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CORRELATION AND PATH ANALYSIS OF GRAIN YIELD AND YIELD COMPONENTS OF SOME TURKISH OAT GENOTYPES

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Abstract

This research was carried out in 2002-03 and 2005-06 crop years in Kahramanmaras province located in East-Mediterranean Region of Turkey. The experimental design was randomized complete block design with four replications. The aim of research was to determine correlation coefficients of 17 oat genotypes among grain yield (GY) and plant height (PH), grain number panicle^{-1} (GNP), grain weight panicle^{-1} (GWP), 1000 grain weight (1000-GW), grain filling period (GFP), days to maturity (DM), panicle number m^{-2} (PN m^{-2}). Determined direct and indirect effects of yield components on GY through path analysis were also determined.

Based on results of correlation coefficients, GY was significantly but negatively correlated with PH (r = - 0.280*), while the other yield components were not significantly related with GY. Path coefficient analysis indicated that PN m^{-2} (0.23), 1000-GW (0.35), GNP (0.22), GFP (0.16) and DM (0.09) had positive direct effects on GY while GWP (-0.40) and PH (-0.24) had negative direct effects on GY. However, when the positive direct and indirect effects were added to the negative direct and indirect effects for traits, the sum of direct and indirect effects of GFP (72.48), PN m^{-2} (57.34) and DM (35.05%) on GY were positive. The effects of these traits were higher than those of 1000-GW and GNP. The sum direct and indirect effects of PH was negative and at the rate of 58.92%. Therefore, GFP, PN m^{-2}, DM and PH could have priorities in breeding programs for the conditions of East Mediterranean region of Turkey.

Introduction

Oat (*Avena sativa* L.) is a cereal crop that is used worldwide for human food and animal feed. Compared to other cereal crops, oat is reputed to be better suited for production under marginal environments, including cool-wet climates and soils with low fertility (Hoffmann, 1995). However, oat yield cannot compete with wheat and barley grain yields, in the other production areas. It needs improved grain yield for most of the production areas. Grain yield is the result of a number of complex morphological and physiological processes affecting each other and occurring in different growing stages (Dokuyucu & Akkaya, 1999; Akhtar *et al*., 2011). In general, oat breeders select varieties based on grain yield and desirable traits, observed from heading to maturity. Beside grain yield, these traits are panicle number per square meter, plant height, number of grains per panicle, grain weight per panicle, 1000-grain weight, days to maturity and grain filling period.

The advantage of path analysis is that it permits the partitioning of the correlation coefficient into its components (Dewey & Lu, 1959). In agriculture, path analyses have been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield (Dewey & Lu, 1959; Milligan *et al*., 1990). This technique is useful in determining the direct influence of one variable on another, and also separates the correlation coefficient into its components (Rodriguez *et al*., 2001). Path analysis is a tool that is available to the breeder for better understanding the causes involved in the associations between traits and to partition the existing correlation into direct and indirect effects, through a main variable (Lorencetti *et al*., 2006). There is rather agreement among plant breeders that associations among oat (*Avena sativa* L.) agronomic traits are very important to increase the use of indirect selection to improve grain yield (Benin *et al*., 2003). Benin *et al*., (2003) reported that direct and indirect effect of panicle weight, panicle number per plant and average grain weight could help to identify oat plants with large grain production and improving genetic gain efficiency. The number of panicles per plant showed to be the most correlated trait with GY of individual oat plants by means of simple correlations as via direct effects on grain yield (Lorencetti *et al*., 2006). Moradi *et al*., (2005) also determined that PN m^{-2} and GNP showed the highest direct effect on GY of oat. Meanwhile, there are too limited researches related with path analyses on oat genotypes in the literature, especially for East-Mediterranean environments.

