Research Journal of Agriculture and Biological Sciences, 4(2): 120-125, 2008


# The Correlation and Path Analysis of Yield and Yield Components of Different Winter Rapeseed (*Brassica napus* ssp. *oleifera* L.) Cultivars

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**Abstract:** This research was conducted in Ankara conditions during 1999-2000 and 2000-01 using 25 winter oilseed rape cultivars. The experiment was carried out in randomized complete block design with 3 replications. The aim of the study was to determine the correlation and path coefficient analyses among some characters and the direct and indirect effect of these characters on seed and oil yield in winter rapeseed. Correlation analysis results showed a high, positive and statistically significant (P < 0.01) statistically correlation between branches per plant, the number of pods on the main stem and plant height during both years. Plant height indicated negative correlation with seed yield, 1000-seed weight, and oil ratio during the first year of the trial. Based on a comparison of the effects of seed and oil yield on different yield components, it was observed that seed yield directly affected oil contents directly. Comparing the indirect effects on oil yield, interactions with other yield components of seed yield had the greatest effect, and except for oil ratio, the indirect effect of all characters was higher during the first year. An increased plant height affected rise in branching adversely, which increased lodging resulting in reduced seed yield.

**Key words:** Rapeseed, Correlation analyses, Path analyses, Seed yield, Oil yield

## INTRODUCTION

Oilseed rape (*Brassica napus* ssp *oleifera* L.) is third most important oil crop in the world. Its total acreage is expanding very fast especially in areas with moderate climatic conditions. In Turkey, rapeseed is planted on an area of 2800 ha on which production results in 6500 tons with in the overall local edible oil production, in spite of its being a new crop[14]. Average yield of rapeseed is very low compared to its genetic potential. To increase the yield, studies carried out on the direct and indirect effects of yield components provide the basis for its successful breeding programmed[4].

To make available high yield is one of the most important purposes for most rape growers. As known, seed yield is a complex character that can be determined by several components which reflect positive or negative effects upon these traits meanwhile, it is important to examine the contribution of each of the various components in order to attract the attention to which one has the greatest influence on seed yield. Therefore, information on the relation of yield components with seed yield is of great importance to a breeder in selecting a desirable genotype[19].

Correlations between yield and yield components have repeatedly been analyzed in traditional cultivars of rape with a high oil ratio[31,22]. There are a few investigations which have been recently released on 0 or 00 type rapeseed cultivars[24]. Basing decisions solely on correlation coefficients may not always be effective because they provide very limited information only, disregarding interrelations among components. Thus, many breeders were involved in analyzing the path coefficient. Usefulness of the information obtained from the correlations coefficient can be enhanced by partitioning into direct and indirect effects for a set of a prior cause - effect interrelationships[12,8].

The Path Coefficient Analysis has been used successfully to clarify interrelationships between yield and several other characteristics for many crops such as rapeseed[19,2], field bean[6], soybeans[11,20], maize[13]. Path analyses provide a measure of relative importance of each independent variable to prediction of changes in the dependent one. The proper use of the method requires that, cause and effect exist between the variables and that the researcher assign direction in the causal system, either a priori or based on experimental evidence[29].

Various researchers studied genetic parameters to determine the selection criteria for yield improvement

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in rapeseed Labana *et al.,*[16] and Ali[1] reported high genotypic and phenotypic variances for plant height and pods per plant in mustard. The significant correlation coefficients were found between seed yield and sowing date, plant height, number of branches, number of pods, oil yield, and winterkill. Similarly, the significant correlation coefficients were found between oil yield and sowing date, plant height, number of branches, number of pods, oil rate, seed yield, and winterkill too. According to the Path Analysis, it was concluded that consideration should be given primarily to seed yield, oil ratio, oil yield in selection studies because of its direct effects are high[18]. High heritability estimates are associated with high genetic advance for plant height, pods per plant and seed yield[27]. They also reported greatest positive direct effect of pods per plant, seeds per plant and 1000 seed weight on seed yield. Sheikh *et al.,*[26] found high heritability estimates coupled with high genetic advance for seed yield / plant, primary and secondary branches, pods per plant and 1000 seed weight in rapeseed (*B. campestris)* genotypes. They also reported positive correlation of all yield components with seed yield. The use of simple Correlation Analysis could not fully explain relationships among the characters. Therefore, the Path Coefficient Analysis has been used by many researchers for more and complete determination of the impact of the independent variable on the dependent one. The Path Coefficient Analysis helps the breeders to explain direct and indirect effects and hence it has extensively been used in breeding work in different crop species by various researchers[9,17,21,25,2].

