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CORRELATION AND PATH COEFFICIENT ANALYSIS OF BULB YIELD COMPONENTS IN GARLIC (*Allium sativum*.L)

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ABSTRACT

Field studies were carried out at Usmanu Danfodiyo University Teaching and Research Fadama Farm Kwalkwalawa, Sokoto, during the 2002/2003 and 2003/2004 dry seasons to investigate the relationship between bulb yield and some growth and yield characters with a view to identifying those characters that could be used in improving bulb yield potential of garlic. The experiment was laid out in a split- plot design with three replications. Growth as well as yield correlation coefficient analyses revealed that virtually all the growth and yield components have indicated interdependency, owing to positive and significant correlation observed amongst nearly all the parameters. Path coefficient analysis showed that yield components made their optimum contribution through bulb weight, clove weight and number of cloves per bulb

Keywords: Path coefficient; Bulb yield components

INTRODUCTION

Garlic (*Allium sativum* L) is an erect biennial usually grown as an annual (Purseglove, 1992). It is an important vegetable crop that virtually all of it part are useful. Bulb which contained the cloves is the most economic part of the crop. In garlic breeding programs, information on the relationship that exists between bulb yield and other characters coupled with the interrelationship among various characters is prerequisite in order to design appropriate selection criteria. By and large, breeding garlic for high yield needs understanding the nature and extent of variation in the available material, relationship of yield parameters with yield and within yield parameters and the extent of environmental effect on the expression of these yield parameters. According to Mwanga and Zamora (1991), changes on yield and yield parameters had attributed to response of plant to its environment which may or may not permit the full genetic expression of individual parameter. Yield is a quantitative trait that emerged owing to the function of many related characters. Correlation coefficient measured the mutual association between pair of variables independent of other variables (Snedecor and Cochran, 1967). Correlation coefficients though are helpful in determining the parameters of complex characters for example the yield, yet cannot provide real picture of the relative importance of direct and indirect effects of individual component traits. Bulb yield in garlic hinges upon a large number of factors that influence the final expression of the character. Complex relationship of this nature which is based on cause and effect relationship could be partitioned by the use of path coefficient analysis. This analysis helps the plant breeders to identify characters that are useful as selection criteria to enhance crop vigour and yield. By and large, there is little information regarding the nature and degree of interrelationships between yield and yield related traits in garlic, and so far no selection criteria have been taken in to consideration.

Therefore, this study was carried out to determine the relationship between yield and yield related traits with a view to identifying component traits that could be selected in improving bulb yield in garlic.

MATERIALS AND METHODS

Study Site

Field trials were carried out during 2002/2003 and 2003/2004 dry seasons from November to March at Usmanu Danfodiyo University Sokoto Fadama Teaching and Research Farm, Kwalkwalawa, 5 km from Sokoto town (latitude 13^0 01'N; longitude 5^o 15'E, 300 m above sea level) to study the response of garlic to varying levels of irrigation, weeding regime and clove size. The site is a lowlying River Sokoto/Rima river flood plain (Fadama). The land is submerged with water from August/September to Octorber/Novemver. The area is characterized by a long dry season with cool air during harmattan (November- February), hot dry air during hot season from March to May. The soil is a well-drained sandy loam with a pH of 5.76 and CEC of 33.20cmol/kg (Ahmed, 2006).

Experimental Treatments

The treatments consisted of four irrigation intervals (3, 5, 7 and 9 days), four weeding regimes (Control, weeding twice, weeding thrice and weed free), and two clove sizes namely small (<2cm) and large (2>3cm) in diameter. The site was ploughed, harrowed, levelled and finally prepared into contigiuous basins of 1.5 x 3m ($4.5m^2$).The treatments were laid laid out in a split-plot designed replicated three times. Leeways (2m wide) separated the replicates. Treatments were assigned in a random manner to both main and subplots using random tables. Irrigation intervals and weeding regimes were assigned in the main plot, while clove size was assigned to the sub-plots. Each main plot consisted of two subplots and each of the latter was made up of 10 rows. Inter and intra-row spacing was 15cm x 10cm respectively. Fertilizer NPK (15:15:15) was applied at the rates of 80, 50 and 50kg/ha respectively. Nitrogen was split in to two equal doses of 40kg and applied at planting and the other half (40kg) was top dressed in form of Urea (45-46%N) at four weeks after the first dose. All of the P and K were applied at clovebed preparation. During the course of this study, no serious disease or insect pest infestations were observed and therefore no crop protection measures were carried out.

