Drought Stress and Sowing Date Effects on Yield and Some grain Traits of Rapeseed Cultivars

1Babak Delkhosh, 2Amir Hossein Shirani Rad, 3Zahra Bitarafan, 4Gelareh Mousavi nejad

1Department of Agro Ecology, Science and Research Branch, Islamic Azad University, Tehran, Iran  
2Department of Oilseed Crops, Seed and Plant Improvement Institute, Karaj, Iran  
3Department of Agronomy, Science and Research Branch, Islamic Azad University, Tehran, Iran  
4Department of food science and industries, Tehran university, Tehran, Iran

ABSTRACT

Environmental stresses are the most significant limiting factors in agriculture world. Improving yield under drought stress and delayed sowing date is one of the main goals of agronomy which could be possible by recognition of resistant cultivars. The effect of sowing date and irrigation regimes on grain and oil yield and some important grain traits (oil percent, protein percent, phosphor content, phospholipids) of rapeseed (Brassica napus L.) cultivars were studied in field experiments conducted for two years (2008-2010) at Karaj, Iran (50°75′ E, 35°9′N; 1313 m A.S.L.). The experiments were laid out on a randomized complete block design arranged in factorial split-plot. Result showed that there were significant differences between cultivars, sowing dates, irrigation regimes and interactions effects of them. Also, delayed sowing date had more negative effect on assessed traits, in comparison with drought stress. The best cultivars from the grain yield and oil yield point of view were Hyola330 (by average of 3228 kg ha⁻¹) and RGS006 (by average of 1339 kg ha⁻¹), respectively (p<0.01). Due to low production under D2I2 treatment in all cultivars, rapeseed cultivation do not recommend in this condition.

Key words: rapeseed; (Brassica napus L.), environmental stress, grain and oil yield, phospholipids.

Introduction

Oilseed rape (Brassica napus L.) is a member of the mustard (Brassicaceae) family and has become one of the most important sources of the vegetable oil in the world. Its oil also has potential in developing biodiesel market [5]. Also rapeseed is the single most important winter-spring oil crop that is globally recognized as an alternative to temperate cereals in the winter-spring grown season of the most temperate agricultural regions [16]. Water stress and temperature can reduce crop yield by affecting both source and sink for assimilates; also canola response to stress depends on the developmental stage, and seed yield in canola depends on the events occurring prior to and flowering stage [18]. Water saving and efficient use of precipitation are the priorities for agricultural improvement in arid and semiarid regions. Although limited regional and global research is available on oilseed rape production under irrigated conditions, it is known to be sensitive to water deficit conditions [1,24,20]. Gammelvind et al. [7] reported that water deficient in late vegetative and early reproductive growth stages reduces photosynthetic rate in leaves and yield. Johnston et al. (2002) resulted once the minimum water use of approximately 127 mm was achieved, seed yield of canola increased at the rate of 6.9-7.2 Kg ha⁻¹ mm⁻¹. Water stress at flowering negatively influenced the formation of pod and seed size, resulting in lower final seed yield. Nuttal et al. [21] have observed that seed yield was positively correlated to total precipitation and negatively correlated to mean maximum daily temperature that belonged to sowing date.

In the lower rainfall area, combination of the early sowing date with early flowering cultivar would be essential for the production of high seed yield [23]. Hocking and stapper [11] reported that, in Australia, seed yield of canola was reduced by 35% for a May sowing and by 67% for a July sowing, compared an April sowing. Stapper & Fischer [25] reported that late sowing date resulted in a shortening of the per-flowering period and decreases in seed yield, harvest index and yield component. The late sowing usually causes a decline in grown, leaf area, and a faster maturation [15].
Phospholipids (PL) have moderate antioxidant activity especially in the presence of phenolic antioxidants and/or acidic synergists [14]. PLs have therapeutic properties and used to improve human physiological and mental performance, lowering cholesterol levels, and treating neurological disorders [9]. Nevertheless, PLs in rapeseed oil are considered as undesirable impurities causing refining problems, oil losses due to the formation of emulsions during the alkali treatment [26]. Crude oil contains two type of PL: hydratable and non-hydratable phospholipids. Crude oil from rapeseed, which has been damaged in the field, during storage or handling and transportation, contain significant amount of non-hydratable phospholipids [27].

