OMÜ Zir. Fak. Dergisi, 2006,21(1):27-32
J. of Fac. of Agric., OMU, 2006,21(1):27-32

PATH ANALYSES OF YIELD AND YIELD-RELATED TRAITS OF COMMON VETCH (*Vicia sativa* L.) UNDER DIFFERENT RAINFALL CONDITIONS

Sebahattin ALBAYRAK
Süleyman Demirel University, Faculty of Agriculture, Department of Field Crops-Isparta

Özgür TÖNGEL
Black Sea Agricultural Research Institute-Samsun

Geliş Tarihi: 16.05.2005

ABSTRACT: This research was conducted to determine characters effecting seed yield in common vetch varieties by using simple correlation coefficient, path analysis and stepwise analysis under different rainfall conditions (high, middle and low; 707.9, 597.1, and 319.5 mm, respectively). The experiment design were randomized block design with three replications. Experiments were established in Çarşamba, Bafra and Gökhöyük in the growing season of 2003-2004. Seed yield was significantly correlated with harvest index and days to maturity in high and middle rainfall conditions. It was significantly correlated with all components except pod number and 1000-seed weight in low rainfall conditions. Harvest index and biologic yield had substantial direct effects on enhancement of seed yield under all rainfall conditions. Stepwise multiple regression analysis showed that 95.78 % of total variation in seed yield could be explained by the variation in biologic yield, pod number, days to maturity and harvest index in high rainfall conditions. It showed that 98.21 and 98.24 % of total variations in seed yield could be explained by the variation in biologic yield, pod number and harvest index in middle and low rainfall conditions respectively. Results suggest that harvest index and biologic yield are primary selection criteria for improving seed yield in common vetch in the high, middle and low rainfall conditions.
Key Words: Common vetch, seed yield and components, correlation coefficient, path and stepwise analyses

FARKLI YAĞIŞ KOŞULLARI ALTINDA YAYGIN FİĞ (*Vicia sativa* L.)'İN VERİM VE VERİMLE İLİŞKİLİ KARAKTERLERİNİN PATH ANALİZLERİ

ÖZET: Bu araştırma farklı yağış koşullarında (yüksek, orta ve düşük; sırasıyla 707.9, 597.1 ve 319.5 mm) korelasyon katsayısı, path ve stepwise analizleri kullanılarak yaygın fiğin tohum verimine etki eden karakterlerin belirlenmesi amacıyla yürütülmüştür. Denemeler tesadüf blokları deneme deseninde 3 tekrarlamalı olarak Çarşamba, Bafra ve Gökhöyük'te 2003-2004 yetiştirme peryodunda kurulmuştur. Yüksek ve orta yağış koşullarında tohum verimi hasat indeksi ve olgunlaşma gün sayısı ile önemli ilişki göstermiştir. Düşük yağış koşullarında ise tohum verimi bin tane ağırlığı hariç diğer tüm karakterlerle önemli derecede ilişkiye sahip olmuştur. Tüm yağış koşullarında hasat indeksi ve biyolojik verim tohum veriminin artmasına direkt olarak etki etmiştir. Stepwise analizi sonuçlarına göre, yüksek yağış koşullarında tohum verimine % 95.78 oranında biyolojik verim, bakla sayısı, olgunlaşma gün sayısı ve hasat indeksi etki ederken, orta yağış koşularında tohum verimine % 98.21 ve düşük yağış koşullarında % 98.24 oranında biyolojik verim, bakla sayısı ve hasat indeksi etki etmiştir. Yüksek, orta ve düşük yağış koşullarında yaygın fiğin tohum verimini artırmak için hasat indeksi ve biyolojik verim birincil derecede seleksiyon kriteri olarak kullanılabilir.
Anahtar Kelimeler: Yaygın fiğ, tohum verimi ve öğeleri, korelasyon katsayisi, path ve stepwise analizleri

