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Determining Possible Relationships between Yield and Yield-Related Components in Forage Maize (*Zea mays* L.) Using Correlation and Path Analyses

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Abstract

This study was carried out to determine the optimum plant density and nitrogen rate in maize (*Zea mays* L.) under the ecological conditions of the Southern Marmara Region. For this purpose, maize was grown at different plant densities and was fertilized with different rates of nitrogen during 2006 and 2007. The dry forage yield, plant height, first ear height, stem diameter, leaf number plant^{-1}, ear number plant^{-1}, leaf ratio, stem ratio, ear ratio, ear diameter, leaf area index, and light interception were measured for all the treatments applied. The values of each parameter mentioned above were reorganized without regard to treatments or with regard to the highest and lowest values of plant density and nitrogen rates and were evaluated to determine the relationships between the dry forage yield and yield-related components. For this purpose, the direct and indirect effects of the corresponding components on dry forage yield were determined by using correlation and path analyses methods. The data averaged over two years, regardless of the treatment effects indicated that the relationship between the dry forage yield and each yield component except for stem ratio was positively significant. Path analysis revealed that most of the yield components had direct effects on the dry forage yield. According to this study, greater priority must be given to first ear height, leaf ratio and light interception to optimize silage maize yield. When the highest and the lowest plant densities and nitrogen rates were considered, it was understood that the nitrogen application had a greater effect on the dry forage yield than the plant density did.

Keywords: maize, correlation coefficient, path analysis, forage yield, yield components, leaf area index, light interception

Introduction

Maize (*Zea mays* L.) is an important cereal which is used as human food, animal feed and a raw material for various agro-based industries throughout the world. Many environmental factors, management systems, and genetic factors influence the yield and quality of forage maize (Struik, 1983; Deinum, 1988; Cox *et al.*, 1994; Cusicanqui and Lauer, 1999). Forage maize growers are usually advised to plant hybrids with high grain yields because a high grain content increases the palatability, energy level, and digestibility of forage maize (Woody *et al.*, 1983; Wolf *et al.*, 1993).

The efficiency of a breeding program depends primarily on the direction and magnitude of the association between the yield and yield components and on the relative importance of each factor to forage yield. Path analysis is a statistical technique that partitions correlations into direct and indirect effects and distinguishes between correlation and causation, whereas, in general, correlation measures the extent and direction (positive or negative) of the relationship between two or more variables. The estimates of correlation and path coefficients can help us to understand the roles and relative contributions of various plant traits in establishing the growth behavior of crop cultivars under given environmental conditions (Shahbaz Akhtar *et al.* 2007).

A number of researchers who study forage maize have tried to explain the relationships between yield-related components by using correlation and path coefficient analysis (Gallais *et al.*, 1976; Schmid *et al.*, 1976; Hunter, 1986; Mo *et al.* 1986; Xu 1986; Jatimliansky *et al.* 1988; Kara *et al.*, 1999; Kumar Srivas and Singh, 2004; Iptas and Yavuz, 2008; Ergul and Soylu, 2009; Icoz and Kara, 2009). Kara *et al.* (1999) reported that the green forage yield in maize was positively correlated with stem diameter, ear diameter, and ear weight. Positive and significant correlations between silage yield and leaf area, ear weight, stem weight, and leaf weight have been reported by Ergul and Soylu (2009). However, these authors did not observe any significant correlation between silage yield and plant height, first ear height, ear diameter, stem ratio, leaf number, leaf ratio, or ear ratio. Schmid *et al.* (1976), Hunter (1986), and Iptas and Yavuz (2008) have reported that plant height and stem diameter are not related to dry matter yield. However, Gallais *et al.* (1976) demonstrated that plant height and stem diameter are related to dry matter yield. Kumar Srivas and Singh (2004) reported that the dry forage yield plant^{-1} is significantly and positively associated with green fodder yield and yield components such as plant height, number of leaves plant$^{-1,}$ and stem diameter. Thus, the improvements in characters such as plant height, number of leaves plant$^{-1,}$ and stem diameter will help improve fodder yield both directly and indirectly. Iptas and Yavuz (2008) reported that dry matter yield is negatively correlated with stem ratio and leaf ratio. Icoz and Kara (2009) suggested that to optimize the silage maize yield, the greater priority must be given to ear weight, leaf number, and stem diameter.

