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Relationships Between Yield and Yield Components on Currently Improved Spring Rapeseed Cultivars

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Abstract: This research was conducted in Erzurum in 1991 and 1992 seasons using 14 spring oilseed rape (*Brassica napus* ssp. oleifera L.) cultivars in order to investigate the relationships between yield and yield components by correlation and path analyses.

Positive values were obtained in both seasons between seed yield and the characters: days to flowering, plant height, number of branch, number of pods per plant, number of seeds per pod, pod diameter, pod length, 1000-seed weight, and oil content. However, seed yield was significantly and positive correlated with only number of pod per plant and 1000-seed weight in both seasons. Relationship between oil content and protein content was negative.

Path analysis identified 1000-seed weight as having the greatest effect on seed yield, with number of pods per plant having a large secondary effect.

Islah Edilmiş Yeni Yazlık Kolza Çeşitlerinde Verim ve Verim Ögeleri Arasındaki İlişkiler

Özet: Bu araştırma, 1991 ve 1992 yıllarında Erzurum'da 14 yazlık kolza çeşiti kullanılarak verim ve verim unsurları arasındaki ilişkilerin korrelasyon ve path analizleri ile incelenmesi amacıyla yürütülmüştür.

Her iki araştırma yılında da tohum verimiyle, çiçek açma süresi, bitki boyu, dal sayısı, bitkideki kapsül sayısı, kapsüldeki tohum sayısı, kapsül çapı, kapsül uzunluğu, 1000-tohum ağırlığı ve yağ içeriği arasında pozitif ilişkiler belirlenmiştir. Ancak, tohum verimi, sadece bitkideki kapsül sayısı ve 1000-tohum ağırlığı ile her ik yılda da pozitif ve önemli ilişki göstermiştir. Yağ içeriği ve protein içeriği arasında ise negatif bir ilişki saptanmıştır.

Path analizleri, tohum verimi üzerine en büyük etkiyi 1000-tohum ağırlığının, ikinci büyük etkiyi ise bitkideki kapsül sayısının gösterdiğini ortaya koymuştur.

Introduction

Optimizing yield is one of the most important goals for most rape growers. Seed yield is a complex character that can be determined by several components reflecting positive or negative effects upon this trait, whereas it is important to examine the contribution of each of the various components in order to give more attention to those having the greatest influence on seed yield. Therefore, information on the association of plant characters with seed yield is of great importance to a breeder in selecting a desirable genotype.

Correlations between yield and yield-determining traits have been repeatedly analysed in former cultivars of rape with high erucic acid and glucosinolate content (1, 2), but only few investigations include recently released (0 or 00 type) rapeseed cultivars (3). Basing decisions solely on correlation coefficients may not always be effective because they provide only limited information, disregarding interrelations among traits. Thus, many breeders were involved in analyzing the path coefficient, Usefulness of information obtained from correlation coefficient can be enhanced by partitioning them into direct and indirect effects for a set of a priori cause -and-effect interrelationship (4, 5).

The objective of the study was to determine the interrelationships between some phenological, morphological yield components, yield and quality characters.

Material and Methods

Currently released fourteen spring oilseed rape (0 or 00 type) cultivars such as Global, Gara, Laras, Liraspz, Lisandra, Tower, Westar, Rico, Regent, Topas, Lirawell, Drakkar, Semu DNK 87/Na, Semu 209/82 RH were used in this study.

Field experiments were conducted on a clay-loamy soil at the Agricultural Experiment and Extension Center of Agriculture Faculty, Atatürk University, in 1991 and 1992, in Erzurum-Turkey. Precipitation for the growing season at the experiment site was 156.6 and 219.8 mm for 1991 and 1992, respectively. The experimental design was a randomized complete block with four replications. Plots consisted of 6 rows, each 6 m long and spaced 40 cm apart. Seeds were sown by hand on May 6 in 1991 and May 5 in 1992 respectively.

In both years, the experimental area was fertilized at a rate of 60 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} before sowing. Additional 60 kg N ha^{-1} was applied just before flowering. One month after planting, the plants were thinned to 10 cm apart within row.