1. INTRODUCTION

There are many factors that effect productivity in agriculture, these factors are plant species and cultivars, agronomical tecnics, soil and climate factors. Even though all the conditions can be provided, yield level greatly depends on climate conditions in especially dry agricultural areas. The most significant factor effecting seed yield is rainfall in dry areas. Besides rainfall quantitiy, rainfall regime in vegetation period is also important for seed yield. Açıkgöz at al. (1989) reported that rainfall quantity is too effective on seed yield in growing period, significantly. Breeders have efforted to develope suitable new cultivars and species. Determination of suitable selection criteria for different enviroment conditions supply easiness to obtain high seed yield. Correlation coefficient which measures the simple linear relationship between two traits does not predict the success of selection. However, path analysis, regression on standardized variables, determine the relative importance of direct and indirect effects on seed yield (Bhatt, 1973). Path coefficient analyses are more informative and useful than simple correlation coefficients and widely used in crop breeding to determine the nature of relationships between yield and some yield components (Dewey and Lu, 1959; Kang et al., 1983; Williams et al., 1990; Gravois and McNew, 1993; Board et al., 1997; Samonte et al., 1998). Path coefficient is a standardized partial regression coefficient that measures the direct influence of one trait upon another and permits the separation of a correlation coefficient into components of direct and indirect effects (Board et al., 1997).

Table 1. Monthly precipitation, mean temperature and relative humidity in the experimental areas.

Months	Precipitation (mm)			Temperature (°C)			Humidity (%)		
	Bafra	Çarşamba	Gökhöyük	Bafra	Çarşamba	Gökhöyük	Bafra	Çarşamba	Gökhöyük
November	106.6	64	24	10.8	11.5	8	73.5	79.7	64.9
December	108.8	104	66.6	7.7	9.3	3.9	74.8	64.6	64.7
January	67.4	84.2	28.2	6.8	8.1	5	74.7	61.3	61.9
February	55.8	43.9	54.7	6.2	7.5	3	75.5	66.3	57.4
March	47.5	66.2	24	8	8.5	4.3	77.8	75.4	56.5
April	113.5	101	60.1	11.4	11.4	11.9	71.1	77.5	51.6
May	78	56.2	33.8	14.4	15	20.1	77.5	83.1	45.2
June	130.3	77.6	28.1	19.5	20	22	76	81.4	41.2
Total	707.9	597.1	319.5	-	-	-	-	-	-
Mean	-	-	-	10.6	11.4	9.8	75.1	73.7	55.4

Path analyses have been used to identify important yield components in various forage crops including bromegrass (*Bromus inermis* Leyss.; Seker and Serin, 2004), crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.; Dewey and Lu, 1959), alfalfa (*Medicago sativa* L.; Bakheit, 1988), sainfoin(*Onobrychis sativa* Lam.; Albayrak and Ekiz, 2004), white lupin (*Lupinus albus* L.; Bellido et al., 2000), narbon bean (*Vicia narbonensis* L.; Yücel, 2004), faba bean (*Vigna faba* L.; Sindhu et al., 1985) and common vetch (*Vicia sativa* L.; Albayrak et al., 2003a, Çakmakçı et al., 1998).

In research with common vetch, Çakmakçı et al., (2003) found significant positive correlation coefficients between seed yield and biologic yield (r=0.810**), harvest index (r=0.423), and pod number (r=0.418**). The researches reported that the direct effects of biologic yield and harvest index on seed yield were greater than those of other traits. They also suggest that common vetch breeding studies should focus on biologic yield, harvest index and number of seeds per plant for seed yield. The aim of this study was to determine characters effecting seed yield in common vetch genotypes using simple correlation, path and stepwise multiple regression analyses in high, middle and low rainfall conditions.

