Effect of sowing dates and NPK levels on active substances in seeds of isabgol plants (*Plantago ovata* Forsk, L.).

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Summary: Two field experiments were carried out in the Experimental Station and Laboratory of the Vegetables and Floriculture Dept., Fac. of Agric., Mansoura Univ., during the winter seasons of 1995/96 and 1996/97. The investigation aimed to study the effect of different sowing dates and NPK fertilization levels, as well as their interactions on active substances extracted from Isabgol plant (mucilage contents). Four sowing dates and six NPK levels were studied. The main findings in this investigation can be summarized as follows:

1. Plants grown in the first sowing data (Nov. 1st week) produced the highest content of mucilage as g/5 g seeds or as percentage of mucilage per plant.
2. The addition of NPK fertilization significantly increased the mucilage content of seed and its percentage per plant. The highest content and percentage were in plants treated with the fourth level of NPK (178.0 g/3m^2).
3. Concerning effect of interaction between sowing dates and NPK levels on mucilage content, the highest content and percentage per plant were produced in plants grown in the first sowing date and treated with the fourth level of NPK.

Key words: isabgol plants, NPK fertilization

Introduction

The genus *Plantago* comprises 200 species, one of them is isabgol plant (*Plantago ovata* Forsk, L.). Such plant is characterized as an annual herb and produces a heavy yield of seeds that makes it the main source of such seeds.

Since early time, several studies proved the importance of isabgol seeds in different pharmaceutical purposes. The seed husks take a lot of attention in this respect as a source forming tasteless mucilaginous substances *(Wallis,* 1967; *Russell,* 1975 and *Trease & Evans,* 1978).

The main constituent of such substances is the mucilage compound. *Anderson* (1987) reported the effective use of mucilaginous husk for lowering blood cholesterol level. As for seeds, *Bloss* (1982) stated their use as a laxative and *Chiej* (1988) found that seeds can be used as cosmetic products, e.g. face masks to makes the skin soft. More recently, *Nordgaard* et al. (1996) pointed to the dietary role of fiber from isabgol seeds as effective in treatment of colonic cancer.

In Egypt, isabgol was found widely in the Nile Delta and along the Mediterranean coastal strip from El-Salam to Rafa. In addition, it was found in the Isthmic desert, i.e. El-Tih and regions of North Wadi Tumilat and Sinai proper, i.e. South of El-Tih desert *(Tackholm,* 1974).

Factors affecting the production of such medical substance did not receive the attention deserved. A very limited study has been carried out, such as those of *Khater* et al. (1994), who found that the highest yield of seeds' mucilage was obtained from Isabgol plants supplied.

Therefore, the objectives of the present research were a trial in this direction. It was designed to test the effect of four sowing dates and six NPK levels either solely or in combinations on certain characteristics represent mucilage content.

Material and method

Isabgol (*Plantago ovata* Forsk [L]) seed has been obtained from Müggenburg Firm, Hamburg, Germany. A seed-bed has been prepared in uniform fine tilt located in the Experimental Station of the Fac. of Agric., Mansoura University. Sowing was performed at four consequent dates in 1995/96 and 1998/97 seasons, the first week of November, the third week of November, the first week of December and the third week of December. During the growth season, six NPK levels were applied at a ratio of 2:1:1.5 and its duplicates as indicated in *Table 1.*

Table 1 Fertilization treatments studied for NPK ratio and rates in 1995/96 and 1996/97 seasons.

NPK treatments	NPK ratio	NPK rates (g/3m^2)			
		NH_4NO_3	$Ca_3(P_2O_5)_2$	K_2SO_4	Total
$N_1P_1K_1$	0 : 0 : 0	0.0	0.0	0.0	0.0
$N_2P_2K_2$	2 : 1 : 1.5	22.8	12.8	11.7	47.3
$N_3P_3K_3$	4 : 2 : 3	45.4	49.6	23.4	118.4
$N_4P_4K_4$	6 : 3 : 4.5	68.0	75.0	35.0	178.0
$N_5P_5K_5$	8 : 4 : 6	90.0	100.0	46.8	236.8
$N_6P_6K_6$	10 : 5 : 7.5	113.6	125.0	58.6	297.2

Each NPK level was divided into two equal doses, the first dose was applied one month after sowing, and the second one was two weeks later.

The obtained seedlings received the rest of horticultural practices as common for isabgol plants.

In both seasons, the effect of two factors (sowing dates and NPK levels) on chemical constituents of isabgol seeds per plant was studied.

Samples of seeds were taken at harvest time (at 130 to 140 days from sowing date) when all spikes were filled with mature seeds and turned from pink to red colour. In addition, the lower leaves began to dry and the upper ones remained in yellow colour. Samples were oven dried at 70 °C to determine content of mucilaginous substance in seed (g per 5 g seeds). Mucilage percentage also was estimated according to the method described by Marzouk (1995) in plants of each sowing date in the two tested seasons.

