Vol. 15(8), pp. 250-256, August 2021
DOI: 10.5897/AJPS2021.2156
Article Number: CDBB32367636
ISSN 1996-0824

http://www.academicjournals.org/AJPS

African Journal of Plant Science

Full Length Research Paper

Correlation and path coefficient analysis studies in Ethiopian Mustard (*Brassica carinata* A. Braun)

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Received 3 May, 2021; Accepted 20 July, 2021

Ethiopia is the center of origin for Ethiopian mustard (*Brassica carinata*). The crop is one of the oldest oil crops and farmers in the highlands of the country grow as a leafy vegetable in their gardens. However, no attempt has been made to assess the association of characters and path analysis in Ethiopian mustard leaf. This study was conducted to assess association of traits among leafy vegetable yield and yield related traits and to determine the direct and indirect effects of the traits. A total of 36 Ethiopian mustard genotypes were evaluated at Holleta in 2017/2018. The results from correlation study showed that the genotypic correlation coefficient among edible vegetable leaf yield as well as all of agro-morphological qualities was positive and significant apart from leaves per plant and leaf width ratio to length. Length of leaf petiole, leaf length, leaf width, petiole width and plant height had positive and highly significant correlation with edible vegetable leaf yield both at levels of genotypic and phenotypic. These traits also had indirect positive effect on yield either though each other or via other traits at genotypic level. The strong association of these traits with leaf yield, the high to low effects of direct and indirect through other traits at level of genotypic for these traits is an indication of the importance of the traits to use in Ethiopian mustard genotypes for high edible vegetable leaf yield selection.

Key words: Correlation, direct, indirect and edible vegetable leaf yield.

INTRODUCTION

The genus *Brassica* is one of the fifty-one genera, and the foremost economically important genus, in the Brassicaceae family, or previously known as Cruciferae (an older name for the family). It means "cross-bearing," because the 4 petals of their flowers are reminiscent of a cross). The genus *Brassica* contains 37 distinctive species (Gomez-Campo and Prakash, 1999). Several species and of Brassicas are significant oilseed crops, vegetables, forage crops, and are utilized in the production of condiments, such as mustard (Nagaharu, 1935). Ethiopian mustard is believed to have originated from the Ethiopian highlands, and its cultivation is thought to have begun about 4000 years B.C. (Schippers, 2000; Nigussie and Becker, 2002).

In plant genetic and breeding sciences, correlated traits are of top significance due to genetic causes of correlations through pleiotropic action, or gene developmental interactions; as well as changes brought

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about by natural or artificial selection (Singh, 1993; Falconer and Mackay, 1996; Sharma, 1998). A clear delineation of direct and indirect effects of interaction among traits upon each other in some conditions was not realized using correlation alone; therefore, use of coefficient of path evaluation is better, particularly because it can observe the direct and indirect associations causes, and provide a measure of the relative importance of all (Sharma, 1998). Given the absence of sufficient information on the association of characters and path analysis in Ethiopian mustard leaf, a correlation and path coefficient study has critical importance in generating information that could help in designing breeding methods for the purpose of developing new varieties. Hence, this study was conducted with the objectives of (i) to estimate association among leafy vegetable yield and yield related traits, and (ii) to determine the direct and indirect effects of yield related traits on leafy vegetable yield of Ethiopian mustard genotypes.

MATERIALS AND METHODS

This research was at Holetta Agricultural Research Center throughout the main cropping season of 2017/2018 under rain fed conditions. The location of Holetta Agricultural Research Center is at 9° 00'N, 38° 30'E at an altitude of 2400 m.a.s.l. The main rainy season is from June to September, which accounts for 70% of the rainfall; while the remaining 30% is from February to April (EIAR, 2005).

For this study, 36 genotypes of Ethiopian mustard were used. Among the tested genotypes, five check varieties were included; which were released for seed production purposes but not for leaf purposes. The experiment was conducted using 6×6 simple lattice design. Each genotype was planted in a plot size of 1.2 by 3 m length in each block of replication. The recorded observations were for ten quantitative characters; viz: Days to 50% maturity, Leaf petiole length (cm), Leaf length (cm), Leaf width (cm), Ratio of leaf blade width to leaf length (cm), Petiole width (cm), Leaves per plant (No), Plant height(cm), Canopy diameter (cm), and Edible vegetable leaf yield (ton ha^{-1}).

