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Correlation and Path Coefficient Analysis for Leaf Yield and Related Traits in Ethiopian Kale (Brassica Carinata A.) Accessions

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Abstract

The cultivation of Ethiopian Kale in Ethiopia is an old practice, primarily as leafy vegetable and for oil in the seeds. It is necessary to take important measure to improve the production potential of domestic source. The knowledge of the association between various yield components and yield is paramount important for effective selection in crop improvement. The present study was carried out to assess the extent of correlation between yield and yield related traits and determine the direct and indirect contribution of traits. Forty nine Ethiopian Kale accession were evaluated at Debre zeit Agricultural research center using 7 × 7 simple lattice design in 2017/18 cropping season. The results from correlation study showed that Leaf yield had positive and significant correlation with number of leaves per plant, leaf fresh weight per plant, leaf dry matter content, days to first leaf picking and days to second leaf picking both at genotypic and phenotypic levels indicating that those traits as a selection criteria could be an effective way to improve yield. Path coefficient analysis revealed positive and direct effect of days to first leaf picking, leaf fresh weight per plant, leaf dry matter content and number of leaves per plant on yield, indicating the true relationship between this traits which should be given prior attention aimed at the improvement of leaf yield of Ethiopian kale.

Keywords: Correlation coefficient; Leaf yield; Brassica; Path coefficient; Association

Introduction

Ethiopian kale (B. carinata A. Braun) is amphidiploid which is originated from cross between Brassica nigra (n=8) and Brassica oleracea (n=9) [1]. Ethiopian kale is a conventional African vegetable, previously collected from the wild for human consumption [2]. It is self-pollinating amphidiploids species, under open field conditions, an average of 30% out-crossing may result from pollination by wind and/ or insects [3]. It is cultivated primarily as leafy vegetable and for oil in the seeds, annual, occasionally biennial and branched, glabrous to slightly hairy at stem and petiole bases, leaves are alternate and simple. It can adapt to highland areas, with cool climate [4].

The species is only found under cultivation, mainly in Ethiopia and surrounding countries [5]. It is cultivated as an option to the other mustard especially for low rainfall areas of the world [6]. It is found exclusively in Ethiopia but, recently it has been cultivated in Zambia, Sera Leon, Guinea, India, China, Bangladeshi, Indonesia Eastern Europe and U.S.A. [7]. In the Ethiopian highlands it is cultivation mostly exercised by small farmers in more fertile and well drained fields, usually around homesteads [2, 8].

At earlier stages of development, the leaves and shoots of the crop are consumed as vegetable either by thinning or topping and seed can also be harvested from the plant for oil extraction and other traditional uses for a range of non-edible applications, such as greasing traditional Enjera and bread-baking (clay pan), curing diseases, lubricants, plasticizers and detergent ingredients. For the small-scale farmers, it is a food security crop, because it is a source of food and income during shortages that mostly occurs at middle of main rainy season. It is the only crop that can be consumed by defoliating its leaves or sold to generate income after a month of sowing [9, 10]. Those selected for their vegetables are often quite robust with thick stems and have large leaves and known to flower very late or none at all [11].

As it is neither a major cash crop nor an export crop, at the national level their importance is usually overlooked and unappreciated. The more alarming indication is that the gap between production and consumption is increasing day by day. The production potential of green kale is not exploited and is still insufficient even to meet the demands of the people. The development of high yielding brassica genotypes needs serious attention for improvement to overcome the shortage [12]. Genetic improvement could contribute significant to improve the situation. It is necessary to take important measure to improve the production potential of domestic source. The improvement through breeding can be made successful by knowing the exact contribution of yield and its components.