The aim of this study was to determine the reciprocal relationships between dry forage yield and yield-related components and to identify the direct and indirect effects of yield-related components on dry forage yield. The data used in this article were taken from a study in which the main purpose was to determine the optimum plant density and nitrogen rate for cultivation of forage maize.

Materials and methods

This experiment was carried out in the 2006 and 2007 growing seasons on a clay loam soil at the Agricultural Research and Experiment Center of Uludag University, near Bursa (40°11′ N, 29°04′ E). Soil test values indicated a pH of 7, low level of saline, low levels of lime and organic matter, and a high level of potassium. The precipitation patterns and amounts differed markedly between the 2006 and 2007 growing seasons. Although the total precipitation in 2006 (151.2 mm) was only 12.2 mm below the long-term mean, the conditions were very dry in May, July and August. The precipitation levels in June and September were much higher than those for the same months of long-term. The total precipitation for the 2007 growing season was 67.2 mm below the long-term mean, and all of the months of this year except June were very dry. There were almost no differences between the mean temperatures and mean relative humidities of the experimental years and the long-term means.

The field experiments were conducted using a split-plot design with three replications on May 15 in 2006 and 2007. The variety ADA-523 was used as the test plant. Five plant densities (60,000, 100,000, 140,000, 180,000 and 220,000 plants ha^{-1}) and five nitrogen rates (0, 100, 200, 300 and 400 kg ha^{-1}) were employed as variable factors of the experiment. The main plots were allotted to the different plant densities, and the split-plots were allotted to the different nitrogen rates. The split plot size was 5 m by 5.2 m, and these plots were sown with eight rows. Split-plots were planted with a 0.65-m row spacing. Half of the nitrogen rates with initial amounts of P and K each at 100 kg ha^{-1} were applied before planting. The rests of the nitrogen rates were side-dressed when plants reached heights of 40-50 cm. Weeds were controlled by a post-emergence application of 2.4-D at a rate of 2.0 l ha^{-1} and by mechanical hoeing whenever it was necessary.

Four plants from the second and third rows of each split-plot were collected, their leaf areas were determined by LI-3000 A (LI-COR, Lincoln) and then the leaf area indexes were calculated at the R2 stage. At the same stage, light interception values were determined using a LI SA191-A Quantum Sensor and were calculated according to the formula of Zaffaroni and Schneiter (1989). Ten plants from the middle rows of each split-plot were collected just prior to the forage harvest to assess morphological characters such as plant height, first ear height, stem diameter, leaf number plant$^{-1,}$ and ear number plant^{-1}. Five out of each 10 sampled plants were assorted into stem, leaf and ear fractions to determine their percentages relative to the weight of the whole plant. The ear diameters of these plants were also measured.

After removing the border effects, two middle rows of each split-plot were harvested and weighed fresh in situ to determine the forage yield when the kernels were doughy. After harvest, two plants from the forage material of each split plot were taken, dried at 78°C for 48 h and weighed to determine the dry forage yields. Then, the dry forage yields of the split plots were calculated and transformed into yield per hectare.

In this study, the correlations between dry forage yield and yield components and the direct and indirect effects of yield components on dry forage yield determined by path analysis were calculated using the Tarist statistical program (Anlarsal and Gulcan, 1989; Sabanci, 1996; Turk and Celik, 2006). For this purpose, both two-year average data without regard to plant densities and nitrogen rates and the data for the lowest and the highest plant densities and nitrogen rates were evaluated.

