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The impact of seed priming and integrated plant nutrition on yield and yield components of black mustard

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Key words: Biological fertilizer, Black mustard, Grain yield, Seed priming

Abstract

A field experiment was conducted to evaluate the effects of seed priming (P_1: unprimed, P_2: hydro-priming and P_3: priming with 1% KNO_3 for 8 hours at 20±1ºC) and chemical fertilizer of control (F_1), 250Kg/ha urea + 200Kg/ha triple superphosphate (F_2) and bio-fertilizer levels of nitrogen fixing (Azoto Barvar 1) and phosphate solubilizing bacterial (Barvar 2), 125Kg/ha urea + 100Kg/ha triple superphosphate (50%) + bio-fertilizer, respectively) on black mustard (*Brassica nigra* L.) performance in 2016. A factorial experiment was arranged with randomized complete block design with three replications. Results showed that primed seeds significantly resulted in higher number of plants per unit area, compared to unprimed seeds. Seed priming and fertilizers improved number of grains per plant, biological and grain yields per unit area of black mustard. Also, the highest biological and grain yields, pods per plant and number of grains per plant were achieved in integrated plant nutrition containing the reduced chemical fertilizer (50%) by application of biological nitrogen and phosphorus fertilizers (100%). Additionally, integrated plant nutrition resulted in decreasing 50% chemical fertilizer application confirming its important role towards environmentally friendly cropping systems such as sustainable agriculture and organic farming systems. In this study, number of seeds per plant had more effect on grain yield, compared to 1000-grain weight. The highest positive correlation with grain yield was recorded for biological yield, followed by grains per plant, suggesting that these traits have the major roles in determining final yield of this medicinal plant.

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Introduction

Medicinal plants were considered as rich sources of secondary metabolites that can be used in pharmaceutical industry. Mustard is an annual plant which belongs to the Brassicaceae family (Abul-Fadl *et al*., 2011). The glucosinolates (thioglucosides) in mustard seeds are pseudo-thioglucosides containing nitrogen and sulphur (Fahey *et al*., 2001). Mustard seed is widely used as a condiment; however, its advantageous chemical composition and relatively low price offer wide possibilities for utilization as additives in human food and in animal feeds (Abul-Fadl *et al*., 2011).

Different techniques could be used to enhance crop yield. In crop production, stand establishment determines plant density, uniformity and management options (Cheng and Bradford, 1999). Seed priming is a useful technique which can be used to improve seedling establishment field performance of crops (Ghassemi-Golezani *et al.,* 2011). Seed priming process is a pre-sowing treatment that exposes seeds to a certain solution for a certain period that allows partial hydration, but radicle emergence does not occur (Rosental *et al*., 2014). Factors such as water potential, priming duration, temperature, seed vigor, plant species and seed primed storage condition affect the seed response to priming. Thus, the optimization of the priming technique is important to achieve the best results (Parera and Cantliffe, 1994; Maiti and Pramanik, 2013).

The positive effects of seed priming have also been reported in many crops, such as maize (*Zea mays* L.) (Abraha and Yohannes, 2013), mung bean (Ghassemi-Golezani *et al*., 2014), chickpea (*Cicer arietinum* L.) (Ghassemi-Golezani and Hosseinzadeh-Mahootchi, 2013), milk thistle (*Silybumm arianum* L.) (Ghassemi-Golezani *et al.,* 2016).

Integrated Plant Nutrient Management (IPNM) is also one of the most important methods that increase plant production (Fretz, 1976). The field level management practices considered under the heading of IPNM would include the use of farmyard manures, natural and mineral fertilizers, soil amendments, agro forestry, green manures, biological fertilizers, cover crops, intercropping and crop rotations. They have made improvements in the biological, physical and chemical proper ting of their soils that farmers can expect to get the full benefits from the supply of additional plant nutrients, in the form of organic and inorganic fertilizer, to their crops. Chemical fertilizers have various negative environmental effects such as soil, water and air pollution, which increase environmental production cost (Moradi *et al*., 2011). Bio-fertilizer as essential components of organic farming, play a vital role in maintaining long term fertility and sustainability of soil (Mishra *et al*., 2013). Bio-fertilizers have the ability to access a major part of nutrients for growing plant along with growth promoting factors (Cordovilla *et al*., 1999).

