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# Combining Ability of Yield Attributed Traits in Rapeseed under Adequate and Low Nitrogen Levels

***Valiollah Rameeh****

## ABSTRACT

Six rapeseed parents and their 15 $F_2$ diallel progenies were studied under stress ($N_0$: no application of nitrogen) and no stress ($N_1$: application of nitrogen) conditions. Significant mean squares of specific combining abilities (SCA) for all the traits, implied the important role of non additive genetic effects for the traits. Nitrogen levels × GCA (general combining ability) mean square was not significant for all the traits which indicating the stability of additive genetic effects in nitrogen application conditions. Nitrogen levels × SCA mean squares were significant for oil content and oil yield, revealed that significant variation of SCA effects of these traits under two nitrogen application conditions. The traits including plant height, 1000-seed weight and seed yield had high narrow-sense heritability estimates at the $N_0$ but 1000-seed weight had high narrow-sense heritability estimates at the $N_0$ and $N_1$conditions. Most of the crosses exhibited significant SCA effects for seed yield at the $N_0$.

**Keywords**: Combining ability, Diallel, Narrow-sense heritability, Nitrogen, Rapeseed.

## INTRODUCTION

Recognizing of yield associated traits and yield responses of rapeseed genotypes to diverse environments will allow the crop breeder to select better genotypes for target production areas. Almost all investigations showed that nitrogen fertilizers gave substantial rapeseed seed yield increases even in diverse and contradicting conditions (Maroni et al. 1994 and Sieling and Christen 1997). However, fertilizer nitrogen requirements can differ very much according to soil type, climate, management practice, timing of nitrogen application, cultivars and etc. (Colnenne et al., 1998). A great variation in nitrogen uptake by rapeseed was noticed ( Rathke et al., 2005; Gan et al., 2007).

The commercial use of synthetic and hybrid cultivars in rapeseed is a reality and also development of synthetic or hybrid cultivars has been successful in oilseed *Brassica* sp ( Sood et al., 2000; Seyis et al., 2006; Qian et al., 2009; Sincik et al., 2011). Several systems for commercial production of $F_1$ hybrid seed are now available, including cytoplasmic male-sterility (CMS) systems (Rahman 2013) and the dominant genetic male sterility (GMS) system. Most studies on heterosis in canola have been conducted within either spring types or winter types (Rameeh 2011; Azizinia 2012). Information on general and specific combining ability effects is very important in conducting a successful breeding program to achieve sufficient heterosis (Malik et al., 2004; Rameeh 2012). Advanced in the yield components and seed yield of brassica

* Agriculture and Natural Resources Research Center of Mazandran, Sari, Iran.
✉vrameeh@yahoo.com
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requires certain information regarding the nature of combining ability of parents available for use in the hybridization program (Rameeh 2010). In addition, information about the nature of gene action involved in expression of quantitative and qualitative traits of economic importance is also required to develop desirable lines.

Most of the studies showed significant GCA and SCA effects for yield and its component characters indicating that both additive and non-additive gene action were important in the inheritance of these traits (Huang et al., 2009; Qian 2009; Rameeh 2010; Azizinia 2012; Farshadfar 2013). Earlier breeders (Rameeh 2010; Azizinia 2012; Farshadfar 2013; Rahman 2013) concluded in their research that with the changes in environment gene effects for different traits contributing to yield or yield itself changes in rapeseed (*B. napus* L.), therefore, for different environment one has to suggest different selection criteria for the improvement in the yield. For those traits that are controlled by additive gene action, simple selection in early segregating generation is suggested, whereas for those traits controlled by non-additive gene action selection in later segregating generation would be more effective (Cheema and Sadaqat, 2004).

Although F1 data of diallel crosses is mostly used to estimate the genetic parameters in Griffing's method (1956), but it is usually difficult to obtain sufficient F1 seeds especially for multi location testing in *B. napus* L. Due to production of large quantity of $F_2$ seeds, many researchers use $F_2$ generation for diallel analysis to estimate of combining abilities (Cho and Scott, 2000). These researchers all reported that $F_2$ diallel analysis provide reliable and better information than F1 generation. Multi locations or conditions testing of GCA and SCA effects and other genetic parameters will reveal the stability of theses parameters for selection criteria ( Baker 1978; Mhater and Jinks 1982).

Diallel analysis are frequently used in rapeseed breeding to assess general and combining abilities for traits but in the most of these studies were conducted at high N levels. The objectives of this study were therefore (i) to evaluate whether $F_2$ rapeseed hybrids utilize nitrogen more efficiently than pure lines at zero and normal N levels, and (ii) to identify general and specific combining abilities for N utilization among a set of adapted cultivars.

