Legume Research, 39 (5) 2016 : 755-761
Print ISSN:0250-5371 / Online ISSN:0976-0571

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com/www.legumeresearch.in

Analysis of some plant measures of narbon vetch (*Vicia narbonensis* L.) effecting plant length using path analysis

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Received: 12-03-2016 Accepted: 23-05-2016
DOI:10.18805/lr.v0iOF.11183

ABSTRACT
The direct and indirect effects of sizes of fresh stem weight, dry stem weight, fresh leafweight, dry leaf weighton plant height of narbon vetch were in vestigated using path analysis in Bingol in 2014-15 years. The plant measures of narbon vetch between 4 and 6 weeks of planting were used.The results showed that the highest correlations at 5 week narbon vetch were determined between plant length and respectively dry stem weightand fresh stem weight(r =0.849 and r =0.824). The direct effects of fresh stem weight, dry stem weight, fresh leaf weight, dry leaf weight on plant length at 6 week narbon vetcies were determined respectively as 51.341%, 50.148%, 37.782%, and 24.276%, respectively. As a result, fresh stem weight, dry stem weight were the most efficient characters on plant length and it was concluded that these characters could be considered as significant selection criterias in narbon vetch breeding for yield under that the conditions.

Key words: Correlation, Narbon vetch, Path analysis, Plant measurement.

INTRODUCTION

Vetch (*Vicia* spp.), which includes numerous species, is a good forage crop, grazing crop, green manure crop, an alternation crop as well as being effective in preventing erosion (Soya *et al.*, 2004). Vetch is an annual forage legume and is widely used as weed and grains in feeding of farm animals in many regions of the world (Ramos *et al.*, 2000; Acikgoz, 2001; Cabellero *et al.*, 2001; Chowdhurry *et al.*, 2001).

Narbon vetch (*Vicia narbonensis* L.), which is quite similar to broad bean, is cultivated for both its weed and grains (Soya *et al.*, 2004). Narbon vetch has naturally ranged over Central Europe tosia Minor. In our country, it is available in every region except Northeast Anatolia (Davis, 1970). The narbon vetch is grown as a dual purpose crop for animal feed and human nutrition in Syria, Northern Iraq and parts of Turkey (Bennett *et al.*, 1997). It is a fast growing crop, with vigorous regrowth.

Correlations express the level of dependence among traits, and out of numerous correlation coefficients it is difficult to determine the actual mutual effects among traits. Path analysis provides better study of the nature of such interdependence, while path coefficients serve as an effective parameter for the impact analysis of traits which have an important effect in forming the given correlations. This method enables more quality and full insight into relations existing among the studied traits, more precise establishment of cause effect connections among them, as well as to separate direct from indirect effects of any particular trait on dependent variable (Ikanovic *et al.*, 2011). Path analysis is important as determining minimum and maximum directly and indirectly effective of various plant features on plants length in narbon vetch.

A positive relationship was found between grain yield and plant lentgh, biological yield, 1000 grains weight and broad bean length, the number of sub branches and the grain number in broad bean; a negative relationship was found between grain yield and the number of broad beans in plant (Buyukburç and Iptas, 2001); it was also found that there was a high and positive relationship between grain yield and harvest index and biological yield and plant length (Turk *et al.*, 2008).

Path coefficient results showed that 100-seed weight had the highest direct effect on yield which was positive. This was followed by the pod length plant^{-1}, number of leaves, and leaf area while plant height plant^{-1} had negative direct effect but very high. Number of pod plant^{-1} had the lowest direct effect on yield (Udensi and Ikpeme, 2012). Since variables have both direct and indirect effects on dependent variables their path coefficients have to be found (Güler *et al.*, 2001; Edwards and Lambert, 2007). It is important to choose productive genotypes in plant breeding in order to know direct and indirect effects of other characteristics on plant length in narbon vetch. Generally, selection criteria according to the results obtained from path analysis in plant characteristics is suggested. Prasad *et al.*

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(2001) suggested the use of selection criteria in accordance 1000 grains weight, number of effective plant, number of fertile grains and yield/plant according to path coefficient analysis.

The aim of this study is to analyse the direct and indirect effects of withers height, rump height, body length, chest peripheral, head length and leg length on plant length of vetch through path analysis.