The objectives of this study were to determine the interrelationships between some phonological, morphological yield components, seed and oil yield and estimate the best selection criteria for yield improvement in winter rapeseed.

## MATERIAL AND METHODS

Twenty-five winter rapeseed (0 or 00 type) cultivars such as Atilla, Alaska, Iris, Orabel, Pronto, Wotan, Express, Liasbel, Apex, Magnum, Alpine, Orkan, Mohican, Oxident, Artus and Lirajet (from Germany), Chang, Hansen (from Denmark), Licord, Liberator, Bristol, Capitol, Contact, Samurai (from France) and Cescade (from USA) were used as a plant material in the study.

Field experiments were conducted at the experimental area of Field Crops Department of Field Crops, Faculty of Agriculture, University of Ankara (Turkey) during 1999-2000 and 2000- 01. The trials were carried out in randomized complete block design with 3 replications.

Soil analysis was carried out at Toprak Mahsülleri Office laboratories. The soil of the experimental of area was clay and loam, and pH value of 8.29, organic ingredients of 1.27 %, lime ratio of 4.4 %, humidity was 4.1 %, clay was of 23.32 %, sand was 37.65 % and silt was 39.04 %.

The plots consisted of 5 rows of five meter length which are spaced 40 cm. Seeds were sown by hand on these plots September 29 during 1999 and September 15 during 2000. The experimental area was fertilized at a rate of 15 kg $ha^{-1}$ ammonium nitrate and 12 kg $ha^{-1}$ potassium sulfate before sowing during both years. Additional 10 kg $ha^{-1}$ ammonium nitrate was applied just before flowering. One month after snowing, the plants were thinned out to create 10 cm spaces within the row.

The crops were irrigated four times, mainly during the flowering stage, and protected against the pests in both years. The experiment received all the agronomic and cultural treatments throughout the season. At maturity data for 8 different characters, including plant height, branches per plant, number of pods on main stem and seeds per pod, seed yield, 1000-seed weight, oil ratio and oil yield were recorded on 15 randomly-selected plants. The 3 center rows of each plot were harvested for seed yield and yield components measurement.

The Simple Correlation Coefficients between all possible combinations of variables were worked out according to Snecedor[28], and the Path-Coefficient technique was performed according to the method suggested by Dewey and Lu[5].

The data collected in this way were processed for The Correlation Coefficients and The Path Coefficient Analysis were conducted following the procedure developed and applied by Dewey and Lu[5].

The simple Correlation and Path Analysis were carried out using Tarist computer statistical program (Aegen Univ., Izmir, Turkey). Also, in the Path Analysis, seed yield and oil yield were dependent variables and the other characteristics were considered as independent variables.

## RESULTS AND DISCUSSION

**Results:**

**Correlation Analysis:** The results of the Correlation Coefficient among the traits studied during 2000 (the upper value per row) and 2001 (the lower value) are shown in Table 1. A high and positive and significant correlation ($P < 0.01$) was observed between number of branches per plant, number of pods on main stem and plant height using both years ($r = 0.617$ and $r = 0.486$ in 2000, $r = 0.572$ and $r = 0.751$ in 2001 respectively). On the other hand, negative correlations

**Table 1:** Correlation Coefficients among characters calculated from twenty-five cultivars of winter oilseed rape grown under Ankara ecological conditions during 2000 (the upper value per row) and 2001 (the lower value).