However, for other cereal plants, grain yield has been reported to be influenced by high direct effects of total tillers and days to flowering (Amirthadevarathinam, 1983), the number of panicles per plant, the number of filled grains per panicle and 1000-grain weight (Yang, 1986), the number of filled grains per panicle and plant height (Ruben & Katuli, 1989), productive tillers, panicle length and flowering time (İbrahim *et al*., 1990), plant height and tiller number (Kumar, 1992), panicle number plant^{-1} and spikelet number panicle^{-1} (Lin & Wu, 1981), the number of effective tillers plant^{-1}, grains panicle^{-1} and 1000 grain weight (Ram, 1992), grains panicle^{-1} and productive tillers (Sundaram & Palanisamy, 1994), the number of filled grains panicle^{-1} and 1000 grain weight (Mehetre *et al*., 1994; Samonte *et al*., 1998) and biological yield, harvest index and 1000-grain weight (Sürek *et al*., 1998).

The objectives of this study were; i) to estimate Pearson correlation coefficients between grain yield and yield components for oat genotypes, and ii) to investigate direct and indirect effects of yield components on oat grain yield.

Material and Method

Seventeen oat (*Avena sativa* L.) genotypes used in this study were nine cultivars (Ankara-76, Ankara-84, Apak 2-3, Bozkır 1-5, Seydişehir, Faikbey, Yeşilköy-330, Yeşilköy-1179, and Checota) and eight landraces (Erzurum, Ordu, Amasya, Sivas, Antalya, Tokat, Çanakakale-Ovacık Köyü and Samsun Ladik-İbiköyü). Field experiments were carried out in rainfed conditions for two winter cropping years (2002-03 and 2005-06) in Kahramanmaras province located in between the coordinates 37° 53' N, 36° 58' E in East-Mediterranean Region of Turkey. Some climatic data in the region are given in Table 1. Available rainfall in experiment years was higher than average rainfall of long term years (Table 1). Some chemical and physical traits of two years experiment soil sampled from 0-30 cm topsoil are given in Table 2.

Table 1. Some average climatically data belong to experiment (2002-03 and 2005-06) and long term years (1930-2006) in Kahramanmaras province.

	Rainfall (mm)			Temperature (˚C)		
Months	**2002-03**	**2005-06**	**Long term (1930-2006)**	**2002-03**	**2005-06**	**Long term (1930-2006)**
November	75.8	69.6	60.1	13.5	10.8	12.0
December	78.1	93.5	119.4	4.2	8,4	6.5
January	120.0	102.0	133.1	7.1	3.8	4.3
February	213.8	232.7	110.1	3.8	6.9	6.3
March	145.8	96.8	90.4	8.0	11.7	10.4
April	88.7	36.6	68.7	15.0	17.0	14.9
May	30.4	14.1	35.0	14.1	21.9	19.9
June	1.6	-	7.0	25.6	27.4	24.7
Total	754.2	645.3	623.8			
Mean				11.4	13.5	12.4

Table 2. Some chemical and physical traits of topsoil (0-30 cm), in the experiment field.

Years	Depth (cm)	Texture	pH	Lime ($CaCO_3$) (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Organic matter (%)
2002-03	0-30	Loamy	7.51	24.48	95.4	911.7	1.077
2005-06	0-30	Loamy	7.54	23.74	55.2	1062.6	1.081

The experimental design was a randomized complete block with four replications. The oat was drill-seeded @ 450 seeds m^{-2} on 5 November 2002 in the first year and on 11 September 2005 in the second year. Each plot was 6m long and consisted of eight rows spaced 0.15m apart. In both years, fertilizer was applied at planting (80 kg/ha N and 80 kg/ha P_2O_5) and tillering (100 kg/ha N). Herbicide (Tribenuron-Methyl 75%) was used for weed control.