Results and discussions

The simple correlation coefficients averaged over all treatments are shown in Tab. 1. Positive and statistically significant relationships existed between the dry forage yield and all of the yield components except for the stem ratio. The correlation between the dry matter yield and the stem ratio was negatively significant. The dry forage yield was positively and significantly correlated with plant height (r = 0.623**), first ear height (r = 0.655**), leaf number plant^{-1} (r = 0.416**), ear number plant^{-1} (r = 0.288**), leaf ratio (r = 0.367**), ear ratio (r = 0.484**), ear diameter (r = 0.435**), leaf area index (r = 0.580**), and light interception (r = 0.328**). Most of the reciprocal relationships among the variable components were significantly positive. For instance, the relationships between plant height and first ear height, stem diameter, leaf number plant^{-1}, ear number plant^{-1}, ear ratio, ear diameter, leaf area index, and light interception; between first ear height and leaf number plant^{-1}, ear diameter, leaf area index, and light interception; between stem diameter and leaf number plant^{-1}, ear number plant^{-1}, leaf ratio, ear ratio, and ear diameter; between leaf number plant^{-1} and ear number

Tab. 1. Correlation coefficients among yield and yield-related components in forage maize (averages of overall data)

	Plant height	First ear height	Stem diameter	Leaf number plant^{-1}	Ear number plant^{-1}	Leaf ratio	Stem ratio	Ear ratio	Ear diameter	Leaf area index	Light interception
Dry forage yield	0.623**	0.655**	-0.001ns	0.416**	0.288**	0.367**	-0.531**	0.484**	0.435**	0.580**	0.328**
Plant height		0.847**	0.323**	0.430**	0.354**	0.127 ns	-0.481**	0.525**	0.560**	0.542**	0.722**
First ear height			-0.059ns	0.348**	0.118ns	0.045ns	-0.253**	0.273	0.255**	0.664**	0.654**
Stem diameter				0.357**	0.643**	0.203*	-0.554**	0.604**	0.717**	-0.339**	0.076ns
Leaf number plant^{-1}					0.432**	0.495**	-0.649**	0.580**	0.582**	0.168*	-0.011ns
Ear number plant^{-1}						0.367**	-0.599**	0.587**	0.644**	-0.128ns	0.001ns
Leaf ratio							-0.714**	0.389**	0.367**	0.099ns	-0.123ns
Stem ratio								-0.905**	-0.828**	-0.190*	-0.115ns
Ear ratio									0.869**	0.174*	0.161*
Ear diameter										0.101ns	0.183*
Leaf area index											0.545**

* significant at the 0.05 probability level, ** significant at the 0.01 probability level, ns: non-significant

plant^{-1}, leaf ratio, ear ratio, ear diameter, and leaf area index; between ear number plant^{-1} and leaf ratio, ear ratio, and ear diameter; between leaf ratio and ear ratio and ear diameter; between ear ratio and ear diameter, leaf area index, and light interception; between ear diameter and light interception; and between leaf area index and light interception were positive and significant. On the other hand, there were some negative but significant correlations among some yield components. For instance, the relationships between stem ratio and plant height, first ear height, stem diameter, leaf number plant^{-1}, ear number plant^{-1}, and leaf ratio were negative, but significantly correlated (Tab. 1). The relationships between yield and yield-related components vary with the ecological conditions. Therefore, there are discrepancies among the findings of researchers who conducted their studies under different ecological conditions. The results of our study agreed with the results of some studies but not others. For instance, Kara *et al.* (1999) demonstrated that green forage yield in maize was positively correlated with stem diameter (opposite result to our study) and ear diameter (same as ours). The results of Ergul and Soylu (2009) indicated that there were no relationships between forage yield and forage yield-related components such as plant height, first ear height, ear diameter, stem ratio, leaf number, ear ratio, and leaf ratio. However, in our study, all of these components except for stem ratio were positively and significantly correlated with dry forage yield. The relationship between dry forage yield and stem diameter was found to be insignificant (Schmid *et al.*, 1976; Hunter, 1986; Iptas and Yavuz, 2008). The relationship between dry forage yield and plant height was positive (Gallais *et al.*, 1976; Kumar Srivas and Singh, 2004; Icoz and Kara, 2009), and the relationship between dry forage yield and stem ratio was negative (Iptas and Yavuz, 2008). All these results are in agreement with ours. Schmid *et al.* (1976), Hunter (1986) and Iptas and Yavuz (2008) observed an insignificant relationship between dry forage yield and plant height, a result that is in opposition to ours. Gallais *et al.* (1976) and Icoz and Kara (2009) found a positive relationship between forage yield and stem diameter; in our study, this relationship was not significant. Iptas and Yavuz (2008) found a negative relationship between forage yield and leaf ratio, a relationship that was positive in our study. Icoz and Kara (2009) reported

