Growth and Seed Characteristics of Isabgol (*Plantago ovata* Forsk) as Influenced by some Environmental Factors

G. Karimzadeh\(^{1}\) and R. Omidbaigi\(^{2}\)

**ABSTRACT**

Isabgol (*Plantago ovata* Forsk), is an annual herb cultivated as a medicinal plant in recent decades. Its seed contains mucilage, fatty oil, large quantities of albuminous matter, a pharmacologically inactive glucoside, namely Aucubin (C\(_{13}\)H\(_{19}\)O\(_8\)H\(_2\)O), and a plantiose sugar. Medicinal plants are rich in secondary metabolites: their biosynthesis is controlled genetically and is affected strongly by environmental factors. In the present work, the influence of sowing dates (20\(^{th}\) April, 5\(^{th}\) and 20\(^{th}\) May) and nitrogen-fertilizer levels (0, 50, 100 and 150 kg ha\(^{-1}\)) was examined on the growth, seed yield and seed swelling factor (content of mucilages) of isabgol. The statistical design was a split-plot arrangement of a randomized complete block design with three replicates: the sowing dates and nitrogen fertilizer were considered as the main and sub-main plots, respectively. The plot experiment was installed in the experimental station of Zanjan region located in the northwest of Iran, under silty-clay soil conditions. According to the resulting data, the best time for sowing isabgol in such a region was 5\(^{th}\) May and the suitable amount of nitrogen fertilizer was 100 kg ha\(^{-1}\). To discover any relationship, all measured independent variables were multiple regressed on the dependent variable (seed yield) followed by stepwise regression analysis. This verified that the seed yield among other independent characteristics tested appeared to show a significant positive effect on the seed swelling.

**Keywords:** Environmental factors, Isabgol, N-Fertilizer, *Plantago ovata*, Sowing date, Swelling factor, Zanjan, (Iran).

**INTRODUCTION**

Isabgol (*Plantago ovata* Forsk) is a 10-45 cm short-stemmed annual herb belonging to the Plantaginaceae family which is known by different names, such as ashwagolan, aspaghol, aspagol, bazarquuta, blond psyllium, ch’-ch’entzu, ghoda, grappicol, Indian plantago, Indische Psylli-samen, isabgul, isabgul gola, isphaghula, isphagol, vithai, issufgul, jiru, obeko, psyllium, plantain, spogel seeds (Kapoor, 1990; Farnsworth, 1995; Galindo *et al.*, 2000; Anonymous, 2002). Its leaves are born alternately on the stem or in rosettes addressed to the soil surface. Leaf count per plant varies between 40-86 and it is strap shaped recurved, linear 6.0-25 cm long and 0.3-1.9 cm broad. Leaf surface is glabrous or slightly pubescent. Spikes are cylindrical or ovoid and measure 0.6-5.6 cm. Flowers are arranged on the spike, in four spiral rows. Sepals are four, free, concave, glabrous and elliptic and petals are four, glabrous, reflexed and white in colour. The ovary is bilocular with single ovule per locule and the placentaion is axile. The capsule is ovate or ellipsoid, dehiscing along the ring of abscission tissue which is...
developed around the capsule (Parsa, 1951; Lamba and Gupta, 1981; Chevallier, 1996). Isabgol seeds are cymbiform, translucent and concavo-convex in shape and they are pinkish-gray, brown or pinkish-white with a brown streak in colour (Handa and Kaul, 1999). Isabgol is grown in warm temperate regions between 26-36°N, latitude, its species are indigenous to the Mediterranean region and west Asia extending up to west Pakistan (Koul and Sareen, 1999; Baghalian, 1999).