Data included in the correlation and path analysis was plant height (PH), grain number panicle^{-1} (GNP), grain weight panicle^{-1} (GWP), 1000 grain weight (1000-GW), grain filling period (GFP), days to maturity (DM) and panicle number m^{-2} (PN m^{-2}) and grain yield (GY). Data for these traits was obtained from inner 6 rows of each plot. Before harvest, the number of panicles^{-2} square meter was counted in the harvest area. Plant height was measured as cm from the base of the lowest culms of oat plant to tip of the furthest panicle on main stem, then 10-panicle sub-samples were randomly harvested before grain yield harvest from these 6 rows, to determine grain number, 1000-grain weight and grain weight panicle^{-1}. The number of days from emergence to maturity and from heading to maturity was used to determine the traits, days to maturity and grain filling periods, respectively. Grain yield (kg/ha) was determined by weighed of grains obtained after the harvest of rest area in each plot.

Correlation coefficients between all pairs of variables were computed. The yield-related traits were arranged into first- and second-order variables in the initial path diagram (Fig. 1) on the basis of previous path and correlation studies (Samonte *et al*., 1998). The whole path diagram can be described as composed of component paths, with each component path having its respective response variable-grain yield, plant height (PH), grain number per panicle (GNP), grain weight panicle^{-1} (GWP), 1000 grain weight (1000-GW), grain filling period (GFP), days to maturity (DM) and panicle number m^{-2} (PN m^{-2}). Pearson correlations and path coefficients among yield and yield components were determined by statistical software of *TARIST* (Açıkgöz *et al*. 1994).

Results and Discussion

Correlation coefficients between all pairs of variables used in this experiment are shown in Table 3. According to the correlation coefficients, there was a negative and significant correlation between GY and PH (r = - 0.280*), while there were positive and significant correlations between PH and GNP (r=0.281*), GWP and GNP (r = 0.702**), 1000-GW and GWP (r = 0.422**), 1000-GW and GFP (r = 0.352**), DM and GFP (r = 0.349**), PN m^{-2} and 1000-GW (r = 0.234*). According to these values, GY was significantly and negatively correlated with PH. This situation may be due to lodging, occurred in plots. In previous works, Buerstmayr *et al*., (2007) determined significant and negative correlations between plant height and grain yield in oat plants and reported that plant height and lodging severity were also positively correlated. Rocquigny *et al*. (2004) also reported that the semi dwarf character in cereals was associated with increased yield. These results are in consistent with our findings.

Table 3. Correlation coefficients between grain yield and yield-related traits.

	1.	2.	3.	4.	5.	6.	7.	8.
Plant Height	1.00							
Grain Number per Panicle	0.28*	1.00						
Grain Weight per Panicle	0.22	0.70**	1.00					
1000 Grain Weight	0.10	0.14	0.42**	1.00				
Grain Filling Period	0.20	0.02	0.20	0.35**	1.00			
Days to Maturity	0.01	0.11	0.19	0.05	0.34**	1.00		
Panicle Number per m^2	0.04	0.005	0.09	0.23*	0.07	0.10	1.00	
Grain Yield	-0.28*	0.17	0.19	0.00	0.21	0.10	0.22	1.00

