International Research Journal of Applied and Basic Sciences. Vol., 3 (5), 961-967, 2012
Available online at http:// www. irjabs.com
ISSN 2251-838X ©2012

Effect of biological phosphorus and Irrigation disruption on biomass, seed yield and protein content of canola (*Brassica napus* L.)

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Abstract

Results of evaluation of irrigation (irrigation disruption at beginning of flowering, end of flowering, grain filling and control) and biological phosphorus (0, 50, 100 and 150 g/ha) on the yield of *Brassica napus* L. *cv.* "Hyola 401", a split plot experiment was carried out based on randomized complete block design with four replications at the research farm of Shahid Beheshti Agriculture College (latitude 38° 51' N and longitude 41° 44' E and 1313 m above sea level) in 2010. Results of ANOVA showed the significant effect of irrigation disruption on 1000 seed weight, and significant interaction effect between irrigation disruptions and phosphorus on seed yield, biomass, protein content, protein yield and Harvest Index (HI) of protein. Means comparisons indicated that the maximum (4.55 g) and minimum (3.25 g) 1000 seed weight belonged to irrigation disruption at the beginning of flowering with 150 and 50 g/ha of biological phosphorus application, respectively. The highest yield of seed (777.58 kg/ha) and protein (189.3 kg/ha), and harvest index of protein (0.52 %) were obtained from irrigation disruption at the end of flowering and 50 g/ha biological phosphorus, and the lowest seed yield (120.87 kg/ha), protein yield (28.58 kg/ha) and harvest index of protein (0.14 %) were obtained from irrigation disruption at the beginning of flowering and without phosphorus. The highest percent of protein (28.26 %) was obtained from irrigation disruption at beginning of flowering without phosphorus and the lowest percent (20.65 %) was obtained at no disruption stage with 150 g/ha phosphorus. Means comparisons showed that the highest biomass (4.007 kg/ha) belonged to normal irrigation with 50 g/ha phosphorus application. The lowest biomass (3.83 kg/ha) belonged to no phosphorus treatment and irrigation disruption at the beginning of flowering stage.

Keywords: Biomass, *Brassica napus*, Irrigation, phosphorus, seed yield, protein

Introduction

Canola is the third most important source of plant oil in the world after soybean and palm oil (Sovero, 1997). It is also an excellent rotation crop to control cereal diseases, pests and weeds (Grombacher and Nelson, 1996). The name 'canola' actually stands for 'Canadian oil, low acid'. Canola's low erucic acid content differentiates it from rapeseed (*Brassica napus*) and is sometimes referred to as LEAR or 'low erucic acid rapeseed'. Canola seed contains about 40% oil and increasing its production in the southern U.S. is of interest for biofuel production (Slaton et al., 2008).

Water is becoming scarce not only in arid and drought prone areas but also in regions where rainfall is abundant (Malano and Burton, 2001). The reaction of plants to water stress differ significantly, at various organizational levels, depending upon intensity and duration of stress as well as plant species and its stage of development (Chaves et al., 2003). Henry and McDonald (1978) reported severe drought decreased oil and increased protein content of rapeseed, whereas Hobbs (1983) reported that drought stress increased protein content. Masoud Sinaki et al. (2007) found that the highest reduction of rapeseed yield was obtained when water stress occurred at flowering and then at pod developmental stages. They reported that seed yield reduction by short term water stresses during stem elongation, flowering and pod development were mostly associated with the reduction of pods per plant. Water stress decreased total biomass, seed yield components, harvest index of canola genotypes Rgs003, Sarigol, Option500, Hyola401, Hyola330 and Hyola420 (Tohidi-Moghadam et al., 2009).

Phosphorus (P) is one of the major plant nutrients that directly or indirectly affect all biological processes and is needed in fairly large quantities by the plants (Shenoy and Kalagudi, 2005). It is well known that more than two-third of phosphatic fertilizers is rendered unavailable within a very short period of time after its application (Mandal and Khan, 1972). Phosphorus solubilizing microorganisms (bacteria and fungi) enable P to become available for plant uptake after solubilization (Afzal et al., 2005). Phosphorus fertilizer and phosphorus solubilizing bacteria application significantly enhanced crude protein content of the forage crops (Daşçi et al., 2010). At high P levels there could be significant decrease in protein contents (Lickfett et al., 1999) but Cheema et al. (2001) reported high protein contents at higher P levels. Mohanty et al., (2006) found that organic fertilizers had a significant direct and residual effect compared to inorganic single super phosphate on the biomass. Therefore, the primary objective of the present investigation was to examine the effect of water disruption and different amounts of biological phosphorus on seed yield, biomass and protein content of canola (*Brassica napus* L.).

