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CORRELATION AND PATH ANALYSIS OF SOME GROWTH AND YIELD COMPONENTS OF PHYSIC NUT (*Jatropha curcas* L).

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Abstract

Field trials were conducted during 2008, 2009 and 2010 seasons at the Institute for Agricultural Research (I.A.R) Farm Samaru to determine the relationship between growth and yield components related traits in physic nut that could be used as a basis for selection programme aimed at improving yield. The treatments consisted of two propagation methods (seeds and stem cuttings), four weed control treatments (Fusilade plus Diuron at 1.0 + 0.8kg a.i ha^{-1}, applied at 4 and 12 weeks after transplanting (WAT), followed by supplementary hoe-weeding at 16 weeks; Atrazine plus Diuron at 1.0 + 0.8kg a.i ha^{-1}, applied at 4 and 12 WAT, followed by supplementary hoe-weeding at 16 weeks; hoe weeded at 4,8,12 and 16 WAT and a weedy check) and three levels of nitrogen (0, 50 and 100kg ha^{-1}). The treatments were laid out in a split-plot design and replicated three times. Nitrogen levels and weed control treatments were assigned to main plots, while the propagation methods were assigned to the sub plots. Data were taken on growth and yield components and simple correlation and path coefficient analysis were deployed to study the relationship among the growth and yield components to seed yield. Results indicated that the relationship between yield of physic nut was positively and highly significantly correlated to growth and yield components such as stem girth, plant height, canopy spread, number of leaves, leaf area index, crop vigour score, number of primary branches, weight $capsule^{-1}$, capsule weight $plant^{-1}$, 100 seed weight, number of capsule $plant^{-1}$, shelling percentage, number of seeds $capsule^{-1}$, seed weight $capsule^{-1}$ and seed weight $plant^{-1}$. However, weed cover score and weed dry weight were negatively and highly significantly correlated with yield of physic nut. The positive association of growth and yield components with these characters indicates that selection based on these characters could improve yield. From the study, it can be concluded that parameters like plant height, number of leaves, leaf area index, 100 seed weight and number of seeds per capsule are major contributors to Jatropha seed yield and therefore, can be suggested for breeding programme for seed yield improvement.

Key Words: *Path analysis, Seed, Stem cuttings, Weed control, Nitrogen, Physic nut and Correlation*

Introduction

Physic nut is one of the prospective bio-diesel yielding crops (Anon., 2006). Diesel from physic nut is renewable. The genus *Jatropha* belongs to the family *Euphorbiaceae* as are cassava, para-rubber and castor bean plant (Heller, 1996). Leading producing regions of jatropha are Central American where it originates and southern Africa and northern Africa (Mali) where it is widely grown as a live hedge. The world annual biodiesel production is about 3.5 billion litres (William, 2006).

The cake is bio-degradable when used as organic manure. The seeds when pounded can be used for tanning, the oil is used for making soap, used as a lubricant and raw material for paint production. The oil has toxic content called curcin which has been proved to have germicidal, antifungal and pesticidal properties (Gour, 2004).

Interest in biofuel is increasing in the light of the growing concern about global warming and the resulting climatic change. The emission of the greenhouse gases such as CO_2 can be reduced when 'green' biomass – derived transportation fuels such as biodiesel are used. Biodiesel is the name of a clean burning alternative fuel, produced from plants.

Despite growing advocacy for large scale cultivation of physic nut, its systematic yield improvement studies, especially information on the relationship among plant characteristics and yield which is very useful in formulating selection scheme with target to improve yield is very limited. A guide to the use of correlation in breeding programme is the determination of phenotypic and genotypic correlation coefficient (Singh and Chaudhary, 1985). Phenotypic correlation is of great practical significance because measurements are based on phenotype. Correlation coefficient helps the breeder to select an efficient trait in breeding programme and allocate appropriate weightage for optimal results. Research on agronomic techniques to optimize yield is also pertinent. Determining the nature of the association between the variables will ease selection for possible improvement of the important horticultural traits. To achieve this, a detailed knowledge of the relationship among the traits and yield is extremely important as a prelude if improvement through selection is to be most effective. Correlating growth and yield attributes for better yield and quality of oil seems to be the immediate task before going for commercial cultivation of Jatropha. In light of the above, the study was designed to determine the nature of association among the traits that would be helpful to plant breeders for designing selection procedures for the overall improvement of this crop.

