

(*Brassica napus* L.)

**Effect of row spacing on grain yield and its components and radiation use efficiency  
 in four rapeseed (*Brassica napus* L.) cultivars grown in paddy fields in Guilan**

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(Ozer, 2003; Egli, 1988 ;Boquet, 1990

(May *et al.*, 1993; Johnson and Hanson, 2003;

Jasinska *et al.*, 1991)

(Johnson and Hanson, 2003)

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(Andrade and Calvino, 2002)

(Morrison *et al.*, 1990b)

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May *et al.*, Johnson and Hanson., 2003

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(Ozer, 2003) .(1993;

(Ozer, 2003)

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(Shibles and Weber, 1995

(Mendham *et al.*, 1981)

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;Andrade and Calvino, 2002; Bengtsson, 1991

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(Morrison *et al.*, 1995).

(Sinclair and Horie, 1989)

(Morrison *et al.*, 1995)

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Table 1. Meteorological Data In field station of Rice Research Institute of Iran in Rasht, in 2003-2004 and 2004-2005 cropping seasons.

| Month | دما (درجه سانتیگراد)<br>Temperature(°C) |                |                    |                | مجموع میزان نزولات<br>(میلی متر)<br>Total precipitation<br>(mm) |                        | مجموع ساعات آفتابی<br>Total sunny hours |                        |
|-------|---|----------------|--------------------|----------------|---|------------------------|---|------------------------|
|       | ۸۲-۸۳<br>2003-2004                      |                | ۸۳-۸۴<br>2004-2005 |                | ۸۲-۸۳<br>2003-<br>2004  | ۸۳-۸۴<br>2004-<br>2005 | ۸۲-۸۳<br>2003-<br>2004                  | ۸۳-۸۴<br>2004-<br>2005 |
|       | کمینه<br>Min.                           | بیشینه<br>Max. | کمینه<br>Min.      | بیشینه<br>Max. |   |                        |   |                        |
| Dec.  | 4.4                                     | 14.9           | 2.5                | 12.6           | 58.2  | 188.6                  | 112.1                                   | 130                    |
| Jan.  | 5.4                                     | 16.1           | 0.6                | 8.3            | 55.9  | 256.9                  | 135.3                                   | 81.6                   |
| Feb.  | 5.6                                     | 13.3           | 5                  | 15.4           | 172.4   | 50.1                   | 79.3                                    | 106.2                  |
| Mar.  | 8.2                                     | 19.7           | 7.1                | 17.9           | 164.4   | 97                     | 218.2                                   | 153                    |
| Apr.  | 13.6                                    | 21.7           | 13.9               | 22.4           | 77.2  | 53.5                   | 118.6                                   | 141.7                  |
| May.  | 16.8                                    | 26             | 18.3               | 27.6           | 70.9  | 54.4                   | 232.5                                   | 234.9                  |
| Mean. | 9.0                                     | 18.6           | 7.9                | 17.3           |   |                        |   |                        |
| Total | -                                       | -              | -                  | -              | 599   | 700.5                  | 896                                     | 847.4                  |

(Sylvester Bradley and Makepeace, 1984)

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(Skye Instruments LTD, UK)

(Sylvester-Bradly and Makepeace,

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(Singer, 2001)

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:(Wells *et al.*, 1991)

$$LI\% = (1 - I/I_0) \times 100 \quad (1)$$

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=I<sub>0</sub>

:(Rietveld, 1987)

$$R_s = R_a [ a + b (n/N) ] \quad (2)$$

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(Soxtec System HT, Tecator, Sweden)

(Rs)

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( ) ( ) .(Keating *et al.*, 1993; Kiniry *et al.*, 2005)

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.(Montieth and Unsworth, 1990)

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.(Kiniry *et al.*, 1989, Kemanian *et al.*, 2004)

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Table 2. Combined analysis of variance for different plant characteristics in four rapeseed cultivars sown in paddy fields in 2003-2004 and 2004-2005 Cropping seasons.