Material and Methods

To evaluate effects of end season water deficit and biological phosphorus on the yield of *Brassica napus* L. *cv.* "Hyola 401", a split plot experiment was carried out based on randomized complete block design with four replications at the research farm of Shahid Beheshti Agriculture College in 2010. The experiment field is located in south west of Urmia (latitude 38° 51' N and longitude 41° 44' E and 1313 m above sea level). At first, we plowed the land after that leveling of the ground with a disk vertically in order to crushing the hunk was applied. Along with planting the canola seeds got from Seed and Plant Improvement Institute of Karaj, was inoculated with pseudomonas and bacillus species of bacteria as biological phosphorus. The experimental units included four rows with 0.30 m inter-raw and 0.10 m intra-row spacing of 12 m length. Treatments were biological phosphorus (0, 50, 100, 150 g/ha) as main plots and irrigation disruptions (without disruptions, disruptions on grain filling, end of flowering stage, beginning of flowering stage) as sub plots.

To measure the 1000 seed weight, 10 samples of each 100 seeds was chosen, weighing and average of seed weight was determined. Plant above-ground biomass was clipped above the soil surface and harvested in 1 m2 and dried at 72℃ for 48 hours to each plot.
To determine the protein content, at first seeds was milled and dried in the oven 75^{0}c for 24 hours. Five grams of mixture sulfates (copper sulfate, potassium sulfate and selenium dioxide) and 20_cc of concentrated sulfuric acid 98% was added on milled samples and the nitrogen content was measured with titration method by kjeldahl distillation apparatus (AOAC, 1995). Protein content was calculated based on the following formula (AOAC, 1995).

$$\text{Nitrogen (\%)} = \frac{0/0014 \times \text{value obtained from titration}}{\text{weight of sample}}$$

Protein yield multiplied by protein content in seed yield. Protein harvest index equals protein yield of biological yield (biomass).
Protein content= nitrogen % × 6.25

$$\text{HI (\%)} = \frac{\text{Protein yield}}{\text{Biological yield(bicmass)}} \times 100$$

Statistical evaluation was performed using MSTATC software (Michigan state university, 1988). The effects of phosphorus amounts (P) and Irrigation disruptions (I) as well as the interactions of these two factors were analyzed with the analysis of variance. The results of statistical analysis are expressed by F-values; asterisks indicate p-values: $P \leq 0.05$ and $P \leq 0.01$. The comparison of means was done with (Student-Neuman Keuls test) (SNK) at $P \leq 0.05$.

Results

Results of analysis of variance showed the significant interaction effect between water disruption and different amounts of biological phosphorus on 1000 seed weight ($P \leq 0.05$), seed yield, biological yield, protein content and yield and harvest index of protein ($P \leq 0.01$) (Table 1).

Table 1. Analysis of variance of some agronomic traits and yield of *Brassica napus* L. *cv*. Hyola 401 under irrigation disruptions and biological phosphorus.

Source of variation	df	1000 Seed weight	Biomass yield	Seed yield	Protein content	Protein yield	HI of protein
Replication (R)	3	0.06	0.001	0.02	6.78	0.01	0.005
Phosphorus (A)	3	0.16	0.01**	0.06	3.75	0.06	0.007
A×R	9	0.24	0.001	0.01	2.79	0.01	0.005
Irrigation (B)	3	0.76**	0.01**	0.34**	42.97**	0.31**	0.06
A×B	9	0.29*	0.005**	0.14**	12.95**	0.15**	0.04**
Error	36	0.12	0.001	0.03	3.01	0.03	0.009
Coefficient of variance(%)		9.63	0.87	7.39	7.02	9.18	26.96

Note: *, ** significant at $P \leq 0.05$ and $P \leq 0.01$, respectively; df: degree of freedom

Means comparisons indicated that the maximum (4.55 g) and minimum (3.25 g) 1000 seed weight belonged to irrigation disruptions at the beginning of flowering stage with 150 and 50 g/ha biological phosphorus application, respectively. The amount of 1000 seed weight of all levels of phosphorus at the end of the flowering stage, seed filling and control treatment was the same to the minimum amount of 1000 seed weight. Biological phosphorus application had no significant effect on 1000 seed weight at the grain filling, end of flowering and control treatment of disruption stages but the seed weight significantly increased in the beginning of flowering stage with more than 100 g/ha of phosphorus (Figure 1).