MATERIALS AND METHODS

This study was conducted in Bingol University Faculty of Agriculture Research and Application field, in 2014 and 2015. The study area was located at 41° 20' and 39° 54' N latitude and 38° 27' and 40° 27' E longitude in the agricultural research farm of Bingol University, Bingol, Turkey. This land has an elevation of about 1151 m. Bingol has terrestrial climatic character in the East Anatolia region. The average temperature from May to September was 23.1 °C, and total rainfall was 157.7 mm in 2014 year. The same period for 2015 year average temperature was 23.6 °C, and rainfall was 30.7 mm. Soil in a depth of 30 cm was sampled before the start of the experiment. Soil was lowed in organic matter (1.26%), medium acid in (pH: 6.37), low in calcium carbonate (0.15%) and high in P (79.1 kg ha^{-1} P_2O_5) and low amount of in K_2O (24.5 kg ha^{-1}) contest. Randomized complete block design with three replications was used. Nrbon vetch genotypes used in experiment were IFVN 564-SEL 2379, IFVN 565 SEL 2380, IFVN 575 SEL 2389, IFVN 567 SEL 2382, IFVN 116-SEL 2461, IFVN 562-SEL 2470, TARMAN, HALILBEY, KARAKAYA and GORKEM.

The plant length, dry stem weight and dry leaf weight were measured on a weekly basis in two years, starting approximately November, and measurements were taken for 6 weeks. Measurements were made by collecting three plants from each parcel. Calculations were made over 2 years average of plant length (cm), dry stem weight - fresh stem weight (g) and dry leaf weight- fresh leaf weight (g) variables' mean values. Direct and indirect effects of the characteristics of dry stem weight (g), fresh stem weight (g), dry leaf weight (g) and fresh leaf weight (g) on plant length (cm) were investigated. Path analysis was used to study on these effects.

The path coefficient suggested by Sewall Wright in 1921 was defined as part of standard deviation of the dependent variable resulting from independent variable while independent variables are fixed except for variable, of which effect could be determined (MacKinnon, 2008). Correlation coefficients and the path coefficient analysis was conducted following the procedure developed by Khan *et al.* (2003) and applied by Rauf *et al.* (2004). Path analysis has been used in various science areas especially in agriculture for purpose of determination the interactions between efficiency and efficiency elements. For path analysis, one usually has to confine one self to selecting variables considered possibly of explanatory value, one is unlikely to include a variable of no apparent significance but only seeming to increase the explanatory significance of another variable (Maassen and Bakker, 2001).

Path coefficient is a standardized partial regression coefficient that measures the direct influence of one trait upon another and permits the separation of acorrelation coefficient into components of direct and indirect effects (Board *et al.*, 1997). It provide a tutorial illustrating anapproach to estimation of and inference about direct, indirect, and total effects in statistical mediation analysis with a multicategorical independent variable (Hayes and Preacher, 2014). For this reason, analysis should be carried out after the cause and effect relationships between the variables have been determined by researcher (Preacher and Hayes, 2004). In path analysis, each dependent variable is analyzed with each independent variable, and multiple regression analysis are performed for this analysis. In fact, path analysis is an extended form of multiple regression analysis. The path coefficientsmust be known to make path analysis. A path coefficient is a standardized regression coefficientrevealing the direct effect of the independent variable on a dependent variable of path model (Alpar, 2011). Regression analysis and correlation analysis are insufficient to determine the direct and indirect relations between variables together. In this case, through path analysis, importance and size of the direct and indirect causal relations between variables can be estimated (Bal and Dogan, 2000). The equation series in equality (1) consisting of path and correlation coefficients are formed (Hu and Wang, 2001; Li *et al.*, 2005). The direct and indirect effects are estimated through the solution of these equation.The equation system consisted of path and correlation coefficients to estimate these effectsis given in equation (2).