Correlation between various characters is of great value as it indicates the degree to which various characters of a plant are associated with the economic productivity [13]. The association between two characters can be directly observed as phenotypic correlation, while genotypic correlation expresses the extent to which two traits are genetically associated [14]. Both genotypic and phenotypic correlations among and between pairs of agronomic traits provide scope for indirect selection in a crop breeding program [15]. Thus, path-coefficient analysis is one of the reliable statistical techniques which, allow quantifying the interrelations of different components and their direct and indirect effects on yield through correlation estimates [16]. Therefore, correlation in combination with path coefficient analysis will be an important tool to find out the association and quantify the direct and indirect influence of one character upon another [17]. Considering the above facts the present study has been undertaken with the following objectives: to estimate the extent of correlation between traits

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at phenotypic and genotypic level, and to determine the direct and indirect effects of traits on vegetable yield.

Materials and Methods

This experiment was conducted at the Field Experimentation of Debre Zeit Agricultural Research Centre (DZARC) throughout the main cropping season of 2017/2018 under rain fed conditions. The location of Debre Zeit Agricultural Research Centre is at 08^0 44'N latitude and 38^{0}58'E longitude at an altitude of 1860 masl. The area has minimum and maximum temperature of 19.03 and 26.91^{0}C respectively, annually and it receives average annual rainfall of 851mm. The soil type of the center is classified as black soil (Vertisol) and light soil.

Forty nine Ethiopian kale accessions including one local check were grown in a simple lattice design. The materials were transplanted a 7x7 simple lattice design and seven accessions were assigned into each incomplete block, using 2 m long x 2 m wide plot. The spacing between replications, incomplete blocks and plots were 2m, 1m and 50cm, respectively. Spacing between rows and plants were 50 cm and 30 cm, respectively. All recommended management practices were followed during the crop season. Plant height, Plant Canopy Width, Leaf fresh weight, Leaf dry matter content, Fresh biomass, Number of leaves per plant, Leaf length, Leaf width, Leaf Petiole length, Leaf petiole thickness, Leaf area, Days to first leaf picking, Days to second leaf picking and Leaf yield **per hectare** were collected on fourteen traits on plot basis, and from randomly taken five plants from the two central rows of each plot. The data collected for each quantitative trait were subjected to the analysis of variance (ANOVA). Phenotypic and genotypic correlations were estimated using the method described by [18] and Path coefficient analysis were computed using the formula suggested by [17].

Statistical analysis

Association of characters and path coefficient analysis

Phenotypic and genotypic correlation coefficient analysis

Phenotypic and genotypic correlations were estimated using the method described by [18].

$$rp_{xy} = \frac{covp_{xy}}{\sqrt{V_{px}.V_{py}}}$$

Where: rpxy = phenotypic correlation coefficient between character x and y,

Covpxy = Phenotypic covariance between character x and y,

Vpx = Phenotypic variance for character x and

Vpy = Phenotypic variance for character y.

$$rg_{xy} = \frac{cov\,g_{xy}}{\sqrt{V_{gx}.V_{gy}}}$$

Where: rgxy = Genotypic correlation coefficient between character x and y,

Covgxy = Genotypic covariance between character x and y,

Vgx= Genotypic variance for character x and

Vgy = Genotypic variance for character y.

Genotypic correlation coefficient was tested with the following formula suggested by [19].

$$t = \frac{rg_{xy}}{SEg_{xy}}$$

The calculated 't' value was compared with the tabulated 't' value at g-2 degree of freedom at 1 and 5% level of significance, where, g = number of genotypes

Phenotypic and genotypic path coefficient analysis

Path coefficient analysis was computed using the formula suggested by [17];

$$Rij = p_{ij} + \sum r_{ik} pk_j$$

Where:

R_{ij} = Mutual association between the independent character (i) and dependent character, Grain yield (j) as measured by the correlation coefficients.

P_{ij} = Components of direct effects of the independent character (i) as measured by the

Path coefficients and

$\Sigma R_{ik}P_{kj}$ = summation of components of indirect effect of a given independent character

i on a given dependent character (j) via all other independent characters (k).