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| S.O.V.          | df  | GY <sup>1</sup> | OP <sup>2</sup>      | OY <sup>3</sup>   | NS <sup>4</sup>     | 1000GW <sup>5</sup>  | HI <sup>6</sup>    | BY <sup>7</sup>      | NGS <sup>8</sup>      | SL <sup>9</sup>    | GD <sup>10</sup>   | PH <sup>11</sup>   | AB(1) <sup>12</sup> | AB(2) <sup>13</sup> | AB(3) <sup>14</sup> |                    |
|-----------------|-----|-----------------|----------------------|-------------------|---------------------|----------------------|--------------------|----------------------|-----------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|--------------------|
| Year (Y)        | 1   | 48412062**      | 208**                | 6623928**         | 250002**            | 2.04**               | 1138.9**           | 378857334**          | 33.6**                | 541.5**            | 11440**            | 33189/8**          | 17.51**             | 37.5**              | 337.5**             |                    |
| R/Year          | /   | 6               | 718988               | 10.96             | 73775               | 5613                 | 0.095              | 226.11               | 3334791               | 5.5                | 9                  | 0.04               | 56                  | 1.67                | 7.1                 | 2.43               |
| Cultivar (C)    |     | 3               | 2328743**            | 36.7**            | 408215**            | 44108.5**            | 5.2**              | 114.93 <sup>ns</sup> | 53677611**            | 85**               | 419**              | 159**              | 4850.06**           | 16.48**             | 6.12*               | 26.7**             |
| C×Y             | ×   | 3               | 90420**              | 44.7**            | 25455*              | 10404**              | 0.13*              | 42.2 <sup>ns</sup>   | 4416358               | 24**               | 58.5**             | 5.25**             | 356.42**            | 1.98**              | 11.6**              | 26.3**             |
| Error a         | a   | 18              | 125579               | 6.5               | 16911               | 1230                 | 0.082              | 130.47               | 7138677               | 2.2                | 10.6               | 0.03               | 40.9                | 0.47                | 1.23                | 1.13               |
| Row Spacing (R) |     | 2               | 42009 <sup>ns</sup>  | 1.6 <sup>ns</sup> | 8228 <sup>ns</sup>  | 45.32 <sup>ns</sup>  | 0.03 <sup>ns</sup> | 196.31*              | 10343917**            | 0.47 <sup>ns</sup> | 0.4 <sup>ns</sup>  | 27**               | 4.59 <sup>ns</sup>  | 0.19 <sup>ns</sup>  | 0.32 <sup>ns</sup>  | 0.37 <sup>ns</sup> |
| R×Y             | ×   | 2               | 64572 <sup>ns</sup>  | 0.5 <sup>ns</sup> | 6908 <sup>ns</sup>  | 1596.4 <sup>ns</sup> | 0.02 <sup>ns</sup> | 65.16 <sup>ns</sup>  | 2507347 <sup>ns</sup> | 1.8 <sup>ns</sup>  | 6.03 <sup>ns</sup> | 0.16*              | 4.15 <sup>ns</sup>  | 0.32 <sup>ns</sup>  | 5.28*               | 2.62*              |
| C×R             | ×   | 6               | 109626 <sup>ns</sup> | 2.5 <sup>ns</sup> | 11286 <sup>ns</sup> | 1409 <sup>ns</sup>   | 0.03 <sup>ns</sup> | 134.87*              | 3295015 <sup>ns</sup> | 1.5 <sup>ns</sup>  | 4.7 <sup>ns</sup>  | 0.48**             | 8.39 <sup>ns</sup>  | 0.75 <sup>ns</sup>  | 1.23 <sup>ns</sup>  | 0.8 <sup>ns</sup>  |
| C×R×Y           | × × | 6               | 81287 <sup>ns</sup>  | 4.3 <sup>ns</sup> | 7463 <sup>ns</sup>  | 595.5 <sup>ns</sup>  | 0.02 <sup>ns</sup> | 40.06 <sup>ns</sup>  | 2984929 <sup>ns</sup> | 0.23 <sup>ns</sup> | 6.6 <sup>ns</sup>  | 0.08 <sup>ns</sup> | 13.32 <sup>ns</sup> | 0.29 <sup>ns</sup>  | 0.92 <sup>ns</sup>  | 1.2 <sup>ns</sup>  |
| Error b         | b   | 48              | 73209                | 2.4               | 6874                | 865.5                | 0.04               | 48.33                | 2014936               | 2.04               | 7.3                | 0.04               | 17.1                | 0.38                | 1.44                | 0.54               |
| CV (%)          | -   |                 | 15.5                 | 4.7               | 14.0                | 17.0                 | 5.5                | 25.0                 | 21.0                  | 5.6                | 3.7                | 1.5                | 4.7                 | 16.5                | 32.2                | 24.0               |

