

## SIMPLE CORRELATION AND PATH COEFFICIENT ANALYSIS INVOLVING SOME GROWTH ANALYSIS PARAMETERS AND CURED BULB YIELD IN GARLIC (*ALLIUM SATIVUM* L.)

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### ABSTRACT

*Three field experiments were conducted in 2007/2008, 2008/2009 and 2009/2010 dry seasons at the Irrigation Research Station, Kadawa (11°39'N, 08°02'E, 500m a.s.l) and Sarai Fadama (11°48'N; 08°34'E, 423m a.s.l) to study the correlation of different growth parameters and their contributions to cured bulb yield of garlic (*Allium sativum* L.). Cured bulb yield was found to be significantly and positively correlated with average plant dry matter, crop growth rate and net assimilation rate in both seasons. The crop growth rate made the highest contribution to cured bulb yield directly, and indirectly via the crop growth rate and net assimilation rate. Thus selection on the basis of these parameters could be helpful in garlic bulb yield improvement.*

**KEYWORDS:** Correlation, path coefficient, cured bulb yield, garlic.

### INTRODUCTION

Garlic (*Allium sativum* L.) is an erect biennial herb normally grown as an annual. It is a member of the Alliaceae family, and ranked second to onion in terms of production and yield (Miko, 1999). Cured bulb yield in garlic was reported to be a function of several growth parameters such as the plant height and number of leaves per plant (Miko *et al.*, 1995; Babaji, 1996). Growth analysis is a useful technique in the study of plants. This is because it bridges the gap between the empirical and the mechanistic approaches to modeling growth and development; a necessary prerequisite to the understanding of the whole behavior of plants (Brand *et al.*, 1987).

Garlic bulb yield was reported to significantly and positively correlated with plant dry matter and crop growth rate (Miko and Manga, 2006). Similarly, path analysis showed that dry matter per plant registered the highest direct contribution to bulb yield, while the indirect effects on bulb yield was obtained from the plant height via the dry matter per plant. Similarly, Bichi (1997) had reported a significant positive correlation between total dry matter to cured bulb yield of garlic. This study was conducted to assess the extent of the relationship between some growth analysis parameters and cured bulb yield of garlic and to evaluate the direct and indirect contributions of these characters to cured bulb yield as a means of selection for enhanced performance.

### MATERIALS AND METHODS

Field experiments were conducted during the 2007/2008, 2008/2009 and 2009/2010 dry seasons at the Irrigation Research Station, Kadawa (11°39'N, 08°02'E, 500m a.s.l) and Sarai Fadama (11°48'N, 08°34'E, 423m a.s.l) to study the relationship between the cured bulb yield of garlic and some growth parameters with the aim

to identify those that could be useful for selection and yield improvement. The treatments laid out in a split-plot design, consisted of three periods of application of gibberellic acid (3, 6 and 9 weeks after planting (WAP) and three irrigation intervals (5, 10 and 15 - day) as the main treatment, while four gibberellic acid concentrations (0, 200, 250 and 300 ppm) were the sub treatments. These treatments were replicated three times.

A total of nine (9) main plots, comprising of thirty six (36) sub plots, each measuring 1.5 x 1m, were marked with pegs and these were replicated three times. Each plot was separated from another by a 0.5m border while 1m was left out between replicates. The net plot size was (0.6 x 1.0m). A local cultivar popularly known as Ex - Kofa was used for the purpose of this research. Garlic bulbs were cracked (splitted into individual cloves) and the viable ones sorted. These were soaked in water overnight to remove scale leaves and facilitate germination. The prepared plots were pre irrigated a day to planting. The individual cloves were planted at 15 x 10cm spacings (Miko and Manga, 2006). An average of larger cloves were used for this purpose as suggested by Statilschmidt *et al.* (2008). The plants were immediately irrigated lightly, and thereafter at weekly interval prior to treatment imposition.