| Characters* | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| (1) | 1.000<br>1.000 | | | | | | | |
| (2) | 0.617**<br>0.572** | 1.000<br>1.000 | | | | | | |
| (3) | 0.486**<br>0.751** | 0.453**<br>0.575** | 1.000<br>1.000 | | | | | |
| (4) | 0.210<br>0.436** | -0.008<br>0.217 | 0.094<br>0.327** | 1.000<br>1.000 | | | | |
| (5) | 0.142<br>-0.071 | 0.095<br>-0.008 | 0.196<br>-0.003 | 0.157<br>-0.066 | 1.000<br>1.000 | | | |
| (6) | 0.168<br>-0.026 | 0.055<br>-0.016 | -0.002<br>-0.003 | 0.157<br>-0.271* | 0.104<br>0.158 | 1.000<br>1.000 | | |
| (7) | -0.028<br>0.066 | -0.047<br>0.014 | 0.091<br>0.107 | -0.053<br>0.114 | 0.031<br>0.215 | 0.149<br>0.006 | 1.000<br>1.000 | |
| (8) | 0.117<br>0.204 | 0.069<br>0.148 | 0.214<br>0.182 | -0.158<br>0.132 | 0.892**<br>0.806** | 0.197<br>0.038 | 0.476**<br>0.526** | 1.000<br>1.000 |

*(1) Plant height (2) Number of branches per plant, (3) Number of pods on main stem, (4) Number of seeds per pod, (5) Seed yield, (6) 1000-seed weight, (7) Oil ratio and (8) Oil yield.

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

were recorded between plant height and seed yield, and between 1000-seed weight, oil ratio and plant height only in one year of trials. In both years, correlation between number of branches per plant and number of pods on main stem was a statistically significant and positive ($P < 0.01$). Moreover, correlations between seeds per pod and oil yield were non-significant and negative during first year ($r = -0.158$). Positive relationship between number of pods on main stem and number of seeds per pod was statistically significant ($P < 0.01$).

We obtained that there was a statistically significant ($P < 0.05$) and negative correlation ($r = 0.271$) between number of seeds per pod and 1000 seed weight. In addition, correlation between number of seeds per pod and seed yield, and correlation oil ratio and oil yield were positive in one year of trials. Seed yield had statistically positive and significant ($P < 0.01$) relationship with oil yield during both years. The other yield components had positive effects on seed yield. Results indicated that positive and non-significant statistically correlations between oil ratio, oil yield and 1000 seed weight were lower in second year than first year. There was a significant ($P < 0.01$) and positive correlation between oil ratio and oil yield in 2000 and 2001.

**Path Analysis:** Seven characters of path coefficient which had direct and indirect effects on seed yield and rates of linear correlation addition are summarized in Table 2. Considering rates of direct effect on seed yield, the highest value was taken from oil yield (1.1262) during 2000. Also, similar results were observed in the same character (0.9686) during 2001. By comparing indirect effects, the highest positive effect on seed yield was recorded from interaction of plant height together with oil yield (0.1321). Number of branches per plant and oil yield was highly and indirectly affected by seed yield (0.0772). For indirect effects on seed yield, it was found that associate effects of others yield components along with oil yield had the highest values. Except for oil ratio, rates of correlation addition of the others characters were higher during first year than second year.

Seven characters of path coefficients having direct and indirect effects on oil yield and rates of linear correlation addition are summarized in Table 3. Comparing direct effects on oil yield, during both years, the highest values were obtained from seed yield and followed by oil ratio. By comparing indirect effects on oil yield, interactions with other yield components of seed yield had the greatest effect, and except for oil ratio, indirect effect of all characters had higher during first year.

