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Correlation and Path Analysis between Seed Yield and some Weed and Quantitative Components in Two Sesame (*Sesamum indicum* L.) Varieties as influenced by Seed Rate and Nitrogen Fertilizer

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Abstract
Field experiment was conducted in the wet seasons of 2009 to 2011, at the Farm of the Institute for Agricultural Research, Ahmadu Bello University, Samaru (Lat., 11° 11´ N, Long. 7° 38´ E, 686 m above sea level); to determine the contributions of some weed and quantitative characters to seed yield of two sesame varieties as affected by seed rate and nitrogen fertilizer The treatments consisted of four seed rates (2, 4, 6 and 8 kg ha^{-1}) and four levels of nitrogen (0, 30, 60 and 90 kg N ha^{-1}) and two sesame varieties (NCRIBEN 01M and E8). The treatments were laid out in a split plot design with three replications. Seed and nitrogen rates were assigned to the main plot, while crop variety was assigned to the sub plot. Seed yield correlated positively and significantly with plant height, branches per plant, leaves per plant, capsules per plant, seeds per capsule and 1000 - seed weight; and seeds per capsule contributed more to seed yield compared with other growth and yield characters measured. Path analysis revealed that greatest direct effect and individual factor contribution to seed yield was made by number of seeds per capsule. The highest indirect effect to seed yield was made by number of seeds per capsule through 1000 – seed weight; and highest combined contribution was by number of seeds per capsule through number of branches per plant. From this study it was observed that seeds per capsule made the most contribution to seed yield and should therefore be used as a selection index for sesame improvement.
Keywords: correlation, path analysis, quantitative component, sesame

1. Introduction

Sesame (*Sesamum indicum* L.) is an important oilseed crop widely cultivated in the tropical and sub-tropical climates of Africa, Asia, as well as Latin America, for its seeds which serves as food, and the high quality oil, protein and antioxidants obtained from the seeds (Yol *et al*. 2010; Haruna *et al*. 2012). The seeds are also use as raw materials in the production of confectionery and bakery products; while the oil is use in the industry to produce soap, perfume, carbon paper, pharmaceuticals and edible vegetable oils (Yol *et al*. 2010). The seed cake is also use in the production of livestock feed and fertilizer (Ogbonna & Umar-Shaaba, 2011). Despite the benefits that exist, the production of this crop is generally low compared to other oilseed crop because the seed yield contributing factors are generally affected by the interaction between the environmental factors (Yol *et al*. 2010; Haruna *et al*. 2012) and the phenotypic and genotypic factors (Gelalcha & Hanchinal 2013).

As with other field crops, seed yield of sesame are strongly associated with numerous interrelated characters and the environmental fluctuation whose knowledge is important for use in sesame yield improvement. For instance, it is claimed that having knowledge of the nature of association between seed yield and its components can determine the appropriate characters to use in indirect selection for seed yield improvement (Siva Prasad *et al*. 2013). Therefore, correlation analysis can be use to understand the relationships existing between yield and yield components associated with it (Mukthar *et al*. 2011). This technique measures the degree of relationship existing between various plant characteristics; and as well predicts the plant characters that can be selected for sesame improvement with respect to associated complex character-yield (Gelalcha & Hanchinal 2013). In this regard, Azeez & Morakinyo (2011) reported that leaf nodes per plant, number of pods per plant, number of pods per main stem, breadth of pod, number of seeds per pod, 100-seed weight, and number of seeds per plant were positively correlated with seed yield of sesame. Though correlation analysis does not provide the exact knowledge and contribution made by a yield attribute, the use of path coefficient analysis has been suggested (Mukthar *et al*. 2011; Gelalcha & Hanchinal 2013). Path analysis is a technique use to determine the direct influence of one variable on another; and is also use to separate the correlation coefficient into direct effect (path coefficient) and indirect effects (effects exerted through other independent variables) (Azeez & Morakinyo, 2011). Furthermore, Gelalcha & Hanchinal (2013) noted that the concept of path analysis also measures the relative importance of causal factors which provide information for effective selection during crop improvement programme.