Tab. 2. Path analysis showing direct and ındirect effects of yield-related components on dry forage yield (averages of overall data)

Yield components	Correlation coefficients	Direct effects (%)	Indirect effects (%)										
			1	2	3	4	5	6	7	8	9	10	11
Plant height (1)	0.623**	17.77	-	26.14	-9.14	-3.86	3.64	1.56	5.64	5.05	9.19	7.17	-10.85
First ear height (2)	0.655**	38.17	18.60	-	2.07	-3.86	1.50	0.69	3.67	3.26	5.18	10.86	-12.15
Stem diameter (3)	-0.001ns	-36.35	7.38	-2.35	-	-4.11	8.49	3.19	8.34	7.47	15.10	-5.77	-1.46
Leaf number plant^{-1} (4)	0.416**	-12.28	10.46	14.69	-13.82	-	6.07	8.30	10.41	7.65	13.06	3.05	0.23
Ear number plant^{-1} (5)	0.288**	14.32	8.77	5.09	25.36	-5.40	-	6.28	9.79	7.88	14.73	-2.37	-0.01
Leaf ratio (6)	0.367**	23.96	4.41	2.74	-11.20	-8.67	7.38	-	16.36	7.32	11.76	2.57	3.62
Stem ratio (7)	-0.531**	-12.87	-9.39	-8.59	17.21	6.39	-6.76	-9.62	-	-9.57	-14.92	-2.77	1.90
Ear ratio (8)	0.484**	10.69	10.35	9.37	-18.96	-5.78	6.70	5.30	11.78	-	15.83	2.56	-2.68
Ear diameter (9)	0.435**	17.64	10.70	8.48	-21.80	-5.61	7.12	4.83	10.43	9.00	-	1.44	-2.96
Leaf area index (10)	0.580**	18.71	13.61	28.96	13.57	-2.14	-1.86	1.72	3.15	2.37	2.34	-	-11.57
Light interception (11)	0.328**	23.13	19.77	31.11	-3.29	0.15	0.01	-2.33	2.08	2.39	4.63	11.11	-

* significant at the 0.05 probability level, ** significant at the 0.01 probability level, ns: non-significant

Tab. 3. Path analysis at 60.000 plants ha-1 showing direct and indirect effects of yield-related components on dry forage yield.

Yield components	Correlation coefficients	Direct effects (%)	Indirect effects (%)										
			1	2	3	4	5	6	7	8	9	10	11
Plant height (1)	0.651**	23.1752	-	18.2643	0.0848	-10.4860	5.2081	1.2793	4.3208	5.0138	- 0.7500	10.0407	-21.3771
First ear height (2)	0.660**	21.9353	22.0940	-	0.0758	-12.0700	5.0200	1.3333	4.4528	4.6727	-0.7079	9.2754	-18.3628
Stem diameter (3)	0.553**	0.2110	20.8367	15.3985	-	-5.8615	5.2840	1.7027	7.0501	9.2046	-1.1470	12.3860	-20.9180
Leaf number plant-1 (4)	0.254ns	-29.3945	18.5787	17.6784	0.0422	-	6.8547	1.1103	3.6855	3.8298	-0.7578	8.3722	-9.6960
Ear number plant-1 (5)	0.696**	27.4086	14.2471	11.3521	0.0588	-10.5833	-	5.8557	8.4018	7.4381	-0.9424	8.6321	-5.0800
Leaf ratio (6)	0.524**	14.1541	11.7431	10.1176	0.0636	-5.7523	19.6496	-	12.7209	5.7992	-1.0277	8.8797	-10.0921
Stem ratio (7)	-0.814**	-9.5157	-15.6659	-13.3462	-0.1040	7.5418	-11.1358	-5.0245	-	-9.7856	1.1913	-11.9223	14.7669
Ear ratio (8)	0.706**	12.6641	16.5472	12.7485	0.1236	-7.1340	8.9739	2.0850	8.9075	-	-1.2980	13.2363	-16.2820
Ear diameter (9)	0.739**	-1.2497	17.7354	13.8378	0.1103	-10.1133	8.1460	2.6474	7.7693	9.2997	-	12.7396	-16.3513
Leaf area index (10)	0.740**	13.2063	19.8726	15.1760	0.0997	-9.3525	6.2454	1.9146	6.5082	7.9378	-1.0663	-	-18.6206
Light interception (11)	0.451*	29.0043	23.6484	16.7928	0.0941	-6.0539	2.0544	1.2162	4.5056	5.4576	- 0.7650	10.4077	-