## MATERIALS AND METHODS

Six spring cultivars of rapeseed (*B. napus* L.) which were selected based on their different agronomic characters were crossed in half diallel crosses during 2004-05. In order to produce $F_2$ progenies, fifteen $F_1$ populations from a 6 × 6 half diallel cross were selfed by light transparent white mesh cloth at Baykol Agriculture Research Station, located in Neka, Iran (13°, 53′ E longitude and 43° 36′ N latitude, 15 m above sea level) during winter 2005-06. F2 progenies along with 6 parents including RGS-003, Option-500, RW-008911, RAS-3/99, 19-H and PF7045/91 were grown in a randomized complete block design with four replications at two experiments including $N_0$: without nitrogen and $N_1$: 150 kg nitrogen per hectare during 2006-07. The plots related to each experiment were consisted of four rows 5 m long and 40 cm apart. The distance between plants on each row was 5 cm resulting in approximately 400 plants per plot, which were sufficient for $F_2$ genetic analysis in each experiment. The soil was classified as a deep loam soil (Typic Xerofluents, USDA classification) contained an average of 280 g clay $kg^{-1}$, 560 g silt $kg^{-1}$, 160 g sand $kg^{-1}$, and 22.4 g organic matter $kg^{-1}$ with a pH of 7.3. Soil samples were found to have 45 kg $ha^{-1}$ (mineral N in the upper 30-cm profile). Fertilized experiment ($N_1$) received 150 kg $ha^{-1}$ N as Urea (50 kg N at planting time, beginning of stem elongation, and at initial of flowering stage) while unfertilized experiment ($N_0$) received no N. All the plant protection measures were adopted to make the crop free from insects. Seed yield (adjusted to kg/ha) was recorded based on three middle rows of each plot. Oil content was estimated with the help of nuclear magnetic resonance spectrometry (Madson, 1976).

Analysis of variance for the crosses was based on Griffing's method 2, model 1 for fixed genotypes (Griffings, 1956) and the linear model (Singh and Chaudhary, 1985). The analysis was performed on individual environments using the diallel-SAS program written by Kang (1994) and a combined analysis over environments using the diallel-SAS program written by Zhang and Kang (1997).The general linear model for an individual environment *was:* $Yijk=\mu+G_i+G_j+S_{ij}+B_k+E_{ijk}$ where; *Yijk* was the response of the kth observation in the ith environment of the plant; $\mu$ was general mean; $G_i$ the general combining ability (GCA) of the ith parent; $G_j$ the general combining ability (GCA) of the jth parent; $S_{ij}$ the specific combining ability associated with the ith and jth cross; $B_k$ the effect of the kth replicate and $E_{ijk}$ is the error associated with each observation.

The general linear model for the combined analysis was:

$$Yijkl= \mu+L_k + B_{l(k)}+ T_{ij}+G_i +G_j+S_{ij}+(LT)_{ijk}+ (LG)_{ik}+ (LG)_{jk} +(LS)_{ijk}+E_{ijk(l)}$$

where μ is a general constant, $L_k$ is the main effect of environment (nitrogen level) *k*, $B_{l(k)}$is the main effect of block *l* within the environment, $T_{ij}$ is the treatment effect, $G_i$ and, $G_j$ are the general combining ability (GCA) of parent *i* and *j*, $S_{ij}$ is the specific combining ability (SCA) of hybrid *ij*, $(LG)_{ik}$, $(LG)_{jk}$, and $(LS)_{ijk}$ are interactions of GCA and SCA with the environment and $E_{ijkl}$ is the residual effect. Each effect was tested using its interaction with the block as error term. A *t*-test was used to test whether the GCA and SCA effects were different from 0.

## RESULTS AND DISCUSSION

### *1-Combined analysis of variances of the traits*

Significant mean squares of nitrogen levels ($N_0$ and $N_1$) were detected for all the studied traits, revealed significant differences of exhibition of the traits in the genotypes in two nitrogen levels application (Table 1). Significant mean squares of SCA were detected for plant height, seed yield, oil percentage and oil yield exposed the importance of non-additive genetic effects for these traits. The high narrow-sense heritability estimates were found for plant height and seed yield at $N_0$ but for 1000-seed weight it was high in both nitrogen levels indicating the prime importance of additive genetic effects for controlling these traits. The results of most of the studies showed significant GCA and SCA effects for yield and its component characters indicating that both additive and non-additive gene action were important in the inheritance of these traits (Huang et al., 2009; Qian 2009; Rameeh 2010; Azizinia 2012; Farshadfar 2013).