Phenotypic and genotypic correlation coefficient

Phenotypic (r_p) and genotypic (r_g) correlations among two traits were assessed using the suggested formula by Johnson et al. (1955) and Singh and Chaudhury (1985).

$$r_p = \frac{P\,cov_{xy}}{\sqrt{(V_p x . V_p y)}}$$

Where, r_p = Phenotypic correlation coefficient;

$$r_g = \frac{G\,cov_{xy}}{\sqrt{(V_g x . V_g y)}}$$

r_g = Genotypic correlation coefficient;

$Pcov_{xy}$ = Phenotypic covariance among variables x and y; $Gcov_{xy}$ = Genotypic covariance among variables x and y; V_px = Phenotypic variance of variable x; V_gx = Genotypic variance of variable x; V_py = Phenotypic variance of variable y;V_gy = Genotypic variance of variable y.

The calculated phenotypic correlation value was tested for its significance using t-test:

$t = r_{ph}/SE\ (r_p)$

Where, r_p = Phenotypic correlation; SE (r_p) = Standard error of phenotypic correlation obtained using the following formula (Sharma, 1998).

$$SE\ (r_p) = \sqrt{\frac{1 - r2\,ph}{n - 2}}$$

Where, n is the number of genotypes tested; r^2_p is phenotypic correlation coefficient.

Levels of genotypic coefficients of correlations were tested for their significance by the formula described by Robertson (1959); namely: $t = r_{gxy}/SEr_{gxy}$.

The calculated "t" value was compared with the tabulated "t" value at (n-2) degrees of freedom at 5% level of significance. Where, n is number of genotypes.

$$SEr_{gxy} = \sqrt{\frac{1 - r2gxy}{h2x} . h2y}$$

Where, h^2x = Heritability of trait x; h^2y = Heritability of trait y.

Path coefficient analysis

Based on genotypic and phenotypic correlations; path coefficient analysis, that refers to the direct and indirect estimation effects of leaf yield identified characters (independent character) on leaf yield (dependent character), was calculated based on the methods of Dewey and Lu (1959) as follows:

$r_{ij} = P_{ij} + \Sigma r_{ik}\, p_{kj}$

where, rij = mutual association among the independent character (i) and dependent character (j) as measured by the genotypic and phenotypic correlation coefficients; Pij = direct effects of the character of independent (i) on the dependent variable (j) as measured by the genotypic path coefficients; and Σrikpkj = components summation of indirect effects of a given character of independent (i) on a given character of dependent (j) through all other characters of independent (k).

The remaining effect, which controls how best the causal factors account for the variability of the dependent yield factor, was calculated using the formula:

$1 = p^2R + \Sigma\ p\ ij\ rij$

Where, p^2R is the residual effect; p ij rij = the product of direct effect of any variable and its correlation coefficient with yield.

RESULTS AND DISCUSSION

Phenotypic and genotypic correlation coefficient of leaf yield with other characters

Most of crop phenology and growth traits (viz. days to

Table 1. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among 10 traits of 36 Ethiopian mustard genotypes.

Parameter	DTM	LPL	LL	LW	RLWLL	PTW	LPP	PH	CD	YLD
DTM		0.63**	0.59**	0.53**	-0.57**	0.64**	-0.04	0.59**	0.67**	0.50**
LPL	0.56**		0.95**	0.90**	-0.54**	0.91**	0.50**	0.84**	0.94**	0.78**
LL	0.52**	0.93**		0.97**	-0.48**	0.96**	0.49**	0.78**	0.96**	0.84**
LW	0.45**	0.86**	0.96**		-0.27	0.94**	0.51**	0.77**	0.93**	0.81**
RLWLL	-0.47**	-0.39**	-0.35**	-0.09		-0.43**	-0.15	-0.38*	-0.50**	-0.43**
PTW	0.59**	0.87**	0.93**	0.90**	-0.30**		0.39*	0.75**	0.95**	0.83**
LPP	-0.09	0.48**	0.49**	0.54**	-0.02	0.38**		0.56**	0.42*	0.33
PH	0.53**	0.82**	0.78**	0.75**	-0.29*	0.73**	0.51**		0.84**	0.55**
CD	0.62**	0.89**	0.94**	0.90**	-0.36*	0.93**	0.40**	0.82**		0.76**
YLD	0.47**	0.75**	0.82**	0.76**	-0.35**	0.79**	0.28*	0.55**	0.73**	

DTM = Days to 50% maturity, LPL (cm) = Leaf petiole length in centimeter, LL (cm) = Leaf length in centimeter , LW (cm) = Leaf width in centimeter, RLWLL (cm) = Ratio of leaf blade width to leaf length in centimeter , PTW (cm) = Petiole width in centimeter, LPP (no) = Number of leaves per plant, PH (cm) = Plant height in centimeter, CD (cm) = Canopy diameter in centimeter, YLD (ton ha^{-1}) = Edible vegetable leaf yield in tons per hectare, respectively.