Rhizobium and phosphate solubilizing bacteria significantly increased yield of faba bean (*Vicia faba* L.) and a synergetic effect was observed when the two types of microorganisms were combined (Rugheim and Abdelgani, 2012). Crop yield and growth increased 20 to 30% by replacing chemical nitrogen and phosphorus with bio-fertilizers (Vessey, 2003). Thus, the objective of this research is to investigate the effects of seed priming and integrated plant nutrition on grain yield and yield components of black mustard in the field.

Materials and methods

Field conditions

The experiment was conducted in 2016 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran (Latitude 38°05′N, Longitude 46°17′E, Altitude 1360m above sea level with the mean annual rainfall of 285mm). Some physical and chemical properties of soil in experimental area were shown in Table 1.

Table 1. Some physical and chemical properties of soil in experimental area.

Texture	EC	pH	$CaCO_3$	OC	N	P	K
Sandy Loam	0.77 dS/m	7.75	14.8 %	0.9 %	0.1 %	13 mg/Kg	3.82 mg/Kg

Experimental design and treatments

A factorial set of treatments were arranged based on RCBD with three replications. Factors were three levels of seed priming (P_1, P_2, P_3: control and primed with distilled water and 1% KNO_3 solution, respectively) and four fertilizer levels [F_1, F_2, F_3, F_4: control, 250Kg/ha urea + 200Kg/ha triple super phosphate (100%), nitrogen fixation (Azoto Barvar 1) + phosphate solubilizing (Barvar 2) bacteria, and 125Kg/ha urea + 100Kg/ha triple superphosphate (50%) + two biological fertilizers, respectively]. Rates of chemical fertilizers were determined on the basis of soil analysis (Table 1).

Seeds were divided into three sub-samples, one of which was kept as control (non-primed, P_1) and two other samples were soaked in distilled water (P_2) and 1% KNO_3 (P_3) solution in an incubator adjusted on 20±1°C in dark conditions for 8 hours and then seeds were dried at 20-23°C for 3 hours. Each unprimed and primed seed lots were divided into two parts, one of which was kept as control (non-inoculated). The other part was inoculated according to instruction on their package. Chemical fertilizers were applied as strip method.

All the seeds were treated with Benomyl at a rate of 2g/kg and then were sown by hand in about 1-2cm depth of a sandy loam soil with a density of 80 seeds m^2 on 26th April 2016. Each plot consisted of 8 rows of 2.5m length; spaced 25cm apart. All plots were immediately irrigated after sowing and subsequent irrigations were carried out after 70mm evaporation from class A pan. Weed control was frequently carried out by hand during crop growth duration.

Measurements

At maturity, plants in $1m^2$ of the middle part of each plot were harvested and number of pods per plant, grains per pod, grains per plant, 1000-grain weight and grain yield per unit area were determined. Above ground biomass was oven-dried at 75˚C for48 hours and then, biological yield per unit area was recorded.

Statistical analysis

Data analysis and mean comparisons were conducted using MSTAT-C software and Duncan multiple range tests at $P \leq 0.05$. Excel software was used to draw figures.

Results and discussion

The highest number of plants per unit area was achieved from the primed seeds with water. However, the differences between P_2 and P_3 plants were not statistically significant (Fig. 1). Reduction of germination imbibition periods, faster and higher emergence as a result of seed priming led to better stand establishment. The efficiency of seed priming for improving seedling emergence was also reported in Lallemantia (*Lallem antiaiberica* Fish et May) (Ayyari *et al*., 2016).

