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EFFECT OF RADIATION AND ORGANIC FERTILIZATION ON GROWTH OF LOVAGE (*LEVISTICUM OFFICINALE* KOCH.)

BY

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ABSTRACT

The effect of radiation and farm yard manure (FYM) on growth of lovage plants (*Levisticum officinale*) was studied in two successive seasons (2003/2004 and 2004/2005). Five doses of gamma rays (0, 20, 40, 60 and 80 Gy) were applied to lovage seeds, and four rates of farmyard manure (0, 20, 30 and 40 m^3/fed.) were added to the soil before sowing. In both seasons, when radiation treatments were applied separately, all the tested doses significantly increased plant height, number of branches, stem thickness and shoot dry weight (except the dose of 80 Gy), compared to the control. Also, the organic fertilization (FYM) treatments significantly increased growth characters of lovage plants in both seasons. Combining gamma radiation at 60 Gy with FYM at 40 m^3/fed. gave the best results in terms of plant height, number of branches, stem thickness and shoot dry weight of lovage plants (in both seasons).

INTRODUCTION

Medicinal and aromatic plants play an important role as a source of national income, due to the continuous demand for their active products in both foreign and local markets, and also for their application in pharmaceutical preparations. Medicinal and aromatic plants have proven to be an important resource of natural active compounds, useful in the medicine, food and cosmetics industries, as well as plant protection, and many other purposes.

Lovage (*Levisticum officinale* Koch.), a member of the *Apiaceae* family, is a perennial herb native to the Mediterranean region. It is widely grown as a garden ornamental plant. All parts of lovage plants (fruits, herb and roots) are odorous and strongly aromatic (Hornok, 1992).

Manure and other waste products of plants and livestock have been used as soil amendments for centuries. These materials were the only way of quickly improving soil fertility before the advent of chemical fertilizers (Lupwayi *et al.*, 2000). Organic manures are a vital resource not only for supplying plant nutrients but also for replenishing organic matter content of most agricultural soils. This would further emphasize the need to use organic manures alone or in conjunction with chemical fertilizers in soil fertility maintenance for sustainable crop production (Reddy *et al.*, 2000). The addition of manure to fields can improve soil pH, cation exchange capacity, water-holding capacity and soil structure. Manure breaks down more slowly in soil than do inorganic fertilizers. It acts as a slow-release fertilizer which provides nutrients over the whole growing season and often has a residual effect which lasts for one or two further growing seasons (Harris, 2002).

Pre-sowing seed irradiation is one of the most effective methods of improving plant production, yield components and chemical composition of medicinal and aromatic plants . The use of ionizing radiation (gamma rays)

for modifying plant development and other physiological applications depends on understanding of basic physiological effects of radiation (Maghraby, 1997).

Several studies have been carried out to evaluate the effect of gamma rays on several aromatic plant species [Selenina and Stepanenko (1979) on chamomile, Hussein *et al.* (1995) on *Datura metel*, Abd-El-Wahab (2000) on coriander, Youssef *et al.* (2000) on *Pelargonium graveolens*, and Nassar *et al.* (2004) on *Chamomilla recutita*]. Such studies have shown that low doses of gamma rays stimulated seed germination, plant growth and oil production.

The objective of the present work was to study the influence of soil application of farmyard manure, and seed irradiation with gamma rays before sowing, and their interaction on the growth of lovage plants under the conditions of new reclaimed soil in the Inshas area, Egypt.

MATERIALS AND METHODS

An experiment was conducted in the field of medicinal and aromatic plants, Experimental Farms Project, Nuclear Res. Center, Atomic Energy Authority at Inshas, during the two successive seasons of 2003/2004 and 2004/2005, with the aim of evaluating the effect of gamma radiation and organic fertilizers on the growth characteristic of lovage plants. Soil of this field was a reclaimed sandy loam soil, which contained 74.60 % sand, 14.70 % silt and 10.70 % clay, with a pH of 7.95. The chemical composition of the soil is shown in Table (A).