Isabgol substance extraction

Representative samples (5 g) each were randomly taken from seed grown under each of the treatment tested. Such seeds sample under investigation were separately percolated with 90% ethanol (5 x 250 ml) to get rid of the coloring matter. The marc, in each case, was air dried, then extracted with cold water (3 x 500 ml) under stirring for 6 hours at room temperature and left to stand for another 12 hours. The supernatant in each case was filtered by passing through folded muslin and the filtrate in each case was centrifuged to remove the seed debris. The mucilages were then precipitated by adding to the aqueous solution four volumes of 95% ethanol under stirring. The precipitated mucilages were then separated by centrifugation, washed several times with ethanol, vigorously shaken with absolute acetone, centrifuged again, pressed between two filter papers and left to dry in a desiccator over anhydrous calcium chloride to obtain the mucilages as a buff to dirty-white starchy powders. In all cases, the obtained mucilages were starch free, protein free, sugar free and did not reduce Fehling's solution.

The marc after the exhaustive extraction with cold water, was repeatedly extracted with boiling water (3 x 250 ml) until complete extraction of the mucilage is affected. The extracted mucilages were precipitated and purified adopting the same procedure mentioned before.

Soil analysis

Soil samples were taken for mechanical and chemical analysis before sowing in the two seasons *(Table 2)*.

Experimental design and statistical analysis

Factorial experiment in a randomized complete blocks design with 4 replicates was used according to *Cochran & Cox* (1957). Collected data were subjected to the statistical analysis according to the technique of analysis of variance (ANOVA) of factorial experiment in RCB design. The treatment means were compared using the least significant difference (LSD) procedures as mentioned by *Gomez & Gomez* (1984).

Table 2 Mechanical and chemical analysis of the soil under investigation during 1995/96 and 1996/97 seasons

Soil properties	1995/96	1996/97
Mechanical analysis:		
Clay (%)	41.70	42.93
Silt (%)	27.65	26.83
Fine sand (%)	28.22	28.39
Coarse sand (%)	2.43	1.85
Air pore space (%)	21.00	25.00
Chemical analysis:		
Available nitrogen (ppm)	43.00	47.00
Available phosphorus (ppm)	9.00	11.00
Available potassium (ppm)	2.51	2.89
Organic matter (%)	0.32	0.36
E.C. (mmhos/cm)	0.26	0.21
E.C. (%)	0.11	0.12
pH	7.63	7.52
$CaCO_3$	2.51	2.33
Soluble cations and anions (meq/100gm soil):		
Ca	0.30	1.00
Mg	0.30	0.50
HCO_3	0.70	0.50
Cl	0.35	0.80
SO_4	0.28	0.64

Results and discussion

The present research was aimed to throw some lights on the relationship between sowing dates and NPK levels solely or in combination and the mucilaginous substance in isabgol seeds, which had different values depending on certain medical purposes.

The results obtained are presented in *Table 3* and showed the effect of sowing dates on mucilage content in the isabgol seeds. It could be seen that plants grown in the first sowing date (first week of Nov.) reflected the highest values of mucilage content related to the other sowing dates (1.57 g/5g or 31.49%) and (1.65 g/5g or 32.91%) in the first and second periods, respectively.

Plants of the second sowing date (third week of Nov.) were the next in this respect, since they tabulated the values of 1.57 g/5g seeds or 31.39% and 1.60 g/5g or 32.01% for both seasons of study, respectively. On the other hand, fourth sowing date (third week of Dec.) indicated the least

Table 3 Effect of sowing dates on the mucilage content in seeds as g per 5 g or as percentage of *Plantago ovata* in 1995/96 and 1996/97 seasons

Sowing dates	Seed mucilage content (g/5g)		Seed mucilage content (%)	
	1995/96	1995/96	1995/96	1996/97
Nov. 1st week	1.57	1.65	31.49	32.91
Nov. 3rd week	1.57	1.60	31.39	32.01
Dec. 1st week	1.53	1.56	30.53	31.27
Dec. 3rd week	1.52	1.53	30.39	30.58
LSD at 5%	–	–	1.01	1.12

content with 1.52 g/5g seeds or 30.39% and 1.63 g/5g or 30.58% values for the same seasons. The differences between sowing dates were significant in both seasons.

The above mentioned results behaved the same manner as those obtained by *Russel* (1975) on isabgol, who reported that isabgol plant when sown in late October and early November became a good source of mucilage content, which are important as pharmaceuticals.