**Table 1. Combined analysis of variance for plant height, seed yield, oil percentage and oil yield of rapeseed (*Brassica napus* L.) based on Griffing's method two.**

| S.O.V | df | MS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Plant height | Pods per Plant | Seeds per Pod | 1000-Seed Weight (g) | Seed yield | Oil% | Oil yield |
| N(nitrogen) | 1 | 25855.75** | 35835.41** | 178.77 | 4.70** | 27607326.07** | 610.29** | 7856717.05** |
| N(R) | 6 | 117.81 | 587.86 | 30.09 | 0.20 | 269432.97 | 9.99 | 86827.42 |
| Treat | 20 | 588.40** | 2708.88** | 29.15** | 1.18** | 1344284.53** | 31.27** | 265647.19** |
| GCA | 5 | 123.87 | 241.11 | 3.20 | 0.395 | 174805.97 | 2.09 | 31880.53 |
| SCA | 15 | 743.26** | 3530.03 | 37.8 | 1.44 | 1734110.07** | 40.99** | 343569.41** |
| N × Treat | 20 | 32.78 | 150.24 | 6.07 | 0.04 | 144202.28* | 5.62** | 28788.72* |
| N × GCA | 5 | 6.27 | 22.23 | 0.47 | 0.008 | 11265.41 | 1.21 | 4012.42 |
| N × SCA | 15 | 41.36 | 192.86 | 7.97 | 0.05 | 188514.50 | 7.09** | 37046.66* |
| Pooled error | 120 | 57.24 | 125.67 | 4.17 | 0.06 | 113421.46 | 1.73 | 17264.41 |
| $h^2$N1 | | 0.71 | 0.07 | 0.11 | 0.53 | 0.57 | 0.12 | 0.16 |
| $h^2$N 2 | | 0.34 | 0.14 | 0.30 | 0.53 | 0.15 | 0.08 | 0.11 |

*, ** Significant at $p<0.05$ and 0.01, respectively.

$h^2$N1:Narrow-sense heritability estimate at NO.

$h^2$N2: Narrow-sense heritability estimate at N1.

***2- Mean values and general combining ability of parents***

The N×GCA level interaction was not significant for all studied traits. For plant height RGS003 and 19H had significant positive and negative GCA effects, respectively at the $N_0$ condition (Table 2) but 19H and Option500 had significant negative GCA effects. RGS003 exhibited significant positive GCA effect of this trait under $N_1$ condition (Table 3). The mean values of this trait at $N_0$ condition were varied from 123.8 to 140 cm in RGS003 and RAS-3/99, respectively and also it ranged from 146.4 to 165.5 cm at $N_1$ condition. PF7045/91 had significant positive GCA effects of pods per plant in both $N_0$ and $N_1$ conditions but RGS003 had only significant positive GCA effect of this trait under $N_0$ condition. The mean values of this trait varied from 85.5 to 140 in Option500 and RW008911, respectively under $N_0$ condition and also it ranged from 109.2 to 173.7 in the same parents under $N_1$condition. Non of parents had significant GCA effect of seeds per pod under $N_0$ condition, but RGS003 and PF7045/91 had significant negative and positive GCA effects of seeds per pod under $N_1$ condition. High mean values of this trait under $N_0$ and $N_1$ conditions were belonged to 19H and PF7045/91, respectively. 19H with significant positive GCA effect of 1000-seed weight was the best combiner of this trait under $N_0$ and $N_1$ conditions. The highest mean values of this trait under $N_0$ and $N_1$ conditions (4.2 and 4.4g, respectively) were detected for 19H. The parent: PF7045/91 with significant positive GCA effect of seed yield was the best combiner of this trait under $N_0$ and $N_1$ conditions. The parents including RW008911, RGS003 and PF7045/91 with seed yield of 2700, 2796.3 and 2520.3 kg $ha^{-1}$ had high amount of this trait under $N_0$ condition and the mean values of these parents under $N_1$ condition were 3347.5, 3375 and 3225 3 kg $ha^{-1}$, respectively. PF7045/91 had significant positive GCA effect of oil percentage and was the best combiner of this trait under $N_0$ condition but under $N_1$condition: RGS003 and Option500 were good combiners for this trait. The highest mean value of this trait under both $N_0$ and $N_1$ conditions was detected for PF7045/91. This parent was the best combiner for oil yield at both $N_0$ and N1 conditions. For those traits that are controlled by additive gene action, simple selection in early segregating generation is suggested, whereas for those traits controlled by non-additive gene action selection in later segregating generation would be more effective (Cheema and Sadaqat, 2004).