The importance of sowing date and drought stress have been reported in many researches [4,19,12], but little information is available on the interactive effects of delayed sowing date and drought stress on grain yield, oil percent, oil yield, protein percent, phosphor content and phospholipids of rapeseed. Therefore the main objective of these studies was to assess these traits of rapeseed cultivars in the Mediterranean types regions in delayed sowing date and interruption of irrigation at reproductive stage.

Material And Methods

Drought stress and sowing date effects on some physiological and agronomical traits of advanced Rapeseed (Brassica napus L.) cultivars were assessed during the 2008-2010 growing seasons at Karaj, Iran (50°75′ E, 35°9′N; 1313 m a.s.l) with a replicated randomized complete block design arranged in factorial split-plot. Treatments were included: Irrigation and sowing date as main plots, in the Mediterranean types regions in delayed sowing date and interruption of irrigation at reproductive stage (D1) and second half-October (delayed sowing date) (D2), and Cultivars as sub plots. RGS006 (V1), Hyola330 (V2), RG4403 (V3), RG405/02 (V4), Hyola401 (V5) were used as experimental cultivars.

Each experimental plot consisted of six rows, with four m long and 30 cm spaced between rows and five cm distance between plants on the rows. Two side rows considered as margin and four middle lines considered for determination of traits such as grain yield. Soil samples were taken in depth of 0-30 and 30-60 cm, and according to the soil tests data, P and K were applied at a rate of 75 kg P2O5 ha−1 and 50 kg K2O ha−1 pre-plant in the form of triple superphosphate and K2SO4 respectively and incorporated in the soil. N was applied at a rate of 75 Kg ha−1 in the form of urea in three stages: one-third in 2-4 leaves stage, one-third in stemming stage and one-third in flowering stage. The soil was a deep silt-loam with 6.8 (1:1 H2O) pH, 0.76 ds/m EC, 1.3% organic mater, and bulk density of 1.6 g cm−3. Water content at field capacity and permanent wilting point was 27.5 and 14%, respectively. Weather data (precipitation, maximum and minimum of temperature and relative humidity) were recorded and reported as mean monthly data for the 2 years that the studies were conducted (Table1).

The following traits were assessed: grain yield, oil percent, oil yield, protein percent, phosphor content, phospholipids. Grains were dried at 40 °C for four hours under vacuum condition to less than 5% moisture content and then milled to desired particle size by a mortar. Oil was extracted by AOCS method [2]. Oil content of the samples was expressed on percent based on whole seed. Phosphor content was extracted by IUPAC standard with IID.16, 20. Number; by preparing of ash solution in acid and determine of absorption amount with spectrophotometer in 729 nm and then compare with standard sample [22].

Results analyzed by MSTAT-C software and Duncan’s multiple rang test at %5 level used for mean comparison.

<table>
<thead>
<tr>
<th>Month</th>
<th>2008-2009</th>
<th>2009-2010</th>
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<tbody>
<tr>
<td>Sep</td>
<td>16.23</td>
<td>15.46</td>
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<tr>
<td>Oct</td>
<td>10.93</td>
<td>24.29</td>
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<tr>
<td>Nov</td>
<td>5.66</td>
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<tr>
<td>Dec</td>
<td>-9.9</td>
<td>7.7</td>
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<tr>
<td>Jan</td>
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<td>59.1</td>
</tr>
<tr>
<td>Feb</td>
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<td>7.34</td>
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<td>21.06</td>
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<tr>
<td>Apr</td>
<td>11.53</td>
<td>24.26</td>
</tr>
<tr>
<td>May</td>
<td>13.64</td>
<td>27.4</td>
</tr>
<tr>
<td>Jun</td>
<td>16.1</td>
<td>33.56</td>
</tr>
</tbody>
</table>

Phospholipids (PL) and second half-October (delayed sowing date) (D2), and Cultivars as sub plots. RGS006 (V1), Hyola330 (V2), RG4403 (V3), RG405/02 (V4), Hyola401 (V5) were used as experimental cultivars.