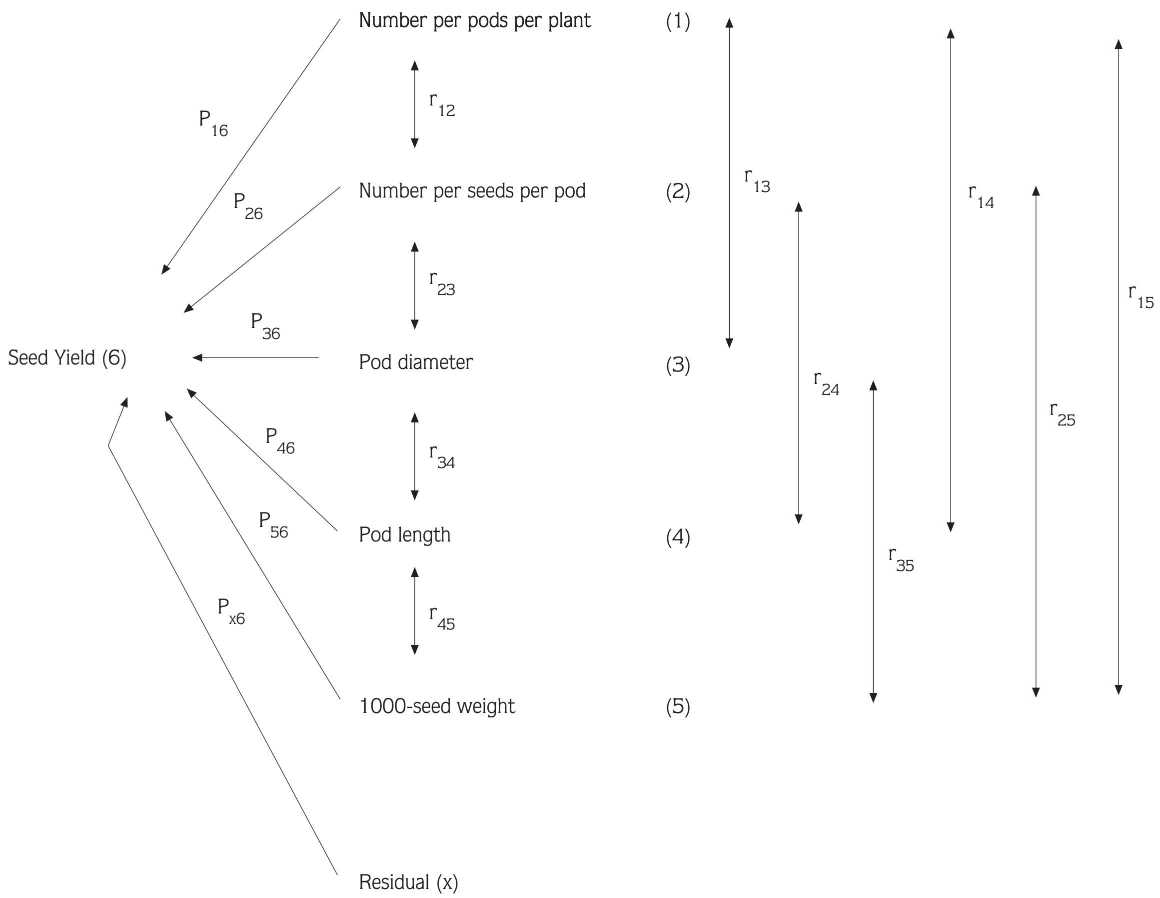
The crops were irrigated four times, mainly during flowering stage, and protected against the pests in both years.

The two center rows of each plot were harvested for yield and yield components measurement. The protein contents of the samples were determined by the micro-Kjeldahl, method and oil content by using Soxhlet apparatus.

Simple correlation coefficients between all possible combination of variables were worked out according to Snecedor (6), and path-coefficient technique was performed according to the method suggested by Dewey and Lu (7), where five variables were included in the analysis:

1. Number of pods per plant
2. Number of seeds per pod
3. Pod diameter
4. Pod length
5. 1000-seed weight

The nature of causal system is presented diagrammatically as follows.



