



## Effect of management practices on yield components and swelling factor of *Plantago indica*: a medicinal plant

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### ABSTRACT

An investigation was carried out to study the impact of sowing date and row spacing on yield components and swelling factor of *Plantago indica* during 2009-10 & 2010-11 at Directorate of Medicinal and Aromatic Plants Research (DMAPR), Anand, Gujarat. Its an endeavour and a step forward to develop Good Agricultural Practices (GAP) in this newly introduced species. In this study, the sowing dates in five levels (30 October, 15 November, 30 November, 15 December and 30 December) and row spacings in six levels (50 × 15 cm, 60 × 15 cm, 65 × 15 cm, 70 × 15 cm, 75 × 15 cm and 80 × 15 cm) were evaluated. Results of experiment revealed that there were significant differences for sowing date and spacing effects on plant height, number of branch per plant, number of spikes per plant, number of grains per plant, biological yield and grain yield. The maximum grain yield belonged to sowing date 15 November and row spacing 50 cm. Maximum number of spikes per plant and grains per plant also belonged to 50 cm row spacing which resulted in increasing grain yield in this row spacing. The results revealed that sowing between 15-30 November is the best time for sowing in *P. indica* with suitable spacing either at 50 or 60 × 15 cm. However, seeds sown on 30 November showed significantly more swelling (12.0 cc/g) compared to those sown on other dates. Swelling factor varied from 9.0 to 12.0 cc/g. Hence, it can be concluded that the sowing date played an important role on the growth parameters and seed characteristics of *Plantago indica*. However, swelling factor in this species is a matter of concern which was not much influenced by these factors.

**Key words:** Date of sowing, Growth, *Plantago indica*, Spacing, Swelling factor, Yield

Medicinal plants are very important and known to Ayurveda in India since long times. The industrial demand on medicinal plant resources has increased tremendously owing to the worldwide buoyancy in the herbal sector for herbal health care formulations; herbal based cosmetic products and herbal nutritional supplements. In this regard, Isabgol (*Plantago ovata*) from Plantaginaceae family is one medicinal plant species in high trade sourced largely from cultivation and is exported in high scale (Ved and Goraya 2007). *Plantago indica*, another important species of the same family, a dicot, is an annual herb that is not native to India was introduced from elsewhere and naturalized in the wild in USA. It has been recently introduced in India and is considered to be commercially important at par with *P. ovata* (blond psyllium).

Psyllium plant is locally known as isabgol or isabghula cultivated on large scale in western India. It has gained agricultural importance because of its wide use in pharmaceutical, cosmetics and food grade industries worldwide. Psyllium seeds have characteristic of mucilage formation on catching humidity. It is cool, laxative, antidiuretic, soothing, antiacidic, emollient, demulcent,

stabilizer and sizer. Due to these properties it is largely used in pharmaceutical industry, food preparations, ayurvedic medicine, unani remedies, preparation of crude drugs, etc. (Gupta 1987, Wolver *et al.* 1994, Lal *et al.* 1999, Handa and Kaul 1999, Galindo 2000, Maiti and Mandal 2000, Lal *et al.* 2007, Aishwath and Ramchandra 2008). *P. indica* seeds also have the properties that *P. ovata* possess (Rahn 1996). More importantly, *P. indica* has not been cultivated anywhere in the world notwithstanding the fact that it possesses tremendous medicinal value alike *P. ovata*. In India, mucilage from *Plantago ovata* is obtained by grinding off the husk. The mucilage is sold as Isabgol, a laxative which is used to control irregular bowel syndrome and constipation. It has been used as an indigenous Ayurvedic and Unani medicine for a whole range of bowel problems (Dagar *et al.* 2006). Its cultivation practices and yield estimation have not been researched till now as that of *P. ovata* and is considered very promising medicinal species by the farmers in this area where this research has been carried out.