$$\begin{aligned} r_{X_1,Y} &= P_{YX_1} + r_{12}P_{YX_2} + r_{13}P_{YX_3} + r_{14}P_{YX_4} \\ r_{X_2,Y} &= P_{YX_2} + r_{21}P_{YX_1} + r_{23}P_{YX_3} + r_{24}P_{YX_4} \\ r_{X_3,Y} &= P_{YX_3} + r_{31}P_{YX_1} + r_{32}P_{YX_2} + r_{34}P_{YX_4} \\ r_{X_4,Y} &= P_{YX_4} + r_{41}P_{YX_1} + r_{42}P_{YX_2} + r_{43}P_{YX_3} \end{aligned} \quad (1)$$

$$r_{X_S,Y} = h$$

Here, while P_{YX_1}, P_{YX_2}, P_{YX_3}, and P_{YX_4} parameters indicate direct effects of Xs on Ys, $r_{12}P_{YX_2}$ indicates the indirect effect of X_1 on X_2 (Wright, 1968).

In equation system (1), the correlations between independent variables and the correlations between independent variables and dependent variable was known. The path coefficients can be calculated depending onthese correlations. To do this, multiple equation system is written in matrix form. While correlation matrix related to independent variables is indicated by A, vector consisting of the correlations between independent variables and dependent variable is indicated by B, and path coefficient is indicated by P, then the matrix form is stated as in Table 2 (Bal and Dogan, 2000).

$$\Rightarrow P = A^{-1}B \qquad (2)$$

Here, A^{-1} is the inverse of A matrix.

By taking into account the direct effects of independent variables, the indirect effects of these variables on the dependent variable can be calculated. To do this, the path coefficients produced by benefiting from multiple equation system stated in equation (1) are multiplied by the correlation matrix consisted of diagonal matrix and independent variables and accordingly, matrix given in equation (3), consisting of indirect effects, is created.

$$\begin{bmatrix} P_{Y1} & P_{Y1}r_{12} & P_{Y1}r_{13} & P_{Y1}r_{14} \\ P_{Y2}r_{21} & P_{Y2} & P_{Y2}r_{23} & P_{Y2}r_{24} \\ P_{Y3}r_{31} & P_{Y3}r_{32} & P_{Y3} & P_{Y3}r_{34} \\ P_{Y4}r_{41} & P_{Y4}r_{42} & P_{Y4}r_{43} & P_{Y4} \end{bmatrix} = \begin{bmatrix} P_{Y1} & 0 & 0 & 0 \\ 0 & P_{Y2} & 0 & 0 \\ 0 & 0 & P_{Y3} & 0 \\ 0 & 0 & 0 & P_{Y4} \end{bmatrix} \begin{bmatrix} 1 & r_{12} & r_{13} & r_{14} \\ r_{21} & 1 & r_{23} & r_{24} \\ r_{31} & r_{32} & 1 & r_{34} \\ r_{41} & r_{42} & r_{43} & 1 \end{bmatrix} \qquad (3)$$

The diyagonal values in the matrix on the left of equation (3) indicate path coefficients, in other words, the direct effects; the values other than the diagonal argument indicate indirect effects interaction of independent values.

RESULTS AND DISCUSSION

The identifier statistics about the plant length of narbon vetch according to weeks, plant length (Y), withers height (X_1), rump height (X_2), body length (X_3), and chest peripheral (X_4) are given in Table 1.

Standardized multiple regression models relating to the body sizes of dogs, such as plant length (Y), fresh stem weight (X_1), dry stem weight (X_2), fresh leaf weight (X_3), and dry leaf weight (X_4), were respectively determined as given below. The number of these regression models are four, including seperately from 4 to 6 week.

$$Y_1 = 0.013X_1 + 0.101X_2 + 0.082X_3 - 0.080X_4$$
$$Y_2 = 0.130X_1 + 0.718X_2 - 0.733X_3 + 0.729X_4$$
$$Y_3 = 0.269X_1 - 0.020X_2 + 0.200X_3 + 0.257X_4$$

Here, since the coefficients were standardized, constantterm yielded as zero. The partial regression coefficients in this equation indicate the direct effects of each variable, such as plant length (Y), fresh stem weight, dry stem weight, fresh leaf weight, and dry leaf weight, on plant length, which is the result variable. Standardized and normal regression coefficients, standard error, t statistics and significance levels are given in Table 2 separately for every age group from 4 to 6 old weeks.