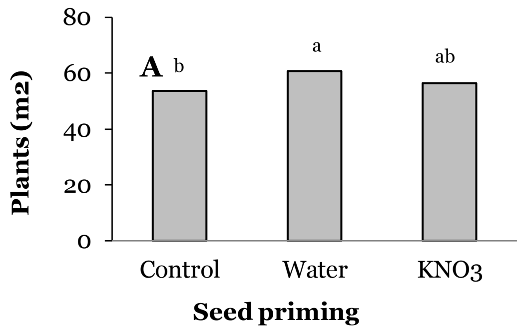

Fig. 1. Mean plants/m^2 of black mustard affected by seed priming.

Different letters indicating significant difference at $p \leq 0.05$.

Between factors, only fertilizer significantly influenced the number of pods per plant and 1000-grain weight (Table 2). Biological and grain yields and the number of grains per plant were significantly affected by seed priming and fertilizer.

The number of pods per plant was increased as fertilizer was applied. The highest pods per plant were obtained from chemical fertilizer (100%) and 50% chemical fertilizer + bio-fertilizers. Minimum number of pods per plant was observed in control. Although, seed inoculation with bio-fertilizers (Barvar 1 and Barvar 2) resulted in enhancing pods per plant compared to control, but it was no significant. Increasing number of pods per plant as a result of application of fertilizer could be attributed to the enhancing nutrients uptake, reducing competition, important photosynthesis and reduce the percentage of flower shedding in this condition. Soybean seed inoculation was also increased pods per plant (Zhang *et al*., 2002).

Table 2. Analysis of variance of field traits of black mustard affected by seed priming and fertilizer.

Source of Variation	Df	MS						
		Pods per plant	1000-grain weight	Grains per pod	Grains per plant	Biological yield	Grain yield	Harvest Index
Replication	2	164.25	1.43	3.62	14129.70	10877.20	1191.26	0.05
Seed priming (A)	2	177.75	0.073	4.48	126637.60**	53265.94**	6125.02**	4.98
Fertilizer (B)	3	780.25**	1.22**	3.60	339058.10**	115499.37**	11002.65**	2.33
A*B	6	52.64	0.19	0.616	10279.90	9878.23*	998.04*	0.77
Error	22	58.37	0.15	3.19	15059.27	4027.93	400.25	3.32
CV (%)	-	12.27	11.10	13.26	15.07	11.50	12.28	6.18

* and **: significant at $p \leq 0.05$ and $p \leq 0.01$ respectively

No significant difference in grain weight of plants from primed and unprimed seeds suggest that 1000-grainweight of plants from primed seeds was not changed by higher density of plants per unit area (Fig. 1) and more grains per plant (Table 3). 1000-grain weight was reduced by application of fertilizers. The highest reduction was caused by chemical fertilizer rather than by bio-fertilizers.

Maximum 1000-grain weight was achieved in control (F_1). Reducing seed weight of plants by application of fertilizer could be attributed to more number of pods per plant, grains per plant (Table 3) and thus reduce the share assimilate for each grain. Reducing seed weight by increasing application of N fertilizer was reported by Rathke *et al.* 2009.

Table 3. Means of yield components and grain yield of black mustard affected by seed priming and fertilizer.

Treatment	Pods per plant	1000-grain weight (gr)	Grains per pod	Grains per plant	Harvest Index (%)
Seed priming					
P1	58.25a	3.50a	12.58a	748.49b	31.71a
P2	64.75a	3.35a	13.05a	892.80a	32.51a
P3	61.00a	3.46a	13.45a	825.41ab	31.64a
Fertilizer					
F1	51.55c	3.86a	12.74a	651.20b	31.55a
F2	66.99a	3.17bc	14.00a	936.10a	31.86a
F3	57.66bc	3.69ab	13.05a	752.81b	31.67a
F4	64.89ab	3.10c	13.96a	903.11a	31.79a

Different letters indicate significant difference at $p \leq 0.05$.