**Table 2. Estimates of GCA effects plant height, seed yield, oil percentage and oil yield of rapeseed (*Brassica napus* L.) at without nitrogen application ($N_0$) and nitrogen application($N_1$) conditions.**

| **$N_0$** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parents** | **Plant height (cm)** | **Pods per Plant** | **Seeds per Pod** | **1000-Seed Weight (g)** | **Seed yield (kg $ha^{-1}$)** | **Oil%** | **Oil yield (kg $ha^{-1}$)** |
| 1-RAS-3/99 | 2.03 | -7.41** | -0.69 | 0.05 | 70.86 | -0.73* | 10.49 |
| 2-RW008911 | 2.19 | 1.28 | 0.16 | 0.03 | -76.78 | -0.77* | -43.81 |
| 3-19H | -6.03** | 0.38 | -0.09 | 0.36** | -46.84 | 0.42 | -12.08 |
| 4-RGS 003 | 3.69* | 3.09** | -0.50 | 0.02 | -38.12 | 0.43 | -10.64 |
| 5-Option 500 | -2.88 | -3.13** | 0.59 | -0.18** | -215.15** | -0.34 | -90.55** |
| 6-PF7045/91 | 1.00 | 5.78** | 0.53 | -0.28** | 306.02** | 0.99** | 146.60** |
| **$N_1$** | | | | | | | |
| **Parents** | **Plant height (cm)** | **Pods per Plant** | **Seeds per Pod** | **1000-Seed Weight (g)** | **Seed yield (kg $ha^{-1}$)** | **Oil%** | **Oil yield (kg $ha^{-1}$)** |
| 1-RAS-3/99 | 2.04 | -6.91* | -0.79 | 0.09 | 42.75 | -0.55 | 3.75 |
| 2-RW008911 | 1.30 | 1.97 | 0.04 | 0.12 | -31.98 | -0.48 | -27.91 |
| 3-19H | -4.77** | -3.45 | 0.64 | 0.29** | -80.93 | 0.13 | -34.58 |
| 4-RGS 003 | 6.65** | 1.06 | -1.11* | 0.02 | 55.05 | 0.64* | 44.01 |
| 5-Option 500 | -4.69** | -4.33 | 0.27 | -0.17* | -173.48* | 0.63* | -59.21 |
| 6-PF7045/91 | -0.53 | 11.66** | 0.94* | -0.35** | 188.60* | -0.37 | 73.94* |

*, ** Significant at $p<0.05$ and 0.01, respectively.

**Table 3. The means of plant height, yield components, seed yield and oil content of six parents of *B.napus* under $N_0$ and $N_1$ conditions.**

| Genotypes | Plant height (cm) | Pods per Plant | Seeds per Pod | 1000-Seed Weight (g) | Seed yield (kg ha$^{-1}$) | Oil% | Oil yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| **$N_0$** | | | | | | | |
| 1-RAS-3/99 | 140.0 | 93.8 | 17.5 | 3.4 | 1650.0 | 38.5 | 635.3 |
| 2-RW008911 | 135.5 | 140.0 | 13.5 | 3.4 | 2700.0 | 36.8 | 992.6 |
| 3-19H | 131.5 | 123.8 | 18.5 | 4.2 | 2160.0 | 41.9 | 904.7 |
| 4-RGS 003 | 123.8 | 108.8 | 16.5 | 3.5 | 2796.3 | 39.3 | 1097.2 |
| 5-Option 500 | 136.5 | 85.5 | 15.3 | 3.0 | 1890.0 | 37.7 | 709.6 |
| 6-PF7045/91 | 133.0 | 114.3 | 17.5 | 2.9 | 2520.3 | 42.8 | 1079.4 |
| $N_1$ | | | | | | | |
| **Genotypes** | **Plant height (cm)** | **Pods per Plant** | **Seeds per Pod** | **1000-Seed Weight (g)** | **Seed yield (kg ha$^{-1}$)** | **Oil%** | **Oil yield (kg ha$^{-1}$)** |
| 1-RAS-3/99 | 165.5 | 130.0 | 21.4 | 4.0 | 2635.5 | 42.2 | 1111.0 |
| 2-RW008911 | 160.9 | 173.7 | 14.9 | 3.9 | 3347.5 | 41.4 | 1385.6 |
| 3-19H | 159.4 | 144.3 | 18.4 | 4.4 | 2982.5 | 46.0 | 1374.8 |
| 4-RGS 003 | 146.4 | 136.7 | 17.4 | 3.7 | 3375.0 | 43.8 | 1476.0 |
| 5-Option 500 | 158.9 | 109.2 | 17.0 | 3.2 | 2615.8 | 42.8 | 1119.0 |
| 6-PF7045/91 | 157.5 | 144.5 | 19.3 | 3.1 | 3225.0 | 45.0 | 1452.0 |
| LSD(α=0.05) | 10.5 | 15.5 | 2.8 | 0.3 | 466.8 | 1.8 | 182.1 |
| LSD(α=0.01) | 13.7 | 20.4 | 3.7 | 0.4 | 612.0 | 2.4 | 238.8 |