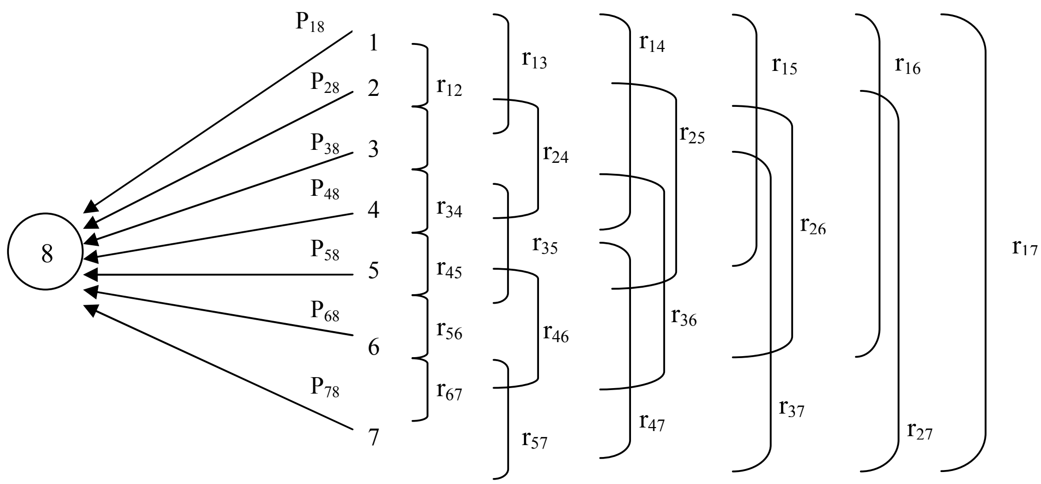

Fig. 1. Path diagram for the seven yield component variables, plant height (1), grain number per panicle (2), grain weight per panicle (3), 1000-grain weight (4), grain filling period (5) days to maturity (6), panicle number per square meter (7) and grain yield (8) as the response variable.

Correlation coefficients were not enough to determine traits as selection criteria in our study. In agriculture, path analyses have been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield (Dewey & Lu, 1959; Milligan *et al*., 1990). Path analysis was conducted to determine direct and indirect effect of traits on oat yield, and the results from path analysis are given in Table 4.

Direct effect of PH on GY was found as negative, and it was @ of 50.60% on GY (Table 4). Its indirect effect on GY through GWP was negative, while its indirect effect on GY through GNP was positive. When the negative direct effect of PH on GY was added to the its negative indirect effects through GWP, GFP, DM, PN and its positive indirect effects through GNP and 1000-GW, the sum effect of PH on GY was negative and at the rate of 58.92%, for our study. Ruben & Katuli (1989), and Kumar (1992) reported direct effect of PH on GY for wheat and barley plants, respectively. Bhutta *et al*. (2005) also reported negative direct effect of PH on grain yield for six-rowed barley genotypes. Our findings are in agreement with these results mentioned above.

GNP had positive direct effect on GY at the rate of 34.3%, while it had negative indirect effects through GWP, PH and 1000-GW at the rate of 44.57%, 10.52 and 8.05%, respectively. Negative indirect effects of GNP through GWP, PH and 1000-GW were higher than its positive direct effect. Yang, (1986) and Moradi *et al*., (2005) also found that GNP showed the highest direct effect on GY of oat genotypes. Our findings are partly in agreement with these results mentioned above.

Grain weight per panicle had negative direct effect on GY at the rate of 48.65%, while it had positive indirect effect through GNP and 1000-GW (18.46 and 17.78% respectively). Benin *et al*., (2003) reported that direct and indirect effect of GWP on GY.

Although, 1000 grain weight had positive direct effect at the rate of 50.51% on GY, it had negative indirect effects @ 49.46% through all the other traits. Therefore, contribution of 1000-GW to GY was less. According to this result, the effect of 1000-GW may be accepted as changeable. In previous works, Yang (1986), Ram (1992), Mehetre *et al*., (1994), Samonte *et al*., (1998), Sürek *et al*., (1998) reported that GY was influenced by 1000-GW. Bhutta *et al*., (2005) also reported negative indirect effect of 1000-GW on GY. Our results are in agreement with findings of previous researchers.

Grain filling period had positive direct effect on GY (34.22%) and it had positive indirect effect through GWP 17.86%, PH 10.22%, DM at 6.68% and PN m^{-2} 3.50%, while it had a negative indirect effects through 1000-GW 26.23% and GNP 1.26%. When the positive direct and indirect effects of GFP on GY were added to its negative indirect effects, the sum effect was positive and @ 72.48%. Therefore, GFP had the highest effect on GY of oat plants. This situation may be due to oat genotypes with higher GY, earliness heading and longer GFP. In previous works, Buerstmayr *et al*., (2007) pointed out that earliness was a breeding goal in many oat breeding programs. Lorencetti *et al*. (2006) also reported that selection for plants with longer period between flowering and maturation. Our findings are in agreement with the results obtained from previous works.