Weeds were manually controlled three times using a narrow bladed hoe at 3, 6 and 9 WAP. Compound fertilizer (N.P.K 15 - 15 - 15) at the rate of 40kg ha<sup>-1</sup> each of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were incorporated into the plots after land levelling just before planting (Miko *et al.*, 2006). Also 25kg ha<sup>-1</sup> of Urea (46%N) was applied by banding at four weeks after planting. Irrigation was however stopped at two weeks before harvest to allow uniform maturity and also avoid bulb stained wrappers (Carl *et al.*, 2007).

Data on leaf area per plant, average plant fresh weight and average plant dry matter were taken fortnightly. These were extrapolated in which the crop growth rate (CGR) and the net assimilation rate (NAR) were derived using standard relations as follows:-

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \quad gcm^2wk^{-1}$$

Where  $W_2$  and  $W_1$  are the shoot dry weights taken at consecutive harvests over a time interval  $T_2$  and  $T_1$  in weeks, while the net assimilation rate

$$NAR = \frac{(W_2 - W_1) (\ln A_2 - \ln A_1)}{(A_2 - A_1) (t_2 - t_1)} \quad gm^2 wk^{-1}$$

Where  $W_2$  and  $W_1$  are the shoot dry weights taken at two consecutive harvests over time intervals  $t_2$  and  $t_1$  and  $A_2$  and  $A_1$  are the leaf areas (Sharma and Mehta, 1991). The net plot size was (0.6 x 1m). These were harvested, air dried for 2 weeks and later weighed using an electronic mettler balance PM 4000. The values obtained were extrapolated into kilogram per hectare for the cured bulb yield.

Simple correlation analysis between the derived growth analysis parameters and cured bulb yield for individual years and combined were done. Path coefficient analysis was carried out as described by Dewey and Lu (1959) to determine the direct and indirect effects of these parameters on cured bulb yield by solving the equations below:

$$p_1 + r_{12}p_2 + r_{13}p_3 = r_{14}$$

$$r_{12}p_2 + p_2 + r_{23}p_3 = r_{24}$$

$$r_{31}p_1 + r_{32}p_2 + p_3 = r_{34}$$

Similarly, the percent contribution of each of the growth and yield components to cured bulb yield were partitioned as reported by Ajala *et al.* (1996).

## RESULTS

Highly significant positive correlation coefficients were observed between the cured bulb yield of garlic and all the parameters assessed for both seasons and the combined (Tables 1 and 2). The path coefficient analysis showed that total contributions of average plant dry matter to cured bulb yield varied from 0.524 (2009/2010) to 0.720 (2008/2009) seasons (Tables 3 and 4). When these were partitioned to direct and indirect effects, the direct contribution of the average plant dry matter to cured bulb yield were small and negative in 2008/2009, 2009/2010 and combined seasons, with 0.304 directly contributed in 2007/2008 season. The indirect contributions via crop growth rate in 2007/2008, 2008/2009, 2009/2010 and combined seasons were however, 0.784, 8.710, 9.670 and -10.408.

The indirect contribution via net assimilation rate were found to be very small and negative in all the 3 seasons except for the combined in which positive values were obtained. The total contributions of crop growth rate to cured bulb yield varied from 0.046 (2007/2008) to 0.667 (2008/2009). When these were partitioned into direct and indirect contributions, a significantly highest contribution was recorded directly from the crop growth rate (0.910, 8.896, 10.250) in all the 3 seasons except that the combined seasons revealed a negative value for the direct contribution of the crop growth rate. When the indirect contribution of the crop growth rate were critically examined, it was found that 0.262, -1.159, -0.670 and -1.826 were contributed indirectly via the average plant dry matter in all the 3 seasons and combined respectively. Similarly, the indirect contributions via net assimilation rate were found to be small and negative in all the 3 seasons and varied from -0.216 to -9.170 in 2007/2008 and 2009/2010 seasons, respectively.