Means comparisons indicated that the highest seed yield (777.58 kg/ha) belonged to irrigation disruption at the end flowering stage with 50 g/ha phosphorus application and this amount was the same with the seed yield of all levels of phosphorus at the end of the flowering, grain filling and normal irrigation stages. The lowest seed yield (120.87 kg/ha) was obtained to irrigation disruption at the beginning of flowering stage with no phosphorus application. Increasing the biological phosphorus did not significantly change the seed yield in control treatment (without irrigation disruption) and irrigation disruption at the grain filling stage. In end of flowering stage, phosphorus enhanced the yield of seed, up to 50 g/ha phosphorus significantly but more than 50 g/ha of P caused in to reduce the yield. In irrigation disruption at the beginning of flowering stage increasing phosphorus application led to upraise the seed yield along with higher amounts of phosphorus (Figure 2).

The maximum protein content (28.26 %) was observed in irrigation disruption at grain filling stage with 100 g/ha phosphorus application and this amount was identical to the protein content of disruption at the beginning of flowering stage with 100 g/ha phosphorus and however the same with disruption at grain filling stage with 150 g/ha phosphorus application. The minimum protein content (20.65 %) belonged to normal irrigation (without disruption) with 150 g/ha of phosphorus and this amount was the same with protein of irrigation disruption at the end of flowering stage with 100 g/ha phosphorus application. Increasing phosphorus more than 50 g/ha, caused lower protein content in control treatment of irrigation. In irrigation disruption at grain filling and beginning of flowering stages, up to application of 100 g/ha phosphorus, protein content increased significantly, but more than that the protein content was decreased. In irrigation disruption at the end of flowering, increasing of phosphorus led to reduction of protein content until 100 g/ha, but it upraised more than that (Figure 3).

Means comparisons indicated that the highest yield of protein (189.3 kg/ha) belonged to irrigation disruption at the end flowering stage with 50 g/ha phosphorus and the lowest yield (28.58 kg/ha) belonged to disruption at the beginning of flowering stage with no phosphorus application. The same yield of protein was observed at all levels of phosphorus in irrigation disruption at the end of flowering, grain filling and normal irrigation. In normal irrigation, seed yield was reduced in 50 g/ha phosphorus compare to control (0 g/ha), but higher amount caused to raise protein yield. In grain filling stage, protein yield was increased until 50 g/ha but with 100 g/ha reduced and again with 150 g/ha increased. Although phosphorus did not affect protein yield significantly in the fist two stages. In irrigation disruption at the end of flowering stage, with increasing phosphorus application, protein yield significantly increased but more than that significantly was reduced. In irrigation disruption at the beginning of flowering, protein yield enhanced with higher amounts of phosphorus application (Figure 4).

Means comparisons showed that the highest biomass (4.007 kg/ha) belonged to normal irrigation with 50 g/ha phosphorus application and this amount was statistically the same with 150 and 100 g/ha of P at control treatment of irrigation and irrigation disruption at the grain filling stage. The lowest biomass (3.83 kg/ha) belonged to no phosphorus treatment and irrigation disruption at the beginning of flowering stage and that was the same with biomass produced by irrigation disruptions at grain filling and the end of flowering stages with 0 g/ha phosphorus. In normal irrigation, application of 50 g/ha phosphorus increased the biomass compared to control (0 g/ha), but amounts of P more than that caused to lower biomass. In irrigation disruption at grain filling, end of flowering and beginning of flowering stages, P application up to 100 g/ha, increased the biomass significantly and then more than that caused to reduce the yield of biomass (Figure 5).

