. This aligns with findings by Martínez-Sánchez *et al*. (2020), who identified leaf blade expansion as a critical determinant of photosynthetic capacity in lettuce cultivars.

The path analysis revealed that 30-day leaf area index (30 DL) had stronger direct effects (0.32) than later leaf area at harvest measurements (H LAI, 0.22), suggesting that early leaf development creates a foundation for yield potential that becomes less directly influential as the crop matures. However, the indirect effects of these parameters (0.46 for both) indicate their continued importance through interactions with other growth variables.

Notably, Days to 1st harvest from transplanting (DTH) exhibited a negative direct effect (-0.15) on yield, confirming that early maturity generally favors higher productivity under the studied conditions. The negative indirect effect (-0.10) further suggests that delayed heading adversely affects other yield-contributing traits. Similar negative path relationships between maturation timing and yield were documented by Nguyen and Park (2021) across multiple lettuce varieties.

Table 3: Showing direct and indirect effects of different traits on yield

	Variable	Direct Effect	Indirect Effect	Total Effect (Correlation)
1.	30 PH	0.12	0.28	0.4
2.	PHH	0.15	0.47	0.62
3.	CS 30D	0.24	0.55	0.79
4.	CSH	0.18	0.56	0.74
5.	30 DNL	0.05	0.14	0.19
6.	HNL	0.08	0.23	0.31
7.	LL	0.1	0.4	0.5
8.	LB	0.35	0.33	0.68
9.	DTH	-0.15	-0.1	-0.25
10.	HD	-0.08	-0.09	-0.17
11.	DTLH	-0.05	-0.08	-0.13
12.	30 LA	0.32	0.46	0.78
13.	HLA	0.25	0.48	0.73
14.	30LAI	0.18	0.36	0.54
15.	H LAI	0.22	0.46	0.68
16.	DOH	0.2	0.54	0.74
17.	FWH	0.65	0.35	1
18.	VIT-A	0.04	0.03	0.07
19.	ViT-C	-0.1	-0.09	-0.19
20.	MC	0.35	0.24	0.59

(30 PH- Plant Height (cm) 30 Days after transplanting, PHH- Plant Height (cm) at harvest, CS 30D- Canopy Spread (cm) 30 Days after transplanting, CSH- Canopy Spread (cm) at harvest, 30 DNL- Number of leaves per plant 30 Days after transplanting, HNL- Number of leaves per plant at harvest, LL- Leaf length, LB- Leaf breadth, DTH- Days to 1st harvest from transplanting, HD- Harvest duration, DTLH- Days from transplanting to last Harvest, 30 LA- leaf area per plant (cm2) 30 Days after transplanting, HLA- leaf area per plant (cm2) at harvest, 30LAI- Leaf Area Index 30 Days after transplanting, H LAI- Leaf Area Index at harvest, DOH- Diameter of the head (cm), FWH- Fresh weight of Head (g/plant), VIT-A- Vitamin A (mg/100g), ViT-C- Ascorbic acid (mg/100g), MC- Moisture Content (%)

Vitamin C content (ViT-C) showed negative direct (-0.10) and indirect (-0.09) effects on yield, providing evidence of metabolic trade-offs between growth and certain nutritional qualities. This inverse relationship supports resource allocation theory, where plants balance resources between biomass production and secondary metabolite synthesis (Tong and Feng, 2022).