The double-arrowed lines indicate correlation between the two variables (r_{ij}) and the single-arrowed lines represent the drirect influence as measured by the path coefficient (P_{ij}). The path-coefficient in this particular instance was computed according to the following equations:

$$r_{16} = P_{16} + r_{12}P_{26} + r_{13}P_{36} + r_{14}P_{46} + r_{15}P_{56}$$
$$r_{26} = r_{12}P_{16} + P_{26} + r_{23}P_{36} + r_{24}P_{46} + r_{25}P_{56}$$
$$r_{36} = r_{13}P_{16} + r_{23}P_{26} + P_{36} + r_{34}P_{46} + r_{35}P_{56}$$
$$r_{46} = r_{14}P_{16} + r_{24}P_{26} + r_{34}P_{36} + P_{46} + r_{45}P_{56}$$
$$r_{56} = r_{15}P_{16} + r_{25}P_{26} + r_{35}P_{36} + r_{45}P_{46} + P_{56}$$

Result and Discussion

The results of correlation coefficient among the traits studied are shown in Table 1. The data show that all the characters, except protein content, were positively correlated with seed yield. The number of pods per plant and 1000-seed weight were positively and significantly associated with seed yield. Positive relationships have frequently been cited between the seed yield and the number of pods per plant, as well as the number of seeds per pod and seed weight per pod (8, 3). 1000-seed weight indicated the highest correlation value of seed yield with comparing the others (r=0.473 and 0.264 in 1991 and 1992, respectively).

The association between days to flowering, plant height and seed yield was significant in 1992 season. By contrast, number of branch did not show significant association with seed yield. These results revealed the importance of the number of pods per plant and 1000-seed weight as a criterion for spring oilseed rape yield improvement. Therefore, selection for increasing seed yield through these traits might be more succesfull.

Regarding oil content, correlation study revealed that in general, the association between seed oil content and the other characters showed consistent trend in the two seasons. It was positively correlated with days to flowering, plant height, number of seeds per pod, pod diameter, pod length and 1000-seed weight. Obviously, the highest correlation coefficients found were those between the 1000-seed weight, number of pods per plant, plant height, and days to flowiering. Oil content was negatively correlated with only protein content. A negative correlation between oil content and crude protein percentage in oilseeds seems reasonably proven (9, 10).

In this study,, the response variable, seed yield, number of pods per plant, number of seeds per pod, pod

Table 1. Correlation Coeeficients between characters calculated from fourteen cultivars of spring oilseed rape grown under Erzurum ecological conditions in 1991 (the upper value per row) and 1992 (the lower value).

Characters	(11)	(10)	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)
(1) Days to flowering	0.217	-0.302*	0.610**	0.530**	0.604**	0.144	0.649**	0.048	-0.213	0.695**	1.000
	0.346**	-0.245*	0.013	0.1116	0.748**	-0.120	0.743**	0.212	0.005	0.473**	1.000
(2) Plant height	0.158	-0.364**	0.528**	0.422**	0.325**	0.017	0.427**	0.069	-0.100		
	0.264*	-0.164	0.075	0.117	0.307**	-0.144	0.333**	0.176	-0.080		
(3) Number of branch	0.217	-0.110	0.026	0.061	-0.254*	0.085	-0.251*	0.201			
	0.156	0.261	-0.043	0.001	0.016	-0.058	0.006	0.183			
(4) Number of pods ped plant	0.276*	-0.172	0.197	-0.088	-0.023	0.101	-0.049				
	0.232*	0.118	0.168	-0.086	0.100	-0.139	0.166				
(5) Number of seeds per pod	0.078	-0.408**	0.563**	0.328**	0.655**	0.320**					
	0.217	-0.228	0.106	0.292*	0.645**	-0.002					
(6) Pod diameter	0.332**	-0.366**	0.218	0.417**	0.263*						
	0.134	-0.265*	0.260*	0.429**	0.051						
(7) Pod length	0.073	-0.169	0.422**	0.330**							
	0.340**	-0.121	0.116	0.305**							
(8) 1000-seed weight	0.473**	-0.233**	0.502**								
	0.264*	-0.125	0.531**								
(9) Oil content	0.480**	-0.541**									
	00.38	-0.155									
(10) Protein content	-0.211										
	-0.151										
(11) Seed yield	1.000										
	1.000										

diameter, pod length, and 1000-seed weight, were studied (Fig. 1). For each of years, the direct effect for number of pods per plant was positive and of greater magnitude than direct effects for the other four traits with the exception of path coefficient value for 1000-seed weight in 1991 and in pod length in 1992.