Table 4. Path analysis showing direct and indirect effects of PH, GNP, GWP, 1000-GW, GFP, DM and PN m^{-2} on oat grain yield for two years.

Traits	Effect values	The ratio in total (%)
Plant Height		
Direct Effect on GY, P_{18}	-0.240	50.60
Grain Number per Panicle, $r_{12}P_{28}$	0.062	13.05
Grain Weight per Panicle, $r_{13}P_{38}$	-0.092	19.45
1000 Grain Weight, $r_{14}P_{48}$	0.035	7.47
Grain Filling Period, $r_{15}P_{58}$	-0.033	6.85
Days to Maturity, $r_{16}P_{68}$	-0.001	0.35
Panicle Number m^{-2}, $r_{17}P_{78}$	-0.010	2.19
Grain Number per Panicle		
Direct Effect on GY, P_{28}	0.220	34.30
Plant Height, $r_{12}P_{18}$	-0.067	10.52
Grain Weight per Panicle, $r_{13}P_{38}$	-0.286	44.57
1000 Grain Weight, $r_{14}P_{48}$	-0.052	8.05
Grain Filling Period, $r_{15}P_{58}$	-0.004	0.68
Days to Maturity, $r_{16}P_{68}$	0.010	1.59
Panicle Number m^{-2}, $r_{17}P_{78}$	0.001	0.19
Grain Weight per Panicle		
Direct Effect on GY, P_{38}	-0.407	48.65
Plant Height, $r_{12}P_{18}$	-0.054	6.49
Grain Number per Panicle, $r_{13}P_{28}$	0.155	18.46
1000 Grain Weight, $r_{14}P_{48}$	0.149	17.78
Grain Filling Period, $r_{15}P_{58}$	-0.033	4.00
Days to Maturity, $r_{16}P_{68}$	0.017	2.10
Panicle Number m^{-2}, $r_{17}P_{78}$	-0.021	2.51
1000 Grain Weight		
Direct Effect on GY, P_{48}	0.352	50.51
Plant Height, $r_{12}P_{18}$	-0.024	3.47
Grain Number per Panicle, $r_{13}P_{28}$	-0.032	4.63
Grain Weight per Panicle, $r_{14}P_{38}$	-0.172	24.68
Grain Filling Period, $r_{15}P_{58}$	-0.057	8.16
Days to Maturity, $r_{16}P_{68}$	-0.004	0.65
Panicle Number m^{-2}, $r_{17}P_{78}$	-0.055	7.87
Grain Filling Period		
Direct Effect on GY, P_{58}	0.162	34.22
Plant Height, $r_{12}P_{18}$	0.048	10.22
Grain Number per Panicle, $r_{13}P_{28}$	-0.006	1.26
Grain Weight per Panicle, $r_{14}P_{38}$	0.084	17.86
1000 Grain Weight, $r_{15}P_{48}$	-0.124	26.23
Days to Maturity, $r_{16}P_{68}$	0.032	6.68
Panicle Number m^{-2}, $r_{17}P_{78}$	0.017	3.50
Days to Maturity		
Direct Effect on GY, P_{68}	0.090	30.29
Plant Height, $r_{12}P_{18}$	0.004	1.47
Grain Number per Panicle, $r_{13}P_{28}$	0.025	8.34
Grain Weight per Panicle, $r_{14}P_{38}$	-0.079	26.53
1000 Grain Weight, $r_{15}P_{48}$	-0.018	5.93
Grain Filling Period, $r_{16}P_{58}$	0.056	18.88
Panicle Number m^{-2}, $r_{17}P_{78}$	0.025	8.53
Panicle Number per m^2		
Direct Effect on GY, P_{78}	0.234	60.64
Plant Height, $r_{12}P_{18}$	0.011	2.76
Grain Number per Panicle, $r_{13}P_{28}$	0.001	0.29
Grain Weight per Panicle, $r_{14}P_{38}$	0.037	9.47
1000 Grain Weight, $r_{15}P_{48}$	-0.082	21.31
Grain Filling Period, $r_{16}P_{58}$	0.011	2.95
Days to Maturity, $r_{17}P_{68}$	0.098	2.54