Table (A): The chemical composition of the soil in the experimental area (mg/100g soil).

Na	Ca	K	Mg	N	P	Cl	HCO_3	CO_3
14	30.5	3.5	15	640	57.8	261	117	Zero

In both seasons, dry lovage seeds were irradiated one day before sowing using a Gamma-cell "Co – 60" apparatus (1.816–1.627 rad/sec.) at doses of 0, 20, 40, 60 and 80 Gray (Gy, 1 gray = 100 rad).

Farmyard manure (FYM) was added to the soil at rates of 0, 20, 30 and 40 m^3/fed. before sowing. The physical and chemical characteristics of the FYM used in this study are shown in Table (B).

Table (B): Physical and chemical analysis of farmyard manure.

FYM characteristics	Weight of 1 m^3 (Kg/m^3)	Organic matter (%)	C/N ratio	pH	N (%)	P (%)	K (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)
First season	454	68.15	21:1	7.25	1.73	0.62	1.27	1830	146	148
Second season	471	60.02	19:1	7.54	1.94	0.49	1.53	1652	123	99

Seeds receiving each of the radiation treatments (five treatments, including the control) were sown separately on November 1st 2003 and 2004, in the first and second seasons, respectively, in beds (1 X 1 m, with 5 rows/bed). Uniform seedlings of about 10 cm lengths were transplanted on 15th December to beds (3 X 3.5 m), with 7 rows/bed, at a spacing of 50 cm between plants, and a total of apart plants/ bed. A drip irrigation system was used for irrigation (drippers at a spacing of 50 cm, with a discharge rate of 4 L./hr per dripper). All plants received the usual agricultural practices. All treatments were replicated three times.

At the full flowering stage (on 15th March and 1st April, in the first and second seasons, respectively), the experiment was terminated and the following data were recorded:

-Plant height (cm)

-Number of branches/plant
- Diameter of the main stem (mm), measured 5 cm above soil surface
- Shoot dry weight per plant (gm)

A randomized complete blocks design was used in this factorial experiment, with three replicates (blocks), each containing 20 treatment combinations (4 FYM rates X 5 gamma radiation doses). The plot area was 10.5 m^2. Analysis of variance for the final data was carried out, and the treatment means were compared using the "Least Significant Difference (L.S.D.)" test, according to Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

1- Plant height

The data in Table (1) show that pre-sowing gamma irradiation of lovage seeds, soil application of farm yard manure (FYM) and their interaction had statistically significant effects on the height of lovage plants. In both seasons, plant height was increased steadily by increasing gamma doses from 0.0 up to 60 Gy, then it declined as the gamma radiation dose was raised to the highest level (80 Gy). Stimulation of plant growth as a result of irradiation with gamma rays, especially at low doses, has been reported by several investigators. Abd-El-Wahab (2000) indicated that gamma radiation at 10, 20, 40 and 80 Gray increased plant height of coriander plants, while Nassar *et al.* (2004) stated that irradiation of chamomile seeds before sowing increased plant height.

Increasing application rate of farm yard manure (FYM) to the soil from 0.0 m^3/fed. up to 40 m^3/fed. resulted in gradual and significant increases in plant height (in both seasons). These results are in accordance with these obtained by Khandkar and Nigam (1996), those reported that plant height of *Zingiber officinale* was greater with FYM than without it, especially at the rate of 3300 kg/ha. Also, El-Ghadban (1998) stated that addition of cattle manure at the rate of 40 or 60 m^3/fed. increased height of *Origanum majorana* plants.

Regarding the interaction between the effects of gamma radiation and FYM treatments, the results presented in Table (1) show that, in most cases, the different treatment combinations increased plant height, compared to that of plants which received no radiation or FYM treatments (control). The only exception to this general trend was recorded on plants receiving the highest radiation dose (80 Gy) without FYM, which were shorter than the control. Among plants receiving the different combinations of gamma radiation and FYM treatments, the highest increase in plant height (in both seasons) was obtained when irradiation using 60 Gy of gamma rays was combined with the application of FYM at 40 m^3/fed.