In both seasons, the indirect effect of number of pods per plant on seed yield through its association with pod length was 0.018 and 0.0303, indicating a positive relationship between number of pods per plant and pod length.

The direct effects of number of seeds per pod on seed yield were all negative and of least importance whereas, in simple correlation study, this trait was positive associated with seed yield in both years. The usefulness of path-coefficient analysis is apparent. This pointed out that number of seeds per pod should be de-emphasized in the selection phenomenon. The indirect effect of number of seeds per pod on yield through its association with 1000-seed weight was positive (0.1597 and 0.0531). The indirect effects of the other traits (number of pods per plant, pod diameter, and pod length) was inconsistent for 1991 and 1992 years. This can be partly attributed to the variation in precipitation during the growing season in the study years. Yield component relationships in oilseed rape appears, therefore, to be characterized by a strong environmental control of the type and degree of stress. This results is in line to those reported by Thurling (1).

Positive direct effects of pod diameter on yield on the two years were small. Path-coeeficient analysis showed that the indirect effect of pod diameter, number of seeds per pod, and pod length were negligible and inconsistent. Pod diameter also had the greatest indirect effect on seed yield (0.2031 and 0.0779 in 1991 and 1992, in the some order, as shown in Table 2).

In our study, pod length was positively correlated with seed yield in both seasons (Table 1). Based on path analysis, however, the direct effect of this character was

Table 2. Path-coefficient values estimated for seed yield and other five characters.

Pathways of associations	Values estimated in 1991	1992
Seed yield vs. number of pods per plant		
Direct effect	0.2999	0.2397
Indirect effect via number of seeds per pod	0.0030	-0.0119
Indirect effect via pod diameter	0.0140	-0.0102
Indirect effect via pod length	0.0018	0.0303
Indirect effect via 1000-seed weight	-0.0428	-0.0156
Correlation, r_{16}	0.276*	0.232*
Seed yield vs. number of seeds per pod		
Direct effect	-0.0612	-0.0715
Indirect effect via number of pods per plant	-0.0146	0.0398
Indirect effect via pod diameter	0.0445	-0.0002
Indirect effect via pod length	-0.0502	0.1957
Indirect effect via 1000-seed weight	0.1597	0.0531
Correlation, r_{26}	0.078	0.217
Seed yield vs. pod diameter		
Direct effect	0.1388	0.0733
Indirect effect via number of pods per plant	0.0303	-0.0332
Indirect effect via pod diameter	-0.0196	0.0002
Indirect effect via pod length	-0.0202	0.0154
Indirect effect via 1000-seed weight	0.2031	0.0779
Correlation, r_{36}	0.332**	0.134
Seed yield vs. pod length		
Direct effect	-0.0766	0.3032
Indirect effect via number of pods per plant	-0.0069	0.0240
Indirect effect via number of seeds per pod	-0.0401	-0.0462
Indirect effect via pod diameter	0.0366	0.0037
Indirect effect via 1000-seed weight	0.1604	0.0553
Correlation, r_{46}	0.073	0.340**
Seed yield vs. 1000-seed weight		
Direct effect	0.4866	0.1817
Indirect effect via number of pods per plant	-0.0264	-0.0206
Indirect effect via number of seeds per pod	-0.0201	-0.0209
Indirect effect via pod diameter	0.0580	0.0314
Indirect effect via pod length	-0.0253	0.0924
Correlation, r_{56}	0.473**	0.264**

* and ** significant at the 0.01 and 0.05 probability level, respectively.

negative in 1991, and but not in 1992. With the exception of pod length on seed yield through other yield components were small and negligible. Correlation study revealed that the association between 1000-seed weight and seed yield showed positive and significant consistent trend. Similarly, path analysis also indicated that this yield component had positively associated with seed yield. Clarke and Simpson (11) also found that positive association between 1000-seed weight and seed yield occured.

Based on these results, number of seeds per pod, pod diameter and pod length would not be as good an effective selection criterion as 1000-seed weight and number of pods per plant.

Results present a usefull picture of the relationships between yield and yield components, and allow a better understanding of yield component compensation. The path coefficient analysis generally confirmed the findings of the correlation analysis, but also provided additional information on component interrelationships which would not have been obtained from an examination of correlation coefficients.

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