The total contributions of net assimilation rate to cured bulb yield varied from 0.350 (2009/2010) to 1.164 (2007/2008) dry seasons. When the direct and indirect contributions of net assimilation rate to cured bulb yield were examined, it was found that the direct contribution of net assimilation rate were positive and high in 2007/2008 and combined seasons (0.218 and 13.846). However, in the 2008/2009 and 2009/2010 seasons, negative values were recorded for this direct effect. Similarly, the indirect contribution via the average plant dry matter were very small and negative in 2008/2009, 2009/2010 and combined seasons, respectively. These ranged from -0.670 to -1.826. The indirect contribution of net assimilation rate via crop growth rate were in the range of 0.402 (2007/2008) to 10.220 (2009/2010). There seems to be a relative increase of these values across the 3 seasons. However, the indirect contribution via the crop growth rate was found to be negative (-11.330) in the combined seasons.

When the individual contributions of the growth analysis parameters were quantified in terms of percentages (Tables 5 and 6), it was observed that the individual percent contribution of average plant dry matter to cured bulb yield were 9.23, 1.43, 49.85 and 398.46% in 2007/2008, 2008/2009, 2009/2010 and combined seasons, respectively. The highest individual percent contribution were recorded with the crop growth rate in which 82.90, 80.75, 10501.55 and 12938.11% were directly contributed to cured bulb yield by the crop growth rate in all the 3 seasons and combined. The net assimilation rate had also contributed 4.77, 51.68, 8472.35 and 19172.36% in 2007/2008, 2008/2009, 2009/2010 and combined seasons, respectively.

When the combined contributions of two characters to cured bulb yield were however examined, it was observed that the percent contributions of the average plant dry matter and crop growth rate were 47.70, - 0.21, -1364.55 and 4155.05 in all the 3 seasons and combined. Similarly, the combined contributions of the average plant dry matter and NAR were -10.62, 1625.16, 1191.85 and -5223.83% in 2007/2008, 2008/2009, 2009/2010 and combined seasons, respectively. The combined contributions of crop growth rate and net assimilation rate to cured bulb yield were negative in all the 3 seasons and combined. These varied from -39.41 (2007/2008) to -31373.50 (Combined). There was however 5.43, 78.80, 57.44 and 33.33% unaccounted residuals recorded in the 2007/2008, 2008/2009, 2009/2010 and combined seasons, respectively (Figures 1 - 4).

#### **DISCUSSION**

Highly significant and positive correlation coefficients were observed between cured bulb yield of garlic and all the characters assessed. This suggests the interdependency amongst these characters as reported by Miko and Manga (2006). The significant positive correlation observed between average plant dry matter, crop growth rate and net assimilation rate to cured

bulb yield in garlic could be explained by the fact that taller plants produced higher number of leaves and these are consequently the main organs where assimilates are produced and hence translocated to the sink, which finally have bearing on the bulb yield. Bichi (1997) reported a similar observation. Consequently, NAR being a measure of gain in dry matter per unit of leaf area per unit of time is an important index for mean photosynthetic efficiency of garlic (Haloi and Beldev, 1986).

The path - coefficient analysis showed that most of the growth analysis parameters registered their greatest contribution to the cured bulb yield via the average plant dry matter, crop growth rate and net assimilation rate. This is expected since dry matter production per plant is a function of all the aforementioned characters.

#### **Conclusion**

Growth analysis is a useful technique for modeling crop growth with a view to improve yield. Findings of this research revealed that selection on the basis of crop growth rate and net assimilation rate could improve garlic bulb yield as they were observed to have significant direct and indirect bearings on the bulb yield of garlic.

Table 1: Matrix of correlation coefficient ( $\rho$ ) showing association between some growth analysis parameters to cured bulb yield of garlic during 2007/2008 and 2008/2009 dry seasons.

	2007/2008				2008/2009			
	APDW	CGR	NAR	CBY	APDW	CGR	NAR	CBY
APDW	1.00				1.00			
CGR	0.862**	1.00			0.969**	1.00		
NAR	0.800**	0.991**	1.00		0.945**	0.996**	1.00	
CBY	0.914**	0.956**	0.927*	1.00	0.718**	0.667**	0.631**	1.00

Table 2: Matrix of correlation coefficient ( $\rho$ ) showing association between some growth analysis parameters to cured bulb yield of garlic during 2009/2010 and Combined dry seasons.

