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Correlation analysis among yield, growth and quality traits in hydroponically grown lettuce (*Lactuca sativa* L.) under NFT system

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Abstract

A study was conducted to analyse the association among yield, growth and quality traits in hydroponically grown lettuce under a Nutrient Film Technique (NFT) system. The experiment was carried out under polyhouse conditions using different nutrient solutions and growing media. Correlation analysis revealed that yield per plant had strong and significant positive associations with leaf area, leaf length, leaf number, plant height and leaf width, indicating the dominant role of vegetative growth in determining productivity. Root length showed a moderate positive association, whereas root shoot ratio exhibited a significant negative relationship with yield. Yield was negatively correlated with days to first harvest and crop duration, suggesting the advantage of early maturity. Among quality parameters, nitrate content, shelf life, antioxidant activity (DPPH) and oxalate content were positively associated with yield. The results indicate that improved canopy development, efficient biomass partitioning and balanced biochemical composition are critical for maximizing yield in hydroponic lettuce.

Keywords: Lettuce, hydroponics, NFT, correlation analysis

Introduction

Lettuce (*Lactuca sativa* L.) is an important leafy vegetable widely cultivated under protected and hydroponic conditions due to its high nutritional value and short growth cycle. Hydroponic cultivation, particularly the Nutrient Film Technique (NFT), ensures continuous nutrient supply and improved resource use efficiency, making it suitable for intensive leafy vegetable production [10]. Yield in lettuce is influenced by several interrelated growth and physiological traits, especially those associated with canopy development and nutrient uptake. Correlation analysis helps in understanding the magnitude and direction of relationships among these traits and is useful in identifying key attributes contributing to yield improvement. In leafy vegetables, traits such as leaf area, leaf number and plant height play a crucial role in biomass accumulation and productivity [2].

In addition to growth attributes, quality parameters such as antioxidant activity, nitrate content and oxalate content are important in determining the nutritional value and consumer acceptability of lettuce. The relationship between yield and quality traits is particularly significant in hydroponic systems where nutrient availability directly influences plant metabolism [8]. Hence, the present investigation was undertaken to analyse the relationships among yield, growth, and quality traits in hydroponically grown lettuce.

Materials and Methods

The experiment was conducted in a naturally ventilated polyhouse, Thiruvananthapuram, Kerala (8°47' N latitude and 76°97' E longitude, 18 m above mean sea level). The crop was grown using the Nutrient Film Technique (NFT) hydroponic system, in which a thin film of nutrient solution was continuously circulated through channels to provide nutrients and aeration to the roots. The study was laid out in a Completely Randomized Design with three replications, involving commonly used nutrient solutions and growing media in hydroponic cultivation. The nutrient solutions included standard inorganic formulations such as Hoagland's solution, Arka Nutri Grow solution, and Cooper's solution, along with an

organic nutrient source and a control treatment. The growing media evaluated were cocopeat, vermiculite, perlite, expanded clay aggregates (LECA) and gravel. Seeds of lettuce variety 'Lolo Bionda' were raised in protrays, and 25-day-old seedlings were transplanted into the NFT system. Standard cultural practices were followed, and the pH and electrical conductivity of the nutrient solution were maintained within optimal ranges for lettuce cultivation [10]. Observations were recorded on growth, yield and quality parameters including plant height, leaf length, leaf width, leaf number, leaf area, root length, root shoot ratio, days to first harvest, crop duration, yield per plant, antioxidant activity (DPPH), oxalate content, nitrate content and shelf life. Correlation analysis was performed using the KAU GRAPES software tool [9].

Results

Association of yield with growth and yield attributes

The correlation analysis revealed strong and significant

associations between yield and vegetative growth traits (Table 1). Yield per plant showed highly significant positive correlations with leaf area (0.920), leaf length (0.890), leaf number (0.886), plant height (0.881) and leaf width (0.860). Among these, leaf area exhibited the strongest association with yield. Root length showed a positive relationship (0.669) with yield, indicating the importance of root development in nutrient uptake. Similar findings have been reported in leafy vegetables where improved root systems enhance nutrient absorption efficiency [2]. In contrast, root-shoot ratio showed a significant negative association (-0.758) with yield, suggesting that excessive allocation of biomass to roots may reduce shoot growth. Days to first harvest and crop duration were negatively associated with yield (-0.767), indicating that early maturing plants tend to produce higher yields. Such relationships have also been observed under protected cultivation conditions [7].