50% maturity, leaf petiole length, leaf length, leaf width, petiole width, plant height and canopy diameter) had positive and significant correlations with edible vegetable leaf yield in ton ha^{-1} at both levels of genotypic and phenotypic. In addition, leaf number per plant had positive as well as significant correlations at phenotypic level. Among the growth parameters, leaf blade width ratio to length of leaf showed negative and significant correlations with leaf yield both at genotypic and phenotypic levels (Table 1). The magnitude of the genotypic correlation coefficient was higher than the traits of phenotypic correlation coefficient for all parameters. Phenotypic correlation (rp) measures the extent to which the two detected characters are linearly connected; although genotypic correlation (rg) measures the extent to which degree of the same genes, or closely related genes, cause covariation (simultaneous variations) in two characters that are different (Singh and Chaudhary, 1977; Falconer and Mackay, 1996; Sharma, 1998). The more significant genotypic association between the different pairs of characters than the phenotypic correlation indicates the presence of strong association between those characters genetically, but the phenotypic value is lessened by the significant interaction of environment (Singh and Chaudhary, 1977; Falconer and Mackay, 1996; Sharma, 1998). Thus, the presence of significant correlation of phenology and most of the growth traits with edible vegetable leaf yield per hectare (both at genotypic and phenotypic levels) suggested the major significance of the traits in selecting program to identify Ethiopian mustard genotypes with high leaf yield.

Edible vegetable leaf yield per hectare showed negative correlation with ratio of leaf width and length at both genotypic and phenotypic levels (Table 1). The existence of negative correlation indicated the associated traits are in opposite direction; and thus, genotype selection for high performance of one trait leads to the reduction of performance in the other traits. Therefore, it is vital to give attention to the two crop traits in the selection process of genotypes for high yield. Association of negative traits is difficult or virtually impossible to improve through concurrent selection of those traits (Akinyele and Osekita, 2006; Nwangburuka et al., 2012; Ahiakpa et al., 2013). Genetic correlation signs amid two characters can either facilitate or obstruct progress of selection (Singh and Chaudhary, 1977; Falconer and Mackay, 1996; Sharma, 1998).

A similar result reported by Buhroy et al. (2017) showed that total yield of the amaranth leaves had significantly and positive correlation with plant height, petiole length, leaf width and leaf length. Kumar et al. (2017) reported most of growth traits (leaf petiole length, leaf length, leaf width, petiole width, plant height and plant spread) had positive and significant correlations with curd yield quintal ha^{-1} of *Brassica oleracea* L. var. *botrytis* both at genotypic and phenotypic levels.

Estimate of correlation coefficients among other characters

The phenology and growth traits (days to 50% maturity, leaf petiole length, leaf length, leaf width, petiole width, plant height and canopy diameter) showed positive and significant associations among them; both at genotypic and phenotypic levels. There were positive as well as significant associations of leaf number per plant with the variables of leaf petiole length, leaf length, leaf width and petiole width, at both genotypic and phenotypic levels. There were positive and significant associations of plant height and canopy diameter with number of leaves per plant at both genotypic and phenotypic levels. Among

Table 2. Estimates of direct (bold and diagonal) and indirect (off diagonal) effects of traits on edible vegetable leaf yield per hectare at the genotypic level.