Concerning the effect of NPK levels, the data in Table 3 indicated that the applied NPK at any level significantly increased the mucilage percentage in seeds compared to the control (No NPK applied). Among the levels tested, the highest mucilage content and percentage (1.71 g/5g seeds or 34.27% and 1.76 g/5g or 35.17% in both seasons, respectively) were of plants treated with the fourth level (178.0 g/3m^2) followed by those under the third NPK level (118.4 g/3m^2), which tabulated for the first and second seasons, respectively, the values 1.62 g/5g seeds or 32.38% and 1.66 g/5g or 33.21%. The lowest mucilage content and percentage were of control plants and those received the second NPK level (47.3 g/3m^2).

These results may be due to the influence of NPK fertilization on photosynthesis and the productivity. Potassium is necessary for the synthesis of carbohydrates and proteins, while phosphorus is an important factor influencing the rate of photosynthesis and phosphates act as catalysts for the action of some enzymes, which are involved in the hydrolytic changes of starch to sugar (one of mucilage constituents) in plants (*Alex*, 1969). So, increasing of P and K fertilization increased the mucilage content and percentage.

Table 4 Effect of NPK levels on the mucilage content in seeds as g per 5 g or as percentage of *Plantago ovata* in 1995/96 and 1996/97 seasons

NPK levels (g/3m^2)	Seed mucilage content (g/5g)		Seed mucilage content (%)	
	1995/96	1995/96	1995/96	1996/97
$N_1P_1K_1$	1.45	1.46	28.91	29.26
$N_2P_2K_2$	1.46	1.51	29.26	30.12
$N_3P_3K_3$	1.62	1.66	32.38	33.21
$N_4P_4K_4$	1.71	1.76	34.27	35.17
$N_5P_5K_5$	1.58	1.63	31.53	32.64
$N_6P_6K_6$	1.54	1.59	30.85	31.91
LSD at 5%	–	–	1.24	1.37

Comparing the results in *Tables 3* and *4*, it could be noticed that the effect of NPK at 178.0 g/3m^2 (fourth level) was higher than that of the earliest sowing date (first week of Nov.). The former factor recorded for mucilage constituents the values 1.75 g/5g seeds or 34.72%, whereas, the corresponding values for the later one were 1.61 g/5g seeds or 31.70%. These values are the average of both seasons studied.

Such significant effect of NPK at the fourth level greatly confirmed the results reported above by *Alex* (1969), *Khater* et al. (1994), *Dessouky* (1995), *Harphool* et al. (1997) and *Patel* et al. (1997). They all reported that mucilage of isabgol was highest with increasing N and P fertilization.

The effect of interaction between sowing dates and NPK levels is presented in *Table 5*. From this table, it was clear that all combinations used gave a significant increase of mucilage % in seeds in both seasons, except for those which combined the late sowing dates and either no application of NPK or low and excess NPK doses. Among such combinations, the greatest values were obtained from seeds sown in Nov. 1st week and received the fourth level of NPK (178.0 g/3m^2).

Otherwise, seeds of the fourth sowing date (third week of Dec.) and did not receive NPK (0.0 level) resulted in the lowest content of mucilage.

These results are expected, since there is a gradual decrease of temperature from October up to December. This gradual decrease makes a gradual absorption of the phosphorus in the soil and makes the phosphorus unavailable for plants as the temperature decreases. The shortage of phosphorus in the soil and the decrease of temperature during this time, restricts nitrogen and potassium uptake *(El-Gamiely* et al., 1998).

Such findings were also in good agreement with the results obtained by *Randhawa* et al. (1978) on isabgol, who reported that supplying Isabgol with 20 or 40 kg N/ha and sown on October 21 were favourable for good seed yield and high content of active constituents.

Table 5 Effect of interaction between the sowing dates and NPK levels on the mucilage content in seeds as g per 5 g or as percentage of *Plantago ovata* in 1995/96 and 1996/97 seasons.

Sowing dates	NPK levels (g/cm^2)					
	0.0	47.3	118.4	178.0	236.8	297.2
1995/96 season						
Nov. 1st week	29.28	29.73	32.52	33.86	29.89	29.78
Nov. 3rd week	28.90	29.06	31.15	32.40	29.34	29.15
Dec. 1st week	27.85	28.40	30.74	32.02	28.94	28.57
Dec. 3rd week	27.57	27.96	30.02	31.52	28.40	28.12
LSD at 5%	1.31					
1996/97 season						
Nov. 1st week	30.58	31.58	33.42	35.17	32.86	31.70
Nov. 3rd week	29.60	30.13	32.33	34.10	31.90	30.81
Dec. 1st week	28.34	29.01	31.96	33.21	30.71	29.90
Dec. 3rd week	28.02	28.91	31.13	32.86	29.37	29.05
LSD at 5%	1.43					

The aforementioned results clearly proved the significant effect of sowing dates and NPK levels either solely or in combination on the active substance in isabgol seeds. Therefore, the growers of such plant must give an attention on these factors. They provide early sowing date for seeds in the beginning and applied the most efficient dose of NPK during the growing season to produce an economic yield of mucilage content. This is, in turn, increases income from their isabgol plantations.

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