2- Number of branches/plant

Data in Table (2) revealed that gamma irradiation and fertilization with FYM, as well as the interaction between these two factors, had considerable effects on the number of branches per plant. In both seasons, the mean number of branches/plant was steadily and significantly increased as the radiation dose was raised from 0 (control) to 20, 40 or 60 Gy. Accordingly, the highest number of branches was obtained when the seeds had been treated with gamma radiation at 60 Gy, whereas the number of branches on plants receiving the highest radiation dose (80 Gy) was insignificantly higher than that found on control plants. The general increase in the branching of plants receiving radiation treatments, especially at relatively low doses, is in agreement with the findings of Youssef and Moussa (1998) on chamomile plants, who reported that irradiation of chamomile seeds before sowing increased number of branches.

Also, Noby (2002) showed that the number of branches on *Delphinium* and *Mathiola* plants was affected by pre-sowing gamma irradiation, as the average number of branches per plant was significantly increased by application of 25 Gy of gamma radiation. Similarly, Ramadan (2003) reported that the

number of branches on fennel plants was generally increased by gamma irradiation at doses of 250, 500, 750, 1000, 1250 and 1500 rad, with the most effective doses being 1000 to 1250 rad, while Nassar *et al.* (2004) found that the number of branches on chamomile plants increased with increasing the dose of pre-sowing gamma irradiation.

The organic fertilization (FYM) treatments also had a generally favorable effect on branching of lovage plants. In both seasons, the number of branches per plant was increased steadily as the FYM application rate was increased, with the highest FYM application rate (40 m^3/fed.) giving the highest values in the two seasons. Similar results have been reported by Jacoub (1999), who found that organic fertilizers significantly increased the number of branches on *Thymus vulgaris* plants.

Regarding the interaction between the effects of gamma radiation and FYM treatments, the data in Table (2) show that combining gamma radiation and FYM treatments markedly increased the number of branches on lovage plants in both seasons, compared to that of plants receiving no radiation or FYM treatments. Among the different treatment combinations, the most effective one in terms of promoting branching was using gamma radiation at 60 Gy, and applying FYM at 40 m^3/fed. Plants receiving these treatments had the highest number of branches in both seasons, compared to plants receiving any other combination of radiation and FYM treatments.

Table (1): Effect of gamma radiation and farm yard manure on height (cm) of lovage plants during the 2003/2004 and 2004/2005 seasons.

FYM (m^3/fed.)	Plant height (cm)					
	Gamma Rays (Gy)					Mean
	0	20	40	60	80	
First season						
0	59.3	64.7	70.7	77.1	55.0	65.4
20	70.7	77.6	79.1	80.9	68.0	75.3
30	74.1	80.9	82.9	88.1	72.5	79.7
40	79.7	84.9	87.5	103.3	74.4	86.0
Mean	71.0	77.0	80.1	87.3	68.0	
L.S.D. at 5%: Gamma Rays	1.7					
F.Y.M	2.2					
Interaction	3.0					
Second season						
0	56.7	70.9	70.8	74.9	54.5	65.6
20	70.6	75.0	80.1	87.4	67.9	76.4
30	74.9	78.2	81.4	92.3	71.9	79.9
40	81.1	87.6	88.1	104.8	76.3	87.6
Mean	70.8	77.9	80.3	89.8	76.6	
L.S.D. at 5%: Gamma Rays	2.1					
F.Y.M	2.5					
Interaction	3.2					

3- Diameter of main stem

Data in Table (3) clearly show the significant response of stem thickness of lovage plants to gamma irradiation and /or soil application of FYM. Gamma rays at doses of up to 60 Gy significantly increased stem thickness, whereas increasing the radiation dose to 80 Gy decreased stem diameter, compared to that of plants receiving lower doses (especially in the second season).

Table (2): Effect of gamma radiation and/ or farm yard manure on number of branches of lovage plant.