Package of practices of *Plantago ovata* has been developed (Maiti and Mandal 2000) and few varieties were also evolved albeit with less yield potential and low swelling factor. *P. indica* on the other hand is brought to cultivation recently by DMAPR grown for its husk and seeds. Cultivation of *P. indica* has started of late but yet to achieve

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its important place to compete with already established crop species *P. ovata* in terms of yield and quality aspect. Sowing date and spacing are prerequisite for assuring optimal ecological conditions during the plant growth and development. In this context, at Anand, which is located in semi-arid region of Gujarat, the sowing of isabgol (*P. ovata*) is ideal between mid-October and mid-November (Maiti and Mandal 2000, Aishwath and Ramchandra 2008). Late sowing, adversely tells upon seed yield due to a short growth period. However, Kalyansundram *et al.* (1984) reported that sowing of *P. ovata* during the first week of December is considered to be ideal under Jammu condition which is altogether a different story than the report given by Koul and Sareen (1999) that sowing of isabgol is proposed to be ideal between mid-October and mid-November.

Now it is ambitiously felt to bring *P. indica* into cultivation by developing Good Agricultural Practices (GAP) and therefore, an attempt has been made to carry out experiments for two years (2009-10 and 2010-11) to evaluate growth and yield of *P. indica* including its swelling factor as quality parameter so as to understand its behaviour under semi-arid condition of Gujarat where it could be used as a potential alternative of *P. ovata*.

#### MATERIALS AND METHODS

Field experiments were conducted at research farm of DMAPR, Anand, Gujarat, India located at 22.5° N latitude and 73.0° E longitudes. The mean annual rainfall (two years) of the place was 600.8 mm, most of which (91.5%) is contributed by south west monsoon during mid June to September. The study (2009-10 and 2010-11) was carried out taking two experiments on dates of sowing (30 October-T<sub>1</sub>, 15 November-T<sub>2</sub>, 30 November-T<sub>3</sub>, 15 December-T<sub>4</sub> and 30 December-T<sub>5</sub>) and spacings (50 × 15 cm -T<sub>6</sub>, 60 × 15 cm -T<sub>7</sub>, 65 × 15 cm -T<sub>8</sub>, 70 × 15 cm -T<sub>9</sub>, 75 × 15 cm -T<sub>10</sub> and 80 × 15 cm -T<sub>11</sub>) to study their influence on growth and yield of *Plantago indica* including quality parameter as swelling factor. The study was conducted following RBD in four replicates for each experiment separately for each treatment. Seeds were sown 50 cm apart and spaced 15 cm apart for date of sowing experiment and other intercultural practices were followed as recommended for *P. ovata* (Maiti and Mandal 2000). The study area falls under the climatic zone VII of semi-arid region of India.

The crop was raised in 24 m<sup>2</sup> plots for each treatment with seed rate of 4 kg/ha. The experimental soil was Fluventic Ustochrept and sandy loam in texture. Physico-chemical characteristics of the soil were EC 0.18, pH 8.2 and organic carbon 0.26%. Soil was low fertile and having available N, P and K as 115.0, 9.8 and 123.4 kg/ha, respectively. The crops were harvested at 138 DAS and then their seeds and straw yield were recorded.

At harvest, different yield and yield parameters including swelling factor were determined. When plants turned yellow and spikes turned brown, they were harvested (Najafi and Moghadam 2002). One square meter of three central rows were taken from each plot to determine the