**Discussion:** The results of correlation analysis showed that all characters were positively correlated during first year negatively correlated during second year with seed yield. Positive relationships have frequently been associated between the seed yield and the number of pods per plant, as well as number of seeds per pod and seed weight per pod[30,24]. The results of our study are

**Table 2:** Path-coefficient values estimated for seed yield and other characters

| Characters | Direct Effects | | Indirect Effects | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (1) | | (2) | | (3) | | (4) | | (6) | | (7) | | (8) | |
| | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 |
| (1) | -0.0066 | -0.2766 | - | - | -0.0041 | -0.1583 | -0.0032 | -0.2078 | -0.0014 | -0.1207 | -0.0011 | 0.0072 | 0.0002 | -0.0182 | -0.0008 | -0.0565 |
| (2) | -0.0116 | 0.025 | -0.0071 | 0.0143 | - | - | -0.0053 | 0.0144 | 0.0001 | 0.0054 | -0.0006 | -0.0004 | 0.0005 | 0.0004 | -0.0008 | 0.0037 |
| (3) | 0.0092 | 0.0658 | 0.0045 | 0.0494 | 0.0042 | 0.0379 | - | - | 0.0009 | 0.0215 | 0 | -0.0002 | 0.0008 | 0.007 | 0.002 | 0.012 |
| (4) | -0.0017 | -0.0374 | -0.0004 | -0.0163 | 0 | -0.0081 | -0.0002 | -0.0122 | - | - | 0.0003 | 0.0101 | 0.0001 | -0.0043 | 0.0003 | -0.0049 |
| (6) | 0.0116 | 0.02 | 0.002 | -0.0005 | 0.0006 | -0.0003 | 0 | -0.0001 | -0.0018 | -0.0054 | - | - | 0.0017 | 0.0001 | 0.0023 | 0.0008 |
| (7) | -0.5106 | -0.3134 | 0.0141 | -0.0206 | 0.024 | -0.0045 | -0.0462 | -0.0335 | 0.0273 | -0.0357 | -0.0761 | -0.0018 | - | - | -0.2432 | -0.1649 |
| (8) | 1.1262 | 0.9686 | 0.1321 | 0.198 | 0.0772 | 0.143 | 0.2407 | 0.176 | -0.1776 | 0.1281 | 0.221 | 0.0366 | 0.5365 | 0.5098 | - | - |

* (1) Plant height (2) Number of branches per plant, (3) Number of pods on main stem, (4) Number of seeds per pod, (6) 1000-seed weight, (7) Oil ratio and (8) Oil yield

**Table 3:** Path-coefficient values estimated for oil yield and other characters

| Characters | Direct Effects | | Indirect Effects | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (1) | | (2) | | (3) | | (4) | | (5) | | (6) | | (7) | |
| | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 |
| (1) | 0.0066 | 0.2616 | - | - | 0.0041 | 0.1497 | 0.0032 | 0.1964 | 0.0014 | 0.1141 | 0.0009 | -0.0186 | 0.0011 | -0.0068 | -0.0002 | 0.0172 |
| (2) | 0.0098 | -0.0181 | 0.0060 | -0.0103 | - | - | 0.0044 | -0.0104 | -0.0001 | -0.0039 | 0.0009 | 0.0001 | 0.0005 | 0.0003 | -0.0005 | -0.0003 |
| (3) | -0.0080 | -0.0538 | -0.039 | -0.0404 | -0.0036 | -0.0309 | - | - | -0.008 | -0.0176 | -0.0016 | 0.0002 | 0.0000 | 0.0002 | -0.0007 | -0.0058 |
| (4) | 0.0014 | 0.0592 | 0.0003 | 0.0258 | 0.0000 | 0.0128 | 0.0001 | 0.0194 | - | - | -0.0002 | -0.0039 | -0.0002 | -0.0160 | -0.0001 | 0.0067 |
| (5) | 0.8833 | 0.7854 | 0.1255 | -0.0559 | 0.0835 | -0.0062 | 0.1729 | -0.0022 | -0.1389 | -0.0516 | - | - | 0.1398 | 0.0817 | 0.0271 | 0.1687 |
| (6) | 0.0101 | -0.0059 | -0.0017 | 0.0002 | -0.0006 | 0.0001 | 0.0000 | 0.0000 | 0.0016 | 0.0016 | -0.0016 | -0.0006 | - | - | -0.0015 | 0.0000 |
| (7) | 0.4534 | 0.3634 | -0.0125 | 0.0239 | -0.0213 | 0.0052 | 0.0410 | 0.0389 | -0.0242 | 0.0414 | 0.0139 | 0.0780 | 0.0676 | 0.0021 | - | - |