	2009/2010				Combined Seasons			
	APDW	CGR	NAR	CBY	APDW	CGR	NAR	CBY
APDW	1.00				1.00			
CGR	0.943**	1.00			0.915**	1.00		
NAR	0.917**	0.997**	1.00		0.945**	0.996**	1.00	
CBY	0.517**	0.405**	0.365*	1.00	0.681**	0.590**	0.631**	1.00

APDW = Average plant dry weight, CGR = Crop growth rate, NAR = Net assimilation rate, CBY = Cured bulb yield.

Table 3: Direct, indirect and total contributions of some growth analysis parameters to cured bulb yield of garlic grown during 2007/08 and 2008/2009 dry seasons.

	2007/2008 Effect Through				2008/2009 Effect Through			
	Average Plant Dry Matter	Crop Growth Rate	Net Assimilation Rate	Total Correlation	Average Plant Dry Matter	Crop Growth Rate	Net Assimilation Rate	Total Correlation
Average Plant Dry Matter	<u>0.304</u>	0.784	-0.174	0.914	<u>-1.196</u>	8.710	-6.794	0.720
Crop Growth Rate	0.262	<u>0.910</u>	-0.216	0.956	-1.159	<u>8.986</u>	-7.160	0.667
Net Assimilation Rate	0.262	0.402	<u>0.218</u>	0.882	-1.159	8.950	<u>-7.189</u>	0.602

Underlined - Direct contribution

Table 4: Direct, indirect and total contributions of some growth analysis parameters to cured bulb yield of garlic grown during 2009/10 and combined dry seasons.

	2009/2010 Effect Through				Combined Seasons Effect Through			
	Average Plant Dry Matter	Crop Growth Rate	Net Assimilation Rate	Total Correlation	Average Plant Dry Matter	Crop Growth Rate	Net Assimilation Rate	Total Correlation
Average Plant Dry Matter	<u>-0.706</u>	9.670	-8.440	0.524	<u>-1.196</u>	-11.208	13.084	0.680
Crop Growth Rate	-0.670	<u>10.250</u>	-9.170	0.410	-1.826	<u>-11.375</u>	13.791	0.590
Net Assimilation Rate	-0.670	10.220	<u>-9.200</u>	0.350	-1.826	-11.330	<u>13.846</u>	0.690

Underlined - Direct contribution

Table 5: Direct and combined contributions % of some growth analysis parameters to cured bulb yield of garlic during 2007/08 and 2008/2009 dry seasons and their residual effect.

Physiological Character	Percentage Contributions	
	2007/2008	2008/2009
<u>Direct Contributions (<math>p_i^2 \times 100</math>)</u>		
Average Plant Dry Matter ( $p_1^2$ )	9.23	1.43
Crop Growth Rate ( $p_2^2$ )	82.90	80.75
Net Assimilation Rate ( $p_3^2$ )	4.77	51.68
<u>Combined Contributions (<math>2p_i p_j r_{ij}</math>) <math>\times 100</math></u>		
Average Plant Dry Matter and Crop Growth Rate ( $2p_1 p_2 r_{12}$ ) $\times 100$	47.70	- 0.21
Average Plant Dry Matter and Net Assimilation Rate ( $2p_1 p_3 r_{13}$ )	-10.62	16.25
Crop Growth Rate and Net Assimilation Rate ( $2p_2 p_3 r_{23}$ )	-39.41	- 128.70
Residual Effect ( $1 - p_1 r_{14} - p_2 r_{24} - p_3 r_{34}$ )	5.43	78.80
Total	100.00	100.00

Table 6: Direct and combined contributions % of some growth analysis parameters to cured bulb yield of garlic during 2009/10 and combined dry seasons and their residual effect.