Materials and Methods

Field trial was conducted during 2008, 2009 and 2010 seasons at the Institute for Agricultural Research (I.A.R) Farm Samaru (11^{o} 11′ N; 07^{o} 38′ E and 686m above sea level). The treatment consisted of two propagation methods of seeds and stem cuttings, four weed control treatments (Fusilade plus Diuron at 1.0 + 0.8kg a.i/ha applied at 4 and 12 weeks after transplanting (WAT), followed by(fb) supplementary hoe weeding at 16 weeks; Atrazine plus Diuron at 1.0 + 0.8kg a.i/ha applied at 4 and 12 WAT, fb supplementary hoe weeding at 16weeks; hoe weeded control (4, 8, 12 and 16 WAT)

and a weedy check) and three levels of nitrogen (0, 50 and 100kg N ha^{-1})

The treatments were laid out in a split plot design, replicated three times. The gross plot size was 6m long by 6m wide ($36m^2$), while the net-plot size was 2m wide by 6m long ($12m^2$). The borders between plots and replicates were 2m and 3m, respectively.

Seeds and stem cuttings were sourced from *Jatropha* plantation of the Agricultural and Rural Development Secretariat in Kuje Area Council, Abuja sourced from local assertion. Two seeds per polythene bag at a planting depth of 5cm according to recommendation. Stem cuttings of 30cm each with 5-6 buds were planted at 10cm depth and at a cutting per bag at the same time with seeds on 4th March, 2008 under partial shade provided by *Eucalyptus* tree. Thinning was done 2 weeks after seed emergence to a seedling per polybag. Irrigation was done daily. Transplanting holes of 30cm length, 30cm width and 30cm depth were excavated in each plot a day after harrowing. Transplanting of physic nut seedlings from seeds and stem cuttings were done simultaneously at 12 weeks of age according to treatments on the 2nd June, 2008 using one seedling per hole at 2 x 2m spacing, giving a population density of 2,500ha^{-1}. Urea (46% N) was applied to supply nitrogen as per treatment in two split applications, Single super phosphate and muriate of potash were applied as basal doses to the crop at 30kg ha^{-1} yearly to supply phosphorus and potassium.

Both herbicide treatments were applied 4 and 12 weeks after transplanting as post-emergence directed spray using a CP3 knapsack sprayer, fitted with a green deflector poly-jet nozzle and set at a pressure of 2.1kg-m^2 to give a spray volume of 250Lha^{-1}, fb supplementary hoe weeding at 16WAT in 2008. Subsequently in 2009 and 2010, its imposition started on the 27th and 20th April, respectively, fb supplementary hoe weeding at 16 weeks. The hoe weeded control plots were each weeded at 4, 8, 12 and 16 WAT in 2008. In 2009 and 2010, it was carried out on the same day that both herbicide treatments were applied.

Observations on the crop and weeds were made monthly from four tagged plants within each net-plot**.** Data were collected on weed dry weight, weed cover score, crop vigour score, plant height, stem girth, leaf area index, canopy spread, number of leaves, number of primary and secondary branches, capsule weight, capsule weight $plant^{-1}$, 100 seed weight, number of capsules $plant^{-1}$, shelling percentage, number of seeds, seed weight $capsule^{-1}$, seed weight $plant^{-1}$ and seed yield. Yellow and brown to black capsules were harvested periodically by hand picking. Capsules were sun dried, weighed and later shell to obtain clean seed

Data Analysis

The magnitude and type of relationship between characters were assessed through simple correlation analysis (Little and Hill, 1978). The direct and indirect contribution of seed yield by selected characters of Jatropha were determined using path coefficient analysis as described by Dewey and Lu (1959).

