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Effect of Plant Density on Yield, Yield Components and Effective Medicine Ingredients of Blond Psyllium (*Plantago ovata* Forsk.) Accessions

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ABSTRACT

The objective of this study was to determine the effect of plant density on yield, yield components and effective medicine ingredients of eight blond psyllium (*Plantago ovata* Forsk.) accessions. Eight accessions were grown in the field at three plant densities (80, 120 & 160 plants m^{-2}). As plant density increased, biological yield increased from 797 to 1430 kg ha^{-1} and seed yield increased from 217 to 367 kg ha^{-1}. Plant density had no significant effect on blond psyllium yield components and effective medicine ingredients. There were significant differences among the accessions for their total biological yield. However, there were no significant differences among the accessions for their seed yield, yield component and effective medicine ingredients. Mashhad accession had the highest total yield and swelling factor; whereas Behbahan had the lowest total yield and swelling factor. In addition, there was no interaction between plant density and accession for these parameters. The optimum density for blond psyllium was 160 plants m^{-2} and Mashhad and India accessions were the best accessions.

Key Words: Density; Accession; *Plantago ovata;* Yield and yield components; Effective medicine ingredients

INTRODUCTION

Blond psyllium (*Plantago ovata* Forsk.) is an important medicinal plant. The seed and husk is used to cure inflammation of the mucous membrane of gastro-intestinal and genitor-urinary tracts, chronic constipation, dysentery, duodenal ulcers, gonorrhea and piles (Youngken, 1950; Bown, 1995). Its oral use helps reduce blood cholesterol levels (Segawa *et al*., 1998). In addition to its medicinal uses it has a place in dyeing, calico printing, setting lotions and the food industry (Bown, 1995).

The crop depends largely on temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. Plant population may affect the maximum availability and utilization of these factors. Therefore, it is necessary to determine the optimum density of plant population per unit area for obtaining maximum yields (Baloch *et al*., 2002). Thus blond psyllium yield development is a sequential process in which the potential number of branches per plant is determined first, followed by spikes per plant, seeds per spike and by seed weight. Therefore, variations in the level of carbon and nitrogen induced by different planting rates, or any other factor, can strongly influence yield and its components sequentially.

Variety is another important factor contributing to yield. For every climate, there are varieties of different crops. Dasneepal and Raychaudhuri (2003) and Lal *et al*. (1999) found significant differences in yields and yield components of different blond psyllium varieties.

A number of workers have reported that medicinal quality (swelling & mucilage contents of seed) of blond psyllium, were less affected by cultural practice. Irannejad (1999) and Czaranecki (1993) indicated that nitrogen fertilizer had no effect on seed mucilage contents but Omidbaigi and Mohebby (2002) indicated that nitrogen fertilizer had significant effect on the seed swelling factor of blond psyllium. They also showed that there was significant effect on seed swelling of sowing date. But reports of associations between medicinal quality and plant population have been inconsistent in the literature.

This study was undertaken to compare eight blond psyllium accessions and determine the influence of plant density on yield, yield components and quality of these accessions.

MATERIALS AND METHODS

The experiment was carried out at the Agricultural Research Station of the College of Agriculture, Isfahan University of Technology, Iran during the year 2003 - 04. The site is located at 32° 32' N latitude, 51° 23'E longitude and an altitude of 1630 m above sea level. Soil was clay loam, Typic Haplargids. The experiment was laid out in factorial experiment within randomized-complete-block design with three replications. Accession and plant density were experimental factors. Accessions were collected from Mashhad, Behbahan, Ahvaz, Shiraz, Isfahan and Chaharmahal Bakhtiari, Iran and two accessions from India and Pakistan. There were three plant densities including 80, 120 and 160 plants m^{-2}. Plots consisted of five rows, 4 m long and spaced 15 cm apart between tow rows. The experiment was hand planted on 16 April 2003. Plots were thinned by hand at seedling and flowering stages. The plots were broadcast fertilized with 50 kg ha^{-1} N when the plants were at flowering stage. Irrigation and other agronomic practices were carried out uniformly for all the experimental units.