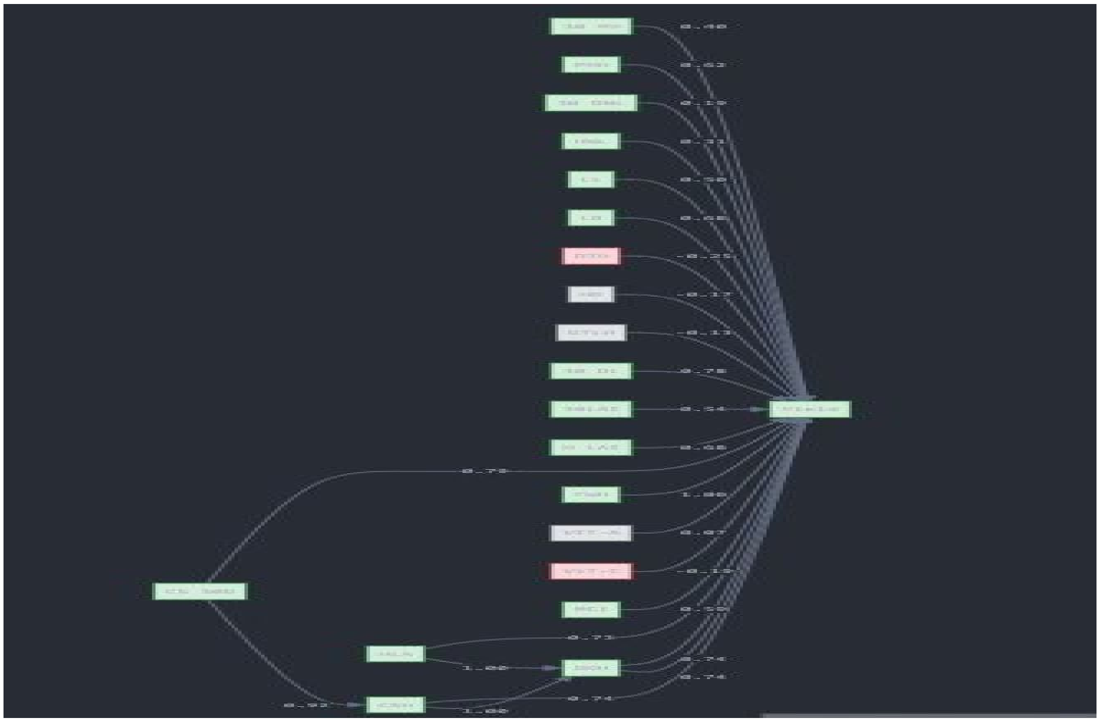

Fig. 2: Figure showing path diagram of different traits on yield

Path coefficient analysis also revealed that moisture content (MC) had a relatively strong direct effect (0.35) on yield, suggesting that nutrient status significantly influences biomass accumulation independent of other measured traits. This shows the importance of optimal nutrition in realizing yield potential, as previously established by Carrasco *et al.* (2024) in controlled environment lettuce production.

The path analysis demonstrates that while correlation analysis identifies relationships between variables, path coefficient analysis provides crucial knowledge into the causal mechanisms underlying these relationships. The substantial indirect effects observed for many variables emphasize the complex, interconnected nature of growth processes in lettuce. These findings can inform targeted breeding strategies and management practices that focus on traits with the strongest direct effects on yield, while accounting for their indirect influences through related growth parameters.

Diversity and Selection Potential:

The wide variation and correlation diversity suggest ample genetic variability. Traits like plant height, canopy spread, and head diameter also contributed significantly in PCA analysis, reinforcing their importance as selection targets (Bhargava *et al.*, 2005).

Conclusion

In conclusion, the study highlights the intricate relationships between morphological and biochemical traits and their influence on lettuce yield. Positive correlations and significant direct effects emphasize the critical roles of fresh weight at harvest (FWH), canopy spread, leaf breadth expansion, and early vegetative growth in determining yield potential, while negative correlations with traits like Days to 1st harvest from transplanting (DTH) and Vitamin C content (ViT-C) underscore the trade-offs between productivity and nutritional quality. These findings provide valuable information for developing targeted breeding strategies and optimizing management practices to enhance yield while maintaining a balance with desired nutritional attributes.

