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CORRELATION AND PATH COEFFICIENT ANALYSES OF FINGER MILLET (*Eleusine coracana* (L.) Gaertn) AT BAGAUDA IN SUDAN SAVANNA OF NIGERIA

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Abstract: This research was to determine the correlations between grain yield and yield components and to measure the direct and indirect effects of yield components on grain yield of finger millet by using correlation coefficient and path analysis methods, respectively. The research was conducted in the 2013 and 2014 rainy seasons, at the research farm of the National Institute for Horticulture Bagauda, Kano in the Sudan savanna ecology of Nigeria. The treatment consisted of three seed rates (3, 6 and 9 kg ha^{-1}), two sowing methods; broadcast and dibbling and poultry manure at 0, 2.5 and 5.0 t ha^{-1} and recommended NPK at (90:60:60 kg ha^{-1}). The experiment was laid out in a split-plot design with three replications. The combination of sowing method and poultry manure including NPK were allocated to the main plot, while seed rate in subplot. Agronomic traits such as grain yield, plant height, leaf area index, number of tillers per plant, crop growth rate, panicle length, number of fingers per plant productive tiller per plant, 1000 grain weigh, straw yield ha^{-1}, panicle yield ha^{-1} and weed parameters such as cumulative weed density and dry weight were determined. Correlation analysis indicated that the grain yield was positively and significantly associated with all the growth and yield characters evaluated but negatively correlated with the weed components. The highest correlation coefficients were found between grain yield and productive tillers per plant and between grain yield and harvest index. The partitioning of the total correlation into direct and indirect contribution showed that productive tillers per plant made greatest individual contribution to yield while productive tillers per plant via harvest index made the highest indirect percent contributions to grain yield of finger millet. Correlation and path analysis revealed that, productive tillers per plant and harvest index are the important yield contributing traits and due critical emphasis needs be given to these traits while selecting for grain yield improvement in finger millet.
Keyword: Correlation, finger millet, grain yield, poultry manure, sowing method.

Introduction

Community nutritional status has been recognized as an important indicator of national development. In other words, malnutrition is an impediment in national development and hence assumes the status of national problem. For solving the problem of food insecurity and malnutrition, dietary quality should be taken into consideration. Diversification of food production must be encouraged both at national and household level in tandem with increasing yields. Growing of traditional food crops suitable for the area is one of the possible potential successful approaches for improving household food security.

Finger millet is an important staple food in parts of eastern and central Africa and India. It is non acid forming food and easy to digest (Anon, 1996). It is considered to be one of the least allergic and most digestible grains available and is a warming grain so it helps to heat the body in cold or rainy season (Anon, 1996). Its grain is highly nutritious, richer in protein, fat and minerals especially calcium and iron compared to rice. It is one of the minor cereals known with several health benefits which are attributed to its high level of polyphenol, dietary fibre, minerals and essential amino acids (Vanderjagt *et al.*, 2007). Epidemiological studies have demonstrated that regular consumption of whole grain and their products can protect against the risk of cardio-vascular diseases, type II diabetes, obesity, gastro-intestinal cancers, anti-tumeregenic and atherosclerogenic effects, antioxidant and microbial properties, and a range of other disorders (McKeown, 2002).

The crop contains nutritionally important starch fractions which are easily digested and absorbed and are favourable in the diet pattern for metabolic disorders such as diabetes, hypertension, and obesity (Sharavathy *et al.*, 2001). Thacher *et al*. (2000) and Vanderjagt *et al.* (2007) reported that finger millet has been found to have high levels of methionine, tryptophan, vitamin B, fibre and minerals such as phosphorus, and iron and 40 times calcium level more than that found in maize (*Zea mays* L.) and rice (*Oryza sativa* L.), 10 times more than that found in wheat (*Triticum aestivum* L.). This makes the crop a good source of balanced diet formulations for diabetic patients, pregnant women, nursing mothers, children, people living with HIV and helps to sustain malnourished people (Vanderjagt *et al.* (2007). Malted millet is extensively used in weaning/infant food (Malleshi, 2005). The high level of iron and calcium content of finger millet has been found to be helpful to people of northern Nigeria where the incidence of iron deficiency causes aneamia, particularly in pregnant women (Vanderjagt *et al.* 2007), and calcium deficiency causes rickets in young children (Vanderjagt, 2001; Thacher *et al.*, 2000). Efforts should be made to educate people on the nutritive value and health benefits of finger millet and its food products.