* significant at the 0.05 probability level, ** significant at the 0.01 probability level, ns: non-significant

Tab. 4. Path analysis at 220.000 plants ha-1 showing direct and indirect effects of yield-related components on dry forage yield

Yieldcomponents	Correlation coefficients	Direct effects (%)	Indirect effects (%)										
			1	2	3	4	5	6	7	8	9	10	11
Plant height (1)	0.675**	18.1413	-	26.1714	- 0.8727	2.0310	0.9872	2.7211	20.0117	- 19.2213	2.8195	6.2824	- 0.7403
First ear height (2)	0.682**	29.9027	- 18.2968	-	-0.7881	1.9460	1.0565	1.9578	18.7851	- 18.2989	2.6496	5.6627	- 0.6558
Stem diameter (3)	0.252ns	- 3.8767	- 13.4489	17.3720	-	2.5865	0.2278	4.2548	22.6242	-24.5239	2.9384	7.4605	- 0.6864
Leaf number plant-1 (4)	0.543**	5.0536	-6.2608	8.5802	-0.5174	-	0.4112	-13.6542	37.1836	-21.3455	2.9121	3.7982	0.2832
Ear number plant-1 (5)	0.485**	2.4325	-16.0731	24.6030	-0.2406	2.1721	-	6.7515	18.7643	-21.4957	3.3312	3.6635	-0.4724
Leaf ratio (6)	0.142ns	-34.8763	2.6373	-2.7141	0.2676	4.2931	0.401-9	-	43.2126	-8.8343	1.1523	0.7636	0.8469
Stem ratio (7)	-0.600**	-40.9446	5.0320	-6.7565	0.3692	-3.0332	-0.2898	11.2112	-	26.0075	-3.3010	2.9232	0.1319
Ear ratio (8)	0.630**	30.7318	-7.1026	9.6718	-0.5880	2.5587	0.4879	-3.3681	38.2184	-	3.7999	3.4022	-0.0706
Ear diameter (9)	0.669**	4.3778	-7.9573	10.6963	-0.5381	2.6662	0.5774	-3.3555	37.0498	-29.0227	-	3.6507	-0.1080
Leaf area index (10)	0.619**	8.8669	-14.5003	18.6950	-1.1174	2.8439	0.5193	-1.8184	26.8315	-21.2508	2.9856	-	-0.5708
Light interception (11)	0.196ns	2.3203	-19.4466	24.6410	-1.1699	-2.4135	0.7621	22.9518	-13.7772	-5.0157	1.0053	6.4966	-

* significant at the 0.05 probability level, ** significant at the 0.01 probability level, ns: non-significant

positive relationships between forage yield and leaf number and between forage yield and ear diameter, which are in agreement with our results.