P_1, P_2, P_3: Control, Seed priming with water and KNO_3 respectively

F_1, F_2, F_3, F_4: Control (0%), Chemical fertilizers (100%), Biological fertilizers (100%) and Chemical fertilizers (50%) + Biological fertilizers (100%) respectively

The highest grains per plant were produced by plants from primed seeds. However, the differences between P_2 and P_3 plants were not statistically significant. Seed priming techniques increased grains per plant by 19.28% (P_2) and 10.28% (P_3), compared with plants from unprimed seeds. Increasing grains per plant from primed plants could be attributed to faster emergence, efficient use of resources as soil nutrient and production of vigorous plants with high efficiency. Seeds primed improved number of grains per plant in fennel (*Foeniculum vulgare* Mill.) (Shabbir *et al.*, 2013).

Maximum number of grains per plant was produced by plants from 100% chemical fertilizer (F_2). However, the differences between F_2 and F_4 plants were not statistically significant. Application of 100% chemical fertilizer (F_2), bio-fertilizer (F_3) and 50% chemical fertilizer + bio-fertilizer (F_4) increased the number grains per plant up to 43.75, 15.60 and 38.68% in comparison with plants from control (F_1), respectively. Increment in number of grains per plant as a result of application of chemical and bio fertilizer can be attributed to the production of plant growth promoting hormones, higher and better uptake of water and mineral by roots, enhancing photosynthetic efficiency and produce more pods per plant (Table 3). Enhancing number of grains per plant in inoculated seeds of soybean was also reported by Kazemi *et al.* (2005).

Biological and grain yields per unit area of plants from unprimed and primed seeds were increased under all fertilizer levels. The highest biological and grain yields were achieved by the fertilized and non-fertilized plants from hydro-primed seeds. Plants from unprimed seeds (P_1) with no fertilization (F_1) had the lowest plant biomass and grain yield. Biological and grain yields of P_1, P_2 and P_3 plants were enhanced by application of all fertilizers, particularly by chemical fertilizers. However, the difference between 100% chemical fertilizer (F_2) and 50% chemical fertilizer + bio-fertilizer was not statistically significant. No significant differences between chemical and bio-fertilizers in plant biomass and grain yield of plants from hydro-primed seeds were observed (Fig. 2).

Improving grain yield of black mustard due to seed priming (Fig. 2B) could be related with higher number of plants per unit area (Fig. 1), the number of grains per plant (Table. 3) and biomass (Fig. 2B) of the resultant plants. The superiority of plants from hydro-primed seeds in grain yield per unit area resulted from higher seedling establishment and production of more grains per unit area, compared to those from unprimed seeds (Ghassemi-Golezani *et al.*, 2012; Ayyari *et al.*, 2016). Shabbir *et al.* (2013) also found that different priming techniques improve number of umbels per plant, grains per umbel, 1000-grain weight, biological and grain yields in fennel.

Enhancing grain yield of black mustard due to application of all fertilizers (Fig. 2B) could be related with more pods per plant, grains per plant (Table 3) and biomass (Fig. 2B) of the resultant plants. Bio-fertilizers and nitrogen and phosphate fertilizers are activator of some enzymatic systems and can influence plants growth and production. In the field trials, single and dual N-fixing *B. subtilis* and *P. solubilizing, B. megaterium* inoculations significantly increased pods number, grain yield and total biomass of chickpea compared with the control treatment, equal to or higher than N, P, and NP treatments (Elkoca *et al.*, 2008). In this study, grains number per plant had more effect on grain yield, compared with 1000-grain weight.