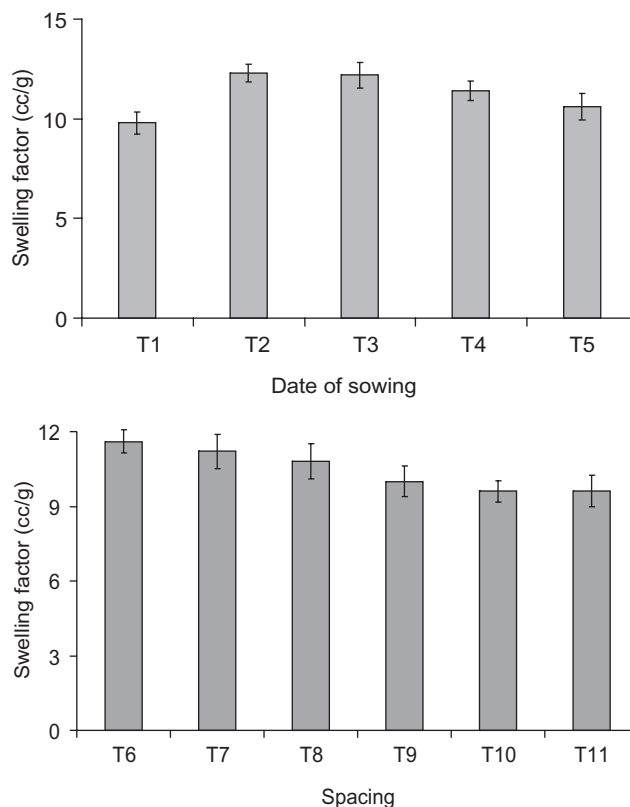


Fig 1 Swelling factor (cc/g) in *P. indica* under the influence of dates of swing (A) and spacing (B), The error bars represent SEM (n = 4) at LSD (P = 0.05). T<sub>1</sub>-T<sub>5</sub> are dates of sowing, while T<sub>6</sub>-T<sub>11</sub> are different spacings.

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 and Koul 1986). Mucilage content in the seed was also determined according to Sharma and Koul (1986). Swelling of 1 g mucilage was calculated by the following equation:

$$\text{Swelling of 1 g mucilage} = \frac{(\text{swelling factor} \times 100)}{\text{mucilage contents}}$$

At harvest total dry weight and seed yield were recorded which included seed yield, total biomass and test weight. Analysis of variance (ANOVA) was done in statistical software MSTAT 4.0 C package for computers (Michigan State University, USA) following the method of Gomez and Gomez (1976). Results of two years were pooled for both the experiments separately. Differences among treatment were compared using LSD values at the 0.05 level of significance and correlation analyses were performed using MS Excel-2003 for showing significant difference between the treatments in the field and also to reflect the association of one parameter with the other. The weather figure (2009-10 and 2010-11) during the growth period of the crop (October to March) is given in Fig 2.

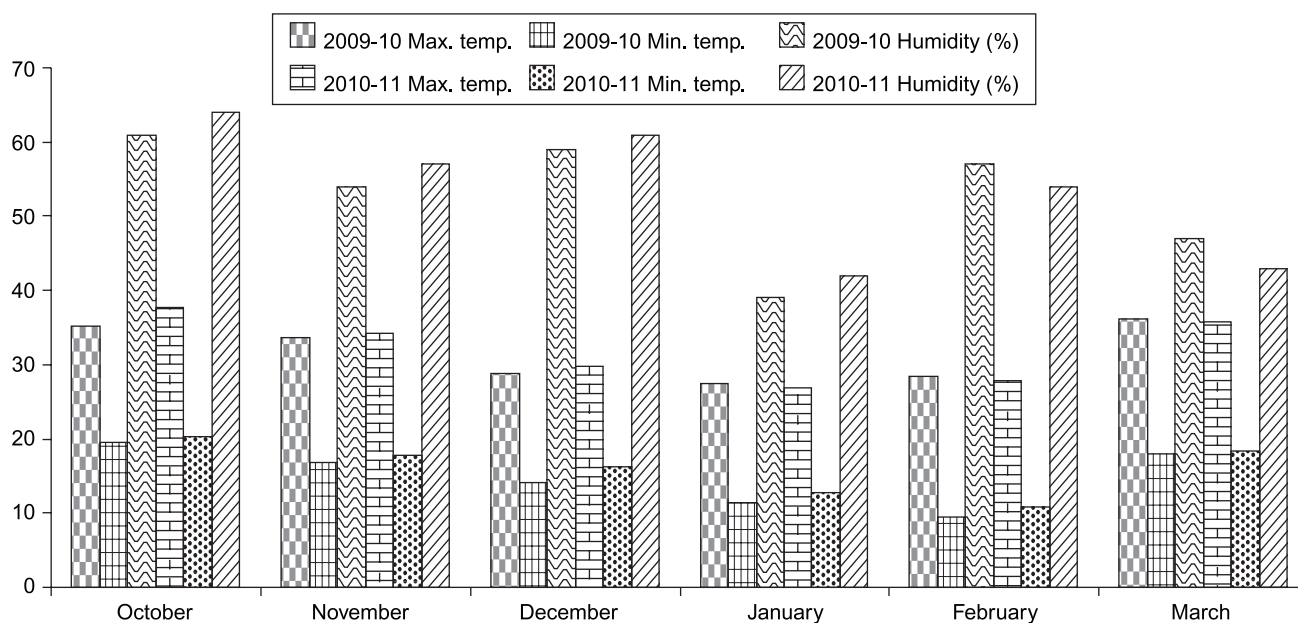


Fig 2 Monthly data for maximum and minimum temperature ( $^{\circ}\text{C}$ ) and Humidity (%) during the growth period (2009-11) of *Plantago indica*