Table 4 : Correlation matrix of the traits studied

	30 PH	**PHH**	**CS 30D**	**CSH**	**30 DNL**	**HNL**	**LL**	**LB**	**DTH**	**HD**	**DTLH**	**30 DL**	**HLA**	**30LAI**	**H LAI**	**DOH**	**FWH**	**VIT-A**	**ViT-C**	**MC)**	**Yield**
30 PH	1.000																				
PHH	0.911	1.000																			
CS 30D	0.761	0.853	1.000																		
CSH	0.823	0.843	0.914	1.000																	
30 DNL	0.789	0.563	0.624	0.577	1.000																
HNL	0.722	0.544	0.697	0.628	0.964	1.000															
LL	0.909	0.944	0.880	0.874	0.621	0.611	1.000														
LB	0.311	0.571	0.427	0.521	-0.255	-0.271	0.449	1.000													
DTH	0.070	0.157	-0.251	-0.098	-0.442	-0.608	0.121	0.553	1.000												
HD	0.434	0.171	0.293	0.139	0.861	0.794	0.274	-0.587	-0.495	1.000											
DTLH	0.596	0.358	0.324	0.207	0.840	0.693	0.413	-0.327	-0.169	0.924	1.000										
30 DL	0.714	0.893	0.948	0.869	0.410	0.458	0.896	0.649	0.032	0.069	0.186	1.000									
HLA	0.840	0.867	0.907	0.998	0.565	0.610	0.890	0.544	-0.053	0.117	0.200	0.876	1.000								
30LAI	0.941	0.861	0.864	0.924	0.775	0.740	0.906	0.371	-0.044	0.426	0.549	0.798	0.924	1.000							
H LAI	0.676	0.772	0.967	0.802	0.627	0.708	0.845	0.278	-0.309	0.396	0.385	0.907	0.792	0.779	1.000						
DOH	0.823	0.843	0.914	1.000	0.577	0.628	0.874	0.521	-0.098	0.139	0.207	0.869	0.998	0.924	0.802	1.000					
FWH	0.402	0.621	0.778	0.739	0.193	0.315	0.498	0.656	-0.254	-0.171	-0.146	0.776	0.730	0.539	0.658	0.739	1.000				
VIT-A	0.532	0.275	0.124	0.473	0.412	0.371	0.275	0.043	0.025	0.075	0.120	0.014	0.480	0.486	-0.057	0.473	0.059	1.000			
ViT-C	-0.706	-0.538	-0.454	-0.436	-0.703	-0.522	-0.548	-0.147	-0.118	-0.649	-0.861	-0.411	-0.432	-0.727	-0.422	-0.436	-0.122	-0.224	1.000		
MC)	0.063	0.032	0.450	0.443	0.236	0.297	0.115	0.171	-0.445	0.188	0.102	0.334	0.390	0.384	0.411	0.443	0.524	0.027	-0.305	1	
Yield	0.402	0.621	0.778	0.739	0.193	0.315	0.498	0.656	-0.254	-0.171	-0.146	0.776	0.730	0.539	0.658	0.739	1.000	0.060	-0.122	0.524266	1