The path coefficient analysis initially suggested by Wright (1921) and described by Dewey and Lu (1959) allows partitioning of path coefficient analysis into direct and indirect contributions (effects) of various traits towards dependent variable and thus helps in assessing the cause-effect relationship as well as effective selection. Hence, this study is aimed to analyse and determine the traits having interrelationship with grain yield in finger millet utilizing the correlation and path analysis. Therefore, the present investigation was undertaken to study the relative contribution of different yield attributes to grain yield and their interrelationship by estimating correlation, path analysis to assess the direct and indirect effect of component character on grain yield of finger millet.

Materials and Methods

Description of the study area

Field trials were conducted in 2013 and 2014 raining seasons, at National Institute for Horticulture, Bagauda (N 11.3712^0 8.2317^0 E, 500m above sea level), Kano State in the Sudan savanna ecology of Nigeria.

Treatments and experimental design

The treatments consisted of three seed rates at (3, 6, 9 kg ha^{-1}), two sowing methods (broadcasting, dibbling) and three poultry manure rates at [0, 2.5, 5.0 t ha^{-1}, NPK (90 kg N + 60 kg P_2O_5 + 60 kg K_2O ha^{-1})]. The experiment was laid out in a split plot design with three replications. A factorial combination of sowing method and poultry manure rate constituted the main plot, while seed rate occupied the subplots.

Cultural practices

The land was harrowed twice to obtained fine soil texture and made into beds. Poultry manure was applied two weeks prior to sowing on the 20^{th} July, 2013 and 9^{th} June, 2014. Seeds were mixed with fine sand at a ratio of 1:4 and sown manually. Dibbling was done at 20 x 10 cm inter and intra-row spacing, respectively. NPK fertilizer at the rate of 90 kg N, 60 kg P and 60 kg K ha^{-1}, was applied by broadcasting. The N was applied in two equal split doses; at 3 WAS. NPK fertilizer (15-15-15) was used to supply P, K and half of N requirements. The second half dose of N, was top dressed at 6 WAS using urea (46% N). Manual weeding was carried out at 3 and 6 WAS. All other agronomic practices were executed as at when due. Harvesting was done on the 12^{th} December, 2013 and 02^{th} December, 2014, respectively, when the crop has attained a physiological maturity. Harvesting was done by cutting the mature heads with a sharp knife and dried for 3 days before threshing using pestle and wooden mortar and winnowed to remove the straws, foreign materials and unfilled grains.

Data collection

Data were recorded on cumulative weed density, cumulative dry weight, plant height, leaf area per plant, number of tillers per plant, crop growth rate, panicle length, number of fingers per plant, productive tiller per plant, 1000 grain weight, straw yield ha^{-1}, panicle yield per hectare and grain yield per hectare.

Statistical analysis

The magnitude and type of relationship between the various parameters measured was determined using simple correlation analysis (Little and Hills, 1978). The direct and indirect individual contribution of some important growth and yield attributes to grain yield were determined using path coefficient analysis according to Dewey and Lu (1959).

Result and Discussions

Correlation analysis

The relationship between grain yield, and weed growth, crop growth and yield attributes of finger millet in the two-year means is presented on Tables 1. The positive and highly significant correlations were observed between grain yield and plant height, leaf area $plant^{-1}$, crop growth rate, number of productive tillers $plant^{-1}$, panicle length, number of fingers $panicle^{-1}$, harvest index, 1000 -grain weight, straw yield ha^{-1} and panicle yield ha^{-1}. On the other hand, grain yield was not correlated with cumulative weed dry weight or cumulative weed density. The highest correlation was recorded between grain yield and number of productive tiller $plant^{-1}$ and the lowest between cumulative weed density and panicle length.