Parameter	DTM	LPL	LL	LW	RLWLL	PTW	LPP	PH	CD	rg
DTM	-0.**1248**	0.1349	0.0285	0.5872	0.2251	0.3538	0.0094	0.0108	-0.7223	0.5025
LPL	-0.0790	**0.2132**	0.0457	0.9843	0.2117	0.5021	-0.1020	0.0152	-1.0084	0.7829
LL	-0.0740	0.2031	**0.0480**	1.0615	0.1904	0.5281	-0.0996	0.0141	-1.0317	0.8398
LW	-0.0667	0.1908	0.0463	**1.0998**	0.1068	0.5170	-0.0456	0.0139	-0.9936	0.8099
RLBLL	0.0715	-0.1149	-0.0233	-0.2991	**-0.3929**	-0.2370	0.0314	-0.0070	0.5365	-0.4346
PTW	-0.0802	0.1944	0.0460	1.0326	0.1691	**0.5506**	-0.0793	0.0135	-1.0130	0.8339
LPP	0.0057	0.1060	0.0233	0.5603	0.0600	0.2128	**-0.2053**	0.0101	-0.4466	0.3263
PH	-0.0743	0.1792	0.0375	0.8469	0.1509	0.4116	-0.1147	**0.0181**	-0.9005	0.5547
CD	-0.0842	0.2007	0.0462	1.0202	0.1968	0.5208	-0.0856	0.0152	**-1.0711**	0.7591

Residual factor = 0.204. rg = Correlation coefficient at genotypic level, DTM = Days to 50% maturity, LPL = Leaf petiole length , LL = Leaf length , LW = Leaf width , RLWLL= Ratio of leaf blade width to leaf length, PTW= Petiole width , LPP = Number of leaves per plant, PH = Plant height and CD = Canopy diameter.

growth parameters, leaf blade ratio width to leaf length had negative and significant association with days to 50% maturity, and all growth traits, except leaf width and leaves per plant (Table 1).

Similarly, Jangde et al. (2017) studied amaranth genotypes, and observed positive and significant association among leaf petiole length, leaf length, leaf width, petiole width, and plant height at both genotypic and phenotypic levels. In addition, leaf number per plant had a positive significant association with petiole length and leaf yield. Anyaoha et al. (2015) reported a strong positive correlation among leaf length, leaf width, petiole length and days to maturity of *Brassica juncea* genotypes. Kumar et al. (2017) also found strong and positive correlations among leaf number, leaf length and leaf width; similarly, plant height was positively and significantly correlated with leaf length, leaf width, petiole length in his study on analysis of midseason *Brassica oleracea* L. var. *botrytis.*

Path analysis

A total of 8 traits showed significant correlations with edible vegetable leaf yield in tons ha^{-1} at genotypic and phenotypic levels, respectively. Therefore, path coefficient analysis was conducted for these traits, taking edible vegetable leaf yield in tons ha^{-1} as the dependent variable and other traits as causal variables to understand the direct and indirect effects of the traits. The results of genotypic and phenotypic path coefficient analyses are presented in Tables 2 and 3, respectively. Information obtained from correlation coefficients can be enhanced by partitioning them into direct and indirect effects for a set of a priori cause-effect interrelationships; thus, providing a convenient method in selecting the characters that have direct and indirect effects, as has been demonstrated in various crops (Kang et al., 1983; Gravois and Helms, 1992; Gravois and McNew, 1993; Board et al., 1997; Murtadha et al., 2004).

Genotypic path analysis of edible leaf yield with other traits

Leaf petiole length, leaf length, leaf width, petiole width and plant height had positive and highly significant genotypic correlation with edible vegetable leaf yield, and also exerted a confident direct effect on crop yield. Lenka and Mishra (1973) set the direct and indirect effects into five categories: negligible (0.00-0.09), low (0.10-0.19), moderate (0.20 -0.29), high (0.30-1.00) and very high (>1.00). Accordingly, using this categorization scheme, leaf width had very high (1.099) effects on edible leaf yield; whereas, petiole width (0.550) and leaf petiole length (0.213) exerted high and moderate positive direct effects on edible leaf yield, respectively; while leaf length and plant height had positive but negligible direct effects (0.048 to 0.018) on edible leaf yield (Table 2).

Leaf width had high positive indirect effects (>0.3) via days to 50% maturity, leaf petiole length, leaf length, petiole width, leaves per plant, plant height, and canopy diameter. Petiole width via days to maturity, leaf petiole length, leaf length, leaf width, plant height and canopy diameter exerted high indirect effect on leaf yield; and, via leaves per plant, exerted a moderate indirect effect on leaf yield. Leaf petiole length and leaf length exerted positive and high-to-low indirect effect via each other along with low-to-negligible effect through days to maturity, petiole width, number of leaves per plant, plant height and canopy diameter.