Results

Tables 1-3 indicates the individual co-efficient analysis of various growth parameters and yield components of physic nut in year 2008, 2009 and 2010. The relationship between yield of physic nut was positively and highly significantly

correlated to growth and yield components among which are stem girth (0.844**), plant height (0.844**), canopy spread (0.740**), number of leaves (0.620**), leaf area index (0.842**), crop vigour score (0.716**), number of primary branches (0.743**), weight capsule^{-1} (0.804**), capsule weight plant^{-1} (0.991**), 100 seed weight (0.797**), number of capsule plant^{-1} (0.972**), shelling percentage (0.741**), number of seeds capsule^{-1} (0.549**), seed weight capsule^{-1} (0.797**) and Seed weight plant^{-1} (0.999**). However, weed cover score (-0.768**) and weed dry weight (-0.710**) were negatively and highly significantly correlated with yield of physic nut (Table 1).

Similarly, in year 2009 (Table 2), physic nut seed yield was also positively and highly significantly correlated to the growth and yield components among which are stem girth (0.881**), plant height (0.895**), canopy spread (0.811**), number of leaves (0.789**), leaf area index (0.938**), crop vigour score (0.791**), number of primary branches (0.732**), number of secondary branches (0.708**) weight capsule^{-1} (0.760**), capsule weight plant^{-1} (0.969**), 100 seed weight (0.755**), number of capsule plant^{-1} (0.946**), number of seeds capsule^{-1} (0.466**), seed weight capsule^{-1} (0.660**) and Seed weight plant^{-1} (0.999**) except shelling percentage (-0.075). While negative and highly significant correlation was observed with both weed cover score (-0.742**) and weed dry weight (0.743**).

In 2010 (Table 3), positive and highly significant correlation were obtained between physic nut seed yield and growth and yield components such as stem girth (0.801**), plant height (0.824**), canopy spread (0.789**), number of leaves (0.843**), leaf area index (0.814**), crop vigour score (0.745**), number of secondary branches (0.719**) weight capsule^{-1} (0.590**), capsule weight plant^{-1} (0.922**), 100 seed weight (0.671**), number of capsule plant^{-1} (0.886**), shelling percentage (0.501**) number of seeds capsule^{-1} (0.461**), seed weight capsule^{-1} (0.609**) and Seed weight plant^{-1} (0.985**) except weed cover score and weed dry weight (-0.349** and -0.698**) that were negatively correlated.

Path Analysis

The path analysis shows the interrelationship of some Jatropha growth and yield components with seed yield at Samaru in 2008, 2009 and 2010 is presented in Table 4. The result of 2008 indicated that the highest individual percent contribution to seed yield was obtained from plant height of 32.5% which was followed by 20.1%, 13.1%, 2.3% and 0.37% were from seed weight per capsule, 100 seed weight, number of seed per capsule and number of leaves respectively. The result of 2009 and 2010 had similar trend where the highest percent individual contribution was recorded from plant height and least was from number of leaves. The highest positive combined contribution to seed yield of 21.9% was from plant height via 100 seed weight in 2008, 29.4% from leaf area index via 100 seed weight in 2009 and 11.7% contributions from plant height via number of leaves in 2010.

The direct and indirect effect of growth and yield attributes on seed yield of Jatropha in 2008, 2009 and 2010 are presented in Table 5. The result in 2008 indicated that plant height, 100 seed weight, and seed weight per capsule showed direct positive effect on seed yield

of 0.569, 0.361 and 0.135 respectively. However, leaf area index and number of seed per capsule indicated positive lower value direct effect. The highest indirect effect was found in plant height via leaf area index, number of leaves via seed weight per capsule, 100 seed weight via number of seed per capsule with the following values 0.482, 0.357, 0.351, 0.303 and 0.253 respectively while the lowest indirect percent contribution was found to be leaf area index via plant height (0.001).

In 2009, the greatest direct effect to seed yield was through 100 seed weight (0.695), followed by leaf area index (0.223), seed weight per capsule (0.139) number of leaves (0.069), number of seed per capsule (0.049) and the least direct effect was found to be through plant height (-0.034). The least indirect effect to seed yield was obtained from number of leaves via number of seeds per capsule (-0.009) while the highest was obtained from 100 seed weight via leaf area index (0.655). 100 seed weight gave the highest total correlated value of 0.969, while lowest was obtained from umber of seed per capsule (-0.075).

In 2010 season number of leaves had the highest direct effect on seed yield (0.417) and lowest was evident on leaf area index (0.124). The highest indirect effect to seed yield was through the leaf area index (0.372). The indirect effect was the leaf area index through number of seed per capsule (-0.020) which made the least contribution.