Days to maturity had positive direct effect on GY (30.29%) and it had positive indirect effect on GY through GFP 18.88%, PN m^{-2} 8.53%, GNP 8.34%, and PH 1.47% but it had negative indirect effect on GY through GWP 26.53% and 1000-GW 5.93%. When the positive total effects was added to the negative effects, the sum effect of DM on GY was positive and @ 35.05%. These findings are in agreement with the result of previous work. It was reported that selection for plants with fewer days from emergence to flowering and longer period between flowering and maturation would provide higher grain yielding genotypes (Lorencetti *et al*., 2006).

Panicle numbers per m^2 had the highest direct effect on GY @ 60.64% and it had positive indirect effects through GWP 9.47%, GFP 2.95%, PH 2.76%, DM 2.54% and GNP 0.29% but it had negative indirect effect on GY through 1000-GW 21.31%. When the positive direct and indirect effects were added to the negative indirect effects of 1000-GW, the sum effect of PN m^{-2} on GY was positive and @ 57.34%. Our findings are in agreement with the results of previous works. Moradi *et al*., (2005) reported that PN m^{-2} and GNP had the highest direct effect on GY. Lorencetti *et al*., (2006) also reported higher direct effect of PN m^{-2} on GY and its great importance in determining GY of a genotype.

Conclusions

According to the correlation coefficients, GY negatively and significantly correlated with PH. Path analysis revealed that PN m^{-2}, 1000-GW, GNP, GFP and DM were the most important traits that had positive direct effect (@ of 60.64%, 50.51%, 34.30%, 34.22% and 30.29% respectively on oat grain yield. On the other hand, PH and GWP had negative direct effects on GY (50.60% and 48.65% respectively). However, when the positive direct and indirect effects were added to the negative direct and indirect effects for traits, the sum of direct and indirect effects of GFP, PN m^{-2} and DM on GY were positive and @ 72.48, 57.34 and 35.05%, respectively. The effects of these traits were higher than those of 1000-GW and GNP. The sum of direct and indirect effects of PH was negative and @ 58.92%. Therefore, GFP, PN m^{-2}, DM and PH could have priorities in breeding programs for the conditions of East Mediterranean region of Turkey.

References

Açıkgöz, N., M.E. Akbaş, A. Moghaddam and K. Özcan. 1994. PC'ler için veri tabanı esaslı Türkçe istatistik paketi: TARİST, I. Tarla Bitkileri Kongresi., 264-267, 24-28 Nisan, İzmir.

Akhtar, L.H., M.A. Pervez and M. Nasim. 2011. Genetic divergence and inter-relationship studies in chickpea (*Cicer arietinum* L.). *Pak. J. Agri. Sci*., 48: 35-39.

Amirthadevarathinam, A. 1983. Genetic variability, correlation and path analysis of yield components in upland rice. *Madras Agric. Journal*, 70(12): 781-785.

Benin, G., F.I.F. de. Carvalho, A.C. de. Oliveira, V.S. Marchioro, C. Lorencetti, A.J. Kurek, J. A.G. Silva, A. Cargnin and D. Simioni. 2003. Correlation estimates and path analysis as selection criteria for grain yield in oat R. Bras. *Agrociência*, (9)1: 09-16.

Bhutta, W.M., T. Barley and M. İbrahim. 2005. Path-coefficient analysis of some quantative characters in husked barley.

Caderno de Pesquisa Ser Biologia, Santa Cruz de Sul., 17(1): 65-70.