***3- Mean values and specific combining ability of the crosses***

Significant negative SCA effect of plant height was found for RAS-3/99×RGS003 under $N_0$ and $N_1$ conditions and also for RGS003×PF7045/91 under $N_0$ condition (Table 4), therefore these combinations are suitable for decreasing of plant height to resistance to lodging. The crosses including RW008911×19H and RGS003×Option500 with low mean values under $N_0$ condition (115 and 121.3 cm, respectively) were good combinations and the mean values of these combinations under $N_1$ condition were 140.4 and 139.3 cm, respectively (Table 5). The crosses with significant negative SCA effect of plant height under $N_0$ and $N_1$ conditions had at least one parent with significant negative GCA effect of this trait. Out of 15 crosses, 13 and 4 crosses had significant SCA effects of pods per plant under $N_0$ and $N_1$ conditions, respectively. RAS-

3/99×RW008911, RW008911×19H had highly significant positive SCA effects of pods per plant under $N_0$ and $N_1$ conditions and also RGS003 ×Option500 and Option500×PF7045/91 had highly significant positive SCA effects for this trait under $N_0$ condition. The crosses including RAS-3/99×19H, RW008911×PF7045/91 and Option500×PF7045/91 with 140.8, 140 and 143 pods per plant under $N_0$ condition and 173.7, 164.3 and 167 pods per plant, respectively under $N_1$ condition had high mean values of this trait in both conditions. RW008911×19H and Option500×PF7045/91 had significant positive SCA effects of seeds per pod under $N_0$ condition and also non of the crosses had significant positive SCA effects of this trait under $N_1$ condition (Table 6). RAS-3/99 × RW008911, RGS003 × Option500 and RGS003×PF7045/91 with 20.3, 20 and 20.3 seeds per pod, respectively had high mean values of this trait under $N_0$ condition and also RAS-3/99×RW008911, RW008911×Option500 and Option500×PF7045/91 with 22.1, 23.1 and 24.3 seeds per pod had high mean values of this trait under $N_1$ condition (Table 7). The crosses including RAS-3/99×19H, RW008911×19H and RGS003×Option500 had significant positive SCA effects of 1000-seed weight under $N_0$ and $N_1$ conditions, and also Option500×PF7045/91 had significant positive SCA effects for this trait under $N_0$ condition. RAS-3/99×19H with 4.1 and 4.3 g of 1000-seed weight had high mean values of this trait in both $N_0$ and $N_1$ conditions. The mean values of seed yield ranged from 1377.50 to 2796.25 kg $ha^{-1}$ related to 19H×RGNO03 and RAS3/99×RGNO03, respectively under $N_0$ condition and also it was varied from 2615.83 to 3431.17 $kgha^{-1}$ in RAS-3/99×Option500 and Option 500×PF7045/91, respectively under $N_1$ condition. The Crosses including RAS-3/99×19H, RAS-3/99×PF7045/91, RW00891×19H, RW008911×PF7045/91 and RGS003×Option500 had significant positive SCA effects for oil percentage under $N_0$ and $N_1$ conditions. For oil yield, Option500×PF7045/91 had significant positive SCA effects for oil percentage under $N_0$ and $N_1$ conditions. The means of oil yield ranged from 568 to 1177.50 $kgha^{-1}$ and also it was varied from 1090 to 1549.91 kg/ha under $N_0$ and $N_1$ conditions, respectively. Out of 15 crosses, 10 and 2 crosses had significant SCA effects of oil yield under $N_0$ and $N_1$ conditions, respectively. All of the crosses with significant positive SCA effects of oil yield had significant positive SCA effects seed yield in both $N_0$ and $N_1$ conditions. Earlier breeders (Rameeh 2010; Azizinia 2012; Farshadfar 2013; Rahman 2013) significant SCA effects for most yield components in spring and winter types of rapeseed varieties.