Isabgol has been used in medicines since ancient times, but it has only been cultivated as a medicinal plant in recent decades (Gupta, 1987; Wolver et al., 1994; Lal et al., 1999; Handa and Kaul, 1999). Its seed contains mucilage, fatty oil, large quantities of albuminous matter, the pharmacologically inactive glucoside, namely Aucubin (C_{13}H_{19}O_{8}H_{2}O) and a plantiose sugar (Chevallier, 1996). Isabgol seed husk has the property of absorbing and retaining water which accounts for its utility in stopping diarrhoea. It is a diuretic, alleviates kidney and bladder complaints, gonorrhea, arthritis and hemorrhoids (Zargari, 1990; Ansari and Ali, 1996). In general, plants known as medicinal are rich in secondary metabolites and have potential as drugs. The biosynthesis of the secondary metabolites is controlled genetically and affected strongly by environmental factors (Yanive and Palevitch, 1982; Omidbaigi, 2000), of which the sowing date is a prerequisite for assuring optimal ecological conditions during the plant growth and development. In this context, at Jammu, the sowing of isabgol is proposed to be ideal between mid-October and mid-November. Late sowing, when winter starts raining is over, adversely tells upon seed yield due to a short growth period (Koul and Sareen, 1999). However, Kalyansundram et al. (1984) reported that sowing of Plantago ovata during the first week of December is considered to be ideal. Concerning the effect of nitrogen on Plantago ovata, Koul and Sareen (1999) pointed out that if the quantity of nitrogen applied increases from 0 to 50 kg ha$^{-1}$, it induces a reduction in both nitrogen concentration and the swelling factor of Plantago seeds. Randhawa et al. (1985) reported that an increase in the seed yield results from an increase in nitrogen application. In the Tarai area, the highest seed yield has been recorded following the application of 40-80 kg ha$^{-1}$ nitrogen (Singh and Nand, 1988).

This study was aimed at discovering the effect of some environmental factors, such as the suitable sowing date and nitrogen-fertilizer, which could be used for isabgol cultivation to increase the quantity of and improve the quality of isabgol productivity as well as to clarify the relationship between measured characteristics.

**MATERIALS AND METHODS**

The isabgol plants were grown in a silty-clay soil with good drainage. The statistical design used was a split-plot arrangement of a randomized complete block design with three replicates of each treatment. The sowing dates were considered as the main plot, consisting of the 5$^{th}$ and 20$^{th}$ April, and 5$^{th}$ and 20$^{th}$ May. Note that seeds sown on 5$^{th}$ April were first grown normally but they were then discarded because of chilling stress occurred. Hence, the other three sowing dates (20$^{th}$ April, and 5$^{th}$ and 20$^{th}$ May) were considered for the present work. Seeds were sown in sub-plots in rows 30 cm apart and spaced 5 cm apart and the effect of nitrogen fertilizer was studied in sub-plots. An untreated control (0 level) in addition to three different nitrogen levels of 50, 100 and 150 kg ha$^{-1}$ were used in the form of urea. Nitrogen was utilized twice: half of it was used two days before sowing and the other half was used at the flowering stage. Plant height, the number of flowers and branches per plant, average seed weight and the swelling factor were measured. After 24 hours of submerging 1 g of seeds in 20 ml dH$_{2}$O, the swelling factor was measured. This work was carried out in the experimental station (36º 40'N latitude, 48º
Growth and Seed Characteristics of Isabgol

26° altitude, 1634 m see level) of Zanjan located in northwest of Iran. The station climatic conditions are semi-arid and moderately cold with 263 mm annual precipitation. The mean annual lowest and highest temperatures are 3.9°C and 18°C, respectively. The soil characteristics are as follows: 15% sand, 45% clay, 40% silt, pH 7.6, 334 ppm K, 7.8 ppm P, 0.082 ppm total N and 0.82% organic C. According to this analysis, the amount of 100 kg ha\(^{-1}\) triple super phosphate with 46% active substance was added to the soil. To identify any relationship, we regressed the plant height, number of branches and flowers per plant, weight of 1000 seeds and seed yield as independent variables and the seed swelling as a dependent variable, using the Minitab Statistical Software Package (Ryan and Joiner, 2001). Moreover, a stepwise multiple regression analysis was computed to examine the statistically significant independent variables influencing the dependent variable (seed swelling) and formulating it. The statistical mean comparisons were calculated according to Duncan’s Multiple Range test (LSR).