| Table 1: precipitation, average monthly temperatures and relative humidity in two years of study |
|-------|-----------|-----------|
| Min. R.H. (%) | Max. R.H. (%) | Min. R.H. (%) | Max. R.H. (%) |
| Temperature (ºC) | Precipitation (mm) | Temperature (ºC) | Precipitation (mm) |
| Sep   | 16.23     | 15.46     |
| Oct   | 10.93     | 24.29     |
| Nov   | 5.66      | 33.2      |
| Dec   | -9.9      | 7.7       |
| Jan   | -9.83     | 59.1      |
| Feb   | -2.82     | 7.34      |
| Mar   | 7.38      | 21.06     |
| Apr   | 11.53     | 24.26     |
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Results analyzed by MSTAT-C software and Duncan’s multiple rang test at %5 level used for mean comparison.
Combined analysis of variance for some rapeseed traits are presented in table 2. In all assessed traits, first sowing date (D1) and normal irrigation (I1) were better than delay sowing date (D2) and drought stress (I2) conditions. Simple effects study of sowing date and irrigation showed that rapeseed was more sensitive to delay sowing date in comparison with drought stress, generally. As an example, oil yield at D2 and I2 conditions was 559.22 and 805.66 kg ha\(^{-1}\) respectively.

Study of interaction effects of sowing date and irrigation revealed that D1I2 was superior to D2I1 conditions as we see for example grain yield under D1I2 by average of 2885 kg ha\(^{-1}\) in comparison with grain yield under D2I1 by average of 1729 kg ha\(^{-1}\).

Study on simple cultivar affect showed that the best cultivar regarding yield (3228 kg ha\(^{-1}\)), oil percent (42.54%), oil yield (1339 kg ha\(^{-1}\)), protein percent (34.96%), grain phosphor content (921.1ppm) and phospholipids content (27630ppm) were: V2, V1, V1, V2, V5 and V5, respectively.

Interaction effects of sowing date and cultivars (DV) showed that in delay sowing date (D2), V2 had the most oil percent (39.93%), oil yield (625.7 kg ha\(^{-1}\)), phosphor content (19863ppm), and phospholipids (18900ppm) were the best cultivars in this condition that recommended (fig 1-6).

But multiple analysis of variance for irrigation and cultivars interaction effects (IV) showed that: in the drought stress condition from reproductive stage, V1 with the most grain yield (2129 kg ha\(^{-1}\)), oil yield (874.2kg ha\(^{-1}\)), protein percent (28.10%); and also V2 with most production of oil percent (40.19%), phosphorcontent (630ppm) and phospholipids (18900ppm) were the best cultivars in this condition that recommended (fig 1-6).

Therefore, for any reason such as delayed harvesting of one spring crop, compelled to fall delayed planting to obtain maximum oil yield V2; and in drought stress condition from reproductive stage or deficit irrigation, V1 recommended.

General results and interaction effects of sowing dates, irrigation regimes and cultivars showed in table 3.

According to table 3, superior cultivars for each trait and condition brought that recommended for the same conditions. For example, if maximum protein percent under delayedsowing with normal irrigation was the main goal of production, V2 would be suggested. Also, rapeseed cultivation not recommended under D2I2 due to low production in this condition in all cultivars.
Fig. 1: Interaction effects of planting date and irrigation and cultivars on grain yield

Fig. 2: Interaction effects of planting date and irrigation and cultivars on oil percent

Fig. 3: Interaction effects of planting date and irrigation and cultivars on oil yield
Fig. 4: Interaction effects of planting date and irrigation and cultivars on protein percent

Fig. 5: Interaction effects of planting date and irrigation and cultivars on phosphor content

Fig. 6: Interaction effects of planting date and irrigation and cultivars on grain phospholipids

Discussion:

In a developing country with arid and semi-arid climate such as Iran and due to its growing population, increasing food requirement and limited water resources, deficit irrigation merits consideration.
Irrigation scheduling is particularly important since many field crops are more sensitive to water deficit at a specific phonological stage. For example, water sensitive stages are flowering and boll formation stages in cotton, vegetative growth stage in soya bean, flowering and grain filling stages in wheat and vegetative forming stages of sunflower and sugar beet [13]. Oilseed rape yield data in different locations under rain-fed and irrigation conditions are also available. For instance: in the different regional of Australia [6,10,13], and in the south west region of Indian Punjab [3], In Iran [8] found yield to be in the range of 1.0-5.3 t ha\(^{-1}\).

Numerous research studies for different climates have shown that sowing date influences the growth, seed yield and quality of rapeseed [11,16,28]

Conclusion:

This study provides new information showed that oilseed rape significantly sensitive to delayed sowing date and also, interrupting irrigation at reproductive stage, causing to yield decrease significantly.

Reference