**Table 4.Estimates of SCA effects for plant height, seed yield, oil percentage and oil yield in the half diallel crosses of six parents of rapeseed at $N_0$.**

| Crosses | Plant height (cm) | Pods per Plant | Seeds per Pod | 1000-Seed Weight (g) | Seed yield (kg $ha^{-1}$) | Oil% | Oil yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| 1- RAS-3/99 × RW008911 | -0.72 | 29.13** | -3.36** | -0.02 | 591.68** | -1.90** | 173.01** |
| 2- RAS-3/99 × 19H | 3.50 | 13.78** | 1.89* | 0.44** | 21.74 | 2.03** | 53.35 |
| 3- RAS-3/99 × RGS 003 | -13.97** | -3.94* | 0.30 | 0.07 | 649.27** | -0.60 | 244.45** |
| 4- RAS-3/99 × Option 500 | 5.34 | -20.97** | -2.05* | -0.18 | -79.95 | -1.44* | -63.20 |
| 5- RAS-3/99 × PF7045/91 | -2.03 | -1.12 | 0.26 | -0.18 | 29.15 | 2.34** | 69.45 |
| 6-RW008911 × 19H | 5.10 | 22.10** | -1.21 | 0.38** | 294.37* | 2.70** | 170.77** |
| 7-RW008911× RGS 003 | 6.13 | -7.13** | 1.20 | -0.06 | 375.65** | -0.68 | 131.68* |
| 8- RW008911× Option 500 | 3.19 | 17.09** | 0.61 | -0.01 | -269.82* | -2.54** | -150.36* |
| 9- RW008911× PF7045/91 | 11.57** | 5.44** | -2.33* | -0.18 | 189.02 | 3.63** | 163.14** |
| 10-19H × RGS 003 | -0.16 | -11.47** | 1.20 | -0.14 | -651.79** | 0.12 | -266.34** |
| 11- 19H × Option 500 | -0.34 | -3.25* | -0.90 | -0.52** | 485.24** | -1.04 | 167.79** |
| 12- 19H × PF7045/91 | 1.78 | 16.85** | -0.58 | -0.29** | 481.59** | -0.32 | 190.09** |
| 13- RGS 003 × Option 500 | -1.32 | 18.28** | -2.24* | 0.29** | 365.02** | 4.51** | 246.00** |
| 14- RGS 003 × PF7045/91 | -12.44** | 1.63 | 0.83 | -0.06 | -102.14 | -1.32* | -70.06 |
| 15- Option 500 × PF7045/91 | 3.13 | 23.35** | 1.73* | 0.22* | 524.90** | 0.45 | 216.91** |

*, ** Significant at $p<0.05$ and 0.01, respectively.

**Table 5.Estimates of SCA effects for plant height, seed yield, oil percentage and oil yield in the half diallel crosses of six parents of rapeseed at $N_1$.**

| Crosses | Plant height (cm) | Pods per Plant | Seeds per Pod | 1000-Seed Weight (g) | Seed yield (kg ha$^{-1}$) | Oil% | Oil yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| 1- RAS-3/99 × RW008911 | 0.76 | 32.41** | -3.83** | 0.03 | 411.34* | -1.55* | 124.12 |
| 2- RAS-3/99 × 19H | 5.30 | 8.38 | -0.88 | 0.37* | 95.33 | 2.49** | 120.01 |
| 3- RAS-3/99 × RGS 003 | -19.14** | -3.68 | -0.11 | -0.06 | 351.84 | -0.30 | 142.58 |
| 4- RAS-3/99 × Option 500 | 4.71 | -25.81** | -1.93 | -0.37* | -178.90 | -1.29* | -111.13 |
| 5- RAS-3/99 × PF7045/91 | -0.85 | -6.48 | -0.30 | -0.31* | 71.08 | 1.96* | 88.70 |
| 6-RW008911 × 19H | 2.24 | 28.97** | -0.58 | 0.28* | 75.04 | 1.48* | 75.62 |
| 7-RW008911× RGS 003 | 3.87 | -13.01 | 0.69 | -0.31* | 249.47 | -1.24 | 69.45 |
| 8- RW008911× Option 500 | 4.40 | 13.35 | 1.60 | 0.06 | -44.93 | -3.35** | -108.50 |
| 9- RW008911× PF7045/91 | 6.73* | -7.36 | -2.45* | -0.21 | 20.30 | 3.65** | 118.62 |
| 10-19H × RGS 003 | 1.53 | -11.34 | 1.57 | -0.08 | -115.55 | -1.73* | -96.19 |
| 11- 19H × Option 500 | 2.95 | 10.88 | 2.72* | -0.37* | 285.71 | -2.71** | 50.06 |
| 12- 19H × PF7045/91 | 1.70 | 9.80 | -3.43** | -0.26 | 290.61 | -1.61* | 73.96 |
| 13- RGS 003 × Option 500 | 1.88 | 19.94* | -3.19 | 0.35* | 164.32 | 2.67** | 154.03 |
| 14- RGS 003 × PF7045/91 | -4.70 | 5.71 | -0.16 | -0.04 | -522.87** | -1.30 | -267.84** |
| 15- Option 500 × PF7045/91 | 2.41 | 13.44 | 0.34 | 0.08 | 493.47** | 0.88 | 258.32** |

*, ** Significant at p<0.05 and 0.01, respectively.