* (1) Plant height (2) Number of branches per plant, (3) Number of pods on main stem, (4) Number of seeds per pod, (5) Seed yield, (6) 1000-seed weight and (7) Oil ratio

in agreement with Guo *et al.*,[10] and Kumar *et al.*,[15] who reported positive correlations between branches per plant and number of pods on main stem for seed in rapeseed.

Number of pods on main stem showed the highest correlation value with seed yield per plant compared to other characters (r = 0.196 in 2000).

Regarding oil yield, correlation study revealed a consistent association between oil yield and the other characters showed during two seasons. This character, except for number of seeds per pod during first year, was positively correlated with plant height, branches per plant, and number of pods on main stem, seed yield, 1000-seed weight and oil ratio. The correlation in 1000 seed weight between number of seeds per pod was (r = -0.271) negatively ($P<0.05$) during 2001. A negative correlation between oil content and crude protein percentage in oilseeds seems reasonably proven[7]. That the relationship between 1000 seed weight and seed yield was low in agreement with Jiang and Guan,[10] in confirmation to our study with r = 0.104 during 2000 and r = 0.158 during 2001.

The direct effects of plant height, branches per plant, and number of seeds per pod and oil ratio were all negative and the effects of others characters were positive on seed yield. The correlation between seed yield and plant height was positive but non- significant in maize under Samsun ecological conditions. But, that indirect effect of plant height on seed yield was high as reported by Torun and Köycü[32]. In another research, under Konya conditions the correlation of plant height and seed yield in maize was positive and statistically significant during first year, and statistically negative and significant during second year[23]. Increased plant height is prone to increased lodging resulting in reduced seed yield. Due to this selection of dwarf plants is important criterion to have stable yield. In this study, the direct effect of oil yield on seed yield was highest and positive (0.9685), after that the direct effect of plant height and oil ratio on seed yield were the highest and positive (-0.2766, -0.3131, respectively).

Path analysis also indicated that branches per plant and oil yield had positive association with seed yield (0.0772 and 0.1430). The other characters showed similar results. Clarke and Simpson[3] also found positive association between 1000 seed weight and seed yield.

Direct and positive effect of seed yield on oil yield was greater during both years compared to other characters (0.8833 in first year, 0.7854 in second year). Similarly, oil ratio gave the highest direct effect on oil yield (0.4534 in 2000 and 0.3634 in 2001). The associated indirect effect of plant height and seed yield was positive (0.1255 in first year) and negative (-0.0559 in second year). The indirect effect of branches per plant and seed yield on oil yield was positive (0.0835) during 2000. The other had indirect effect on branches per plant and oil yield through its association with plant height (0.1497). Associated indirect effect of seed yield and 1000 seed weight on oil yield was similar in both years (0.1398 in 2000, and 0.0817 in 2001).

Comparing correlation coefficient values of seven independent variables on seed yield and oil yield, significant differences were observed. Number of seed per pod and number of pods on main stem had highly significant association with oil yield. Based on the results of our study, branches per plant and plant height would be as good on effective selection criteria as number of seeds per pod, 1000 seed weight, and number of pods on main stem. According to the findings of correlation and path analyses in our work very close relationship was recorded among seed yield and oil ratio. On the other hand, the most important yield components were plant height, branches per plant, number of pods on main stem, and number of seeds per pod in conducted breeding research to increase oil yield. As a result, it may be recommended that cultivars having high oil ratio and seed yield should be criteria preferred specifically in both cultivation and selection in rapeseed.

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