## RESULTS AND DISCUSSION

Growth was influenced due to different dates of sowing and spacing in *P. indica*. There was significant increase in plant height at harvest. Maximum plant height of 129 cm was obtained in plants sown on 15 November ( $T_2$ ) which was 12 and 34% more as compared to plant height at 30 October (early sowing) and 30 December (late sowing) sowing, respectively. Again in spacing experiment, maximum plant height of 120 cm was recorded in spacing of  $50 \times 15$  cm ( $T_6$ ) and  $T_7$  ( $60 \times 15$  cm) which was 10.5% more as compared to spacing of  $80 \times 15$  cm ( $T_{11}$ ). However, results of plant height was at par between  $T_2$  and  $T_3$  (date of sowing) and in between  $T_6$  and  $T_7$  (spacing) (Table 2).

Similarly number of branches was significantly influenced by different dates of sowing and spacings and followed the similar trend as plant height. Mean number of branches per plant varied from 20-23 at harvest and maximum number was attained by 15 November sowing and in spacing of  $50 \times 15$  cm (23) which was 40 and 47% more as compared to the minimum, i.e. 30 December sowing and  $80 \times 15$  cm spacing (Table 2).

In yield data, results revealed that economic yield (seed) is highly significant and the yield recorded was maximum in  $T_2$  (15 November sowing) and  $T_6$  ( $50 \times 15$  cm spacing) giving an yield of 10.8 to 11.6 q/ha followed by  $T_3$  (30 November sowing) which is on par with  $T_2$  and  $T_7$  ( $60 \times 15$  cm spacing) and with  $T_6$ , whereas, minimum yield was recorded to the tune of 5.8 to 6.3 q/ha which is 87% less as compared to the maximum (Table 2). Harvest index (HI) was also significant and was in the range of 6.2% ( $T_5$ ) to 14.6% ( $T_2$ ) in date of sowing experiment, whereas it was in the range of 9.8 ( $T_{11}$ ) to 18.3% ( $T_6$ ) in spacing experiment with a test weight (1000 seeds) in the range of 1.209 g ( $T_5$ ) to 1.478 g ( $T_2$ ) and 1.180 g ( $T_{11}$ ) to 1.520 g ( $T_6$ ). These

results are in agreement with the work done in *P. ovata* by several workers (Ramesh *et al.* 1989, Ganpat *et al.* 1992, Baghalian 1999, Ryan and Joiner 2001). Other yield characters were also significantly influenced by different dates of sowing and spacings (Table 1).

The results revealed that sowing between 15-30 November would be beneficial for the better growth of the plant and sowing early and late in the months of October and December would not be suitable for this crop. Results of yield data further revealed that all the yield parameters were significant and maximum yield could be achieved in  $T_2$  (15 November sowing) and spacing at  $50 \times 15$  cm would produce more growth in terms of plant height, leaf growth and dry matter accumulation in leaf, stem and root (data not shown) and yield followed by spacing at  $60 \times 15$  cm.

Results indicated that the sowing date had highly significant effects on plant height, number of branches and number of flowers per plant, seed yield, swelling factor and weight of 1000 seeds ( $P = 0.05$ ). The mean comparisons of the above-mentioned characters which were planted on 15 November grew much better compared with those planted on other sowing dates except 30 November sowing which was at par (Tables 1 and 2). On the other hand, seeds sown on 30 November showed significantly ( $P = 0.05$ ) more swelling (12.0 cc/g) compared to those sown on other dates (Fig 1). Swelling factor varied from 9.0 to 12.0 cc/g. Hence, it can be concluded that the sowing date played an important role on the growth parameters and seed characteristics of *Plantago indica*. Ramesh *et al.* (1989) also indicated similar trend in *P. ovata*. The correlation testing indicates that only the seed yield trait among other independent variables tested showed a significant positive effect ( $P = 0.05$ ) on seed swelling.