The maximum harvest index of protein (0.52 %) was observed in irrigation disruption at end of flowering stage with 50 g/ha phosphorus application and this amount was identical to the harvest index of disruption at the beginning of flowering stage with 150 g/ha phosphorus and however disruption at grain filling stage with 0, 50 and 150 g/ha of phosphorus application. The minimum harvest index of protein (0.14 %) belonged to irrigation disruption at the beginning of flowering without phosphorus and this amount was the same with harvest index of irrigation disruption at the beginning of flowering and normal irrigation with 50 g/ha phosphorus application. Increasing the phosphorus more than 50 g/ha, caused to higher harvest index in control treatment of irrigation. In irrigation disruption at grain filling stage, harvest index was declined in 100 g/ha of phosphorus application. In irrigation disruption at the end of flowering stage, harvest index was significantly increased along with increasing phosphorus application. But more than that led to reducing harvest index, significantly. In irrigation disruption at the beginning of flowering stage, harvest index enhanced along with raised amounts of phosphorus application (Figure 6).

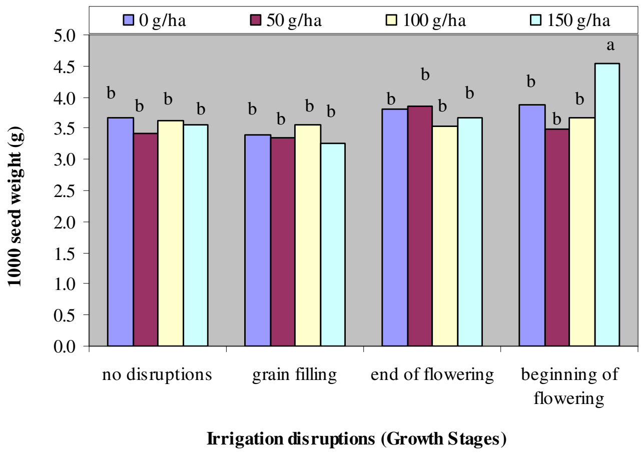

Figure 1. Means comparisons of 1000 seed weight of *Brassica napus* L. *cv.* Hyola 401 affected by biological phosphorus and irrigation disruptions. Dissimilar letters indicate significant difference at $P \leq 0.05$.

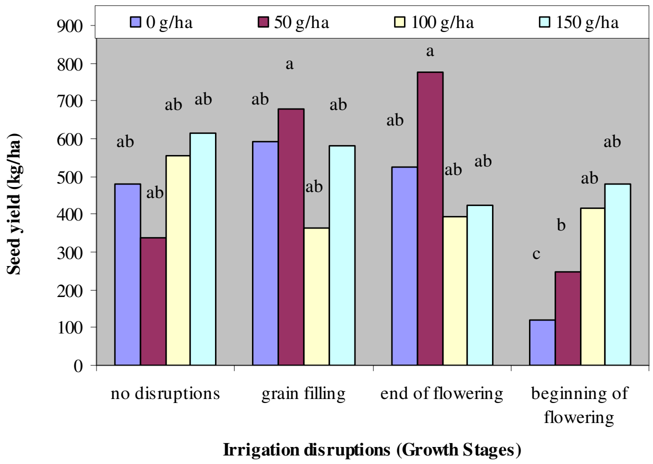

Figure 2. Means comparisons of seed yield of *Brassica napus* L. *cv.* Hyola 401 affected by biological phosphorus and irrigation disruptions. Dissimilar letters indicate significant difference at $P \leq 0.05$.

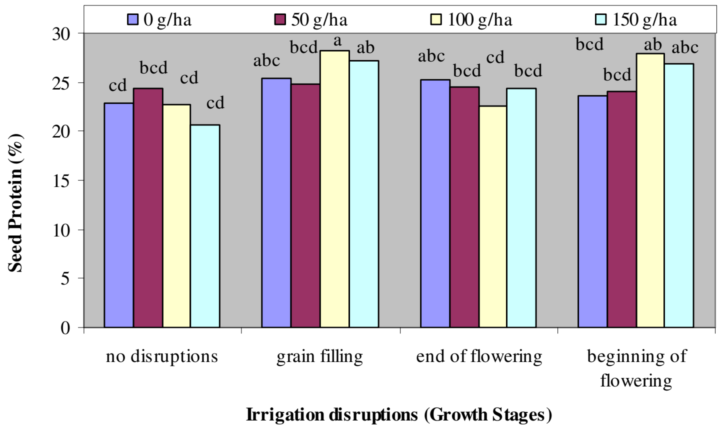

Figure 3. Means comparisons of seed protein content of *Brassica napus* L. *cv.* Hyola 401 affected by biological phosphorus and irrigation disruptions. Dissimilar letters indicate significant difference at *P*≤0.05.