2. MATERIALS AND METHODS

Twelve common vetch (*Vicia sativa* L.) genotypes provided by ICARDA and Black Sea Agricultural Research Institute, Turkey were used as genetic materials which were selected from yield experiments (Albayrak and Töngel, 2003b, c). Field experiments were established at Bafra (41° 34′ N Lat., 35° 54′ E Long., and 4 m elevation), Çarşamba (41° 21′ N Lat., 36° 15′ E Long., and 4 m elevation), and Gökhöyük (40° 35′ N Lat., 35° 39′ E Long., and 450 m elevation), in November 2003. The experimental design was a randomized complete block design with three replications. Seeding rates were 100 kg ha^{-1}. Individual plot size was 2.1 x 4 m= 8.4 m^2. All plots were harvested for seed yield in June 2004. The following data were measured: (1) seed yield (2) biologic yield (3) harvest index (4) days to maturity (5) 1000-seed weight (6) pod number (average of 10 randomly selected plants), and (7) seed number per pod (average of 10 randomly selected plants). Monthly total rainfall (mm) and average temperature (°C) for three locations are shown in Table 1. Normal growing season precipitation (November through June) is 707.9 mm at Bafra (high rainfall conditions), 597.1 mm at Çarşamba (middle rainfall conditions) and 319.5 mm at Gökhöyük (low rainfall conditions). Normal mean temperatures during this period are 10.60, 11.41 and 9.85 ^oC at Bafra, Çarşamba and Gökhöyük, repectively. Soil types of Bafra and Çarşamba are clay loam, of Gökhöyük is silty clay loam. Levels of P were 195, 230 and 150 kg ha^{-1}, levels of K were 850, 952 and 510 kg ha^{-1}, organic matter concenration were 2.03, 2.42 and 1.45 %, and soil pH was 7.4, 7.1 and 8.2 at Bafra, Çarşamba and Gökhöyük, respectively.

Simple correlation and stepwise multiple regression analysis' were carried out using SAS statistical program. Also, the relative importance of direct and indirect effects on seed yield was determined by path analysis for the different rainfall conditions of data (SAS Institute, 1998). In path analysis, seed yield was the dependent variable and the six plant characteristics were considered as independent variables.

3. RESULTS AND DISCUSSION

The correlataion coefficients between seed yield and yield components of common vetch showed variations in the different rainfall conditions. In high rainfall conditions, positive and significant relationships existed between seed yield and harvest index (r=0.535**) while negative correlation coefficients were found for days to maturity, pod number and thousand seed weight (r=-0.582**, -0.252, -0.195, respectively). Seed number per pod and biologic yield gave positive correlation with seed yield (Table 2).

Table 2. Simple correlation coefficients of seed yield components in common vetch under different rainfall conditions

Traits	BIY	HI	TSW	SNP	PN	DYM
high rainfall conditions in Bafra location						
SEY	0.185	0.535**	-0.195	0.311	-0.257	-0.582**
BIY		-0.717**	0.084	0.003	-0.029	-0.303
HI			-0.198	0.213	-0.144	-0.114
TSW				0.013	-0.335**	0.072
SNP					-0.016	-0.235
PN						-0.104
middle rainfall conditions in Çarşamba location						
SEY	0.218	0.798**	-0.082	0.245	0.226	-0.751**
BIY		-0.404*	-0.038	0.160	-0.063	-0.352*
HI			-0.043	0.135	0.224	-0.486**
TSW				-0.016	-0.381*	0.093
SNP					0.097	-0.115
PN						-0.322
low rainfall conditions in Gökhöyük location						
SEY	0.605**	0.373*	-0.006	0.369*	-0.111	-0.682**
BIY		-0.510**	-0.002	0.337*	-0.059	-0.446**
HI			-0.062	0.004	-0.029	-0.211
TSW				0.072	-0.447**	-0.068
SNP					-0.025	-0.192
PN						-0.016

SEY: Seed yield; **BIY:** Biologic yield; **HI:** Harvest index; **TSW:** 1000-seed weight; **SNP:** Seed number per pod; **PN:** Pod number; **DYM:** Days to maturity; *P<0.05, ** P<0.01.