\* and \*\*: Significant at 5% and 1% levels of probability, respectively.

ns: Non significant.

1, 2, ..., 14 are abbreviation for: Grain Yield, Oil Percent, Oil Yield, Number of Siliques, 1000 Grain Weight, Harvest Index, Biologic Yield, Number of Grains per Silique, Silique Length, Growth Duration, Plant Height, First order Auxiliary Branches, Second order Auxiliary Branches, Third order Auxiliary Branches.

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Table 3. Mean comparison of different plant characteristics of four rapeseed cultivars grown in Paddy field, in 2003-2004 and 2004-2005 cropping seasons.

| Treatment                   | (<br>GY<br>(kg/ha) | (<br>OP(%) | (<br>OY<br>(kg/ha) | NS     | (<br>1000GW<br>(g) | (<br>HI<br>(%) | (<br>BY<br>(kg/ha) | NGS   | (<br>SL<br>(mm) | (<br>GD<br>(Day) | (<br>PH<br>(cm) | AB(1) | AB(2)  | AB(3) |
|-----------------------------|--------------------|------------|--------------------|--------|--------------------|----------------|--------------------|-------|-----------------|------------------|-----------------|-------|--------|-------|
| <b>Cropping season</b>      |                    |            |                    |        |                    |                |                    |       |                 |                  |                 |       |        |       |
| 2003-2004                   | 2448a              | 34.6a      | 852a               | 223.6a | 3.7b               | 30.4a          | 8618a              | 24.7b | 70.3b           | 118.8a           | 106a            | 3.3b  | 4.3a   | 4.9a  |
| 2004-2005                   | 1028b              | 31.6b      | 327b               | 121.5b | 4.04a              | 23.5b          | 4645b              | 25.9a | 75.1a           | 140.7b           | 69b             | 4.1a  | 3.1b   | 1.8b  |
| <b>Cultivar</b>             |                    |            |                    |        |                    |                |                    |       |                 |                  |                 |       |        |       |
| Hyola308                    | 1303b              | 31.36b     | 406.4c             | 147.2c | 3.46c              | 30.2a          | 4489b              | 26.4a | 77.50a          | 126.8d           | 69.2c           | 2.87c | 3.33b  | 4.54a |
| RGS003                      | 1817a              | 33.67a     | 629.1ab            | 177.8b | 3.89b              | 26.4a          | 7100a              | 24.6b | 73.90b          | 130.9b           | 88.2b           | 3.70b | 3.66ab | 2.79b |
| PF7045/91                   | 2043a              | 34.19a     | 714.6a             | 230.9a | 3.68bc             | 25.7a          | 7968a              | 22.9c | 67.50c          | 132.7a           | 103.9a          | 4.87a | 4.45a  | 2.04b |
| Hyola401                    | 1788a              | 33.3ab     | 606.6b             | 134.7c | 4.54a              | 25.6a          | 9697a              | 27.1a | 72.04b          | 128.6c           | 88.7b           | 3.58b | 3.45b  | 2.87b |
| <b>Row spacing (cm)</b> ( ) |                    |            |                    |        |                    |                |                    |       |                 |                  |                 |       |        |       |
| (20)                        | 1777a              | 33.35a     | 607.6a             | 173.2a | 3.9a               | 28ab           | 6544ab             | 25.4a | 72.7a           | 128.7b           | 87.3a           | 3.68a | 3.65a  | 3.00a |
| (25)                        | 1731a              | 32.9a      | 581.1a             | 173.5a | 3.86a              | 28.7a          | 6111b              | 25.2a | 72.8a           | 130.3a           | 87.6a           | 3.84a | 3.84a  | 3.18a |
| (30)                        | 1706a              | 33.15a     | 578.8a             | 171.3a | 3.82a              | 24.1b          | 7238a              | 25.2a | 72.6a           | 130.3a           | 87.3a           | 3.75a | 3.7a   | 3.00a |