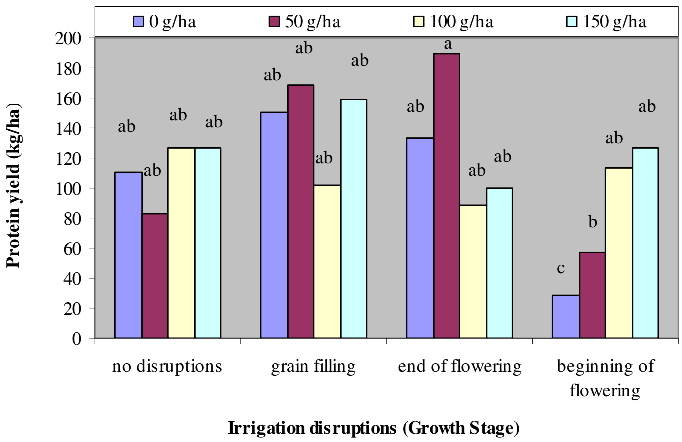

Figure 4. Means comparisons of protein yield of *Brassica napus* L. *cv.* Hyola 401 affected by biological phosphorus and irrigation disruptions. Dissimilar letters indicate significant difference at *P*≤0.05.

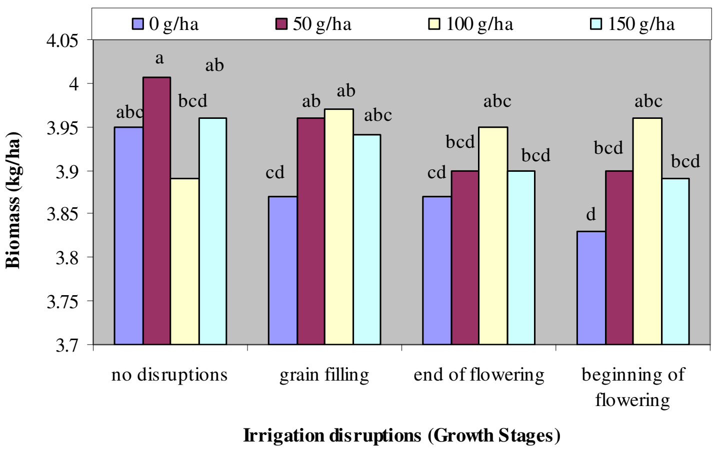

Figure 5. Means comparisons of biomass of *Brassica napus* L. *cv.* Hyola 401 affected by biological phosphorus and irrigation disruptions. Dissimilar letters indicate significant difference at *P*≤0.05.

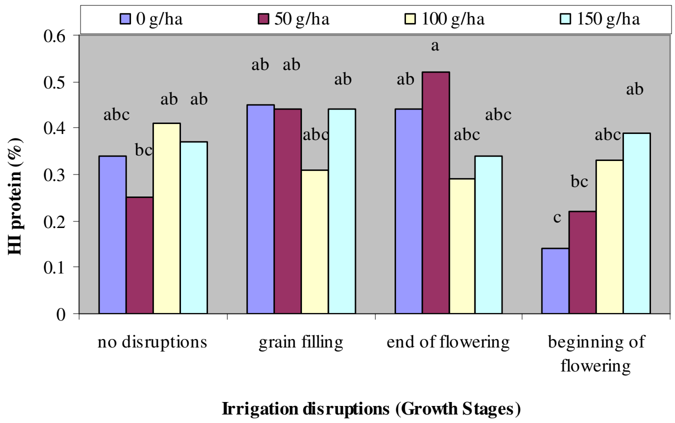

Figure 6. Means comparisons of Harvest Index of protein of *Brassica napus* L. *cv.* Hyola 401 affected by biological phosphorus and irrigation disruptions. Dissimilar letters indicate significant difference at $P \leq 0.05$.

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