Table 3. Path coefficients for seed yield components of common vetch at Bafra

Days to maturity vs seed yield	r=-0.582	**Thousand seed weight vs seed yield**	r=-0.195
Direct effect	-0.087	Direct effect	-0.054
Indirect effect via pod number	0.009	Indirect effect via days to maturity	-0.006
Indirect effect via seed number per pod	0.007	Indirect effect via pod number	0.031
Indirect effect via thousand seed weight	-0.004	Indirect effect via seed number per pod	-0.0004
Indirect effect via harvest index	-0.175	Indirect effect via harvest index	-0.258
Indirect effect via biologic yield	-0.332	Indirect effect via biologic yield	0.092
Pod number vs seed yield	r=-0.257	**Harvest index vs seed yield**	r=0.535
Direct effect	-0.091	Direct effect	1.293
Indirect effect via days to maturity	0.009	Indirect effect via days to maturity	0.012
Indirect effect via seed number per pod	0.0005	Indirect effect via pod number	0.012
Indirect effect via thousand seed weight	0.018	Indirect effect via seed number per pod	-0.007
Indirect effect via harvest index	-0.161	Indirect effect via thousand seed weight	0.011
Indirect effect via biologic yield	-0.032	Indirect effect via biologic yield	-0.797
Seed number per pod vs seed yield	r=0.311	**Biologic yield vs seed yield**	r=0.185
Direct effect	-0.029	Direct effect	1.096
Indirect effect via days to maturity	0.021	Indirect effect via days to maturity	0.027
Indirect effect via pod number	0.002	Indirect effect via pod number	0.003
Indirect effect via thousand seed weight	-0.0007	Indirect effect via seed number per pod	-0.0001
Indirect effect via harvest index	0.316	Indirect effect via thousand seed weight	-0.005
Indirect effect via biologic yield	0.003	Indirect effect via harvest index	-0.935

In middle rainfall conditions, positive correlation were found between seed yied and all its components with the exceptions of the days to maturity and thousand seed weight (r=-0.751** and -0.082). Seed yield was the highest correlated with harvest index (r=0.798**). (Table 2).

In low rainfall conditions, seed yield was positively and highly correlated with biologic yield, seed number per pod and harvest index (r= 0.605**, r= 0.369* and r=0.373*, respectively), but it was correlated negatively with days to maturity, pod number and thousand seed weight (r=-0.682**, r=-0.111 and r=-0.006, respectively). Days to maturity and pod number gave negative correlation with all other components (Table 2).

Table 4. Path coefficients for seed yield components of common vetch at Çarşamba

Days to maturity vs seed yield	r=-0.751	**Thousand seed weight vs seed yield**	r=-0.082
Direct effect	-0.011	Direct effect	-0.011
Indirect effect via pod number	-0.012	Indirect effect via days to maturity	-0.01
Indirect effect via seed number per pod	-0.0007	Indirect effect via pod number	-0.01
Indirect effect via thousand seed weight	-0.001	Indirect effect via seed number per pod	-0.0001
Indirect effect via harvest index	-0.503	Indirect effect via harvest index	-0.033
Indirect effect via biologic yield	-0.224	Indirect effect via biologic yield	-0.024
Pod number vs seed yield	r=0.226	**Harvest index vs seed yield**	r=0.798
Direct effect	0.037	Direct effect	1.039
Indirect effect via days to maturity	0.003	Indirect effect via days to maturity	0.005
Indirect effect via seed number per pod	0.0006	Indirect effect via pod number	0.008
Indirect effect via thousand seed weight	0.004	Indirect effect via seed number per pod	0.0007
Indirect effect via harvest index	0.222	Indirect effect via thousand seed weight	0.0004
Indirect effect via biologic yield	-0.041	Indirect effect via biologic yield	-0.258
Seed number per pod vs seed yield	r=0.245	**Biologic yield vs seed yield**	r=0.218
Direct effect	0.006	Direct effect	0.636
Indirect effect via days to maturity	0.001	Indirect effect via days to maturity	0.004
Indirect effect via pod number	0.003	Indirect effect via pod number	-0.002
Indirect effect via thousand seed weight	0.0002	Indirect effect via seed number per pod	0.0009
Indirect effect via harvest index	0.133	Indirect effect via thousand seed weight	0.0004
Indirect effect via biologic yield	0.102	Indirect effect via harvest index	-0.422