Means, in each column and treatment, followed by at least one similar letter are not significantly different at 5% probability level-using Tukey's Test.

1, 2, ..., 14 are abbreviation for: Grain Yield, Oil Percent, Oil Yield, Number of Siliques, 1000 Grain Weight, Harvest Index, Biologic Yield, Number of Grains per Silique, Silique Length, Growth Duration, Plant Height, First order Auxiliary Branches, Second order Auxiliary Branches, Third order Auxiliary Branches.

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Table 4. Interaction of cropping season × cultivar on different plant characteristics in four rapeseed cultivars grown in Paddy field in 2003-2004 and 2004-2005 cropping seasons.

| Cultivar                         | ( GY )<br>(kg/ha) | OP(%)  | ( OY )<br>(kg/ha) | NS      | ( )<br>1000GW<br>(g) | ( )<br>HI<br>(%) | ( BY )<br>(kg/ha) | NGS    | ( )<br>SL<br>(mm) | ( )<br>GD<br>(Day) | ( )<br>PH<br>(cm) | AB(1)  | AB(2) | AB(3) |
|----------------------------------|-------------------|--------|-------------------|---------|----------------------|------------------|-------------------|--------|-------------------|--------------------|-------------------|--------|-------|-------|
| <b>Cropping season 2003-2004</b> |                   |        |                   |         |                      |                  |                   |        |                   |                    |                   |        |       |       |
| Hyola308                         | 2031.2b           | 33.88b | 629.0b            | 227.0b  | 3.22e                | 32.9a            | 6745.2abc         | 27.06a | 77.4a             | 115.3h             | 82.6c             | 2.75c  | 4.91a | 7.91a |
| RGS003                           | 2597.1a           | 35.94a | 931.25a           | 230.7ab | 3.75cd               | 28.6a            | 9548.2a           | 23.5b  | 70.9b             | 120.3f             | 110.8b            | 2.91c  | 3.6ab | 4.5b  |
| PF7045/91                        | 2676.0a           | 36.74a | 980.67a           | 266.3a  | 3.63d                | 29.4a            | 9576.0a           | 21.4c  | 64.8c             | 122.2e             | 122.2a            | 4.58ab | 5.0a  | 3c    |
| Hyola401                         | 2487.8ab          | 34.86a | 866.67a           | 170.7c  | 4.39b                | 30.8a            | 8603.0ab          | 26.9a  | 68.3bc            | 117.6g             | 108.7b            | 3.08c  | 3.90a | 4.3b  |
| <b>Cropping season 2004-2005</b> |                   |        |                   |         |                      |                  |                   |        |                   |                    |                   |        |       |       |
| Hyola308                         | 575.1d            | 31.84b | 184e              | 67.4e   | 3.7d                 | 27.5a            | 2233.3d           | 25.7a  | 77.6a             | 138.4d             | 55.7e             | 3.0c   | 1.7c  | 1.1d  |
| RGS003                           | 1037.2cd          | 31.4b  | 327d              | 124.9d  | 4.0c                 | 24.2a            | 4653.3cd          | 25.9a  | 76.9a             | 141.5b             | 65.5d             | 4.5ab  | 3.7a  | 1.1d  |
| PF7045/91                        | 1410.7c           | 31.65b | 448.5c            | 195.5bc | 3.7d                 | 22.0a            | 6360.8abc         | 24.5b  | 70.1b             | 143.2a             | 85.5c             | 5.1a   | 3.9a  | 1.1d  |
| Hyola401                         | 1088.0c           | 31.75b | 346.5cd           | 98.6de  | 4.7a                 | 20.4a            | 5332.5bcd         | 27.4a  | 75.7a             | 139.6c             | 68.8d             | 4.9ab  | 3bc   | 4.1d  |