So as to determine the direct and indirect effects of plant specifications affecting the plant length, equation system given in equation (2) is solved using of path and correlation coefficients defined in equation (1). In the

Table 1: The identifier statistics related with various body sizes at dogs

	4 week (n=30)		5 week (n=30)		6 week (n=30)	
Variables	$\bar{X}$	$S_{\bar{x}}$	$\bar{X}$	$S_{\bar{x}}$	$\bar{X}$	$S_{\bar{x}}$
PL	24.48	0.60	24.29	0.73	33.60	1.13
FSW	2.26	0.15	2.38	0.19	2.07	0.12
DSW	1.62	1.04	0.49	0.04	1.13	0.06
FLW	3.00	0.18	2.99	0.21	2.60	0.21
DLW	1.36	0.62	0.70	0.05	1.39	0.10

$\bar{X}$: Average, $s_{\bar{x}}$: Standard error, n: Number of plants, PL: Plant length, FSW: Fresh Stem Weight, DSW: Dry Stem Weight, FLW: Fresh Leaf Weight, DLW: Dry Leaf Weight,

equation system, the inverse of the correlation matrix between the independent variablesis multiplied with dependent variable and vector consisting of correlation coefficientsbetween independent variables, and accordingly, path coefficients vector, in other words, direct effect quantities belonging to related independent variables are produced. In order to establish the matrix consisting of the direct and indirect effects, path coefficients vector ismultiplied with correlation matrix formed by correlation between independent variables. In the resulting 4*4 dimensional matrix, the diagonal values are path coefficients creating effect directly. The values other than diyagonal are the interacted indirect effects of independent variables. The correlation coefficients given in Table 3 were replaced in equation (1) and there upon, the equations given below were created. Firstly, the equations were given for all vetches.

$$0.122 = P_{YX_1} + 0.158P_{YX_2} + 0.920P_{YX_2} - 0.212P_{YX_4}$$

$$0.123 = 0.158P_{YX_1} + P_{YX_2} + 0.208P_{YX_2} - 0.034P_{YX_4}$$

$$0.134 = 0.920P_{YX_1} + 0.208P_{YX_2} + P_{YX_2} - 0.234P_{YX_4}$$

-

$$-0.106 = 0.212P_{YX_1} - 0.034P_{YX_2} - 0.234P_{YX_2} + P_{YX_4}$$

By converting this equation system into the matrix form specified in equation (2), path coefficients were calculated as follows:

$$P = A^{-1}B = \begin{bmatrix} P_{YX_1} \\ P_{YX_2} \\ P_{YX_3} \\ P_{YX_4} \end{bmatrix} = \begin{bmatrix} 1 & 0.158 & 0.920 & -0.212 \\ 0.158 & 1 & 0.208 & -0.034 \\ 0.920 & 0.208 & 1 & -0.234 \\ 0.212 & -0.034 & -0.234 & 1 \end{bmatrix}^{-1} * \begin{bmatrix} 0.122 \\ 0.123 \\ 0.134 \\ -0.106 \end{bmatrix} = \begin{bmatrix} 0.016 \\ 0.101 \\ 0.078 \\ -0.088 \end{bmatrix}$$

The indirect effects affecting plant length at 4 week narbon vetch,

$$\begin{bmatrix} 0.016 & 0 & 0 & 0 \\ 0 & 0.101 & 0 & 0 \\ 0 & 0 & 0.078 & 0 \\ 0 & 0 & 0 & -0.088 \end{bmatrix} * \begin{bmatrix} 1 & 0.158 & 0.920 & -0.212 \\ 0.158 & 1 & 0.208 & -0.034 \\ 0.920 & 0.208 & 1 & -0.234 \\ 0.212 & -0.034 & -0.234 & 1 \end{bmatrix} = \begin{bmatrix} 0.016 & 0.025 & 0.015 & -0.003 \\ 0.016 & 0.101 & 0.021 & -0.003 \\ 0.072 & 0.016 & 0.078 & -0.018 \\ -0.019 & 0.003 & 0.021 & -0.088 \end{bmatrix}$$