Physiological Character	Percentage Contributions	
	2009/2010	Combined Seasons
<u>Direct Contributions (<math>p_i^2 \times 100</math>)</u>		
Average Plant Dry Matter ( $p_1$ )	49.85	398.46
Crop Growth Rate ( $p_2^2$ )	10501.55	12938.11
Net Assimilation Rate ( $p_3^2$ )	8472.35	19172.36
<u>Combined Contributions (<math>2p_i p_j r_{ij}</math>) <math>\times 100</math></u>		
Average Plant Dry Matter and Crop Growth Rate ( $2p_1 p_2 r_{12}$ ) $\times 100$	-1364.55	4155.05
Average Plant Dry Matter and Net Assimilation Rate ( $2p_1 p_3 r_{13}$ )	1191.85	-5223.83
Crop Growth Rate and Net Assimilation Rate ( $2p_2 p_3 r_{23}$ )	-18808.50	-31373.50
Residual Effect ( $1 - p_1 r_{14} - p_2 r_{24} - p_3 r_{34}$ )	57.44	33.33
Total	100.00	100.00

Figure 1: Path diagram showing association of some growth analysis parameters to cured bulb yield of garlic during 2007/2008 dry season.

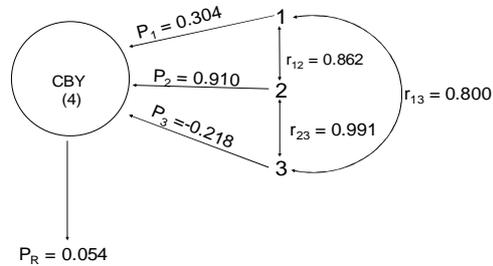
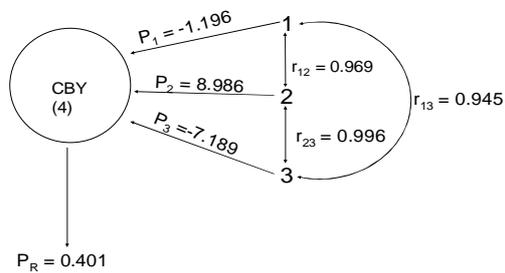


Figure 2: Path diagram showing association of some growth analysis parameters to cured bulb yield of garlic during 2008/2009 dry season.



**Key:**

- 1 = Average Plant Dry Matter
- 2 = Crop Growth Rate
- 3 = Net Assimilation Rate

- Single headed arrow = Direct effect
- Double headed arrow = Indirect effect
- CBY = Cured Bulb Yield

Figure 3: Path diagram showing association of some growth analysis parameters to cured bulb yield of garlic during 2009/2010 dry season.

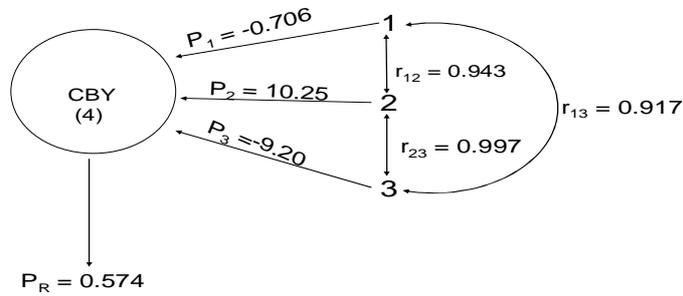
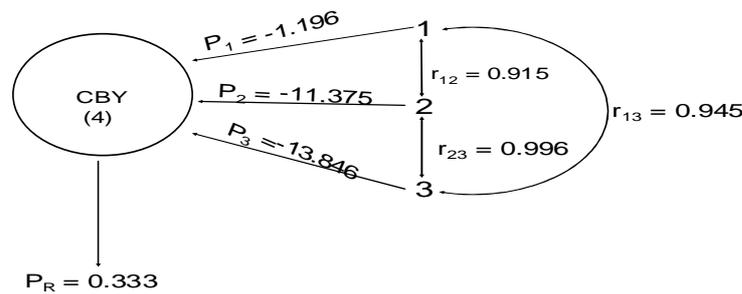


Figure 4: Path diagram showing association of some growth analysis parameters to cured bulb yield of garlic during 2007/08, 2008/09, and 2009/10 (Combined).



Key:

- 1 = Average Plant Dry Matter
- 2 = Crop Growth Rate
- 3 = Net Assimilation Rate

- Single headed arrow = Direct effect
- Double headed arrow = Indirect effect
- CBY = Cured Bulb Yield

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