Data Collection and Analysis

Data were taken on seven randomly sampled plants from the middle three rows of each sub-plot and expressed per plant basis. The means of seven plants were used for the analysis. The parameters measured include; plant establishment count, number of leaves per plant at maturity, plant height (cm) at maturity, number of cloves per bulb, clove weight (g), bulb weight (g), clove diameter and cured bulb yield (kg/ha). Correlations between bulb yield and these yield parameters and within the yield parameters were determined according to Miller et al. (1958). Path coefficient analysis was calculated using the method described by Dewey and Lu (1959).

RESULTS

Simple correlation coefficient between bulb yield and growth and yield parameters and within yield parameters was presented in Tables 1 &2. Cured bulb yield was found to have significantly and positively correlated with all the parameters in both seasons. Likewise, average bulb weight had positive and significant correlation with the rest of the

Table 1: Simple correlation matrix involving growth and yield parameters of garlic during 2002/2003 dry season at UDU Teaching and Research Fadama Farm, Sokoto.

	1	2	3	4	5	6	7	8
1	1.000							
2	0.449**	1.000						
3	0.250*	0.287**	1.000					
4	0.022ns	0.080ns	0.060ns	1.000				
5	0.143ns	0.970**	0.374**	0.323**	1.000			
6	0.296**	0.344**	0.449**	0.629**	0.540**	1.000		
7	0.183ns	0.266**	0.398**	0.518**	0.436**	0.641**	1.000	
8	0.032ns	0.028ns	0.031ns	0.186ns	0.215*	0.337**	0.079ns	1.000
9	0.028ns	0.118ns	0.074ns	0.194ns	0.087ns	0.357**	0.307**	0.020ns

*and**Significant at 5% and 1% level of probability; Key: 1= Establishment count; 2= DM 12WAS kg/ha; 3=No. of leaves/plant at maturity; 4= Plant height (cm); 5= Fresh bulb yield kg/ha; 6= Cured bulb yield kg/ha; 7= Bulb weight (g); 8= Clove weight(g); 9= No. of cloves per bulb

Table 2: Simple correlation matrix involving growth and yield parameters of garlic during 2003/2004 dry season at UDU Teaching and Research Fadama Farm, Sokoto.

	1	2	3	4	5	6	7	8
1	1.000							
2	0.711**	1.000						
3	0.570**	0.442**	1.000					
4	0.167**	0.266**	0.162ns	1.000				
5	0.326**	0.305**	0111ns	0.057ns	1.000			
6	0.316**	0.458**	0.422**	0.598**	0.543**	1.000		
7	0.319**	0.478**	0.497**	0.626**	0.567**	0.730**	1.000	
8	0.090ns	0.341**	0.243**	0.420**	0.357**	0.522**	0.222**	1.000
9	0.146ns	0.394**	0.259**	0.409**	0.355**	0.581**	0.156**	0.644**

*and**Significant at 5% and 1% level of probability; Key: 1= Establishment count; 2= DM 12WAS kg/ha; 3=No. of leaves/plant at maturity; 4= Plant height (cm); 5= Fresh bulb yield kg/ha; 6= Cured bulb yield kg/ha; 7= Bulb weight (g); 8= Clove weight(g); 9= No. of cloves per bulb parameters in both seasons. In 2003/2004, bulb weight had a significant and positive correlation with average clove weight, average number of cloves per bulb and average clove diameter. Average clove weight had no significantly correlation with other characters, but was positively correlated with average number of cloves per bulb (Table 1 & 2).

Path coefficient involving direct and indirect contribution of growth parameters is presented in Table 3. The results showed that when the individual parameters were examined, plant height had high direct contribution (0.096) to cured bulb yield followed by dry matter at 12WAS (0.089) in 2002/2003 season. In 2003/2004 season, number of leaves had the highest direct contribution followed also by dry matter at 12WAS. The total correlation between establishment count and cured bulb yield varied from 0.281 in 2002/2003 season to 1.130 in 2003/2004 season. From the total, the direct contribution of establishment count was negative in 2002/2003 season and contributed positively in 2003/2004 season (Table 3). Establishment count, contributed more indirectly via fresh bulb weight than via any other parameter, but in 2003/2004, establishment count contributed more and positively via dry matter at 12WAS. The direct contribution of dry matter at 12WAS to cured bulb yield in both seasons was positive and found to be higher than that of the establishment count. Dry matter at 12WAS contributed high via fresh bulb yield than via any other parameters in 2002/2003 season, while in 2003/2004 season it was via bulb weight (Table 3). Number of leaves at maturity directly contributed negatively to bulb yield. The indirect contribution of the number of leaves was high via fresh bulb yield followed by clove weight (Table 2a). Number of leaves at maturity had a positive indirect contribution of 0.644 out of the total correlation of 0.890 in 2003/2004. Number of leaves contributed high to cured bulb yield via bulb weight than any other parameter. The direct contribution of plant height to cured bulb yield was positive (0.096) in 2002/2003 and was negative (-0.179) in 2003/2004. The indirect contribution of plant height was higher via fresh bulb yield (0.176) and via bulb weight (0.737) than the rest of the parameters in both seasons respectively.