Similarly, path coefficients for 5 week narbon vetch,

Table 2: The results of the regression analysis of plantlength in narbon vetch

	Constant	FSW	DSW	FLW	DLW
4 week old plants					
	Constant	**FSW**	**DSW**	**FLW**	**DLW**
Coefficient	23.566	0.054	0.059	0.267	-0.078
Standard error	2.167	2.003	0.117	1.666	0.197
Beta		0.013	0.101	0.082	-0.080
t	10.874	0.027	0.501	0.160	-0.398
P	0.000	0.979	0.621	0.874	0.694
5 week old plants					
	Constant	**FSW**	**DSW**	**FLW**	**DLW**
Coefficient	16.249	0.498	13.887	-2.575	11.104
Standard error	1.373	2.827	9.864	2.367	9.497
Beta		0.130	0.718	-0.733	0.729
t	11.831	0.176	1.408	-1.088	1.169
P	0.000	0.862	0.171	0.287	0.253
6 week old plants					
	Constant	**FSW**	**DSW**	**FLW**	**DLW**
Coefficient	21.798	2.546	-0.369	1.082	2.983
Standard error	3.986	2.785	4.172	1.312	2.160
Beta		0.269	-0.020	0.200	0.257
t	5.468	0.914	-0.088	0.825	1.381
P	0.000	0.369	0.930	0.417	0.179

$$0.824 = P_{YX_1} + 0.973P_{YX_2} + 0.953P_{YX_2} + 0.953P_{YX_4}$$

$$0.849 = 0.973P_{YX_1} + P_{YX_2} + 0.894P_{YX_2} + 0.906P_{YX_4}$$

$$0.751 = 0.953P_{YX_1} + 0.894P_{YX_2} + P_{YX_2} + 0.895P_{YX_4}$$

$$0.781 = 0.953P_{YX_1} + 0.906P_{YX_2} + 0.985P_{YX_2} + P_{YX_4}$$

$$\begin{bmatrix} P_{YX_1} \\ P_{YX_2} \\ P_{YX_3} \\ P_{YX_4} \end{bmatrix} = \begin{bmatrix} 1 & 0.973 & 0.953 & 0.953 \\ 0.973 & 1 & 0.894 & 0.906 \\ 0.953 & 0.894 & 1 & 0.895 \\ 0.953 & 0.906 & 0.985 & 1 \end{bmatrix}^{-1} * \begin{bmatrix} 0.824 \\ 0.849 \\ 0.751 \\ 0.781 \end{bmatrix} = \begin{bmatrix} 0.073 \\ 0.823 \\ -0.192 \\ -0.140 \end{bmatrix}$$

The indirect effects affecting live weight at 5 week narbon vetch,

$$\begin{bmatrix} 0.073 & 0 & 0 & 0 \\ 0 & 0.823 & 0 & 0 \\ 0 & 0 & -0.192 & 0 \\ 0 & 0 & 0 & -0.140 \end{bmatrix} * \begin{bmatrix} 1 & 0.973 & 0.953 & 0.953 \\ 0.973 & 1 & 0.894 & 0.906 \\ 0.953 & 0.894 & 1 & 0.895 \\ 0.953 & 0.906 & 0.985 & 1 \end{bmatrix} = \begin{bmatrix} 0.073 & 0.071 & 0.070 & 0.070 \\ 0.801 & 0.823 & 0.736 & 0.746 \\ -0.183 & -0.172 & -0.192 & -0.189 \\ -0.133 & -0.127 & -0.127 & -0.140 \end{bmatrix}$$

Path coefficients for 6 week narbon vetch,

$$0.498 = P_{YX_1} + 0.632P_{YX_2} + 0.688P_{YX_2} + 0.408P_{YX_4}$$

$$0.299 = 0.632P_{YX_1} + P_{YX_2} + 0.261P_{YX_2} + 0.378P_{YX_4}$$

$$0.478 = 0.688P_{YX_1} + 0.261P_{YX_2} + P_{YX_2} + 0.384P_{YX_4}$$

$$0.435 = 0.408P_{YX_1} + 0.378P_{YX_2} + 0.384P_{YX_2} + P_{YX_4}$$

$$\begin{bmatrix} P_{YX_1} \\ P_{YX_2} \\ P_{YX_3} \\ P_{YX_4} \end{bmatrix} = \begin{bmatrix} 1 & 0.632 & 0.688 & 0.408 \\ 0.632 & 1 & 0.261 & 0.378 \\ 0.688 & 0.261 & 1 & 0.384 \\ 0.408 & 0.378 & 0.384 & 1 \end{bmatrix}^{-1} * \begin{bmatrix} 0.498 \\ 0.299 \\ 0.478 \\ 0.435 \end{bmatrix} = \begin{bmatrix} 0.268 \\ -0.019 \\ 0.200 \\ 0.256 \end{bmatrix}$$