Table 5. Path coefficients for seed yield components of common vetch at Gökhöyük

Days to maturity vs seed yield	r=-0.682	**Thousand seed weight vs seed yield**	r=-0.006
Direct effect	-0.02	Direct effect	0.034
Indirect effect via pod number	0.0001	Indirect effect via days to maturity	0.001
Indirect effect via seed number per pod	0.0001	Indirect effect via pod number	0.003
Indirect effect via thousand seed weight	-0.002	Indirect effect via seed number per pod	0.00001
Indirect effect via harvest index	-0.197	Indirect effect via harvest index	-0.042
Indirect effect via biologic yield	-0.462	Indirect effect via biologic yield	-0.002
Pod number vs seed yield	r=-0.111	**Harvest index vs seed yield**	r=0.373
Direct effect	-0.007	Direct effect	0.891
Indirect effect via days to maturity	0.0003	Indirect effect via days to maturity	0.005
Indirect effect via seed number per pod	0.00001	Indirect effect via pod number	0.0002
Indirect effect via thousand seed weight	-0.015	Indirect effect via seed number per pod	0.00001
Indirect effect via harvest index	-0.029	Indirect effect via thousand seed weight	-0.002
Indirect effect via biologic yield	-0.061	Indirect effect via biologic yield	-0.512
Seed number per pod vs seed yield	r=0.369	**Biologic yield vs seed yield**	r=0.605
Direct effect	-0.0004	Direct effect	1.036
Indirect effect via days to maturity	0.004	Indirect effect via days to maturity	0.009
Indirect effect via pod number	0.0002	Indirect effect via pod number	0.0004
Indirect effect via thousand seed weight	0.002	Indirect effect via seed number per pod	-0.0002
Indirect effect via harvest index	0.014	Indirect effect via thousand seed weight	0.009
Indirect effect via biologic yield	0.349	Indirect effect via harvest index	-0.441

Seed yield was correlated significantly positively with harvest index, but correlated significantly negatively with days to maturity under all rainfall conditions (Table 2). In former studies with common vetch, harvest index (Çakmakçı et al., 2003), days to maturity (Albayrak et al., 2003a) exhibited strong positive and negative correlations with seed yield, respectively. Our results confirm the finding of Çakmakçı et al. (2003) and Albayrak et al. (2003a) for harvest index and days to maturity. Sinebo (2002) reported that shorter vegetative duration and higher harvest index for higher seed yield were important in barley, this result is consistent with our results (Table 2). Biologic yield and seed number per pod were positively correlated with seed yield in all rainfall conditions. Our results are consistent with Albayrak et al. (2003a).

Table 6.Stepwise multiple regression analysis of seed yield and yield components in common vetch under different rainfall conditions.

Regression equations	**Coefficient of determination**
high rainfall conditions in Bafra location	
SEY= 107.50+0.02 BIY-3.290 PN	0.0975
SEY= -93.81+0.143 BIY-0.673 PN+7.003 HI	0.9542
SEY= 68.11+0.134 BIY-0.907 PN-0.672 DYM+6.683 HI	0.9578
middle rainfall conditions in Çarşamba location	
SEY= 37.45+0.07 BIY+5.077 PN	0.1053
SEY= -130.71+0.180 BIY+0.917 PN+6.967 HI	0.9821
low rainfall conditions in Gökhöyük location	
SEY= 73.56+0.198 BIY-1.281 PN	0.3719
SEY= -131.44+0.347 BIY-0.345 PN+3.847 HI	0.9804

SEY: Seed yield; **BIY:** Biologic yield; **HI:** Harvest index; **PN:** Pod number; **DYM:** Days to maturity

Pod number except in middle rainfall conditions and 1000-seed weight in all rainfall conditions were negatively correlated with seed yield. This is contrary to the finding of Çakmakçı et al (2003).