In view of the above, the objective of the present study was to assess the magnitude and nature of relationship between some weed, quantitative character and seed yield for sesame crop improvement.

2. Materials and Methods

2.1 Experimental Site

A field experiment was conducted during the rainy seasons of 2009, 2010 and 2011 at the Institute for Agricultural Research farm, Ahmadu Bello University, Samaru (Lat. 11° 11' N, Long. 7° 38' E, 686 m above sea level) in the northern Guinea savanna zone of Nigeria.

2.2 Treatments and Experimental Design

The treatments consisted of four seed rates (2, 4, 6 and 8 $kgha^{-1}$), four levels of nitrogen (0, 30, 60 and 90 kg ha^{-1}) and two sesame varieties (NCRIBEN-01M and E-8). Factorial combination of the treatments were arranged in a split–plot design and replicated three times. Seed and nitrogen rates were assigned to the main plot, while crop variety was assigned to the sub- plot. Gross plot size was 3.6 m x 4 m (14.4 m^2) consisting of six rows, and net plot size was 1.2 m x 4 m (4.8 m^2) consisting of two rows. An alley of 1 m and 0.7 m were left between the main plots and sub plots respectively. In each year, the land was ploughed and harrowed twice. The field was then levelled and marked out into flat seed beds, each of which constituted experimental plot.

2.3 Cultural Practices

Sesame seeds were dressed with Apron plus® (metalaxyl- M 20% w/w, difenoconazole 2% w/w, thiamethoxam 20% w/w) at the rate of 10 g per 4 kg of seed, prior to sowing to protect them from soil-borne pests and diseases. Sowing was manually done on a flat seed bed. The seeds were mixed with fine sand in 1: 4 proportions before drilling. Sesame seeds were sown by drilling in shallow trenches made at 60 cm spacing inter- row according to seed rate. No thinning was carried out. Sowing was done on 3 August, 2009; 29 July, 2010 and 26 July, 2011 respectively.

Basal dose of 6.54 kg ha^{-1} P (15 kg ha^{-1} P_2O_5) and 12.45 kg ha^{-1} K (15 kg ha^{-1} K_2O) was done and incorporated into the soil during land preparation in each year. Half of N was applied at sowing by banding, 5 cm away from the seed row and 5 cm depths, and according to treatment. The remaining half of N was applied at 4 WAS by drilling, 5 cm away from seed row (Anon. 2008). Urea (46% N), single super phosphate (18% P_2O_5) and muriate of potash (60% K_2O) were the fertilizers used. Manual weeding of the plots was carried out at 3 and 6 WAS using hand hoes.

The crop was harvested on 16^{th}, 11^{th} and 8^{th} of November, 2009, 2010 and 2011, respectively when the lower capsules turn from green to yellow; but before they open, as well as when the stems and leaves had turned yellow with a reddish tint on them and the leaves had begun to drop. All the plants in each net plot were harvested manually with the aid of a sickle by cutting at the base close to the ground, then immediately tied into sheaves to racks in an upright position and left there to adequately dry under the sun. Thereafter, threshing of the sesame plants was done by turning the plants upside down, on a tarpaulin and covered with the tarpaulin and then gently beaten with stick to separate all the seeds from the capsules. The seeds were separated from the chaff by winnowing, cleaned and weighed.

2.4 Observations and Data Collection

Weeds were harvested from two quadrat (0.25 m^{-2}) placed randomly in each plot at 9 WAS. The sum of all the species recorded at this sampling period in each plot was taken as the weed density. Weed samples from the same plots were bulked and oven dried at 70 ^{0}C to a constant weight to calculate weed dry matter. Data was also collected on plant height per plant, branches per plant, number of leaves per plant, crop dry weight per plant at 12 WAS. Other observations recorded were number of capsules per plant, seeds per capsule, 1000 – seed weight, seed oil content and seed yield ha^{-1} at harvest.