Discussion

High and positive correlation between yield and the above listed growth characters throughout the study indicates the importance of vegetative development in producing high yield and also the interdependency within and between these characters. Similarly, the positive and highly significant correlation between yield and yield characters suggests that these characters are most critical determinants of seed yield in physic nut and thus constitutes important character that should be considered by breeders for improvement. There was a positive correlation between castor seed yield to capsule weight and 100-seed weight (Abubakar *et al*., 2010).

The positive and highly significant relationship between physic nut yield and crop vigour score indicated interdependency between the characters. Such consistent correlation in all seasons is indicative of the fact that these characters are very important yield contributing traits in physic nut. These factors determine the vegetative photosynthetic surface area for the manufacture and translocation of assimilates to physic nut that constituted yield. Al-Barrak (2006) reported that fruit or seed yield is a function of yield component. Similarly, the highly significant positive correlation between leaf area and fruit yield might not be unconnected with the fact that larger leaf areas achieved maximum photosynthesis and thereafter maximum dry matter accumulation. The leaf being the source of assimilates which are later partitioned to the storage sink (fruits). The significant positive correlation between plant height and stem diameter is in agreement with the findings of Fakuta and Ojiekpon (2009) and Chaturvedi and Pandey (2005). In the same vein, highly significant and positive correlation between growth characters might be due to the fact that the larger the

leaf area, the maximum photosynthesis will be achieved.

Conversely, the negative association between physic nut yield, weed cover score and weed dry weight shows the deleterious effects of the limited growth resources which eventually resulted in depressed yield. Larger canopy cover means greater interception of light energy and greater photosynthesis resulting in higher assimilate production.

The partitioning of the total correlation into direct and indirect contribution showed that most of growth and yield components that made their greatest contributions to seed yield individually are plant height, number of leaves, leaf area index, 100 seed weight and number of seeds per capsule. The path analysis between growth and yield components showed that the greatest indirect contribution to total seed yield was via leaf area index.

Conclusion

From the study, it can be concluded that the significant and positive correlation of growth and yield attributes observed to seed yield indicates that these characters could improve yield. Characters like plant height, number of leaves, leaf area index, 100 seed weight and number of seeds per capsule indicates that they are major contributors to Jatropha seed yield and therefore, it can be suggested for breeding programme for improvement.

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Table 1: Matrix of correlation coefficient between yields (kg ha^{-1}), growth and yield component in 2008 at Samaru

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19
V1	1.000																		
V2	0.851**	1.000																	
V3	0.762**	0.824**	1.000																
V4	0.727**	0.619**	0.641**	1.000															
V5	0.826**	0.851**	0.672**	0.536**	1.000														
V6	0.701**	0.551**	0.437**	0.481**	0.653**	1.000													
V7	-0.628**	-0.530**	-0.348**	-0.324*	-0.714**	-0.713**	1.000												
V8	-0.573**	-0.482**	-0.260*	-0.303*	-0.672**	-0.669**	0.967**	1.000											
V9	0.781**	0.7620*	0.763**	0.776**	0.635**	0.623**	-0.388**	-0.324*	1.000										
V10	0.626**	0.519**	0.413**	0.415**	0.605**	0.546**	-0.726**	-0.697**	0.432**	1.000									
V11	0.833**	0.848**	0.718**	0.608**	0.844**	0.704**	-0.789**	-0.731**	0.718**	0.816**	1.000								
V12	0.617**	0.532**	0.491**	0.414**	0.599**	0.552**	-0.667**	-0.605**	0.444**	0.915**	0.786**	1.000							
V13	0.824**	0.875**	0.754**	0.609**	0.844**	0.717**	-0.768**	-0.700**	0.742**	0.700**	0.980**	0.703**	1.000						
V14	0.461**	0.474**	0.449**	0.384**	0.423**	0.605**	-0.558**	-0.509**	0.534**	0.646**	0.724**	0.686**	0.721**	1.000					
V15	0.445**	0.445**	0.459**	0.339*	0.359*	0.467**	-0.375**	-0.333*	0.503**	0.419**	0.484**	0.442**	0.487**	0.646**	1.000				
V16	0.617**	0.617**	0.491**	0.414**	0.599**	0.552**	-0.667**	-0.605**	0.444**	0.915**	0.786**	1.000**	0.703**	0.686**	0.442**	1.000			
V17	0.843**	0.843**	0.739**	0.619**	0.842**	0.714**	-0.768**	-0.711**	0.741**	0.805**	0.991**	0.798**	0.971**	0.741**	0.549**	0.798**	1.000		
V18	0.844**	0.844**	0.740**	0.620**	0.842**	0.716**	-0.768**	-0.710**	0.743**	0.804**	0.991**	0.797**	0.972**	0.741**	0.549**	0.797**	0.999**	1.0000	
V19	0.294*	0.012	0.307**	0.150	0.182	0.222	-222	-0.213	0.220	0.138	0.212*	0.172	0.232*	0.138	0.103	0.172	0.203	0.203	1.0000