Buerstmayr, H., N. Krenn, U. Stephan, H. Grausgruber and E. Zechner. 2007. Agronomic performance and quality of oat (*Avena sativa* L.) genotypes of worldwide origin produced under central European growing conditions. *Field Crops Res*., (101): 341-351.

Dewey, D.R. and K.H. Lu. 1959. A correlation and path co-efficient analysis of components of crested wheat grass and seed production. *Agron. J*., 1: 515-518.

Dokuyucu, T. and A. Akkaya. 1999. Path coefficient analysis and correlation of grain yield and yield components of wheat (*Triticum aestivum* L.) genotypes. *Rachis Newsletters*, 18(2): 17-20.

Hoffmann, L.A. 1995. World production and use of oats. In: *The Oat Crop Production and Utilization*. (Ed.): R.W. Welch. Chapman and Hall, London, pp. 34-61.

İbrahim, S.M., A. Ramalingam and M. Subramanian. 1990. Path analysis of rice grain yield under rainfed lowland conditions. *IRRN*, 15(1): 11.

Kumar, C.R.A. 1992. Variability and character association studies in upland rice. *Oryza*, 29(1): 31-34.

Lin, F.H. and Y.L. Wu. 1981. Relationships between harvest index and grain yield of rice in Taiwan. *J. Agric. Assoc. China*, 115: 33-41.

Lorencetti, C., F.I.F. de. Carvalho, A.C. de. Oliveira, I.P. Valério, I. Hartwig, G. Benin and D.A.M. Schmidt. 2006. Applicability of phenotypic and canonic correlations and path coefficients in the selection of oat genotypes. *Sci. Agric. (Piracicaba, Braz*.), 63(1): 11-19.

Mehetre, S.S., C.R. Mahajan, P.A. Patil, S.K. Lad and P.M. Dhumal. 1994. Variability, heritability, correlation, path analysis, and genetic divergence studies in upland rice. *IRRN*, 19(1): 8-9.

Milligan, S.B., K.A. Gravois, K.P. Bischoff and F.A. Martin. 1990. Crop effects on genetic relationships among sugarcane traits. *Crop Sci*., 30: 927-931.

Moradi, M., A. Rezai and A. Arzani. 2005. Path analysis for yield and related traits in oats..*Journal of Science and Technology of Agriculture and Natural Resources*, 9(1): 173-180.

Ram, T. 1992. Character association and path coefficient analysis in rice hybrids and their parents. *Jour. Andaman Sci. Assoc*., 8(1): 26-29.

Rocquigny, P.M., M.H. Entz, R.M. Gentile and S.D. Duguid. 2004. Yield physiology of a semi dwarf and tall oat cultivar. *Crop Sci*., 44: 2116-212.

Rodriguez, D.J., J.L. Angulo-Sanchez and R. Rodriguez-Garcia. 2001. Correlation and path coefficient analyses of the agronomic trait of a native population of guayule plants. *Industrial Crops and Products*, 14: 93-103.

Ruben, S.O.W. and S.D. Katuli. 1989. Path analysis of yield components and selected agronomic traits of upland rice breeding lines. *IRRN*, 14(4): 11-12.

Samonte, S.O.P.B., L.T. Wilson and A.M. Mcclung. 1998. Path analyses of yield and yield-related traits of fifteen diverse rice genotypes. *Crop Sci*., 38: 1130-1136.

Sundaram, T. and S. Palanisamy. 1994. Path analysis in early rice (*Oryza Sativa* L.). *Madras Agric. J*., 81(1): 28-29.

Sürek, H., Z.K. Korkut and O. Bilgin. 1998. Correlation and path analysis for yield and yield components in rice in a 8-parent half diallel set of crosses. *Oryza*, 35(1): 15-18.

Yang, H.S. 1986. Studies on the main traits of inter varietals hybrid progenies in indica rice. *Fujan-Agricultural Science and Technology*, 6: 2-4.

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