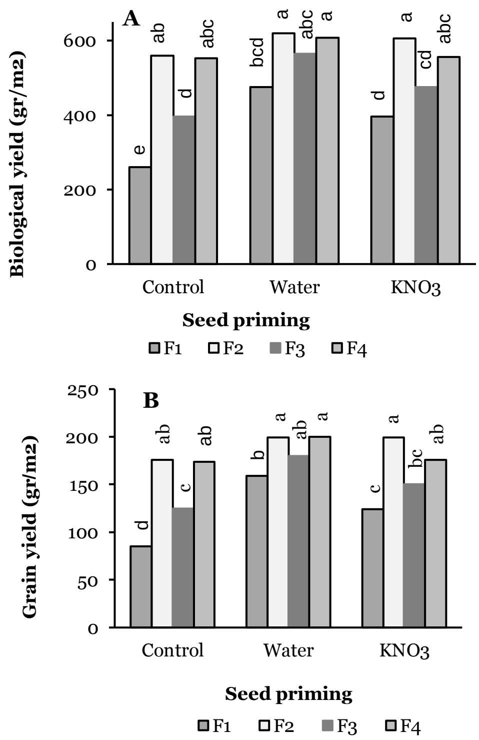

Fig. 2. Mean biological yield (A) and grain yield (B) per unit area for plants from primed and unprimed seeds of black mustard under different fertilizer application.
Different letters indicate significant difference at $p \leq 0.05$.
P_1, P_2, P_3: Control, Seed priming with water and KNO_3 respectively
F_1, F_2, F_3, F_4: Control (0%), Chemical fertilizers (100%), Biological fertilizers (100%) and Chemical fertilizers (50%) + Biological fertilizers (100%) respectively

Correlation of pods per plant and grains per pod with grains per plant and correlation of pods per plant, grains per plant, biological yield and harvest index with each other and with grain yield were positive and significant. The highest positive correlation with grain yield was recorded for biological yield, followed by grains per plant (Table 4). This suggests that grains per plant and biological yield had the major roles in determining final grain yield of black mustard.

Table 4. Correlation coefficients of different field traits.

	Pods per plant	1000-grain weight	Grains per pod	Grains per plant	Biological yield	Grain yield	Harvest Index
Pods per plant	1						
1000-grain weight	-0.63**	1					
Grains per pod	0.28	-0.32	1				
Grains per plant	0.86**	-0.83**	0.70**	1			
Biological yield	0.66**	0.37	0.35	0.77**	1		
Grain yield	0.63**	-0.41	0.41	0.79**	0.95**	1	
Harvest Index	0.42*	-0.18	0.14	0.44*	0.79**	0.71**	1

*and**: Statistically significant at $p \le 0.05$ and $p \le 0.01$ respectively

Conclusion

Seed priming, particularly hydro-priming and fertilizer levels improved grain yield of black mustard via higher number of plants per unit area, grains per plant and biological yield per unit area. Application of 50 % chemical fertilizer + bio-fertilizers can reduce the use of chemical fertilizer. In this study, seed number per plant had more effect on grain yield, compared with 1000-grain weight. Thus, replacing part of the chemical fertilizer by bio-fertilizer could improve black mustard yield. Finally, it was concluded that hydro-priming and bio-fertilizer can reduce the environmental risk and increase field performance of medicinal plants such as black mustard.

References

Abraha B, Yohannes G. 2013. The role of seed priming in improving seedling growth of maize (*Zea mays* L.) under salt stress at field conditions. Agricultural Science **4**, 666-672.

Abul-Fadl MM, El-Badry N, Ammar MS. 2011. Nutritional and chemical evaluation for two different varieties of mustard seeds. World Applied Sciences Journal **15**, 1225-1233.

Ayyari M, Zehtab-Salmasi S, Ghassemi-Golezani K. 2016. Effects of seed priming and supplementary irrigation on yield and yield component of *Lallem antiaiberica*. Journal of Medicinal Plants Studies **4**, 88-90.

Cheng Z, Bradford KJ. 1999. Hydrothermal time analysis of tomato seed germination responses to priming treatments. Journal of Experimental Botany **33**, 89-99.

Cordovilla MP, Berrido SI, Ligero F, Lluch CL. 1999. Rhizobium strain effects on the growth and nitrogen assimilation in (*Pisum sativum* L.) and (*Vicia faba* L.) plants. Plant Science Limerick **140,** 127-136.