Plant height had positive but insignificant indirect effects on leaf yield through maturity days, leaf petiole length, length of leaf, leaf width, petiole width, leaf number per plant as well as canopy diameter. This suggested that selection of genotypes for leaf width,petiole width, leaf petiole length, leaf length and plant height themselves (and through other traits) could be regarded as a reliable source of getting high leaf yield in Ethiopian mustard.

Similarly, Hasan et al. (2013) found a positive direct effect of leaf width on marketable yield of amaranths, and a low positive indirect effect of leaf width via plant height and number of leaves per plant on marketable yield. Sabaghina et al. (2013) reported a positive direct effect on leaf yield of spinach, that was categorized as high for leaf length, medium for leaf width and low for petiole length. Similarly, Kumar et al. (2017) reported negligible positive direct effect of plant height and days to maturity on marketable yield of *B. oleracea* L. var. *botrytis*; and also observed a moderate indirect effect on marketable yield by leaf width via petiole length and number of leaves per plant. Days to 50% maturity and leaves per plant had positive significant genotypic correlations with edible leaf yield per hectare, but had negative and low direct effect on the trait. Canopy diameter and ratio of leaf blade width to leaf length showed highly significant positive and negative genotypic correlation with edible leaf yield per hectare and exerted negative and negligible to moderate direct effect on the trait, respectively. The negative direct effect of leaves per plant and canopy diameter on leaf yield was due to these traits negligible to high negative indirect effects via each other. Moreover, the negative effect of days to maturity is due to negligible to high indirect effect of canopy diameter via each other. Whereas, the positive and significant genotypic correlations of days to 50% maturity, leaves per plant and canopy diameter with leaf yield was due to the traits negligible to high positive indirect effects on leaf yield via leaf width, petiole width, leaf length, ratio of leaf blade width to leaf length, leaf petiole length and plant height.

Therefore, days to 50% maturity, ratio of leaf blade width to leaf length, number of leaves per plant and canopy diameter should not be considered for selection of genotypes for high leaf yield; but it is necessary to consider the indirect traits that caused the positive and significant correlations of these traits with leaf yield. If the variable has correlation that is positive, and the variable direct effect is negative or negligible; the positive correlation of the trait is due to the indirect effects through other traits. The indirect causal factors/traits are to be considered simultaneously for selection in such a situation (Singh and Chaudhary, 1977).

Outstanding effect in the current study was the residual factor of 0.204 (Table 2) showing that 79.57% of the edible vegetable leaf variability yield per hectare was accounted for by the factors of component. The remaining is explained by other traits in the study that are not considered. The determination of the residual effect inidicates to what extent the causal factors or dependent variables account for the variability of the dependent variable (Dabholkar, 1992; Singh and Chaudhary, 1977).

Phenotypic path analysis of edible leaf yield with other traits

Leaf petiole length, leaf length, and leaf and petiole width had highly positive significant phenotypic correlation with edible vegetable leaf yield and also exerted a positive direct effect on yield. Leaf length (0.7076), leaf width (0.3748) and petiole width (0.3161) had positive direct effects on edible leaf yield, whereas leaf petiole length (0.0643) had negligible positive direct effects.

Leaf length had high and positive indirect effects (>0.3) via days to 50% maturity, leaf petiole length, leaf width, petiole width, number of leaves per plant, plant height and canopy diameter. Leaf width via leaf petiole length, leaf length, petiole width and canopy diameter exerted high indirect effect on leaf yield, and leaves per plant and days to maturity, exerted moderate and negligible indirect effect on leaf yield, respectively. Petiole width via leaf petiole length, leaf length, leaf width, plant height and canopy diameter exerted high and via days to 50% maturity and leaves per plant exerted low indirect effect on leaf yield.

Petiole width exerted positive and moderate indirect effect via leaf petiole length, leaf length, leaf width, plant height and canopy diameter and low through days to 50% maturity and number of leaves per plant. Leaf petiole length had positive but negligible indirect effects on leaf yield and through days to maturity, leaf length, leaf width, petiole width, leaves per plant, plant height and canopy diameter. This suggested that selection of genotypes for leaf length, petiole width, leaf width and leaf petiole length of leaf themselves, and through other traits, could be regarded as a reliable source of getting high leaf yield in Ethiopian mustard. Similarly, Jangde et al. (2017) reported positive and significant phenotypic correlations among leaf length and leaf width, and had direct effect on leaf yield of vegetable amaranths. Kumar et al. (2017) reported leaf width and petiole length had positive low direct effect on marketable yield. In addition, leaf width had positive indirect effect via leaf length, plant height and number of leaves per plant; and plant height had negligible indirect effect via leaf length, leaf width and number of leaves per plant.