The residual effect $(h) = \sqrt{1 - R^2}$

Where: $R^2 = \Sigma rijpij$

Results and Discussion

Association among traits

In the present study, the genotypic and phenotypic correlation coefficient between all possible pairs of the traits were estimated, then partitioned into direct and indirect effect using path coefficient analysis and presented in.

Correlation of yield with other characters at phenotypic and genotypic level

The genotypic and phenotypic correlations among the fourteen characters are presented in. At phenotypic level, number of leaves per plant, leaf fresh weight, leaf dry matter content, leaf petiole length, days to first leaf picking and second leaf picking exhibited positive and significant association with leaf yield ha^{-1}. Leaf fresh weight and leaf dry matter content displayed highly significant and positive correlation with leaf yield ha^{-1} (0.70).The present study is consistent with the results reported by [20], who evaluated seventeen genotypes of Amaranthus (Amaranthus tricolor L.) and revealed that green yield was positively correlated with leaf weight and dry weight. [21] Evaluated Amaranthus and revealed that yield per plant showed moderate and positive correlation with leaf width.

Highly significant and negative associations were obtained for leaf petiole thickness (-0.34) and leaf yield with leaf width (-0.27). These results indicated that any increase in these traits could result in decrease in leaf yield ha^{-1}. Presence of thick leaf petiole accessions is important to overcome mechanical damage. However, too much thickness leads to high accumulation of photosynthates in the petiole and finally ends up with low leaf yield. Therefore, selection for thin to medium petiole thickness in Ethiopian kale accessions could be effective in increasing leaf yield in the study area. Negative correlation coefficient of leaf width with leaf yield indicates that the widest leaf in Ethiopian kale reduces the leaf yield, due to decrease in number of leaf per plant.

A positive and significant genotypic association was found between leaf yield per hectare and leaf fresh weight per plant (0.72**), leaf dry matter content (0.72**), days to first leaf picking (0.65**), days to second leaf picking (0.40**), number of leaves per plant (0.39**) and leaf petiole length (0.27*), which indicates that considering those trait as a selection criteria could be an effective way to increase yield. The positive genotypic correlation of yield with other component traits indicated that increase in one of the trait will result in increasing of the correlated trait. This result of such genotypic correlation could possibly from pleiotropic effect or linkage of gene governing inheritance of these traits. Therefore, priority should be given to these traits together, for leaf yield improvement. Similar results were reported by [22] on Amaranthus foliage yield per plant which recorded positive and significant correlation with leaf weight per plant and leaf width. According to [23], leaf yield per plant exhibited significant positive correlation with number of leaves per plant and leaf weight. [24] Conducted experiment on Swiss chard genotypes and reported positive correlation of leaf weight, petiole length and petiole thickness with leaf yield.

Negative and highly significant correlation of yield were found with leaf petiole thickness (-0.37) and leaf width (-0.29). It indicated that increase in one of the trait will result in decrease the negatively correlated trait. Therefore, the improvement through breeding could be made successfully, by selecting the genetic material after determining the exact contribution of various components towards yield.

Correlation among yield related traits at phenotypic and genotypic levels

Plant height displayed non-significant phenotypic correlation with all other component traits, except with biomass (0.25) which shows highly significant and positive association **(Table 1).** These result emphasized that as plant height increases, biomass also ultimately increases. Number of leaves per plant had highly significant and positive correlation with leaf dry matter content (0.61), leaf fresh weight (0.44) and leaf petiole length (0.38) at phenotypic level, revealing that with the increase in number of leaves per plant will also increase leaf fresh weight, leaf dry matter content and leaf petiole length proportionately. Negative and significant phenotypic correlation with petiole thickness (-0.77**), width (-0.72**), leaf area (-0.62*) and leaf length (-0.43*). At genotypic level number of leaves per plant exhibited highly significant and positive correlation with leaf dry matter content (0.62), leaf fresh weight (0.44) and leaf petiole length (0.41), and highly significant and negative association with leaf petiole thickness (-0.82), leaf width (-0.78), leaf area (-0.70), leaf length (-0.54) and biomass (-0.38).