RESULTS

Effect of Sowing Date

ANOVA (Table 1) showed that the sowing date had highly significant effects on plant height, number of branches and number of flowers per plant, seed yield (P<0.001), swelling factor (P<0.01) and weight of 1000 seeds (P<0.05). The mean comparisons of the above-mentioned characters are given in Table 2. The plants which were planted on 5\(^{th}\) May grew much better compared with those planted on 20\(^{th}\) May (Table 2). On the other hand, seeds sown on 5\(^{th}\) May showed significantly (P<0.01) more swelling compared to those sown on other dates (Figure 1). Hence, it can be concluded that the sowing date played an important role on the growth parameters and seed characteristics of Plantago ovata. Isabgol seeds appear to be cold sensitive, hence, they should not be sown in the early Spring. According to the resultant data, 5\(^{th}\) May is suggested as the best sowing date for Plantago ovata at the above-mentioned experimental station.

Table 1. Analysis of variance for six growth characteristics of Plantago ovata.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Df</th>
<th>Plant Height (cm)</th>
<th>No. of Branches per Plant(^{1})</th>
<th>No. of Flowers per Plant(^{1})</th>
<th>1000 Seed Weight (g)</th>
<th>Seed Yield (g m(^{-2}))</th>
<th>Swelling Factor (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block</td>
<td>2</td>
<td>1.251(^{**})</td>
<td>0.025(^{**})</td>
<td>0.414(^{**})</td>
<td>0.05(^{**})</td>
<td>8.651(^{**})</td>
<td>0.09(^{**})</td>
</tr>
<tr>
<td>Sowing Date (A)</td>
<td>2</td>
<td>147.679(^{***})</td>
<td>32.077(^{***})</td>
<td>53.534(^{***})</td>
<td>0.285(^{*})</td>
<td>2695.736(^{***})</td>
<td>15.715(^{**})</td>
</tr>
<tr>
<td>Error 1</td>
<td>4</td>
<td>1.254</td>
<td>1.521</td>
<td>2.824</td>
<td>0.025</td>
<td>7.936</td>
<td>0.392</td>
</tr>
<tr>
<td>Nitrogen (B)</td>
<td>3</td>
<td>8.903(^{***})</td>
<td>5.939(^{***})</td>
<td>13.336(^{***})</td>
<td>0.192(^{**})</td>
<td>379.009(^{***})</td>
<td>5.933(^{***})</td>
</tr>
<tr>
<td>AB</td>
<td>6</td>
<td>0.832(^{**})</td>
<td>0.402(^{**})</td>
<td>0.882(^{**})</td>
<td>0.014(^{**})</td>
<td>41.039(^{***})</td>
<td>0.252(^{**})</td>
</tr>
<tr>
<td>Error 2</td>
<td>18</td>
<td>0.355</td>
<td>0.172</td>
<td>0.401</td>
<td>0.024</td>
<td>5.542</td>
<td>0.069</td>
</tr>
</tbody>
</table>

\(^{**}\) Non Significant at 0.05 probability level
\(^{*}, **, ***\) Significants at 0.05, 0.01 and 0.001 probability levels, respectively.
Effect of Nitrogen-Fertilizer

ANOVA (Table 1) exhibited that the N-fertilizer significantly (P<0.001) influenced all of the growth and seed characters and the swelling factor measured in this experiment. The mean comparisons of these characters are demonstrated in Table 3. The utilization of 100 kg ha$^{-1}$ of N-fertilizer for this plant appeared to show the best results on most of the growth characters. The highest seed swelling (15.6 mm) also resulted from Isabgol seeds treated with this amount of nitrogen (Figure 2). Therefore, it can be deduced that the best treatment for cultivation of Plantago ovata is to use 100 kg ha$^{-1}$ nitrogen, applying half of it before seed sowing and the other half at flowering stage.