A strong association between total dry matter (TDM) and seed yield was reported for different crops and it has

Table 1 Influence of dates of sowing and spacing on different yield parameters of *P. indica*

Treatment	Effective number of spike of spike per plant	Un-effective number of spikes/plant	No. of nodes/ plant	No. of internodes/ plant	Wt. of one spike (g)	Length of one spike (cm)	Spike diameter (mm)	No. of seeds/ spike	Seed wt./ spike (g)	Spike wt./plant (g)	Seed wt./plant (g)
<i>Date of sowing</i>											
T <sub>1</sub>	112.3	22.8	18.3	17.3	0.19	2.15	8.03	52.3	0.06	22.2	6.78
T <sub>2</sub>	135.8	12.3	20.3	19.3	0.22	3.22	8.83	66.7	0.08	26.3	10.4
T <sub>3</sub>	121.0	24.6	18.6	17.6	0.20	2.87	7.98	59.5	0.05	23.7	8.12
T <sub>4</sub>	88.4	33.9	16.3	15.7	0.16	1.88	7.42	38.9	0.04	18.4	4.56
T <sub>5</sub>	78.3	46.8	14.2	13.2	0.14	1.72	7.34	37.0	0.04	16.7	4.06
Mean	107.2	28.1	17.5	16.6	0.18	2.37	7.92	50.9	0.05	21.5	6.78
LSD	19.7	7.78	2.11	1.76	0.05	0.44	0.77	7.54	ns	2.06	2.37
(P = 0.05)											
<i>Spacing</i>											
T <sub>6</sub>	92.3	11.5	20.6	19.6	0.19	2.35	7.47	53.1	0.06	25.8	8.90
T <sub>7</sub>	90.3	11.8	19.0	18.0	0.17	1.98	7.30	46.1	0.06	22.3	8.25
T <sub>8</sub>	77.8	13.3	18.6	17.6	0.15	1.73	7.50	41.8	0.05	18.7	7.60
T <sub>9</sub>	71.5	12.9	18.3	16.7	0.14	1.68	7.40	39.5	0.05	18.1	7.34
T <sub>10</sub>	65.6	20.9	17.2	16.2	0.13	1.66	7.54	37.4	0.04	16.3	7.03
T <sub>11</sub>	62.9	20.8	15.8	14.8	0.13	1.54	5.96	31.2	0.04	14.5	5.01
Mean	76.7	15.2	18.3	17.3	0.15	1.82	7.19	41.5	0.05	19.3	7.35
LSD	6.23	3.45	1.23	1.34	0.03	0.19	0.17	4.78	ns	3.31	1.02
(P = 0.05)											

Dates of sowing: T<sub>1</sub>- 30 October, T<sub>2</sub>- 15 November, T<sub>3</sub>- 30 November, T<sub>4</sub>- 15 December and T<sub>5</sub>- 30 December and T<sub>5</sub>-30 December and spacing: T<sub>6</sub>- 50 × 15 cm, T<sub>7</sub>-60 × 15 cm, T<sub>8</sub>-65 × 15 cm, T<sub>9</sub>- 70 × 15 cm, T<sub>10</sub>-75 × 15 cm and T<sub>11</sub>-80 × 15 cm. and spacings: T<sub>6</sub>- 50 × 15 cm, T<sub>7</sub>- 60 × 15 cm, T<sub>8</sub>- 65 × 15 cm, T<sub>9</sub>- 70 × 15 cm, T<sub>10</sub>- 75 × 15 cm and T<sub>11</sub>- 80 × 15 cm

Table 2 Influence of dates of sowing and spacing on different yield parameters of *P. indica*