When plants turned yellow and spikes turned brown, they were harvested (Najafi & Moghadam, 2002). One square meter of three central rows were taken from each plot to determine the seed and biological yield and 10 plants were sampled from each plot to measure yield components, spike length, plant height, seed swelling factor and mucilage contents. To determine the swelling factor, 1 g of seed was put into beaker of 25 mL capacity and 20 mL distilled water was added. The swelling of seeds was calculated after 24 h (Sharma & Koul, 1986). Mucilage contents in the seed were also determined according to Sharma and Koul (1986). Swelling of 1 g mucilage was calculated by the following equation:

Swelling of 1 g mucilage = (swelling factor × 100)/mucilage contents

Analysis of variance (ANOVA) was done in SPSS statistical software package version 11. Differences among treatment were compared using LSD values at the 0.05 level of significance.

RESULTS AND DISCUSSION

Differences among the accessions for biological yield were significant (Table I). Mashhahd accession had the highest biological yield and Behbahan had the lowest biological yield. Differences between accessions for seed yield and harvest index was not significant. In spite of that Mashhad had the highest seed yield and Shiraz had the highest harvest index and Chaharmahal Bakhtiari had the lowest seed yield and harvest index.

The differences between accessions were not significant for yield components (branches per plant, spikes per plant, seeds per spike & weight of 1000 seeds), plant height and spike length (Table II). However, Mashhad and India accessions had the greater yield components than other accessions and these high yield components potential could be reason of higher yield in these accessions.

The differences among accessions for swelling factor, mucilage contents and swelling of 1 g mucilage was not significant (Table III). However, Mashhad accession had the highest seed yield, swelling factor and swelling for 1 g mucilage. This accession was the best accession for qualitative and quantitative yield. Behbahan accession had the lowest seed yield, swelling factor and swelling of 1 g mucilage.

Consequently, the best accessions for purposes of seed and biological yield and medicinal quality were Mashhad and India, because these accessions were better adapted to agro-ecological condition of our study site than other accessions. This may be due to the origin of these accessions. Our results showed that genetic variation in the accessions was low whereas the previous researchers (Lal *et al*., 1999; Dasneepal & Raychaudhuri, 2003) showed wide variation among the accessions of *Plantago ovata*. This could be due to difference between the origin of the accessions and climatic difference.

There was a significant effect of plant density on seed yield, biological yield and harvest index (Table IV). As plant density increased, seed and biological yield increased. Plant density of 160 plants m^{-2} had the highest seed and biological yield and plant density of 80 plants m^{-2} had the lowest seed and biological yield. Difference between 160 and 120 plants m^{-2} for their seed yield was not significant. However, 160 plants m^{-2} produced the highest yield. Therefore, this density may be the best for *Plantago ovata*. Increase in seed and biological yield with increase in the plant density attributed to the greater number of plants per square meter in higher density. This result agree with those given by Najafi and Moghadam (2002) who revealed that with increase in the plant density (20, 60, 100 & 140 plants m^{-2}) seed and biological yield increased. Asgharipoor (2002) also reported that higher seed rate produced more plants per square meter than lower seed rate in blond psyllium and that resulted in higher seed and biological yield. Randhawa *et al*. (1978) demonstrated that increase in seed yield by increasing seed rate in blond psyllium was due to the greater number of spikes per half meter length of row.

Plant density had no significant effect on harvest index; however, the greatest harvest index was produced from plants at the lowest population, perhaps due to lower competition between stem and spike for biological, associated with fewer plants in low density. Our result confirm the finding of López-Bellido *et al*. (2000) who reported that increasing plant density had an adverse effect on harvest index.