2.5 Statistical Analysis

The mean data collected were subjected to simple correlation analysis as described by Little & Hill (1978). The direct and indirect effects on and individual and combined (two factors) contributions of yield components to seed yield were determined using path analysis as described by Dewey & Lu (1959).

3. Results and Discussion

In the combined (2009 – 2011) years, with the exception of weed density and dry weight at 9 WAS, crop dry weight and seed oil content that negatively correlated with seed yield; all the growth characters measured correlated positively and significantly with seed yield (Table 1). The strongest relationship between a growth parameter and seed yield in the combined data was that recorded between seeds per capsule and seed yield (r = 0.8359**), which in turn was also the strongest relationship between any two growth parameters recorded in this study. The significant and positive correlations recorded between some growth characters; particularly plant height, branches, leaves, crop dry weight, capsules, seeds per capsule, 1000–seed weight, harvest index and seed yield suggest an inter–dependency between these characters as important yield determinants. This finding is in line with those of Muhamman *et al.* (2010), Tamina & Tapash (2011), and Haruna *et al.* (2012) who each reported significant and positive correlations between growth characters and final seed yield in sesame.

In the combined data with the exception of 1000 seed weight which was negative, the direct contribution of the other growth and yield components to seed yield measured were positive (Table 2). Seeds per capsule made the greatest direct effect on seed yield of sesame (0.6928), while the weakest direct effect was from 1000 seed weight (-0.0141). In the same vein, the highest combined indirect effect on seed yield was from seeds per capsule via 1000 seed weight (0.4327), while the effect of crop dry weight via 1000 seed weight (-0.0248) made the weakest contribution. The highest direct and indirect contribution to seed yield was made by seeds per capsule. The findings of this study also strongly emphasized that seeds per capsule made the greatest direct percent contribution to seed yield. This could be attributed to the fact that most of the assimilates produced were translocated to the sink (capsule) which bears the seeds (Haruna *et al*. 2012). This probably meant that sesame seed yield was dependent on number of seeds per capsule. This finding agreed with those of Ibrahim & Khidir (2012) and Azeez & Morakinyo (2011), who revealed that number of seeds per capsule among other yield attributes had the highest direct influence on seed yield per sesame plant.

Seeds per capsule made the highest percent contribution to seed yield (47.99 %) in the combined (2009 – 2011) years (Table 3). This was followed by branches (5.23 %) and capsules per plant (3.64 %). The greatest and positive combined contribution of 6.00 % was made by branches via seeds per capsule, followed by capsules per plant via seeds per capsule (5.54 %). The individual or combined percent contribution of two parameters to sesame seed yield showed that crop dry weight via seeds per capsule, and number of capsules via seeds per capsule made the highest contribution to seed yield. This probably could be attributed to the fact that the dry matter produced was translocated more to the developing seeds. In a similar finding, Haruna *et al*. (2012) reported that the highest percent contribution to seed yield in sesame was made by and via total dry matter. It is also established that yield and its components are polygenic and strongly affected by the environment as well as yet to be identified factors (Ibrahim & Khidir, 2012). This probably could have been responsible for the unaccounted effect or contribution to seed yield observed in this study.

4. Conclusion

Based on the results obtained from this study, it can be concluded that all the growth and yield characters measur ed contributed positively and significantly to seed yield, but negative with weed density and dry weights, crop dr y weight and seed oil content. The highest direct effect to seed yield was by seeds per capsule than any growth and yield attributes. The greatest direct effect and individual factor contribution were by seeds per capsule. The highest indirect effect was by seeds per capsule through 1000 – seed weight; while the highest combined contribution was by seeds per capsule through number of branches per plant. The overall result suggest that due consideration be given to these traits for improving the seed yield of sesame.