The results of the path analysis between yield and yield-related components are presented in Tab. 2. We found that some yield-related components such as plant height, first ear height, ear number plant^{-1}, leaf ratio, ear ratio, ear diameter, leaf area index, and light interception had significant and direct effects on the dry forage yield of maize. Among these, the direct effects of first ear height (38.17 %), leaf ratio (23.96 %), light interception (23.13 %), leaf area index (18.75 %), plant height (17.77 %), and ear diameter (17.64 %) on dry forage yield were the greatest effects, in decreasing order. The greatest and positive indirect effects of first ear height, leaf ratio, light interception, leaf area index, plant height and ear diameter were realized via plant height, stem ratio, first ear height, first ear height, first ear height, and plant height, respectively (Tab. 2). Earlier studies indicated that ear diameter had significant direct effects on forage dry matter (Xu 1986; Mo *et al.* 1986; Jatimliansky *et al.* 1988). Kara *et al.* (1999) reported that plant height and ear weight were the characters with the greatest direct effects on fresh forage in maize. In this study, the effects of stem diameter and ear length on fresh forage were indirect via ear weight.

Correlation coefficient and path analyses of yield and yield-related components were done at the lowest and the highest levels of plant density and nitrogen rate. The results of the calculations at the lowest and the highest nitrogen levels revealed no significant correlation or direct and indirect effects between yield and yield-related components. These results indicate that the plant density had no effect on yield or yield components. Therefore, these results were not included in this article. However, the results of the correlations and path analyses calculated using the data of the lowest and the highest plant densities were usually significant, and these results are presented in Tab. 3 and 4. These data indicate that plants were affected by the different nitrogen rates applied to plots with the lowest and highest plant densities. Plant height, first ear height, ear number plant^{-1}, ear ratio, ear diameter, and leaf area index were positively and significantly correlated with dry forage yield (Tab. 3 and 4). The relationship between the stem ratio and the dry forage yield was negative at each plant density. While leaf number plant^{-1} was not related to the dry forage yield at the lowest plant density, a positive relationship was observed between these components at the highest plant density. The stem diameter was significantly correlated with the forage yield at the lowest plant density, but no relationship was found at the highest plant density. At the lowest plant density, the direct effect of the stem diameter on the dry forage yield was low, but its indirect effects via plant height, first ear height, leaf area index, and ear ratio were positive, greater, and more significant than other indirect effects. Even the indirect effect of the stem diameter via light interception was negative and very low. Some yield-related components that had significant and positive relationships with the dry forage yield both at the lowest and the highest plant densities had greater direct effects at the same plant densities. However, some yield components such as stem diameter, leaf number plant^{-1}, leaf ratio, and ear diameter yielded different results for direct effects at the lowest and the highest plant densities. While the direct effect of leaf number plant^{-1} was not significant at the lowest plant density, the direct effects of stem diameter, leaf ratio and light interception were not significant at the highest plant density. Kara *et al.* (1999) indicated that the effect of ear weight on forage yield was the greatest and positive. Icoz and Kara (2009) reported that ear weight, leaf number, and stem diameter had the greatest direct effects on plant weight at the lowest and the highest plant densities. Their results for ear weight are in agreement with our results for ear ratio. However, there are not many references in the literature with which we can compare our results.

Conclusions

In this study, (1) when the highest and the lowest plant densities and nitrogen rates were considered, the nitrogen applications affected the dry forage yield more than plant density; and (2) all of the yield-related components with the exception of stem diameter and stem ratio were positively related to the dry forage yield, and among these components, the first ear height, leaf ratio, light interception, leaf area index, plant height, and ear diameter had direct effects that were greater than those of the other components.

In summary, our results suggest that the relationships between yield and yield components such as first ear height, leaf ratio, and light interception should be considered for increasing the dry forage yield of maize.

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References

Anlarsal, A. E. and H. Gulcan (1989). Determination of relations between yield and yield components in common vetch (*Vicia sativa* L.) by using path analysis under Cukurova conditions. Turk. J. Agric. For. 13:487-494.

Cox, W. J., J. H. Cherney, D. J. R. Cherney and W. D. Pardee (1994). Forage quality and harvest index of corn hybrids under different growing conditions. Agron. J. 86:277-282.