**Table 6. The means of plant height, seed yield, oil percentage and oil yield of six parents and their half $F_1$ crosses of *B.napus* under $N_0$ condition.**

| Genotypes | Plant height (cm) | Pods per Plant | Seeds per Pod | 1000-Seed Weight (g) | Seed yield (kg ha$^{-1}$) | Oil% | Oil yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| 1- RAS-3/99 × RW008911 | 123.8 | 86.3 | 20.3 | 3.3 | 1370.3 | 38.0 | 521.1 |
| 2- RAS-3/99 × 19H | 133.3 | 140.8 | 16.3 | 4.1 | 2285.0 | 42.5 | 967.8 |
| 3- RAS-3/99 × RGS 003 | 144.0 | 114.3 | 18.3 | 3.3 | 2375.0 | 39.1 | 930.1 |
| 4- RAS-3/99 × Option 500 | 134.5 | 132.3 | 18.8 | 3.2 | 1552.5 | 36.5 | 568.2 |
| 5- RAS-3/99 × PF7045/91 | 146.8 | 129.5 | 15.8 | 2.9 | 2532.5 | 44.0 | 1118.8 |
| 6-RW008911 × 19H | 115.0 | 98.8 | 17.0 | 4.1 | 1705.0 | 39.3 | 670.9 |
| 7-RW008911× RGS 003 | 129.5 | 109.0 | 18.0 | 3.6 | 1377.5 | 41.1 | 563.8 |
| 8- RW008911× Option 500 | 122.8 | 111.0 | 17.0 | 3.0 | 2337.5 | 39.2 | 918.1 |
| 9- RW008911× PF7045/91 | 128.8 | 140.0 | 17.3 | 3.1 | 2855.0 | 41.3 | 1177.5 |
| 10-19H × RGS 003 | 150.3 | 124.5 | 15.8 | 3.3 | 1720.0 | 40.0 | 688.8 |
| 11- 19H × Option 500 | 131.5 | 135.3 | 15.3 | 3.4 | 2226.0 | 44.8 | 997.7 |
| 12- 19H × PF7045/91 | 124.3 | 127.5 | 18.3 | 3.0 | 2280.0 | 40.3 | 918.8 |
| 13- RGS 003 × Option 500 | 121.3 | 93.5 | 20.0 | 3.1 | 1171.3 | 39.5 | 463.2 |
| 14- RGS 003 × PF7045/91 | 133.3 | 143.0 | 20.3 | 3.1 | 2730.0 | 41.3 | 1125.9 |
| 15- Option 500 × PF7045/91 | 133.0 | 105.5 | 18.5 | 3.0 | 2165.0 | 39.8 | 861.3 |
| LSD(α=0.05) | 10.5 | 15.5 | 2.8 | 0.3 | 466.8 | 1.8 | 182.1 |
| LSD(α=0.01) | 13.7 | 20.4 | 3.7 | 0.4 | 612.0 | 2.4 | 238.8 |

**Table 7. The means of yield components, grain yield and oil content of six parents and their half F1 crosses of *B.napus*.(N1).**