The indirect effects affecting live weight at 6week narbon vetch,

$$\begin{bmatrix} 0.268 & 0 & 0 & 0 \\ 0 & -0.019 & 0 & 0 \\ 0 & 0 & 0.200 & 0 \\ 0 & 0 & 0 & 0.256 \end{bmatrix} * \begin{bmatrix} 1 & 0.632 & 0.688 & 0.408 \\ 0.632 & 1 & 0.261 & 0.378 \\ 0.688 & 0.261 & 1 & 0.384 \\ 0.408 & 0.378 & 0.384 & 1 \end{bmatrix} = \begin{bmatrix} 0.268 & 0.169 & 0.184 & 0.109 \\ -0.012 & -0.019 & -0.005 & -0.007 \\ 0.138 & 0.052 & 0.200 & 0.077 \\ 0.104 & 0.097 & 0.098 & 0.256 \end{bmatrix}$$

Path coefficients are the regression coefficients belonging to standardized data given in Table 2. The regression coefficients have a direct effect on the dependent variable. The values of these resulting effects belonging to week range between 4 and 6 are given in Table 4.

The correlation coefficients and significance levels belonging to the variables examined at vetchs are given inTable 3. The correlation coefficients between plant length and fresh stem weight, dry stem weight, fresh leaf weight, and dry leaf weight were determined as unsignificant statistically at 4wekvetch. The correlation coefficients between plant length and fresh stem weight, dry stem weight, fresh leaf weight, and dry leaf weight were determined as significant statistically at 5 week vetch ($P<0.01$). The correlation coefficients between plant length and fresh stem weight, fresh leaf weight, and dry leaf weightwere determined as significant statisticallyat 6 week vetch ($P<0.01$).

When Model parameters were examined it was seen that, when fresh stem weight was changed one unit,plant length was change 0.016 unit, when dry stem weight, fresh leaf weight, dry leaf weight were changed one unit, plant length was change respectively 0.025, 0.015 and -0.003 unit at 4weeknarbon vetch. When fresh stem weight, dry stem weight, fresh leaf weight, dry leaf weight were changed one unit, plant length was change respectively 0.073, 0.071, 0.070

Table 3. The correlation coefficients between the variables examined in vetch

4 week	Y	X_1	X_2	X_3
X_1	0.122			
X_2	0.123	0.158		
X_3	0.134	0.920**	0.208	
X_4	-0.106	-0.212	-0.034	-0.234
5 week	**Y**	X_1	X_2	X_3
X_1	0.824**			
X_2	0.849**	0.973**		
X_3	0.751**	0.953**	0.894**	
X_4	0.781**	0.953**	0.906**	0.985**
6 week	**Y**	X_1	X_2	X_3
X_1	0.498**			
X_2	0.299	0.632**		
X_3	0.478**	0.688**	0.261	
X_4	0.435**	0.408**	0.378*	0.384*

* P<0.05; ** P<0.01

and -0.070 unit at 5 week narbon vetch. When fresh stem weight, dry stem weight, fresh leaf weight, dry leaf weight were changed one unit, plant length was change respectively 0.268, 0.169, 0.184 and 0.109 unit at 6 week narbon vetch. These changes are direct effects.