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Table 1. Correlation matrix between some growth and yield characters against seed yield in sesame due to the effect of variety, seed and nitrogen rates in the combined (2009 – 2011) rainy season at Samaru.

	1	2	3	4	5	6	7	8	9	10	11
2	0.8532**	1.0000									
3	-0.0843	-0.0753	1.0000								
4	-0.1900*	-0.2194*	0.1815*	1.0000							
5	0.0199	-0.0037	0.3029**	0.6323**	1.0000						
6	0.2450**	0.2263*	0.3377**	0.0106	0.3239**	1.0000					
7	-0.1714*	-0.1191*	0.4965**	0.3551**	0.2396**	0.0483	1.0000				
8	-0.5616**	-0.5383**	0.3361**	0.3792**	0.2035*	-0.2314**	0.4195**	1.0000			
9	-0.5373**	-0.4988**	0.1615	0.1416*	-0.1362*	-0.3882**	0.3207**	0.6247**	1.0000		
10	0.6257**	0.6227**	-0.0356	-0.21589	0.0163	0.3934**	-0.1437*	-0.5356**	-0.5538**	1.0000	
11	-0.4370**	-0.4080**	0.3861**	0.5578**	0.3628**	-0.0793	0.5611**	0.8359**	0.4874**	-0.4365**	1.0000

*: Significant at 5 % level of probability. **: Significant at 1 % level of probability.

1. Weed density at 9 WAS (no./0.50m^2)
2. Weed dry weight at 9 WAS (g/0.50m^2)
3. Plant height at 12 WAS (cm)
4. Branches per plant at 12 WAS
5. Leaves per plant at 12 WAS
6. Crop dry weight at 12 WAS (g/plant)
7. Capsules per plant
8. Seeds per capsule
9. 1000 seed weight (g)
10. Seed oil content (%)
11. Seed yield (kg /ha)

Table 2. The direct and indirect contribution of growth and yield component to seed yield (kg ha^{-1}) of sesame in the combined (2009 – 2011) rainy season at Samaru

	Effect through					
	Branches at 12 WAS	Crop dry weight at 12 WAS	Capsules per plant	Seeds per capsule	1000 seed weight	Total (y)
Branches at 12 WAS	**0.2287**	0.0007	0.0677	0.2627	-0.0020	0.5578
Crop dry weight at 12 WAS	0.0024	**0.0639**	0.0092	-0.1603	0.0055	-0.0793
Capsules per plant	0.0812	0.0031	**0.1907**	0.2906	-0.0045	0.5611
Seeds per capsule	0.0867	-0.0148	0.0800	**0.6928**	-0.0088	0.8359
1000 seed weight	0.0324	-0.0248	0.0612	0.4327	**-0.0141**	0.4874
Total	0.4314	0.0281	0.4088	1.5185	-0.0239	

Bold = direct effect

Table 3. Percent contribution of different growth and yield attributes of sesame to seed yield (kg ha^{-1}) in the combined (2009 – 2011) rainy season at Samaru.

Growth parameter	% contribution
Direct contribution	
Branches at 12 WAS	5.23
Crop dry weight at 12 WAS	0.41
Capsules per plant	3.64
Seeds per capsule	47.99
1000 seed weight	0.02
Combined contribution	
Branches at 12 WAS via Crop dry weight at 12 WAS	0.02
Branches at 12 WAS via Capsules per plant	1.55
Branches at 12 WAS via Seeds per capsule	6.00
Branches at 12 WAS via 1000 seed weight	-0.05
Crop dry weight at 12 WAS via Capsules per plant	0.06
Crop dry weight at 12 WAS via Seeds per capsules	-1.02
Crop dry weight at 12 WAS via 1000 seed weight	0.04
Capsules per plant via Seeds per capsule	5.54
Capsules per plant via 1000 seed weight	-0.08
Seeds per capsule via 1000 seed weight	-0.61
Residual	31.26
Total	100.00