* r value at 0.05 level of significance **r value at 0.01 level 0f significance

V_1 = Stem girth, V_2 = Plant height, V_3 = Canopy spread, V_4 = Number of leaves, V_5 = Leaf area index, V_6 = Crop vigour score,
V_7 = Weed cover score, V_8 = Weed dry weight, V_9 = Number of primary branches, V_{10} = Capsule weight V_{11} = Capsule weight $plant^{-1}$
V_{12} = 100 seed weight, V13 = Number of capsules $plant^{-1}$ V14 = Shelling percentage, V15 = Number of seeds $capsule^{-1}$, V_{16} = Seed weight $capsule^{-1}$
V_{17} = Seed weight $plant^{-1}$, V_{18} = Seed yield ($kgha^{-1}$), V19 = Capsule girth.

Table 2: Matrix of correlation coefficient between yields (kg ha^{-1}), growth and yield component in 2009 at Samaru

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20
V1	1.000																			
V2	0.915**	1.000																		
V3	0.807**	0.793**	1.000																	
V4	0.812**	0.800**	0.790**	1.000																
V5	0.905**	0.896**	0.750**	0.708**	1.000															
V6	0.779**	0.697**	0.584**	0.594**	0.849**	1.000														
V7	-0.684**	-0.639**	-0.436**	-0.430**	-0.837**	-0.804**	1.000													
V8	-0.690**	-0.638**	-0.435**	-0.441**	-0.837**	-0.824**	0.994**	1.000												
V9	0.804**	0.750**	0.814**	0.766**	0.664**	0.684**	-0.412**	-0.431**	1.000											
V10	0.794**	0.717**	0.756**	0.796**	0.639**	0.612**	-0.368*	-0.380*	0.854**	1.000										
V11	0.572**	0.581**	0.589**	0.523**	0.685**	0.694**	-0.659**	-0.658**	0.499**	0.460**	1.000									
V12	0.905**	0.917**	0.810**	0.782**	0.942**	0.776**	-0.741**	-0.741**	0.742**	0.727**	0.760**	1.000								
V13	0.552**	0.556**	0.516**	0.512*	0.668**	0.661**	-0.673**	-0.665**	0.463**	0.430**	0.979**	0.741**	1.000							
V14	0.921**	0.926**	0.830**	0.753**	0.952**	0.761**	-0.714**	-0.715**	0.746**	0.732**	0.622**	0.971**	0.601**	1.000						
V15	-0.181	-0.103	-0.119\\	-0.136	-0.162	-0.089	0.181	0.200	-0.130	-0.043	0.075	-0.130	0.047	-0.158	1.000					
V16	0.313*	0.293*	0.431**	0.372*	0.344*	0.378**	-0.220	-0.230	0.342*	0.327*	0.221	0.334*	0.234*	0.355*	0.056	1.000				
V17	0.490**	0.483**	0.467**	0.378*	0.597**	0.590**	-0.602**	-0.585**	0.433**	0.420*	0.815**	0.628**	0.842**	0.535**	0.124	0.270*	1.000			
V18	0.881**	0.895**	0.811**	0.789**	0.937**	0.791**	-0.742**	-0.743**	0.732**	0.708**	0.760**	0.969**	0.755**	0.946**	-0.075	0.466**	0.660**	1.000		
V19	0.881**	0.895**	0.811**	0.789**	0.938**	0.791**	0.742**	-0.743**	0.732**	0.708**	0.760**	0.969**	0.755**	0.946**	-0.075	0.466**	0.660**	0.999**	1.000	
V20	0.265*	0.207	0.271*	0.137	0.221	0.228*	0.225	-0.215	0.237*	0.245*	0.236*	0.224	0.240	0.212	-0.065	-0.007	0.325**	0.219	0.219	1.000