Cusicanqui, J. A. and J. G. Lauer (1999). Plant density and hybrid influence on corn forage yield and quality. Argon. J. 91:911-915.

Deinum, B. (1988). Genetic and environmental variation in quality of forage maize in Europe. Netherlands J. of Agric. Sci. 36:400-403.

Ergul, Y. and S. Soylu (2009). Evaluation of yield and morphological characters as selection criteria in silage maize cultivars. VIII. Field Crops Congress in Turkey.

Gallais, A., M. Pollacsek and L. Huguet (1976). Possibilities de selection du mais en tant que plante fourragere. Annales d'Amelioration ds Plantes 26:591-605.

Hunter, R. B. (1986). Selection hybrids for silage maize production, 140-146 pp. In: A Canadian experience. Dolstra, O. and P. Miedema (Eds.). Breeding of silage maize. Proc. 13th congress on the maize and sorghum section of Eucarpia, Wageningen, The Netherlands, 9-12 Sept. 1985, Pudoc, Wageningen, The Netherlands.

Icoz, M. and S. M. Kara (2009). Effect of plant density on yield and yield component relationships in silage corn. VIII. Field Crops Congress in Turkey.

Iptas, S. and M. Yavuz (2008). Effect of pollination levels on yield and quality of maize grown for silage. Turk. J. Agric. For. 32:41-48.

Jatimliansky, J. R., M. I. Urrutia, M. J. Arturi (1988). Path analysis in dry matter production and flint type maize. Maize-Genetics-Cooperation-Newsletter, No. 62, 73.

Kara, S. M., M. Deveci, O. Dede and N. Sekeroglu (1999). The effects of different plant densities and nitrogen levels on forage yield and some attributes in silage corn. III. Field Crops Congress in Turkey, Adana III:172-177.

Kumar Srivas, S. and U.P. Singh (2004). Genetic variability, character association and path analysis of yield and its component traits in forage maize (*Zea mays* L.). Range Mgmt. and Agroforesty 25(2):149-153.

Mo, H. D., X. H. Hu and Y. Q. Lo (1986). Genetics analysis of quantitative characters of maize. Journal of Jiangsu Agricultural College 7(1):1-8.

Sabanci, C. O. (1996). Determination of relations between yield and yield components in common vetch (*Vicia sativa* L.) by using path analysis. III, 656-660 pp. Grassland and Forages Congress in Turkey. Erzurum.

Schmid, A.R., R.D. Goodrich, R.M. Jordan, G.C. Marten and J.C. Meiske (1976). Relationships among agronomic characteristics of corn and sorghum cultivars and silage quality. Agron. J. 68:403-405.

Shahbaz Akhtar, M., Y. Oki and T. Adachi (2007). Path and correlation analyses of the factors affecting biomass production of brassica cultivars under phosphorus-deficiency stress environment. Comm Soil Sci Plant Anal 38:2659-2679.

Struik, P. C. (1983). Physiology of forage maize (*Zea mays* L.) in relations to its production and quality. Ph. D.diss. Agricultural Univ., Wageningen, The Netherlands.

Turk, M. and N. Celik (2006). Correlation and Path Coefficient Analyses of Seed Yield Components in the Sainfoin (*Onobrychis sativa* L.). J Biol Sci 6(4):758-762.

Wolf, D. P., J. G. Coors, K. A. Albrecht, D. J. Undersander and P. R. Carter (1993). Agronomic evaluations of maize genotypes selected for extreme fiber concentrations. Crop Sci 33:1359-1365.

Woody, H. D., D. G. Fox and J. R. Black (1983). Predicting net energy value of maize silage varying in grain content. J. Dairy Sci 57:710-716.

Xu, Z. B. (1986). Influence of major characters of maize on the productivity of individual plants. Ningxia Agric Sci Techn 5:26-27.

Zaffaroni, E. and P. J. Schneiter (1989). Water-use efficiency and light interception of semi-dwarf and standard-height sunflower hybrids grown in different row arrangements. Agron. J 81:831-836.