Leaf fresh weight displayed highly significant and positive phenotypic association with leaf dry matter content (0.85), days to first leaf picking (0.54), leaf petiole length (0.51), leaf length (0.28) and days to second leaf picking (0.27), and negative association with leaf width (-0.33**) and leaf petiole thickness (-0.21*). Leaf fresh weight showed significant and positive genotypic association with leaf dry matter content (0.85**), days to first leaf picking (0.60**), leaf petiole length (0.55**), days to second leaf picking (0.42**), and leaf length (0.29*), and significant and negative association with leaf width (-0.37**). Days to first leaf picking had significant and positive phenotypic correlation with days to second leaf picking (0.56**). Association between days to first leaf picking and days to second leaf picking (0.81**) was highly significant and positive. Days to second leaf picking had significant and positive phenotypic and genotypic correlation with biomass (0.21**) and (0.3*), respectively.

Table 1: List of experimental material used for the study.

No	Sample/ coll. Number	Region	Zone	Genotypes
1	EK-002	Oromia	Guji	Landrace
2	EK-003	Oromia	Guji	Landrace
3	EK-004	Oromia	Guji	Landrace
4	EK-005	Oromia	Guji	Landrace
5	EK-006	Oromia	Guji	Landrace
6	EK-007	Oromia	Guji	Landrace
7	EK-012	Oromia	Guji	Landrace
8	EK-018	SNNPR	Sidama	Landrace
9	EK-020	SNNPR	Sidama	Landrace
10	EK-021	SNNPR	Sidama	Landrace
11	EK-022	SNNPR	Sidama	Landrace
12	EK-024	SNNPR	Sidama	Landrace
13	EK-027	SNNPR	Sidama	Landrace
14	EK-028	SNNPR	Sidama	Landrace
15	EK-033	SNNPR	Sidama	Landrace
16	EK-034	SNNPR	Sidama	Landrace
17	EK-035	SNNPR	Sidama	Landrace
18	EK-036	SNNPR	Sidama	Landrace
19	EK-038	SNNPR	Sidama	Landrace
20	EK-039	SNNPR	Sidama	Landrace
21	EK-040	SNNPR	Sidama	Landrace
22	EK-041	SNNPR	Sidama	Landrace
23	EK-042	SNNPR	Sidama	Landrace
24	EK-043	SNNPR	Sidama	Landrace
25	EK-044	SNNPR	Sidama	Landrace
26	EK-046	SNNPR	Sidama	Landrace
27	EK-047	SNNPR	Gedeo	Landrace
28	EK-048	SNNPR	Gedeo	Landrace
29	EK-051	SNNPR	Gedeo	Landrace
30	EK-052	SNNPR	Gedeo	Landrace
31	EK-053	SNNPR	Gedeo	Landrace
32	EK-054	SNNPR	Gedeo	Landrace
33	EK-056	SNNPR	Gedeo	Landrace
34	EK-057	SNNPR	Gurage	Landrace
35	EK-058	SNNPR	Gurage	Landrace
36	EK-059	SNNPR	Gurage	Landrace
37	EK-060	SNNPR	Gurage	Landrace
38	EK-061	SNNPR	Gurage	Landrace
39	EK-062	SNNPR	Gurage	Landrace
40	EK-063	SNNPR	Gurage	Landrace
41	EK-064	SNNPR	Gurage	Landrace
42	EK-066	SNNPR	Gurage	Landrace
43	EK-067	SNNPR	Gurage	Landrace
44	EK-069	SNNPR	Gurage	Landrace
45	EK-070	SNNPR	Gurage	Landrace
46	EK-074	SNNPR	Gurage	Landrace
47	EK-075	SNNPR	Gurage	Landrace
48	EK-076	SNNPR	Gurage	Landrace
49	EK-081	Oromia	E/Shoa	Local check