Table 1: Matrix of correlation coefficients of two-year means of grain yield, weed growth, crop growth and yield components at Bagauda in 2013 and 2014 wet seasons

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.000												
2	0.303**	1.000											
3	-0.051	-0.144	1.000										
4	0.184	-0.098	0.072	1.000									
5	-0.070	0.162	0.410**	0.062	1.000								
6	-0.089	-0.500**	0.153	0.132	0.468**	1.000							
7	-0.006	0.0910	0.267**	0.298**	0.140	0.205	1.000						
8	-0.122	-0.321**	0.230**	0.310**	0.194*	0.057	0.053	1.000					
9	-0.026	-0.108	0.517**	0.635**	0.382**	0.471**	0.274**	0.341**	1.000				
10	-0.084	-0.161	0.549**	0.390**	0.285**	0.193*	0.195*	0.493**	0.489**	1.000			
11	-0.105	-0.106	0.029	0.595**	0.054	0.118	0.263**	0.249**	0.480**	0.426**	1.000		
12	-0.237*	-0.165	0.324**	0.599**	0.344**	0.315**	0.206*	0.411**	0.529**	0.356**	0.433**	1.000	
13	-0.082	-0.086	0.685**	0.779**	0.378**	0.895**	0.250**	0.525**	0.750**	0.474**	0.543**	0.663**	1.000

Df =n-2= (70); * significant at $P \leq 0.05$; ** significant at $P \leq 0.01$; 1. Cumulative weed dry weight; 2. Cumulative weed density; 3. Plant Height; 4. Leaf Area $plant^{-1}$; 5. Crop Growth Rate; 6. Productive tiller $plant^{-1}$; 7. Number of fingers $panicle^{-1}$; 8. Panicle length $plant^{-1}$; 9. Harvest Index; 10. 1000-grain weigh; 11. Straw yield ha^{-1}; 12. Panicle weight ha^{-1}; 13. Grain yield ha^{-1}

The significant and highly positive correlations of grain yield, growth and yield characters indicates the importance of these characters in net assimilate production and partitioning to grain yield in finger millet. Such consistent and similar trend in all the seasons at both locations shows that those characters are very important yield-contributing characters in finger millet. These traits determine the efficiency in diverting assimilates to grain yield. This result is in conformity with findings of Sarmezy (1987) who reported that yield was correlated positively and significantly with the selected growth parameters of finger millet. However, cumulative weed dry weight and weed density correlated negatively with the yield. This indicates that weed infestation critically reduced grain yield of finger millet due to competition for growth factors such as light, nutrients and moisture, Gani (2012) and Bulus (2002) obtained negative correlation of weed dry weight and grain yield in finger millet.

Direct and indirect effects of growth and yield attributes on grain yield of finger millet

The direct and indirect effects of different growth and yield component on grain yield ha^{-1} in 2013, 2014 and their two-year mean are presented in Table 2. In 2013, the greatest direct positive effect on grain yield was from the number of productive tillers plant^{-1}, followed by panicle yield ha^{-1}, harvest index, 1000-grain weight and straw yield ha^{-1}. Plant height and panicle length had a direct negative effect on grain yield. The highest positive indirect effect on grain yield was from number of productive tillers plant^{-1} via harvest index. The least indirect effect on grain yield was from plant height via harvest index. All the indirect effects on grain yield through plant height and panicle length were negative.

In 2014, the number of productive tillers plant^{-1} had the highest direct effect on yield, followed by harvest index, panicle yield ha^{-1}, 1000-grain weight, plant height and straw yield ha^{-1} while panicle length had the least and negative direct effect on grain yield. The highest indirect effect on grain yield was through harvest index via number of productive tillers plant^{-1}. The indirect effect of panicle length via 1000-grain weight made the least contribution to grain yield. However, all the indirect effects of panicle on grain yield were negative. With respect to the two-year means, the highest direct effect on grain yield was recorded from the number of productive tillers plant^{-1}, followed by panicle weight ha^{-1}, harvest index, 1000-grain weight and straw yield ha^{-1}. Negative direct effects obtained from plant height and panicle length. The number of productive tillers plant^{-1} had the highest combined indirect contribution to grain yield via harvest index, while the lowest combined contribution was recorded from plant height via harvest index.