Table 1: Correlation coefficient analysis for growth and quality characters in lettuce

	Yield	Plant height	Leaf length	Leaf width	Leaf number	Leaf area	Root length	Root shoot ratio	Days to first harvest	Crop duration	DPPH	Oxalate content	Nitrate content	Shelf life
Yield	1													
Plant height	0.881**	1												
Leaf length	0.890**	0.835**	1											
Leaf width	0.860**	0.857**	0.875**	1										
Leaf number	0.886**	0.855**	0.879**	0.849**	1									
Leaf area	0.920**	0.886**	0.919**	0.869**	0.902**	1								
Root length	0.669**	0.683**	0.548**	0.637**	0.577**	0.636**	1							
Root shoot ratio	-0.758**	-0.745**	-0.820**	-0.778**	-0.765**	-0.791**	-0.496**	1						
Days to first harvest	-0.767**	-0.795**	-0.740**	-0.719**	-0.775**	-0.763**	-0.478**	0.552**	1					
Crop duration	-0.767**	-0.795**	-0.740**	-0.719**	-0.775**	-0.763**	-0.478**	0.552**	1.000**	1				
DPPH	0.697**	0.717**	0.653**	0.660**	0.740**	0.726**	0.505**	-0.540**	-0.650**	-0.650**	1			
Oxalate content	0.679**	0.681**	0.681**	0.740**	0.624**	0.706**	0.685**	-0.682**	-0.465**	-0.465**	0.524**	1		
Nitrate content	0.843**	0.857**	0.877**	0.831**	0.872**	0.857**	0.532**	-0.802**	-0.773**	-0.773**	0.677**	0.619**	1	
Shelf life	0.796**	0.782**	0.807**	0.792**	0.809**	0.808**	0.590**	-0.727**	-0.673**	-0.673**	0.666**	0.560**	0.815**	1

** Correlation is significant at 0.01 level (two tailed)

* Correlation is significant at 0.05 level (two tailed)

Association of yield with quality attributes

Yield exhibited strong positive associations with quality parameters. Nitrate content showed the highest correlation (0.843), followed by shelf life (0.796), antioxidant activity (0.697) and oxalate content (0.679). The positive relationship between yield and nitrate content reflects the role of nitrogen in promoting vegetative growth and biomass accumulation [10]. Similar associations between nitrate content and fresh weight have been reported in lettuce [5]. The positive association between yield and antioxidant activity indicates enhanced synthesis of bioactive compounds in high-yielding plants [6]. Shelf life also showed a strong positive association with yield, suggesting improved post-harvest performance under better growth conditions [4].

Discussion

The study demonstrated that vegetative growth parameters significantly influence yield in hydroponically grown lettuce. The strong positive association between yield and leaf area highlights the importance of photosynthetic surface in biomass production, which is consistent with earlier

reports [2]. Leaf number, leaf length and leaf width also contributed significantly to yield, indicating that canopy development is a key determinant of productivity. Root traits also influenced yield, with root length showing a positive association, while root shoot ratio showed a negative relationship. This indicates the importance of balanced biomass partitioning under hydroponic conditions. The negative association between yield and phenological traits such as days to first harvest and crop duration suggests that early maturity is advantageous for higher productivity, as reported in lettuce under protected environments [7]. Quality traits showed positive associations with yield, indicating a close relationship between productivity and biochemical composition. The strong correlation between nitrate content and yield emphasizes the role of nitrogen in plant metabolism [10]. The positive association with antioxidant activity supports earlier findings in leafy vegetables [6].

Conclusion

The correlation analysis revealed that yield in hydroponically grown lettuce is primarily governed by

vegetative growth traits, particularly leaf area, leaf length and leaf number. Early maturity and efficient biomass partitioning further enhance productivity. Quality traits such as nitrate content, antioxidant activity and shelf life were also positively associated with yield, indicating the possibility of achieving both high productivity and improved quality under optimized hydroponic conditions.

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