Path coefficient involving direct and indirect contribution of yield parameters to cured bulb yield is presented in Table 4. The result revealed that when the individual contribution of yield parameters were examined, it was observed that in 2002/2003 season, fresh bulb yield had higher direct contribution (0.600) than the rest of the parameters, while clove weight had lower direct contribution. In 2003/2004 season, bulb weight had higher direct contribution than any other parameter (Table 4). Fresh bulb yield and number of cloves per bulb had negative individual contribution of -0.722 and -0.529 respectively. Fresh bulb yield contributed indirectly high via bulb weight in both seasons than via any other parameter. Bulb weight contributed higher to cured bulb yield via fresh bulb yield than via any other parameter in 2002/2003 season, and in 2003/2004 season it contributed higher via clove weight than via other parameters. Bulb weight had positive indirect contributions to cured bulb yield only via establishment count, dry matter at 12WAS, number of leaves at maturity and clove weight, while its contribution via the rest of the parameters was negative (Table 3). Clove weight contributed indirectly higher via fresh bulb yield and via bulb weight in both seasons. However contributed negatively only via number of leaves at and maturity stages in 2002/2003 season. Number of cloves per bulb had higher contribution to cured bulb yield via bulb weight than any other parameter in 2003/2004 season. However, their direct contributions were negative.

Table 3: Direct and Indirect contribution of growth parameters to cured bulb yield in 2002/2003 and 2003/2004 dry seasons at UDU, Teaching and Research Fadama Farm, Sokoto

Relationship	Coefficients	
Establishment count versus cured bulb yield	2002/2003	2003/2004
Direct	0.024	0.143
Indirect via dry matter at 12 WAS	0.040	0.329
Indirect via no. of leaves at maturity	0.013	0.108
Indirect via plant height	0.001	-0.005
Indirect via fresh bulb yield	0.014	-0.228
Indirect via bulb weight	0.178	0.156
Indirect via clove weight	0.007	0.112
Indirect via no, of cloves per bulb	0.004	0.139
Total (Direct + Indirect)	0.281	0.476
Dry matter at 12 WAS versus cured bulb yield		
Direct	0.089	0.463
Indirect via establishment count	0.011	0.102
Indirect via no. of leaves at maturity	0.001	0.340
Indirect via plant height	0.027	-0.056
Indirect via fresh bulb yield	0.431	-0.514
Indirect via bulb weight	0.069	0.907
Indirect via clove weight	0.049	0.444
Indirect via no. of cloves per bulb	NA	-0.887
Total (Direct + Indirect)	0.677	0.799
Number of leaves at maturity versus cured bulb yield		
Direct	0.033	0.644
Indirect via establishment count	0.001	0.024
Indirect via dry matter at 12 WAS	0.044	0.244
Indirect via no. of leaves at maturity	0.003	0.020
Indirect via plant height	0.001	0.080
Indirect via fresh bulb yield	0.025	0.477
Indirect via bulb weight	0.018	0.186
Indirect via clove weight	0.003	0.492
Indirect via no. of cloves per bulb	NA	-1.277
Total (Direct + Indirect)	0.128	0.890
Plant height versus cured bulb yield		
Direct	0.096	-0.179
Indirect via establishment count	0.003	0.004
Indirect via dry matter at 12 WAS	0.025	0.146
Indirect via no. of leaves at maturity	0.000	0.288
Indirect via fresh bulb yield	0.176	0.288
Indirect via bulb weight	0.002	0.737
Indirect via clove weight	0.051	0.267
Indirect via no. of cloves per bulb	NA	-0.566

Total (Direct + Indirect)	0.353	0.985

Table 4: Direct and Indirect contribution of yield parameters to cured bulb yield in 2002/2003 and 2003/2004 dry seasons at UDU, Teaching and Research Fadama Farm, Sokoto