Path coefficient analysis

Path coefficient analysis at phenotypic level

Traits that showed significant correlation with leaf yield ha^{-1} were advanced to path coefficient analysis at both phenotypic and genotypic levels. phenotypic path coefficient analysis for yield and yield component revealed, positive direct effect of leaf dry matter content (0.39), days to first leaf picking (0.29), leaf fresh weight (0.28) and number of leaves per plant (0.03). Positive direct effects of these traits indicated true relationship between this trait and importance in determining this complex character and should be given prior attention in practicing selection aimed at the improvement of leaf yield of Ethiopian kale, because of major influence on leaf yield. [22] Reported that leaf weight per plant had the highest positive direct effect on yield which is in agreement with the present study.

Leaf petiole length (-0.12) and days to second leaf picking (-0.08) exerted negative direct effect on leaf yield ha^{-1}. In such situations, direct selection for accessions that tallest leaf petiole length and took long time to second leaf harvest might be ineffective for leaf yield improvement in Ethiopian kale accessions. Similar finding was reported in Indian Spinach petiole length that exhibited negative direct effect on total plant vegetable yield [25].

The indirect exertion of number of leaves per plant on leaf yield was positive for leaf dry matter content (0.24), leaf fresh weight (0.12), days to first leaf harvest (0.03) and days to second leaf harvest (0.003). While negative for leaf petiole length (-0.05). Therefore, along with number of leaves per plant, indirect selection for high leaf fresh weight, high leaf dry matter content, long time to first and second leaf harvest and also short leaf petiole length might be considered simultaneously, during in the process of selection for leaf yield improvement program in Ethiopian kale accessions. The current findings suggested that improvement of leaf yield of Ethiopian kale through selection could be achieved through direct selection for positively contributed component traits to leaf yield.

Path coefficient analysis at genotypic level

Genotypic path coefficient analysis indicated that days to first leaf picking showed the maximum positive direct effect (0.58) and significant genotypic correlation (0.65**) with leaf yield. High direct effects of these traits give the impression to be the main factor for their strong relationship with yield and should be considered as important trait improvement via direct selection. The least but positive and direct effect of number of leaves per plant (0.04) on yield could be compensated via the high and positive indirect effect of leaf dry matter content (0.22), leaf fresh weight (0.07), days to first leaf picking (0.05) and days to second leaf picking (0.01). Thus, considering number of leaves per plant alone as the most important direct yield component might be ineffective in improvement program. Therefore, from the present genotypic path coefficient analysis, traits like, number of leaves per plant, leaf fresh weight, leaf dry matter content and days to first leaf picking had positive direct effect on yield, which indicate considering of this trait during selection of genotype would be more rewarding to evolve potential varieties of Ethiopian kale. Similarly [23] reported maximum positive direct effect of number of leaf per plant (0.72) followed by average leaf weight (0.67) and days to first picking (0.44) on leaf yield per plant.

Days to second leaf picking exerted negative direct effect on yield. This indicates that, selection for early to medium days to second harvest accessions might lead to high leaf yield in Ethiopian kale accessions that helps to minimize pest damage. It has negative direct effect and it also expressed negative indirect effect on leaf yield through leaf weight (-0.10), leaf dry matter content (-0.08) and days to first leaf picking (-0.20).

Conclusion and Recommendation

Traits that showed positive direct effect as well as positive and significant correlation coefficient with yield were known to affect yield to the favorable direction. The present study revealed that days to first leaf picking, leaf fresh weight per plant, leaf dry matter content and number of leaves per plant on yield had the highest contribution in determining leaf yield. Maximum positive effect of days to first leaf picking and leaf dry matter content on leaf yield coupled with relatively strong and positive value of genotypic correlation suggested that direct selection for this trait would be effective for selecting for high yielding Ethiopian Kale. Likewise, correlation and path coefficient studies also showed that Days to second leaf picking and leaf petiole length are also much use to plant breeders for selection and breeding genotypes with increased yield potential.

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