Table 2: Direct and indirect contribution of growth and yield components to grain yield in 2013 and 2014 wet seasons and in two-year means at Bagauda

Yield Attributes	Effect Through							
	Plant Height	Harvest Index	Productive Tillers plant^{-1}	1000-Grain Weight	panicle length plant^{-1}	Panicle Yield ha^{-1}	Straw Yield ha^{-1}	Total Correlation
2013								
Plant Height	**-0.0856***	0.1967	0.4853	0.0181	-0.0647	0.1687	0.0446	0.7631
Harvest Index	-0.1181	**0.1426***	0.5177	0.0238	-0.0747	0.1346	0.0352	0.6660
Productive Tillers plant^{-1}	-0.1021	0.1594	**0.5988***	0.0358	-0.0532	0.1400	0.0458	0.8248
1000-Grain Weight	-0.0267	0.0338	0.2035	**0.1052***	-0.0091	0.0645	0.0226	0.3940
Panicle Length	-0.0443	0.1639	0.2098	0.0048	**-0.1991***	0.1632	0.0057	0.3042
Panicle Yield ha^{-1}	-0.0651	0.1358	0.3435	0.0278	-0.0922	**0.2443***	0.0269	0.6210
Straw Yield ha^{-1}	-0.0620	0.1308	0.4092	0.0355	-0.0170	0.0982	**0.0670***	0.6618
2014								
Plant Height	**0.0167***	0.1503	0.2980	0.0290	-0.0078	0.1257	0.0002	0.6121
Harvest Index	0.0110	**0.2538***	0.3880	0.0442	-0.0093	0.1370	0.0011	0.8258
Productive Tillers plant^{-1}	0.0112	0.2144	**0.5297***	0.0322	-0.0129	0.1884	0.0015	0.9640
1000-Grain Weight	0.0072	0.1740	0.2324	**0.0226***	-0.0181	0.1344	0.0013	0.5539
Panicle Length	0.0099	0.1810	0.3440	0.0315	**-0.0124***	0.1588	0.0021	0.7150
Panicle Yield ha^{-1}	0.0094	0.1648	0.3718	0.0324	-0.0079	**0.1322***	0.0022	0.7049
Straw Yield ha^{-1}	0.0003	0.1552	0.3208	0.0049	-0.0025	0.1294	**0.0100***	0.4178
Mean								
Plant Height	**-0.03444***	0.1735	0.3069	0.0236	-0.0363	0.1472	0.0224	0.6875
Harvest Index	-0.0535	**0.1785***	0.453	0.0340	-0.0420	0.1358	0.0363	0.7499
Productive Tillers plant^{-1}	-0.0455	0.1869	**0.5644***	0.0340	-0.0326	0.1643	0.0237	0.8944
1000-Grain Weight	-0.0097	0.1039	0.2180	**0.1278***	-0.0135	0.0995	0.0120	0.4734
Panicle Length	-0.0172	0.1225	0.2519	0.0182	**-0.1057***	0.1360	0.0039	0.5096
Panicle Yield ha^{-1}	-0.0278	0.1504	0.3077	0.1031	-0.0501	**0.1883***	0.0146	0.6630
Straw Yield ha^{-1}	-0.0308	0.0930	0.2650	0.0202	-0.0098	0.0638	**0.0383***	0.5398

*** = Direct effect**

Path-coefficient and percent contribution

Table 3 shows the percent contributions of individual and combined contribution of some growth and yield attributes of finger millet in 2013, 2014 and in their two-year mean. The results in 2013, 2014 and the means indicated that the highest individual percent contribution to grain yield was made by the number of productive tillers plant^{-1}, followed by panicle yield plant^{-1}, harvest index, straw yield, 1000-grain weight, panicle length and plant height. Harvest index made the highest positive combined contribution to grain yield via the number of productive tillers plant^{-1} in 2013, 2014 and in the mean, while the least was obtained from panicle length via panicle yield. The percent contribution to grain yield unaccounted for was highest in the means, followed by 2013 and 2014. In this study, the highest direct and indirect contributions of productive tillers plant^{-1} and harvest index to grain yield of finger millet, suggests that this crop has efficiency for partitioning dry matter into effective tiller production and grain yield.