Relationship	Coefficients	
Fresh bulb yield versus cured bulb yield	2002/2003	2003/2004
Direct	0.600	-0.722
Indirect via establishment count	0.007	0.045
Indirect via dry matter at 12WAS	0.064	0.330
Indirect via no. of leaves at maturity	0.001	0.426
Indirect via plant height	0.028	0.071
Indirect via bulb weight	0.080	1.474
Indirect via clove weight	0.072	0.542
Indirect via no, of cloves per bulb	NA	-1.199
Total (Direct + Indirect)	0.852	0.917
Bulb weight versus cured bulb yield		
Direct	0.204	1.738
Indirect via establishment count	0.001	0.013
Indirect via dry matter at 12 WAS	0.030	0.242
Indirect via no. of leaves at maturity	0.003	0.439
Indirect via plant height	0.001	-0.076
Indirect via fresh bulb yield	0.236	-0.612
Indirect via clove weight	0.058	0.525
Indirect via no. of cloves per bulb	NA	-1.234
Total (Direct + Indirect)	0.533	0.677
Clove weight versus cured bulb yield		
Direct	0.138	0.764
Indirect via establishment count	0.001	0.021
Indirect via dry matter at 12 WAS	0.032	0.269
Indirect via no. of leaves at maturity	-0.001	0.415
Indirect via plant height	0.035	-0.062
Indirect via fresh bulb yield	0.310	-0.512
Indirect via bulb weight	0.085	1.196
Indirect via no. of cloves per bulb	NA	-1.185
Total (Direct + Indirect)	0.600	0.906
Number of cloves per bulb versus cured bulb yield		
Direct	-0.120	-0.529
Indirect via establishment count	0.002	0.013
Indirect via dry matter at 12 WAS	0.011	0.269
Indirect via no. of leaves at maturity	0.058	0.538
Indirect via plant height	-0.003	-0.066
Indirect via fresh bulb yield	-0.056	-0.566
Indirect via bulb weight	0.214	0.403
Indirect via clove weight	0.201	0.592
Total (Direct + Indirect)	0.307	0.654

DISCUSSION

For the simple correlation study, virtually all the growth and yield parameters have indicated interdependency as a result of positive and significant correlation observed amongst nearly all the parameters. This suggested that improvement aimed at any of the character would automatically lead to improvement in the other. The work of Umar *et al*. (2007) confirmed this in onion that strong correlation among characters indicates that the characters were controlled by the same genetic system and therefore anticipated to be linked to each other. The negative association or rather correlation observed between number of leaves at maturity in 2002/2003 and other parameters and almost all other parameters in 2003/2004 showed that the higher the number of leaves at maturity, the smaller would be these parameters. It is also true without contemplating that the higher the number of leaves as the crop growth the more the photosynthate would be utilized for vegetative growth rather than reproductive growth. This may signify that as the accumulation of dry matter increases in the storage bulb there could be a reduction in the accumulation of assimilates in the foliage which in turn may indicate that a genotype that possesses vigorous vegetative growth tends to produce less storage bulb yield. This may also imply the existence of competition between the shoots and the storage bulb for photosynthete.Inconformity with this finding. Rahman and Das (1985) reported that in garlic the shoot system served as an alternative sink for assimilate during early growth period and resulted in delayed storage bulb bulking. They added that seriously competitive shoot sink early in the ontogeny of storage bulb resulted in low yield only when there was poor distribution of assimilates to storage bulb during the later growth period. Correlation between bulb yield and the other yield parameters have shown that bulb weight, cloves number per bulb as well as clove size are the most important yield determinants in garlic. This was in conformity with what was reported by Miko (2000).

In path coefficient analysis, correlation coefficients of cured bulb yield with other characters were again divided in to direct and indirect effect using path coefficient analysis. The result revealed that yield components made optimum positive indirect contribution to cured bulb yield through average bulb weight, clove weight and number of cloves per bulb in both seasons (Table 4). This could be as a result of high negative indirect effect via number of leaves at vegetative stage (-0.004) and (-0.019) in 2002/2003 and 2003/2004 respectively on the cured bulb yield more over its correlation with the yield was also positive and highly significant. The positive direct and indirect effect confirmed that variety with good average bulb weight could be developed without sacrificing the entire bulb yield. Fresh bulb yield, bulb weight and clove weight contributed 0.600, 0.204 and 0.138 directly to cured bulb yield respectively in 2002/2003. Bulb weight and clove weight contributed (1.738) and (0.764) directly and positively to cured bulb yield in 2003/2004. This indicated that these parameters had direct effect in building up correlation with total cured bulb yield. This research fiding was inlined with what was reported by Miko *et al*. (2000) where he reported positive direct effects of fresh bulb yield, bulb weight and clove weight on cured bulb yield of garlic. In addition, Rahman *et al*. (2002) and Umar *et al*. (2007) reported the same finding in onion.

CONCLUSION

In this study, both correlation and path coefficient analysis were discussed and it can be deduced that number of leaves, plant height, bulb weight, clove weight were greater growth and attributes of garlic. Therefore, any effort in increasing growth and final yield of garlic should be focus on these parameters.

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