* r value at 0.05 level of significance **r value at 0.01 level 0f significance

V_1 = Stem girth, V2 = Plant height, V3 = Canopy spread, V4 = Number of leaves, V5 = Leaf area index, V_6 = Crop vigour score,
V_7 = Weed cover score, V_8 = Weed dry weight, V_9 = Number of primary branches, V_{10} = Number of secondary branches, V_{11} = Capsule weight,
V_{12} = Capsule weight $plant^{-1}$, V_{13} = 100 seed weight, V14 = Number of capsules $plant^{-1}$, V_{15} = Shelling percentage, V_{16} = Number of seeds $capsule^{-1}$
V_1 = Seed weight $capsule^{-1}$, V_{18} = Seed weight $plant^{-1}$, V_{19} = Seed yield ($kgha^{-1}$), V_{20} = Capsule girth

Table 3: Matrix of correlation coefficient between yields (kg ha^{-1}), growth and yield component in 2010 at Samaru

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19
V1	1.000																		
V2	0.934**	1.000																	
V3	0.891**	0.880**	1.000																
V4	0.873**	0.893**	0.825**	1.000															
V5	0.891**	0.884**	0.773**	0.795**	1.000														
V6	0.747**	0.676**	0.672**	0.602**	0.853**	1.000													
V7	-0.337*	-0.333*	-0.293*	-0.256*	-0.350*	-0.451**	1.000												
V8	-0.672**	-0.625**	-0.524**	-0.564**	-0.850**	-0.869**	0.362**	1.000											
V9	0.859**	0.815**	0.857**	0.835**	0.703**	0.589**	-0.282	-0.420**	1.000										
V10	0.360*	0.406**	0.405**	0.415**	0.422**	0.411**	-0.288	-0.399**	0.378**	1.000									
V11	0.859**	0.892**	0.850**	0.891**	0.837**	0.732**	-0.231	-0.682**	0.764**	0.579**	1.000								
V12	0.385**	0.398**	0.355*	0.383**	0.535**	0.505**	-0.230	-0.588**	0.263*	0.634**	0.542**	1.000							
V13	0.914**	0.923**	0.883**	0.893**	0.848**	0.765**	-0.348**	-0.680**	0.810**	0.423**	0.955**	0.432**	1.000						
V14	0.199	0.182	0.195	0.164	0.256*	0.303**	-0.386**	-0.313**	0.184	0.246*	0.168	0.497**	0.183	1.000					
V15	0.219	0.229	0.300*	0.266*	0.167	0.215	-0.271*	-0.170	0.247*	0.411**	0.297*	0.195	0.251*	0.542**	1.000				
V16	0.193	0.314*	0.268*	0.296*	0.430**	0.389**	-0.204	-0.473**	0.229*	0.486**	0.398**	0.784**	0.301*	0.784**	0.210	1.000			
V17	0.798**	0.823**	0.789**	0.838**	0.802**	0.713**	-0.342**	-0.675**	0.706**	0.597**	0.917**	0.655**	0.875**	0.478**	0.451**	0.597**	1.000		
V18	0.801**	0.824**	0.789**	0.843**	0.814**	0.745**	-0.349**	-0.698**	0.719**	0.590**	0.922**	0.671**	0.886**	0.501**	0.461**	0.609**	0.985**	1.000	
V19	0.273*	0.105	0.298*	0.144	0.214	0.227*	-0.353**	-0.220	0.234*	0.019	0.139	0.051	0.177	-0.023	-0.020	0.012	0.046	0.069	1,000

* r value at 0.05 level of significance **r value at 0.01 level 0f significance

V1 = Stem girth, V2 = Plant height V3 = Canopy spread, V4 = Number of leaves, V5 = Leaf area index, V6 = Crop vigour score,
V7 = Weed cover score, V8 = Weed dry weight, V9 = Number of secondary branches, V10 = Capsule weight, V11 = Capsule weight plant^{-1}
V12 = 100 seed weight, V13 = Number of capsules plant^{-1}, V14 = Shelling percentage, V15 = Number of seeds capsule^{-1}, V16 = Seed weight capsule^{-1}
V17 = Seed weight plant^{-1}, V18 = Seed yield (kgha-1), V19 = Capsule girth.