| Genotypes | Plant height (cm) | Pods per Plant | Seeds per Pod | 1000-Seed Weight (g) | Seed yield (kg $ha^{-1}$) | Oil% | Oil yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| 1- RAS-3/99 × RW008911 | 150.4 | 123.0 | 22.1 | 4.0 | 2505.8 | 43.5 | 1090.2 |
| 2- RAS-3/99 × 19H | 155.6 | 173.7 | 19.5 | 4.3 | 2887.5 | 45.0 | 1298.8 |
| 3- RAS-3/99 × RGS 003 | 168.6 | 136.3 | 19.1 | 3.5 | 3197.9 | 42.9 | 1371.2 |
| 4- RAS-3/99 × Option 500 | 157.8 | 156.7 | 21.3 | 3.7 | 2675.0 | 40.8 | 1090.0 |
| 5- RAS-3/99 × PF7045/91 | 164.3 | 152.5 | 18.0 | 3.2 | 3099.5 | 46.8 | 1450.3 |
| 6-RW008911 × 19H | 140.4 | 116.0 | 21.0 | 4.3 | 2447.9 | 45.3 | 1104.7 |
| 7-RW008911× RGS 003 | 160.2 | 132.5 | 20.6 | 3.9 | 2784.2 | 43.0 | 1198.9 |
| 8- RW008911× Option 500 | 150.3 | 149.3 | 23.1 | 3.4 | 2956.7 | 42.0 | 1241.9 |
| 9- RW008911× PF7045/91 | 153.2 | 164.3 | 17.6 | 3.3 | 3320.8 | 42.1 | 1398.9 |
| 10-19H × RGS 003 | 178.4 | 149.6 | 17.8 | 3.8 | 2971.8 | 46.2 | 1372.6 |
| 11- 19H × Option 500 | 160.7 | 162.9 | 15.4 | 3.9 | 2971.3 | 47.9 | 1424.4 |
| 12- 19H × PF7045/91 | 158.2 | 164.7 | 19.1 | 3.3 | 2643.3 | 42.9 | 1135.7 |
| 13- RGS 003 × Option 500 | 139.3 | 121.7 | 20.2 | 3.4 | 2218.6 | 47.1 | 1045.8 |
| 14- RGS 003 × PF7045/91 | 154.0 | 167.0 | 21.0 | 3.2 | 3431.2 | 45.4 | 1558.7 |
| 15- Option 500 × PF7045/91 | 153.1 | 162.0 | 24.3 | 3.3 | 3131.9 | 41.4 | 1297.6 |
| LSD(α=0.05) | 10.5 | 15.5 | 2.8 | 0.3 | 466.8 | 1.8 | 182.1 |
| LSD(α=0.01) | 13.7 | 20.4 | 3.7 | 0.4 | 612.0 | 2.4 | 238.8 |

**CONCLUSION**

The creation of good hybrids to be cultivated in low-input systems at low N level will be facilitated by the high GCA effects observed. The GCA x N level interaction indicates that results classically obtained at high N level would not be enough to identify parents and that specific experiments at low N level will be necessary. Among the six parents, PF7045/91 showed the best GCA for seed yield under $N_0$ condition. It has also a high GCA under $N_1$ condition but its low oil content under $N_1$ condition is certainly disadvantageous as the quality of the hybrid is often intermediate between the two parents. For oil content good combiner parents were varied based on nitrogen levels. The parent PF7045/91 was good combiner for oil content under $N_0$ condition and the parents including RGNO03 and Option500 were good combiners under $N_1$ condition.

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# قدرات الجمع المنسوبة للانتاج في نبات اللفت تحت مستويات ملائمة ومنخفضة للنيتروجين

***فاليولا، رميح****

## ملخص

تمت دراسة الوراثة في ستة أباء وأليلات جيل الابناء (F2) رقم 15 في نبات اللفت تحت ظروف الاجهاد ( عدم استخدام النتروجين $N_{0:}$ ) و تحت الظروف العادية (استخدام النتروجين $N_{1:}$ ). كانت الأوساط الحسابية المعنوية لقدرات الجمع المحددة (SCA) لجميع الصفات، وقد تضمن هذا البحث على أهمية دور التأثيرات الجينية غير المضافة على الصفات الموروثة. مستوى النتروجين ×GCA (قدرة الجمع العامة) لمربع الأوساط لم تكن معنوية لجميع الصفات والتي تشير إلى استقرار في الصفات الجينية الإضافية في الظروف التي تم فيها إضافة النتروجين. مستوى النتروجين × قدرات الجمع المحددة (SCA) للأوساط الحسابية كانت معنوية لمحتوى الزيوت ومردود الزيت، وقد حققت اختلافات معنوية لقدرات الجمع المحددة (SCA) لهذه الصفات تحت تأثير إضافة النتروجين. وقد شملت الصفات طول النبات, وزن 1000 حبة و مردود البذور كان له تقديرات لرفع التأثيرات الوراثية الضيقة عند طور (عدم استخدام النتروجين $N_{0:}$ )، لكن وزن ألف بذرة كان له دور في رفع التأثيرات الوراثية الضيقة عند ظروف (عدم استخدام النتروجين $N_{0:}$ ) وتحت الظروف العادية (استخدام النتروجين $N_{1:}$ ). معظم عمليات العبور الوراثية نشطت تحت تأثير قدرات الجمع المحددة (SCA) لمردود البذور عند طور ( عدم استخدام النتروجين $N_{0:}$ ).

**الكلمات الدالة:** قدرات الجمع، أليلات ثنائية، التأثيرات الوراثية الضيقة، النتروجين، بذور اللفت.

* مركز البحوث الزراعية والموارد الطبيعية، ايران.
✉vrameeh@yahoo.com
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