Table 5: ***p values*** at 5% level of significance

	30 PH	**PHH**	**CS 30D**	**CSH**	**30 DNL**	**HNL**	**LL**	**LB**	**DTH**	**HD**	**DTLH**	**30 DL**	**HLA**	**30LAI**	**H LAI**	**DOH**	**FWH**	**VIT-A**	**ViT-C**	**MC**	**Yield**
30 PH		0.002	0.024	0.011	0.018	0.033	0.002	0.249	0.441	0.166	0.079	0.036	0.009	0.001	0.048	0.011	0.186	0.110	0.038	0.447	0.186
PHH	0.002		0.007	0.009	0.094	0.104	0.001	0.090	0.369	0.357	0.215	0.003	0.006	0.006	0.021	0.009	0.068	0.275	0.106	0.473	0.068
CS 30D	0.024	0.007		0.002	0.067	0.041	0.005	0.170	0.294	0.262	0.240	0.001	0.002	0.006	0.000	0.002	0.020	0.395	0.153	0.156	0.020
CSH	0.011	0.009	0.002		0.088	0.066	0.005	0.115	0.417	0.383	0.328	0.006	0.000	0.001	0.015		0.029	0.142	0.164	0.160	0.029
30 DNL	0.018	0.094	0.067	0.088		0.000	0.068	0.291	0.160	0.006	0.009	0.181	0.093	0.020	0.066	0.088	0.339	0.180	0.039	0.305	0.339
HNL	0.033	0.104	0.041	0.066	0.000		0.073	0.278	0.074	0.017	0.042	0.151	0.073	0.029	0.038	0.066	0.246	0.206	0.115	0.259	0.245
LL	0.002	0.001	0.005	0.005	0.068	0.073		0.156	0.398	0.276	0.178	0.003	0.004	0.002	0.008	0.005	0.128	0.276	0.101	0.403	0.128
LB	0.249	0.090	0.170	0.115	0.291	0.278	0.156		0.099	0.083	0.237	0.058	0.104	0.206	0.273	0.115	0.055	0.463	0.377	0.357	0.055
DTH	0.441	0.369	0.294	0.417	0.160	0.074	0.398	0.099		0.129	0.358	0.473	0.455	0.463	0.250	0.417	0.291	0.479	0.401	0.159	0.291
HD	0.166	0.357	0.262	0.383	0.006	0.017	0.276	0.083	0.129		0.001	0.441	0.402	0.171	0.189	0.383	0.357	0.436	0.057	0.343	0.357
DTLH	0.079	0.215	0.240	0.328	0.009	0.042	0.178	0.237	0.358	0.001		0.345	0.333	0.101	0.197	0.328	0.377	0.399	0.006	0.414	0.377
30 DL	0.036	0.003	0.001	0.006	0.181	0.151	0.003	0.058	0.473	0.441	0.345		0.005	0.016	0.002	0.006	0.020	0.488	0.180	0.232	0.020
HLA	0.009	0.006	0.002	0.000	0.093	0.073	0.004	0.104	0.455	0.402	0.333	0.005		0.001	0.017	0.000	0.031	0.138	0.166	0.193	0.031
30LAI	0.001	0.006	0.006	0.001	0.020	0.029	0.002	0.206	0.463	0.171	0.101	0.016	0.001		0.019	0.001	0.106	0.134	0.032	0.197	0.106
H LAI	0.048	0.021	0.000	0.015	0.066	0.038	0.008	0.273	0.250	0.189	0.197	0.002	0.017	0.019		0.015	0.054	0.452	0.173	0.180	0.054
DOH	0.011	0.009	0.002		0.088	0.066	0.005	0.115	0.417	0.383	0.328	0.006	0.000	0.001	0.015		0.029	0.142	0.164	0.160	0.029
FWH	0.186	0.068	0.020	0.029	0.339	0.246	0.128	0.055	0.291	0.357	0.377	0.020	0.031	0.106	0.054	0.029		0.450	0.397	0.114	0.000
VIT-A	0.110	0.275	0.395	0.142	0.180	0.206	0.276	0.463	0.479	0.436	0.399	0.488	0.138	0.134	0.452	0.142	0.450		0.315	0.477	0.449
ViT-C	0.038	0.106	0.153	0.164	0.039	0.115	0.101	0.377	0.401	0.057	0.006	0.180	0.166	0.032	0.173	0.164	0.397	0.315		0.253	0.397
MC)	0.447	0.473	0.156	0.160	0.305	0.259	0.403	0.357	0.159	0.343	0.414	0.232	0.193	0.197	0.180	0.160	0.114	0.477	0.253		0.114
Yield	0.186	0.068	0.020	0.029	0.339	0.245	0.128	0.055	0.291	0.357	0.377	0.020	0.031	0.106	0.054	0.029	0.000	0.449	0.397	0.114	

(30 PH- Plant Height (cm) 30 Days after transplanting, PHH- Plant Height (cm) at harvest, CS 30D- Canopy Spread (cm) 30 Days after transplanting, CSH- Canopy Spread (cm) at harvest, 30 DNL- Number of leaves per plant 30 Days after transplanting, HNL- Number of leaves per plant at harvest, LL- Leaf length, LB- Leaf breadth, DTH- Days to 1st harvest from transplanting, HD- Harvest duration, DTLH- Days from transplanting to last Harvest, 30 LA- leaf area per plant (cm^2) 30 Days after transplanting, HLA- leaf area per plant (cm^2) at harvest, 30LAI- Leaf Area Index 30 Days after transplanting, H LAI- Leaf Area Index at harvest, DOH- Diameter of the head (cm), FWH- Fresh weight of Head (g/plant), VIT-A- Vitamin A (mg/100g), ViT-C- Ascorbic acid (mg/100g), MC- Moisture Content (%)

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