Elkoca E, Kantar F, Sahin F. 2008. Influence of nitrogen fixing and phosphorus solubilizing bacteria on the nodulation, plant growth, and yield of chickpea. Journal of Plant Nutrition **31,** 157-171.

Fahey JW, Zalcmann AT, Talalay P. 2001. The chemical diversity and distribution of glucosinolates and isothiocyanates among plants. Phytochemistry **56,** 5-51.

Fretz TA. 1976. Effect of photoperiod and nitrogen on the composition of *Juniperus horizontalis* Moench. cv. Plmosa. Journal of the American Society for Horticultural Science **101,** 611-613.

Ghassemi-Golezani K, Farshbaf-Jafari S, Shafagh-Kolvanagh J. 2011. Seed priming and field performance of soybean (*Glycine max* L.) in response to water limitation. Notulae Botanicae Horti Agrobotanici Cluj-Napoca **39,** 186-89.

Ghassemi-Golezani K, Hassanpour-Bourkheili S, Bandeh-Hagh A, Farhanghi-Abriz, S. 2014. Seed hydro-priming, a simple way for improving mungbean performance under water stress. International Journal of Biosciences **4,** 12-18.

Ghassemi-Golezani K, Hosseinzadeh-Mahootchy A, Zehtab-Salmasi S, Tourchi M. 2012. Improving field performance of aged chickpea seeds by hydro-priming under water stress. International Journal of Plant, Animal and Environmental Sciences **2,** 168-176.

Ghassemi-Golezani K, Hosseinzadeh-Mahootchy A. 2013. Influence of Hydro-Priming on Reserve Utilization of Differentially Aged Chickpea Seeds. Seed Technology **35,** 117-123.

Ghassemi-Golezani K, Yaghoubian I, Raei Y. 2016. The impact of hydro priming duration on seed invigoration and field emergence of milk thistle. Journal of Biodiversity Environmental Science **2,** 229-234.

Kazemi S, Ghanbari S, Ghanbari A, Kianoush GE. 2005. Effects of planting date and seed inoculation by the bacteria on the yield and yield components of two soybean varieties. Agricultural Sciences and Natural Resources **12,** 20-26.

Maiti R, Pramanik K. 2013. Vegetable seed priming: a low cost, simple and powerful techniques for farmers' livelihood. International Journal of Bio-Resource and Stress Management **4,** 475-481.

Moradi R, Rezvani-Moghaddam P, Nasiri-Mahallati M, Nezhadali A. 2011. Effects of organic and biological fertilizers on fruit yield and essential oil of sweet fennel (*Foeniculum vulgare* var. *dulce*). Spanish Journal Agricultural Research **9,** 546-553.

Parera CA, Cantliffe DJ. 1994. Pre-sowing seed priming. Horticultural Reviews **16,** 109-141.

Rathke GW, Behrens T, Diepenbrock W. 2009. Effect of timing and nitrogen fertilizer application on winter oilseed rape (*Brassica napus* L.) nitrogen uptake dynamics and fertilizer efficiency. Crop Science **190,** 314-323.

Rosental L, Nonogaki H, Fait A. 2014. Activation and regulation of primary metabolism during seed germination. Seed Science Research **24,** 1-15.

Rugheim AME, Abdelgani, ME. 2012. Effect of microbial and chemical fertilizer on yield and seed quality of faba bean (*Vicia faba*L.). International Food Research Journal **19,** 417-422.

Shabbir I, Shakir M, Ayub M, Tahir M, Tanveer A, Shahbaz M, Hussain M. 2013. Effect of seed priming agents on growth, yield and oil contents of fennel (*Foeniculum vulgare* Mill.). Advances in Agriculture and Biology **1,** 58-62.

Vessey JK. 2003. Plant growth-promoting rhizobacteria as biofertilizers. Plant and Soil **255,** 571-586.

Zhang H, Charles TC, Driscoll B, Prithiviraj T, Smith DL. 2002. Low temperature-tolerant *Bradyrhizobium japonicum* strains allowing improved soybean yield in short-season. Agronomy Journal **94,** 870-875.