Relationship among Measured Characteristics

Plant breeders need production measurement of given traits to improve plant characteristics. To formulate the relationship between five independent growth variables measured in our experiment, with a dependent variable, multiple regression analysis was carried out for the plant height, number of branches and flowers per plant, weight of 1000 seeds and yield as independent variables and seed swelling as a dependent variable. The multiple regression

Table 2. The means ± Se of growth and seed characteristics of Plantago ovata from different sowing dates.

<table>
<thead>
<tr>
<th>Sowing Date</th>
<th>Plant Height (cm)</th>
<th>No. of Branches per Plant</th>
<th>No. of Flowers per Plant</th>
<th>1000 Seed Weight (g)</th>
<th>Seed Yield (g m$^{-2}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 20</td>
<td>11.41 ± 0.32$^b$</td>
<td>3.23 ± 0.18$^b$</td>
<td>4.51 ± 0.25$^b$</td>
<td>5.90 ± 0.05$^b$</td>
<td>64.82 ± 0.83$^b$</td>
</tr>
<tr>
<td>May 5</td>
<td>18.06 ± 0.46$^a$</td>
<td>5.67 ± 0.32$^a$</td>
<td>8.18 ± 0.53$^a$</td>
<td>6.20 ± 0.04$^a$</td>
<td>91.04 ± 2.74$^a$</td>
</tr>
<tr>
<td>May 20</td>
<td>16.68 ± 0.17$^a$</td>
<td>6.34 ± 0.29$^a$</td>
<td>8.16 ± 0.38$^a$</td>
<td>6.05 ± 0.65$^{ab}$</td>
<td>65.28 ± 1.84$^b$</td>
</tr>
</tbody>
</table>

Means followed by the same letter symbols in each column-according to Duncan’s multiple range test - are not significantly (P<0.05) different from each other.
equation is shown as follows:

\[
\text{Seed swelling} = 7.18 - 0.00185 \times X_1 + 0.0063 \times X_2 - 0.0031 \times X_3 + 0.328 \times X_4 + 0.0824 \times X_5.
\]

Where:
- \(X_1\) = Plant height (cm),
- \(X_2\) = No. of branches plant\(^{-1}\),
- \(X_3\) = No. of flowers plant\(^{-1}\),
- \(X_4\) = 1000 seeds weight (g),
- \(X_5\) = Seed yield (g m\(^{-2}\)),
- Seed swelling (mm),
- 7.18 = Constant value.

Furthermore, the stepwise regression analysis was also carried out for the data obtained to test the significance of the independent variables shown in the above equation affecting the seed swelling as a dependent variable. Therefore, the resulted stepwise regression equation is shown as follows:

\[
\text{Seed swelling} = 8.874 + 0.0765 \times \text{Seed yield} \quad R^2 = 75.4\%
\]

This equation indicates that only the seed yield trait among other independent variables tested showed a significant positive effect (\(P<0.05\)) on seed swelling. In other words, with increasing of 1 g of seed yield, 0.0765 mm of seeds swelled.

**DISCUSSION**

Plants known as medicinal are rich in secondary metabolites and have potential as drugs. The biosynthesis of the secondary metabolites of the medicinal plants is under genetic control, and environmental factors play an important role (Yanive and Palevitch, 1982; Omidbaigi, 2000).

Environmental factors such as cultivation practices (such as sowing date, fertilizer