Days to 50% maturity, plant height, canopy diameter and leaves per plant had positive significant phenotypic correlations with edible leaf yield per hectare; but had negative and negligible to high direct effect on the trait. Ratio of leaf blade width to leaf length showed highly significant negative phenotypic correlation with edible leaf yield per hectare, and exerted negative and low direct effect on the trait. This trait also had negative direct effects on leaf yield via other traits. The negative direct effect of several variables (days to 50% maturity, number of leaves per plant, plant height and canopy diameter on.

Table 3. Estimates of direct (bold and diagonal) and indirect (off diagonal) effect of traits on edible vegetable yield per hectare at the phenotypic level.

Parameter	DTM	LPL	LL	LW	RLBLL	PT	LPP	PH	CD	rp
DTM	**-0.0009**	0.0359	0.3690	0.1668	0.0855	0.1863	0.0152	-0.0361	-0.3505	0.47
LPL	-0.0005	**0.0643**	0.6582	0.3233	0.0708	0.2759	-0.0766	-0.0556	-0.5036	0.75
LL	-0.0005	0.0598	**0.7076**	0.3585	0.0624	0.2953	-0.0787	-0.0529	-0.5323	0.82
LW	-0.0004	0.0555	0.6769	**0.3748**	0.0172	0.2860	-0.0865	-0.0511	-0.5087	0.76
RLBLL	0.0004	-0.0252	-0.2445	-0.0357	**-0.1805**	-0.0956	0.0030	0.0199	0.2062	-0.35
PT	-0.0005	0.0561	0.6610	0.3391	0.0546	**0.3161**	-0.0609	-0.0498	-0.5248	0.79
LPP	0.0001	0.0307	0.3468	0.2020	0.0034	0.1198	**-0.1606**	-0.0351	-0.2268	0.28
PH	-0.0005	0.0524	0.5487	0.2808	0.0528	0.2309	-0.0827	**-0.0682**	-0.4656	0.55
CD	-0.0006	0.0571	0.6645	0.3364	0.0657	0.2928	-0.0643	-0.0560	**-0.5667**	0.73

Residual factor = 0.27. rp = Correlation coefficient at phenotypic level, DTM = Days to 50% maturity, LPL = Leaf petiole length , LL = Leaf length , LW = Leaf width , RLWLL= Ratio of leaf blade width leaf length, PTW = Petiole width , LPP = Number of leaves per plant, PH = Plant height and CD = Canopy diameter.

leaf yield) was due to these traits negligible to high negative indirect effects via each other on leaf yield Whereas, the positive and significant phenotypic correlations of days to 50% maturity, leaves per plant, plant height and canopy diameter with leaf yield was due to the traits negligible to high positive indirect effects on leaf yield via leaf petiole length, leaf length, leaf width, ratio of leaf blade width to leaf length and petiole width.

In the current study, the residual effect was 0.27 (Table 3), showing that 72.9% of the edible vegetable leaf variability yield per hectare was explained by the factors of the component. The remaining is explained by other traits in the study that are not considered.

Conclusion

The genotypic correlation coefficient among edible vegetable leaf yield and all of agro-morphological traits was positive and significant, except leaves per plant and ratio of leaf width to length. Leaf petiole length, leaf length, leaf width, petiole width and plant height had a positive and highly significant genotypic correlation with edible vegetable leaf yield, both at genotypic and phenotypic levels. These traits also had a positive indirect effect on yield, either though each other or via other traits at the genotypic level. The strong association of these traits with leaf yield, and the high to low direct and indirect effects through other traits at the genotypic level, are an indication of the importance of the traits to use in selection of Ethiopian mustard accessions for high edible vegetable leaf yield. Days to maturity, leaves per plant and canopy diameter had positive and significant correlations with edible leaf yield per hectare, both at genotypic and phenotypic levels. However, the traits had negative and low to high direct effects on edible leaf yield at the genotypic level. In addition, ratio of leaf blade width to leaf length showed a significant and negative correlation with edible leaf yield per hectare; and exerted a negative high direct effect on the trait. This suggested that it is not necessary to consider these traits for selection of genotypes for high yield, rather it is necessary to consider the traits such as leaf petiole length, leaf length, leaf width and petiole width.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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