Effect of plant density on yield components (branches per plant, spikes per plant, seeds per spike & weight of 1000 seeds), plant height and spike length was not significant (Table V). The results are confirmed by Najafi and Moghadam (2002) reported that plant density had no significant effect on spike length, plant height, number of seeds per spike and 1000 seed weight in blond psyllium. Asgharipoor (2002) also stated that seed rate had no significant effect on plant height, number of leaves per plant and number of branches per plant in blond psyllium. Randhawa *et al*. (1978) indicated that seed rate had no significant effect on plant height of blond psyllium. But other studies (Angadi *et al*., 2003; Carr *et al*., 2003; Taj *et al*., 2003; Wajid *et al*., 2004) showed that plant population had significant effect on yield components. The reduction of crop yield components by increasing plant population was due to greater inter-plant competition for incident light, soil nutrition and soil water in high plant density than low plant density (Sangoil, 2000). Insignificant effect of plant density on yield components in our study could be attributed to our

Table I. Mean grain yield, biological yield and harvest index of eight accessions of blond psyllium

Accessions	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index
Mashhad	390.26^{a*}	1470.78^{a}	0.212^{a}
Behbahan	260.81^{a}	930.22^{b}	0.220^{a}
Ahvaz	340.48^{a}	1250.55^{ab}	0.226^{a}
Shiraz	290.69^{a}	1050.78^{b}	0.229^{a}
Isfahan	240.69^{a}	940.44^{b}	0.208^{a}
Chaharmahal Bakhtiari	240.07^{a}	960.00^{b}	0.200^{a}
India	320.43^{a}	1280.67^{ab}	0.217^{a}
Pakistan	290.33^{a}	910.11^{b}	0.234^{a}

* Means followed by the same letter in a column are not significantly different from each other at P= 0.05 level based on LSD.

Table II. Mean of yield components, spike length and plant height of eight accessions of blond psyllium

Accessions	Branches plant^{-1}	Spikes plant^{-1}	Seeds spike^{-1}	1000 seed mass (g)	Spike length (cm)	Plant height (cm)
Mashhad	1.44^{a*}	8.67^{a}	32.78^{a}	1.29^{a}	1.68^{a}	15.98^{a}
Behbahan	0.89^{a}	6.89^{a}	30.33^{a}	1.32^{a}	1.63^{a}	14.87^{a}
Ahvaz	1.11^{a}	8.22^{a}	33.89^{a}	1.33^{a}	1.72^{a}	16.02^{a}
Shiraz	1.00^{a}	7.33^{a}	31.11^{a}	1.38^{a}	1.60^{a}	14.93^{a}
Isfahan	1.33^{a}	8.89^{a}	35.00^{a}	1.31^{a}	1.66^{a}	16.31^{a}
Chaharmahal Bakhtiari	1.33^{a}	7.89^{a}	31.11^{a}	1.39^{a}	1.71^{a}	16.44^{a}
India	1.33^{a}	9.78^{a}	33.00^{a}	1.37^{a}	1.65^{a}	15.61^{a}
Pakistan	1.00^{a}	8.44^{a}	32.22^{a}	1.41^{a}	1.69^{a}	15.65^{a}

* Means followed by the same letter in a column are not significantly different from each other at P= 0.05 level based on LSD

Table III. Mean of swelling factor, mucilage contents and swelling of 1g mucilage of eight accession of blond psyllium

Accessions	Swelling factor (ml)	Mucilage contents (g)	Swelling of 1 g mucilage
Mashhad	14.72^{a*}	17.26^{a}	87.11^{a}
Behbahan	12.67^{a}	17.26^{a}	73.89^{a}
Ahvaz	12.61^{a}	18.24^{a}	71.22^{a}
Shiraz	12.28^{a}	15.86^{a}	78.00^{a}
Isfahan	13.00^{a}	19.06^{a}	68.78^{a}
Chaharmahal Bakhtiari	13.22^{a}	17.00^{a}	79.00^{a}
India	13.94^{a}	17.41^{a}	80.77^{a}
Pakistan	12.33^{a}	18.91^{a}	67.33^{a}