Table 3: Percentage contribution of different growth and yield attributes of finger millet to grain yield in 2013 and 2014 wet seasons and in the two-year means at Bagauda

Treatment	2013	2014	Mean
Individual Contribution			
Plant Height	1.87	0.03	0.95

Harvest Index	6.39	10.20	8.30
Productive Tillers plant^{-1}	19.86	15.55	17.71
1000-Grain Weight	1.11	2.03	1.57
Panicle Length	1.97	2.44	2.21
Panicle yield	8.97	3.06	6.02
Straw Yield	3.45	5.01	4.23
Combined Contribution			
Plant Height via Harvest Index	0.68	0.56	0.62
Plant Height via Productive Tillers plant^{-1}	0.09	0.42	0.26
Plant Height via 1000-Grain Weight	0.71	-0.03	0.34
Plant Height via Panicle Length plant^{-1}	-2.54	0.50	-1.02
Plant Height via Panicle Yield ha^{-1}	1.64	1.00	1.32
Plant Height via Straw Yield	1.75	0.01	0.88
Harvest Index via Productive Tillers plant^{-1}	30.00	33.21	31.61
Harvest Index via 1000-Grain Weight	-0.56	-0.08	-0.32
Harvest Index via Panicle Length	1.76	1.60	1.68
Harvest Index via Panicle Yield ha^{-1}	6.18	8.43	7.31
Harvest Index via Straw Yield ha^{-1}	-0.83	0.01	-0.41
Productive Tillers plant^{-1}via 1000-Grain Weight	1.28	1.85	1.57
Productive Tillers plant^{-1} via Panicle Length	1.37	1.06	1.22
Productive Tillers plant^{-1} via Panicle Yield ha^{-1}	2.78	2.01	2.40
Productive Tillers plant^{-1} via Straw Yield ha^{-1}	1.49	3.06	2.28
1000-Grain Weight via Panicle Length	-0.19	-0.63	-0.41
1000-Grain Weight via Panicle Yield ha^{-1}	1.36	-0.84	0.26
1000-Grain Weight via Straw Yield ha^{-1}	0.48	-0.01	0.24
Panicle Length via Panicle Yield ha^{-1}	-4.51	-2.46	-3.49
Panicle Length via Straw Yield ha^{-1}	-0.23	0.11	-0.06
Panicle Yield ha^{-1} via Straw Yield ha^{-1}	1.32	0.23	0.78
Residual	11.35	10.80	11.98
Total	**100.00**	**100.00**	**100.00**

This finding is in agreement with the report of several studies: Kumar *et al.* (2014) obtained maximum positive direct effects of productive tillers plant^{-1} (2.850), biological yield (1.248), harvest index (0.867), number of fingers/ear (0.404), plant height (0.037), and days to 50% flowering (0.021) to grain yield. Ganapathy*et al.* (2011) reported that productive tillers per plant and finger length are the important yield-contributing traits in finger millet and therefore appropriate critical emphasis needs be given to productive tillers plant^{-1} and finger length while selecting for grain yield improvement. This finding is supported by that of Sumathi *et al.* (2006) who reported that number of productive tillers plant^{-1} was the most important yield-contributing character and needed to be considered while selecting character in finger millet breeding programme.

Conclusion

In conclusion, productive tillers plant^{-1} and harvest index could be used as a selection criterion due to its highly positive direct effect on grain yield also indirect effects on all other characters as selection criteria in finger millet breeding.

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