### Table 3. The means ± Se of growth and seed characteristics of *Plantago ovata* in different N-fertilizer levels.

<table>
<thead>
<tr>
<th>N–Fertilizer (kg ha(^{-1}))</th>
<th>Plant Height (cm)</th>
<th>No. of Branches per Plant(^{-1})</th>
<th>No. of Flowers per Plant(^{-1})</th>
<th>1000 Seed Weight (g)</th>
<th>Seed Yield (g m(^{-2}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14.13 ± 0.97</td>
<td>4.16 ± 0.40</td>
<td>5.46 ± 0.47</td>
<td>5.94 ± 0.072</td>
<td>66.78 ± 3.44</td>
</tr>
<tr>
<td>50</td>
<td>15.21 ± 1.07</td>
<td>4.69 ± 0.48</td>
<td>6.49 ± 0.64</td>
<td>6.02 ± 0.043</td>
<td>71.22 ± 4.07</td>
</tr>
<tr>
<td>100</td>
<td>15.67 ± 1.02</td>
<td>5.97 ± 0.65</td>
<td>8.16 ± 0.81</td>
<td>6.27 ± 0.070</td>
<td>82.13 ± 5.67</td>
</tr>
<tr>
<td>150</td>
<td>16.52 ± 1.11</td>
<td>5.51 ± 0.49</td>
<td>7.69 ± 0.73</td>
<td>5.98 ± 0.076</td>
<td>74.80 ± 4.45</td>
</tr>
</tbody>
</table>

Means followed by the same letter symbols in each column according to Duncan’s multiple range test - are not significantly (\(P<0.05\)) different from each other.

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**Figure 2.** Effect of nitrogen-fertilizer levels on the seed swelling factor of *Plantago ovata*. 
level and water supply) have marked effects on plant growth and the production of secondary metabolites (Yanive and Palevitch, 1982; Randhawa et al., 1992). In this work, sowing dates showed conspicuous effects on all growth and seed characteristics examined on Plantago ovata. These data are in agreement with those reported by Koul and Sareen (1999). Isabgol seeds sown on 5th April were first grown normally but they were then discarded because chilling stress occurred. According to this, it can be deduced that isabgol is chilling sensitive, therefore, its seeds should not be sown in the early spring. In other words, early spring cold in the Zanjan region can damage the emergence of isabgol seeds and potentially restricts the early seed growth. According to such resultant data, among three sowing dates studied, 5th May is suggested as the best sowing date for Plantago ovata at the Zanjan experimental station.

Furthermore, all of the growth characteristics and the swelling factor of Isabgol were clearly influenced by nitrogen fertilizer in the present work, leading to the dedvetion that the best treatment for cultivation of Plantago ovata is to use 100 kg ha\(^{-1}\) nitrogen in the above-mentioned experimental station, applying half of which as pre-sowing and the other half at flowering stage. These findings are in agreement with the results reported by other workers (Singh and Nand, 1988; Ramash et al., 1989; Ganpat et al., 1992). Meanwhile, in the present work, the highest seed swelling also resulted from Isabgol seeds grown under 100 kg ha\(^{-1}\) of nitrogen. The stepwise regression analysis verified that the seed yield among other growth and seed characteristics studied in this work had a marked increasing effect on the seed swelling factor.

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رشد و خصوصیات بذری اسفرزه (Plantago ovata Forsk.) تحت تأثیر برخی فاکتورهای محیطی

ق. کریم زاده و ر. امیدیگی

چکیده

اسفرزه (Plantago ovata Forsk.) گیاهی یکساله علفی است که به عنوان گیاه دارویی در سال های اخیر کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود. بذرهای آن حاوی ترکیباتی لغزشی به نام موسیلزل است که بیشتر این کشت می‌شود.
در شمال غربی ایران در شرایط خاکی لومی - رسی اجرای گردید. بر اساس نتایج حاصله، بهترین زمان برای کاشت اسپرزه در این منطقه 15 اردیبهشت و مقدار مناسب کود نیتروژن 100 کیلوگرم در هکتار بوده است. به منظور مطالعه و نجوم تأثیر گذاری متفاوت‌های مستقل بر روی متغیر وایسته (تورم بذر) تجزیه رگرسیون چند متغیره انجام شد. سپس، تجزیه رگرسیون گام به گام بر روی داده‌ها اعمال گردید و معادله نهایی حاصله از آن نشان داد که عملکرد بذر از میان دیگر خصوصیات مستقل اثر مثبت معنی‌داری بر روی تورم بذر نشان داد.