Table 4: Percentage contribution of different growth and yield attributes of Jatropha seed yield in 2008-2010 wet season at Samaru

Variable	**Percent Contribution (%)**		
Individual contribution	**2008**	**2009**	**2010**
Plant height	32.46	20.12	20.45
Number of leaves	0.37	0.48	0.41
Leaf area index	2.33	3.24	1.54
100 Seed weight	13.05	8.43	12.76
Number of seed per capsule	5.32	5.01	4.69
Seed weight per capsule	20.10	19.1	15.43
Combined Contribution			
Plant height via Number of leaves	4.32	-0.38	11.66
Plant height via Leaf area index	0.01	-1.38	3.43
Plant height via 100 seed weight	21.93	-4.41	2.41
Plant height via Number of seeds per capsule	0.00	0.03	1.55
Plant height via seed weight per capsule	9.52	-0.27	1.82
Number of leaves via Leaf area index	0.00	2.19	8.23
Number of leaves via 100 seed weight	1.83	7.54	6.23
Number of leaves via Number of seeds per capsule	0.00	-0.09	4.80
Number of leaves via seed weight per capsule	0.68	0.71	4.57
Leaf area index via 100 seed weight	0.00	29.35	2.57
Leaf area index via Number of seeds per capsule	0.09	-0.36	0.89
Leaf area index via seed weight per capsule	0.02	2.30	1.36
100 seed weight via Number of seeds per capsule	0.03	-0.90	1.64
100 seed weight via seed weight per capsule	7.71	6.42	5.63
Number of seeds per capsule via seed weight per capsule	0.04	0.07	1.68
Residual	6.17	2.97	8.14
Total	100.00	100.00	100.00

Table 5: The direct and indirect contribution of growth and yield component to Jatropha seed yield in 2008-2010 wet season at Samaru

Effect through	**Plant height**	**Number of leaves**	**Leaf area index**	**100 Seed weight**	**Number of seed per capsule**	**Seed weight per capsule**	**Total correlated**
Direct and Indirect contributions 2008							
Plant height	**0.569**	0.037	0.000	0.192	0.000	0.083	0.884
Number of leaves	0.352	**0.061**	0.003	0.149	2.470	0.056	0.620
Leaf area index	0.484	0.032	**0.001**	0.216	0.026	0.082	0.842
100 Seed weight	0.303	0.025	0.009	**0.361**	0.002	0.106	0.797
Number of seed per capsule	0.253	0.020	0.005	0.159	**0.000**	0.059	0.549
Seed weight per capsule	0.351	0.025	0.005	0.284	3.221	**0.135**	0.797
Direct and Indirect contributions 2009							
Plant height	**-0.034**	0.055	0.200	0.638	-0.005	0.040	0.895
Number of leaves	-0.027	**0.069**	0.158	0.544	-0.006	0.051	0.789
Leaf area index	-0.030	0.049	**0.223**	0.655	-0.008	0.047	0.937
100 Seed weight	-0.031	0.054	0.210	**0.695**	-0.006	0.046	0.969
Number of seed per capsule	0.003	-0.009	-0.036	-0.090	**0.049**	0.007	-0.075
Seed weight per capsule	-0.010	0.025	0.077	0.232	0.002	**0.138**	0.466
Direct and Indirect contributions 2010							
Plant height	**0.156**	0.372	0.109	0.077	0.049	0.058	0.824
Number of leaves	0.139	**0.417**	0.098	0.074	0.057	0.054	0.843
Leaf area index	0.138	0.331	**0.124**	0.103	0.036	0.079	0.814
100 Seed weight	0.062	0.160	0.066	**0.194**	0.042	0.145	0.671
Number of seed per capsule	0.035	0.110	0.020	0.037	**0.216**	0.038	0.461
Seed weight per capsule	0.049	0.123	0.053	0.152	0.045	**0.185**	0.609

Bold = Direct effect