The correlation description shares are given as effect share (%). The correlation coefficient between plant length and fresh stem weightwas determined as 0.122at4 week narbon vetchs. When this correlation was separated into the elements, the indirect effects of fresh stem weight on plant measures were determined as follows: on dry stem weight is 0.016 with 13.008% ratio; on fresh leaf weight is 0.072 with 58.537% ratio; on dry leaf weight is 0.019 with 15.447% ratio. The correlation coefficient between plant length and dry stem weight was calculated as 0.123. When this correlation was separated into the elements, the indirect effects of dry stem weight on plant measures were determined as follows: on fresh stem weight is 0.101 with 69.655% ratio; on fresh leaf weight is 0.016 with 11.034% ratio; on dry leaf weight is 0.003 with 2.069% ratio. The correlation coefficient between plant length and fresh leaf weight was calculated as 0.134. When this correlation was separated into the elements, the indirect effects of fresh leaf weight on plant length, such as, fresh stem weight, dry stem weight, dry leaf weight were determined respectively as 15.556, 57.778, and 15.556 on percent basis. The correlation coefficient between plant length and dry leaf weight was calculated as -0.106. When this correlation was separated into the elements, the indirect effects of dry leaf weighton plant length, such as, fresh stem weight, dry stem weight, fresh leaf weight were determined respectively as 2.679, 16.071and 78.571 on percent basis.

The correlation coefficient between plant length and fresh stem weight was determined as 0.824 at 5 week narbon vetch. When this correlation was separated into the elements, the indirect effects of fresh stem weight on plant measures were determined as follows: on dry stem weight is 0.801 with 67.311% ratio; on fresh leaf weight is -0.183 with 15.378% ratio; on dry leaf weight is -0.133with 11.176% ratio. The correlation coefficient between plant length and dry stem weight was calculated as 0.849. When this correlation was separated into the elements, the indirect effects of dry stem weight on plant measures were determined as follows: on fresh stem weight is 0.823 with 68.986% ratio; on fresh leaf weight is -0.172 with 14.417% ratio; on dry leaf weight is -0.127 with 10.645%ratio. The correlation coefficient between plant length and fresh leaf weight was calculated as 0.751. When this correlation was separated into the elements, the indirect effects of fresh leaf weight on

Table 4: Direct and indirect effects of plant length at narbon vetch.

		4 week			5 week			6 week		
Dir. E.	**Ind. E.**	**r**	**PC**	**ES (%)**	**r**	**PC**	**ES (%)**	**r**	**PC**	**ES (%)**
X_1		0.122	0.016	13.008	0.824**	0.073	6.134	0.498**	0.268	51.341
	X_2		0.016	13.008		0.801	67.311		-0.012	2.299
	X_3		0.072	58.537		-0.183	15.378		0.138	26.437
	X_4		0.019	15.447		-0.133	11.176		0.104	19.923
X_2		0.123	0.025	17.241	0.849**	0.071	5.951	0.299	0.169	50.148
	X_1		0.101	69.655		0.823	68.986		-0.019	5.638
	X_3		0.016	11.034		-0.172	14.417		0.052	15.430
	X_4		0.003	2.069		-0.127	10.645		0.097	28.783
X_3		0.134	0.015	11.111	0.751**	0.070	6.222	0.478**	0.184	37.782
	X_1		0.021	15.556		0.736	65.422		-0.005	1.027
	X_2		0.078	57.778		-0.192	17.067		0.200	41.068
	X_4		0.021	15.556		-0.127	11.289		0.098	20.123
X_4		-0.106	-0.003	2.679	0.781**	0.070	6.114	0.435**	0.109	24.276
	X_1		-0.003	2.679		0.746	65.153		-0.007	1.559
	X_2		-0.018	16.071		-0.189	16.507		0.077	17.149
	X_3		-0.088	78.571		-0.140	12.227		0.256	57.016

* P<0.05, ** P<0.01; Dir. E.: Direct effect; Ind. E.: Indirect effect; r: Correlation coefficient; PC: Path coefficient; E. S. (%): Effect share; X_1: Fresh stem weight; X_2: Dry stem weight; X_3: Fresh leaf weight; X_4: Dry leaf weight.

plant length, such as, fresh stem weight, dry stem weight, dry leaf weight were determined respectively as 65.422, 17.067 and 11.289 on percent basis. The correlation coefficient between plant length and dry leaf weight was calculated as 0.781. When this correlation was separated into the elements, the indirect effects of dry leaf weight on plant length, such as, fresh stem weight, dry stem weight, fresh leaf weight were determined respectively as 65.153, 16.507 and 12.227 on percent basis.