Path coefficients divided the correlation coefficient into a series of direct an indirect effect of yield components on the seed yield of common vetch (Table 3, 4, 5). In high rainfall conditions, path coefficient analysis (Table 3) identified harvest index as having the greatest direct effect on seed yield, with biologic yield having a large secondary effect. Other componets had negative direct effects on seed yield. Seed number per pod showed a large positive indirect effect via harvest index whereas biological yield had a large negative indirect effect via harvest index on seed yield. Although seed number per pod had high correlation value (r=0.311) its direct effect on seed yield was negative. If the correlation coefficient is positive, but the direct effect is negative or negligible, the indirect effects seem to be reason of correlation. In such situations, the indirect causal factors must be considered simultaneously (Singh and Chaudhary, 1977). So seed number per pod gave a large positive indirect effect via harvest index on seed yield.

In middle rainfall conditions, path coefficient analysis (Table 4) revealed that harvest index (1.039) had the highest positive direct effect, followed by biologic yield (0.636) on seed yield. The direct effect of pod number and seed number per pod were considerably smaller on seed yield. Days to maturity and thousand seed weight showed negative direct effect. On the other hand, pod number showed a large positive indirect effect through harvest index whereas days to maturity had a large negative indirect effect through harvest index on seed yield.

In low rainfall conditions, path coefficient analysis showed that harvest index, biologic yield and thousand seed weight had positive directs effects on the seed yield, while other components had strongly negative or negligible direct effects. Seed number per pod showed a large positive indirect effect via biologic yield whereas harvest index had a large negative indirect effect via biologic yield on seed yield (Table 5). The positive correlation coefficient of seed number per pod with seed yield resulted from positive indirect effect of biologic yield. Conversely, the negative correlation coefficient of 1000-seed weight with seed yield resulted from negative indirect effect of harvest index. Although 1000-seed weight had negative correlation value (r=-0.006) its direct effect on seed yield was positive. Correlation coefficient can be negative but the direct effect may be positive and high. Under these circumstances, a restricted simultaneous selection model is to be followed, ie. Restrictions are to be imposed to nullify the undesirable indirect effects to make use of the direct effect (Singh and Chaudhary, 1977).

Although very strong negative correlations between seed yield and days to maturity were found in the all rainfall conditions, the direct effect of days to maruirty was considerably smaller on seed yield. The significant negative correlation coefficient of days to maturity with seed yield resulted from negative indirect effects of harvest index and biologic yield. Albayrak et al. (2003) and Çakmakçı et al. (1998) reported that days to maturity was negatively correlated with seed yield in common vetch. As days to maturity is getting late, seed yield of common vetch decreases.

Stepwise multiple regression analysis showed that 95.78% of total variation in seed yield could be explained by the variation in biologic yield, pod number, days to maturity and harvest index in high rainfall conditions. It showed that 98.21 and 98.24 % of total variations in seed yield could be explained by the variation in biologic yield, pod number and harvest index in middle and low rainfall conditions, respectively (Table 6).

4. CONCLUSION

The data obtained from this study could be useful for common vetch breeders and seed producers in order to increase seed yield in different rainfall conditions. The correlation coefficients between seed yield and yield components showed variation in the high, middle and low rainfall conditions. Results suggest that harvest index and biologic yield are primary selection criteria for improving seed yield in common vetch in the high, middle and low rainfall conditions. In addition, it should be focused on the genotypes which have early maturity day for high seed yield.

5.REFERENCES

Açıkgöz, E., Turgut, İ. and Ekiz, H. 1989. Variation of seed yield and its compenents in common vetch under different conditions. XVI. International Grassland Congress. Nice-France. 641-642.