Treatment	Plant height (cm)	No. of branches/plant	No. of spikes/plant	Total wt. of the plant (q/ha)	Straw wt. (q/ha)	Total seed wt. (q/ha)	1000 seed wt. (g)	HI (%)
<i>Date of sowing</i>								
T <sub>1</sub>	100.2	21.7	135.1	8.4	9.2	9.8	1.30	11.9
T <sub>2</sub>	129.2	23.4	148.1	11.0	8.9	11.6	1.48	14.6
T <sub>3</sub>	118.7	22.3	145.6	9.2	9.5	10.6	1.42	12.5
T <sub>4</sub>	93.2	20.3	122.3	8.3	11.0	7.6	1.34	7.8
T <sub>5</sub>	94.0	19.0	125.1	7.1	10.5	5.8	1.20	6.2
Mean	107.1	21.3	135.2	14.0	9.83	9.08	1.35	10.6
LSD (P = 0.05)	6.67	1.16	10.5	321.8	109.2	112.8	0.11	2.2
<i>Spacing</i>								
T <sub>6</sub>	120.1	23.5	106.8	8.8	6.7	10.8	1.52	18.3
T <sub>7</sub>	120.1	22.4	107.1	9.6	6.1	10.5	1.50	17.8
T <sub>8</sub>	112.5	20.5	91.1	9.1	6.0	8.8	1.42	14.5
T <sub>9</sub>	109.8	20.0	84.4	7.4	6.2	8.2	1.35	13.2
T <sub>10</sub>	110.3	18.6	86.5	7.2	6.3	7.0	1.21	11.0
T <sub>11</sub>	110.6	19.8	83.7	7.0	6.4	6.3	1.18	9.8
Mean	113.9	20.8	93.3	8.19	6.14	8.60	1.36	14.1
LSD (P = 0.05)	5.67	1.14	4.51	745.9	112.6	92.4	0.21	2.23

Dates of sowing: T<sub>1</sub>-30 October, T<sub>2</sub>-15 November, T<sub>3</sub>-30 November, T<sub>4</sub>-15 December and T<sub>5</sub>-30 December and spacings: T<sub>6</sub>-50 × 15 cm, T<sub>7</sub>-60 × 15 cm, T<sub>8</sub>-65 × 15 cm, T<sub>9</sub>-70 × 15 cm, T<sub>10</sub>-75 × 15 cm and T<sub>11</sub>-80 × 15 cm, HI: Harvest index

been suggested that this simple parameter can be used as a surrogate for photosynthesis (Bhatia *et al.* 1996, Suresh *et al.* 1997). This study also followed such trend at harvest (R = 0.812 at P = 0.05) in relation to seed yield (Table 3).

However, a negative trend was observed with respect to plant height and number of branches in spite of the fact that it was found to be significant (P = 0.05). These characters at later dates of sowing (delayed sowing) and in increased

Table 3 Correlation between selected *P. indica* characters with seed yield and swelling factor

Characters	Seed yield*	Swelling factor*
Plant height	-0.456	-0.378
Number of branches/plant	-0.537	-0.412
Number of spikes/plant	0.645	0.567
Number of seeds/spike	0.714	0.604
1000 seed weight	0.609	0.561
Total dry matter	0.812	0.467
Total wt. of the plant	0.801	0.511
HI	0.713	

\*P = 0.05

row spacing had a non-significant result (Table 1) vis-à-vis optimum sowing time ( $T_2$  and  $T_3$ ) and acceptable row spacing ( $T_6$  and  $T_7$ ). Results further revealed that HI though significant with respect to seed yield could not show better correlation as it was low at early ( $T_1$ ) and late sowing ( $T_4$  and  $T_5$ ) and also in respect to wider spacing from 60 to 80 cm. Another character, i.e. total weight of the plant had significant and positive correlation with the seed yield ( $R = 0.801$  at  $P = 0.05$ ) and influenced HI at all the time of sowing and spacings.

Environmental factors such as cultivation practices (such as sowing date, geometry and water supply) have marked effects on plant growth and the production of secondary metabolites (Yanive and Palevitch 1982, Randhawa *et al.* 1992, Ryan and Joiner 2001). In this study, sowing dates showed conspicuous effects on all growth and development examined on *P. indica*. These data are in agreement with those reported by Koul and Sareen (1999) and Karimzadeh and Omidbaigi (2004). Isabgol seeds sown between 15-30 November were first grown normally and produced better growth and gave maximum yield, whereas, seeds sown in October and December could not produce much as the plants were reduced in growth and gave very poor yield.

Thus it can be deduced that *P. indica* is a growth sensitive crop, therefore, its seeds should not be sown in the early October or later in the month of December. In other words, early sowing can damage the emergence of its seeds and potentially restricts the early seed growth. According to such resultant data, among five sowing dates studied, 15-30 November sowing with  $50 \times 15$  cm spacing is suggested as the best sowing date and spacing for *Plantago indica* to produce more growth and better yield. However, there is need to focus on targeting genotypes of *P. indica* with higher swelling factor and more seed yield with a HI more than 20% to compete with *P. ovata* in the commercial market.

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