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Means, in each column and treatment, followed by at least one similar letter are not significantly different at 5% probability level-using Tukey's Test.

1, 2, ..., 14 are abbreviation for: Grain Yield, Oil Percent, Oil Yield, Number of Siliques, 1000 Grain Weight, Harvest Index, Biologic Yield, Number of Grains per Silique, Silique Length, Growth Duration, Plant Height, First order Auxiliary Branches, Second order Auxiliary Branches, Third order Auxiliary Branches.



Table 5. Correlation coefficients between different plant characteristics in four rapeseed cultivars grown in Paddy field, in 2003-2004 and 2004-2005 cropping seasons.

| Traits      | 1                   | 2                   | 3                   | 4                   | 5                   | 6                  | 7                   | 8                  | 9                   | 10                 | 11      | 12                  | 13      | 14 |
|-------------|---------------------|---------------------|---------------------|---------------------|---------------------|--------------------|---------------------|--------------------|---------------------|--------------------|---------|---------------------|---------|----|
| (1) OP      | 1                   |                     |                     |                     |                     |                    |                     |                    |                     |                    |         |                     |         |    |
| (2) OY      | 0.82**              | 1                   |                     |                     |                     |                    |                     |                    |                     |                    |         |                     |         |    |
| (3) GY      | 0.75**              | 0.99**              | 1                   |                     |                     |                    |                     |                    |                     |                    |         |                     |         |    |
| (4) SL      | -0.79**             | -0.77**             | -0.73**             | 1                   |                     |                    |                     |                    |                     |                    |         |                     |         |    |
| (5) NGS     | -0.66**             | -0.52**             | -0.46*              | 0.68**              | 1                   |                    |                     |                    |                     |                    |         |                     |         |    |
| (6) NS      | 0.51**              | 0.81**              | 0.84**              | -0.63**             | -0.60**             | 1                  |                     |                    |                     |                    |         |                     |         |    |
| (7) 1000 GW | 0.02 <sup>ns</sup>  | -0.16 <sup>ns</sup> | -0.20 <sup>ns</sup> | -0.04 <sup>ns</sup> | 0.38 <sup>ns</sup>  | -0.50*             | 1                   |                    |                     |                    |         |                     |         |    |
| (8) PH      | 0.84**              | 0.97**              | 0.95**              | -0.88**             | -0.61**             | 0.83**             | -0.13 <sup>ns</sup> | 1                  |                     |                    |         |                     |         |    |
| (9) AB(1)   | -0.07 <sup>ns</sup> | -0.18 <sup>ns</sup> | -0.20 <sup>ns</sup> | -0.29 <sup>ns</sup> | -0.31 <sup>ns</sup> | 0.04 <sup>ns</sup> | 0.16 <sup>ns</sup>  | 0.02 <sup>ns</sup> | 1                   |                    |         |                     |         |    |
| (10) AB(2)  | 0.20 <sup>ns</sup>  | 0.56**              | 0.60**              | -0.40 <sup>ns</sup> | -0.25 <sup>ns</sup> | 0.81**             | -0.35 <sup>ns</sup> | 0.58**             | 0.22 <sup>ns</sup>  | 1                  |         |                     |         |    |
| (11) AB(3)  | 0.12 <sup>ns</sup>  | 0.55**              | 0.62**              | -0.01 <sup>ns</sup> | 0.14 <sup>ns</sup>  | 0.60**             | -0.46*              | 0.41*              | -0.61**             | 0.57**             | 1       |                     |         |    |
| (12) BY     | 0.73**              | 0.91**              | 0.90**              | -0.77**             | -0.48*              | 0.80**             | -0.08 <sup>ns</sup> | 0.91**             | 0.05 <sup>ns</sup>  | 0.61**             | 0.47*   | 1                   |         |    |
| (13) HI     | 0.21*               | 0.48*               | 0.51*               | -0.12 <sup>ns</sup> | 0.10 <sup>ns</sup>  | 0.40 <sup>ns</sup> | -0.41*              | 0.34 <sup>ns</sup> | -0.53 <sup>ns</sup> | 0.20 <sup>ns</sup> | 0.57**  | -0.12 <sup>ns</sup> | 1       |    |
| (14) GD     | -0.53**             | -0.81**             | -0.84**             | 0.36 <sup>ns</sup>  | 0.12 <sup>ns</sup>  | -0.66**            | 0.32 <sup>ns</sup>  | -0.70**            | 0.60**              | -0.50*             | -0.87** | -0.67**             | -0.65** | 1  |