Albayrak, S. and Ekiz, H. 2004. Determination of characters regarding to hay yield using correlation and path analysis in some perennial forage crops. Turkish Journal of Agricultural Science. 10 (3): 250-257.

Albayrak, S., Sevimay, C.S. and Töngel, M.Ö. 2003a. Determination of characters regarding to seed yield using correlation and path analysis in inoculated and non-inoculated common vetch. Turkish Journal of Field Crops. 8 (2). 76-84.

Albayrak,S ve M.Ö. Töngel. 2003b. Fiğ hatlarında tohum verimi ve bazı bitkisel özellikler. GAP III. Tarım Kongresi. 02-03 Ekim 2003, Şanlıurfa, 213-218.

Albayrak,S ve M.Ö. Töngel. 2003c. Fiğ hatlarının Samsun koşullarına adaptasyonu. Türkiye 5. Tarla Bitkileri Kongresi, Diyarbakır. (1): 326-330.

Çakmakçı, S., Aydınoğlu, B. and Karaca, M. 2003. Determining relationships among yield and yield components using correlation and path analysis in summer sown common vetch (*Vicia sativa* L.) genotypes. Pakistan Journal of Botany. 35(3): 387-400.

Çakmakçı, S., Ünay, A. and Açıkgöz, E. 1998. An investigation on determination of characters regarding to seed and straw yield using different methods in common vetch. Turkish Journal of Agriculture and Forestry. 22, 161-165.

Dewey, D.R. and Lu, K.H. 1959. A correlation and path-coefficient analysis of components of crested wheatgrass seed production. Agronomy Journal. 51, 515-518.

Bakheit, B.R. 1988. Variation, correlation and path coeficient analysis in some world varieties of alfalfa. Journal of Agricultural Sciences. 149-163.

Ball, R.A., McNew, R.W., Vories, E.D., Keisling, T.C. and Purcell, L.C. 2001. Path analyses of population density effects on short-season soybean yield. Agronomy Journal. 93:187–195.

Bhatt, G.M. 1973. Significance of path coefficient analysis determining the nature of character association. Euphytica. 22, 89-97.

Bellido L.L., Fuentes, M. and Castillo, J.E. 2000. Growth and yield of white lupin under mediterranean conditions. Effect of plant density. Agronomy Journal. 92:200-205.

Board, J.E., Kang, M.S. and Harville, B.G. 1997. Path analyses identify ındirect selection criteria for yield of late planted soybean. Crop Science. 37: 879-884.

Gravois, K.A. and McNew, R.W. 1993. Genetic relationships among and selection for rice yield and yield components. Crop Science. 33:249–252.

Kang, M.S., Miller, J.D. and Tai. P.Y.P. 1983. Genetic and phenotypic path analyses and heritability in sugarcane. Crop Science. 23:643-647.

SAS Institute. 1998. INC SAS/STAT users' guide release 7.0, Cary, NC, USA

Samonte, S.O., Wilson. L.T. and McClung, M. 1998. Path analyses of yield and yield-related traits of fifteen diverse rice genotypes. Crop Science. 38: 1130-1136.

Seker, Y. and Serin, Y. 2004. Explanation of the relationships between seed yield and some morphological traits in smooth bromegrass (*Bromus inermis* Leyss.) by path analysis. European Journal of Agronomy. 21: 1-6.

Sindhu, J.S., Singh, O.P. and Singh, K.P. 1985. Components analysis of the factors determining grain yield in faba bean (*Vicia faba* L.). FABIS-Newsletter ICARDA. Faba bean Imformation Service. 13: 3-5.

Sinebo, W. 2002. Yield relationships of barleys grown in a tropical highland environment. Crop Science 42:428-437.

Singh, K.B. and Chaudhary, B.D. 1977. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers. New Delhi-India, 304p.

Yücel, C. 2004. Correlation and path coefficient analyses of seed yield components in the narbon bean (*Vicia narbonensis* L.). Turkish Journal of Agriculture and Forestry. 28, 371-376.