* Means followed by the same letter in a column are not significantly different from each other at P= 0.05 level based on LSD

Table IV. Effect of plant density on grain yield, biological yield and harvest index of blond psyllium

Plant density (plant m^{-2})	Grain yield (kg ha^{-1})	Biological (kg ha^{-1})	Harvest index
80	210.73^{b*}	790.66^{c}	0.229^{a}
120	310.80^{a}	1130.50^{b}	0.218^{ab}
160	360.76^{a}	1430.04^{a}	0.208^{b}

* Means followed by the same letter in a column are not significantly different from each other at P= 0.05 level basd on LSD

tested plant densities that might have not produced high competition for blond psyllium plants for growth resources. However the highest branches/plant, spikes/plant, seeds/spike and spike length was recorded in the plot having plant density of 80 plant m^{-2} The more branches/plant, spikes/plant, seeds/spike and spike length in case of less plant population was attributed to better nutrition and growth resources for the plants. Furthermore, Effect of plant density on plant height was not significant but plant height increased, while plant density increased. These results are consistent with the tendency of plants to etiolate as light levels decrease and indicated greater competition for light under the high density than the low density.

Table V. Effect of plant density on yield components, spike length and plant height of blond psyllium

Plant density (plant m^{-2})	Branches plant^{-1}	Spikes plant^{-1}	Seeds spike^{-1}	1000 seed mass (g)	Spike length (cm)	Plant height (cm)
80	1.21^{a*}	8.71^{a}	32.71^{a}	1.39^{a}	1.72^{a}	15.22^{a}
120	1.21^{a}	8.12^{a}	32.33^{a}	1.34^{a}	1.66^{a}	15.86^{a}
160	1.12^{a}	7.96^{a}	32.25a	1.32^{a}	1.63^{a}	16.11^{a}

* Means followed by the same letter in a column are not significantly different from each other at P= 0.05 level based on LSD

Table VI. Effect of plant density on swelling factor, mucilage contents and swelling of 1 g mucilage

Plant density (plant m^{-2})	Swelling factor (ml)	Mucilage contents (g)	Swelling of 1 g mucilage
80	13.60^{a*}	17.79^{a}	78.71^{a}
120	13.58^{a}	17.69^{a}	76.83
160	13.10^{a}	17.40^{a}	71.75$^{a\ a}$

* Means followed by the same letter in a column are not significantly different from each other at P= 0.05 level based on LSD

Plant density had no significant effect on swelling factor, mucilage contents and swelling of 1 g mucilage (Table VI). Khodashenas (1995) also reported row space and plant space had no significant effect on mucilage and gam percent in *Borago officinalis*. However, quality of seed decreased as plant density increased. High plant population produces intense interplant competition for incident photosynthetic photon flux density, soil nutrients and soil water. That causes limited supplies of carbon and nitrogen and consequent decrease in quality.

There was no interaction between plant density and accession for total characters, suggesting that accessions response would be similar across this range of plant densities. Taj *et al*. (2003) also reported that the interaction of seed rates and varieties had no significant effects on pods per plant and grains per pod in mungbean. Cusicanqui and Lauer (1999) indicated that plant density × hybrid interactions were not observed for most quality traits in maize.

CONCLUSION

In summary, seed and biologic yield of blond psyllium increased significantly as plant density increased and 160 plants m^{-2} was the optimum density for blond psyllium under our conditions. In this range of plant density, yield component and medicinal quality of seed were not significantly affected by plant density. There were no-significant differences among accessions in regard to seed yield and medicinal quality of seed. However, Mashhad and Indian were the best accessions among other. Interaction between plant density and accession for total characters was not significant therefore accessions response would be similar across this range of plant densities.

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