\* and \*\*: Significant at 5% and 1% levels of probability, respectively.

ns: Non significant.

1, 2, ..., 14 are abbreviation for: Grain Yield, Oil Percent, Oil Yield, Number of Siliques, 1000 Grain Weight, Harvest Index, Biologic Yield, Number of Grains per Silique, Silique Length, Growth Duration, Plant Height, First order Auxiliary Branches, Second order Auxiliary Branches, Third order Auxiliary Branches.

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## **Effect of row spacing on grain yield and its components and radiation use efficiency in four rapeseed (*Brassica napus* L.) cultivars grown in paddy fields in Guilan**

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### **ABSTRACT**

**Hossein Zadeh, M. H., M. Isfahani, B. Rabiei and M. Rabiee. 2007.** Effect of row spacing on grain yield and its components and radiation use efficiency in four rapeseed (*Brassica napus* L.) cultivars grown in paddy fields in Guilan. **Iranian Journal of Crop Sciences. 9(3): 263-281.**

The effect of row spacing on grain yield, yield components and oil content of four rapeseed (*Brassica napus* L.) cultivars was investigated in a paddy fields as second crop after rice at Rice Research Institute of Iran (Rasht), in 2003-2004 and 2004-2005 cropping seasons. The experiment was conducted as a split plot arrangement in a randomized complete block design with four replications. Four rapeseed cultivars: Hyola308, RGS003, PF7045/91 and Hyola401 were assigned to main plots and three row spacings: 20, 25 and 30 cm at constant plant densities` (40 plant/m<sup>2</sup>) were randomized in sub-plots. Results showed that rapeseed cultivars were significantly different in grain yield, oil content, oil yield, biological yield, days to maturity, number of siliques per plant, number of grains per silique, silique length, 1000- grain weight, number of first, second and third order auxiliary branches, and plant height. Results also indicated that, PF7045/91 ranked the first in grain yield, oil content, oil yield, biological yield, days to maturity ,number of siliques per plant and number of first and second order branches and plant height. Row spacing had significant effect on biological yield, harvest index and days to maturity, but its effect on grain yield, oil content and oil yield was not significant. However, row spacing of 20 cm ranked the first in grain yield, oil content, and oil yield. Correlation coefficients between traits indicated that grain yield was significantly correlated with number of siliques per plant, second order branches and plant height. Number of siliques per plant and plant height were significantly correlated with oil content. Results showed that PF7045/91 ranked the first in light interception (LI%) and radiation use efficiency (RUE) (75.5% and 2.33 g.MJ<sup>-1</sup>, respectively) and Hyola308 ranked the least (61.5% and 1.54 g.MJ<sup>-1</sup>, respectively). Row spacing of 20 cm also ranked the first in light interception (68.5%).

**Key words:** Correlation, Light interception, Radiation use efficiency, Rapeseed (*Brassica napus* L.) , Row spacing, Yield, Yield components.

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**Received: September, 2007.**

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