The correlation coefficient between plant length and fresh stem weight was determined as 0.498 at 6 week vetchs. When this correlation was separated into the elements, the indirect effects of fresh stem weight on plant measures were determined as follows: on dry stem weight is -0.012 with 2.299% ratio; on fresh leaf weight is 0.138 with 26.437% ratio; on dry leaf weight is 0.104 with 19.923% ratio. The correlation coefficient between plant length and dry stem weight was calculated as 0.299. When this correlation was separated into the elements, the indirect effects of dry stem weight on plant measures were determined as follows: on fresh stem weight is -0.019 with 5.638% ratio; on fresh leaf weight is 0.052 with 15.430% ratio; on dry leaf weight is 0.097 with 8.783% ratio. The correlation coefficient between plant length and fresh leaf weight was calculated as 0.478. When this correlation was separated into the elements, the indirect effects of fresh leaf weight on plant length, such as, fresh stem weight, dry stem weight, dry leaf weight were determined respectively as 1.027, 41.068 and 20.123 on percent basis. The correlation coefficient between plant length and dry leaf weight was calculated as 0.435. When this correlation was separated into the elements, the indirect effects of dry leaf weight on plant length, such as, fresh stem weight, dry stem weight, fresh leaf weight were determined respectively as 1.559, 17.149 and 57.016 on percent basis.

Chandirakala and Subbaraman (2010) found out that 100 seed weight, days to maturity, days to 50 per cent flowering, pod length and seeds per pod had high positive direct effect on seed yield in Pigeonpea. Goksoy ve Turan (2003) determined grain number (75.3%) and 1000 grains number (64.9%) had the biggest direct effect on sunflower grain yield with the help of path analysis. Yucel (2004) used path analysis in narbon vetch (*Vicia narbonnesis* L.) to determine that seed yield was affected by days to flowering, number of seeds per plant, number of pods per plant, one thousand seed weight, and harvest index.Karadavut *et al.* (2005) found important relationships between ripening period, broad bean number in plant, grain number in plant and a hundred grains weight and yield in Eskisehir 855 bean (*Phaseolus vulgaris* L.) plant according to path analysis in their study conducted in Sakarya. In the study, it was seen that a hundred grains number had the biggest direct effect. Kara ve Akman (2007) found out positive and important relationships between grain yield and plant length, 1000 grains weight and hectolitre in wheat in their study. Turk *et al.* (2008) proposed harvest index and biological yield to be the primary selection criteria to improve seed yield in narbon vetch. In the study conducted with narbon vetch (Seydosoglu *et al.*, 2014), in genotypes plant length was 44.2-61.3 cm, main stem length was 70.8-92.5 cm, broad bean number in plant was 9.6-14.6, green plant yield was 2207.0-4097.8 kg da^{-1}, dry plant yield was 526.2-935.2 kg da^{-1} and seed yield was 267.7-431.6 kg da^{-1}. According to path analysis, characteristics like plant length, hectolitre weight and 1000 grains weight which had both direct and indirect positive effects on grain yield were evaluated as yield criteria. The given study results are different from the results obtained from this study.

In this study, the direct and indirect effects of fresh stem weight, dry stem weight, fresh leaf weight and dry leaf weight, which are considered to have an effect on plant length of narbon vetch, were estimated using path analysis.

The relationship between plant length and fresh stem weight was positive in narbon vetch plant. The rise in fresh stem weight would cause plant lentgh to increase. The relationship between plant length and dry stem weight was positive. The rise in dry stem weight would cause plant lentgh to increase. The relationship between plant length and fresh leaf weight in narbon vetch plant of 4 and 6 weeks was positive; this relationship was negative in narbon vetch plant of 5 weeks. The rise in fresh leaf weight negatively affects plant length in narbon vetch of 5 weeks while it causes plant length to increase in plants of 4 and 6 weeks. The relationship between plant length and dry stem weight was negative in narbon vetch plant old 4 weeks; this relationship was positive in narbon vetch plant of 5 and 6. The rise in dry leaf weight in narbon vetch negatively affects plant length whereas it causes plant length to increase in plants of 5 and 6 weeks.

Consequently, in narbon vetch plant dry stem weight had a more direct effect on plant length in plants of 4 weeks and fresh stem weight had a more direct effect on plant length in plants of 5 and 6 weeks.

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