FYM (m^3/fed.)	Number of branches/plant					
	Gamma Rays (Gy)					Mean
	0	20	40	60	80	
	First season					
0	7.7	8.7	9.0	10.3	7.3	8.6
20	8.7	10.3	10.3	13.0	9.0	10.3
30	9.7	12.3	13.0	15.7	10.0	12.1
40	12.0	14.3	16.7	19.3	12.7	15.0
Mean	9.5	11.4	12.3	14.6	9.8	
L.S.D. at 5%: Gamma Rays	0.6					
F.Y.M	0.7					
Interaction	1.4					
	Second season					
0	6.7	8.3	9.0	11.3	6.0	8.3
20	8.0	9.3	9.0	10.3	8.7	9.1
30	9.7	11.3	12.0	14.0	10.3	11.5
40	9.7	11.7	14.7	18.7	10.7	13.1
Mean	8.5	10.2	11.2	13.6	8.9	
L.S.D. at 5%: Gamma Rays	0.7					
F.Y.M	0.8					
Interaction	1.6					

Table (3): Effect of gamma radiation and/ or farm yard manure on stem diameter (mm). of lovage plant.

FYM (m^3/fed.)	Stem diameter (mm)					
	Gamma Rays (Gy)					Mean
	0	20	40	60	80	
	First season					
0	7.53	10.63	13.10	14.03	7.50	10.56
20	17.73	18.40	19.27	20.77	18.23	18.88
30	19.63	20.33	20.70	21.50	19.57	20.35
40	19.97	20.67	21.00	24.27	20.57	21.39
Mean	16.22	17.51	18.52	20.14	16.47	
L.S.D. at 5%: Gamma Rays	0.06					
F.Y.M	0.06					
Interaction	0.13					
	Second season					
0	8.07	10.43	11.37	12.33	7.67	9.97
20	17.87	19.83	19.17	20.40	16.87	18.83
30	19.43	20.97	21.73	23.30	17.00	20.49
40	20.50	23.20	25.83	27.83	18.20	23.11
Mean	16.47	16.81	19.53	20.97	14.93	
L.S.D. at 5%: Gamma Rays	0.06					
F.Y.M	0.06					
Interaction	0.13					

The generally favorable effect of gamma radiation on stem diameter is in agreement with the results reported by Abd-El-Wahab (2000), who revealed that stem thickness of coriander plants was markedly and significantly increased by gamma radiation treatments, with a peak at 40 Gy. Also, Noby (2002) found that irradiation with of 25 gray was the only significant effective dose, which significantly increased stem diameter of *Delphinium* plants, compared to the control.

As with the other vegetative growth parameters, stem diameter also showed steady and significant increases with raising the FYM application rates. Similar results have been reported by Uzun *et al.* (2007), who found that aubergine (*Solanum melongena* L.) plants grown in a medium containing decomposed farmyard manure, sieved garden soil and sand (2 mm) at 1:1:1 gave the highest stem diameter.

Regarding the interaction between the effects of the two factors (gamma irradiation and FYM application), it is clear that most of the different combinations of gamma ray treatments (20, 40 and 60 Gy) and FYM application rates (20, 30 or 40 m^3/fed.) had a generally favorable effect in terms of increasing stem diameter, compared to plants receiving no gamma radiation or FYM treatments. In both seasons, the thickest stems were those of plants receiving gamma radiation at 60 Gy and FYM at 40 m^3/fed.

In general, it can be stated that stem thickness of lovage plants was markedly increased by the tested gamma radiation doses (especially the 60 Gy dose), and by FYM application (especially at 40 m^3/fed.), as well as the combination of these two treatments (gamma radiation at 60 Gy x FYM at 40 m^3/fed.).

4- Shoot dry weight/plant

Dry matter yield is considered a real indication of plant growth. As shown by the data in Table (4), dry matter accumulation in lovage shoots was influenced by pre-sowing gamma irradiation and / or farm yard manure fertilization. The effects of gamma radiation, FYM fertilization and their interaction on dry weight of shoots was statistically significant in the two seasons. Mean shoots dry weight showed steady and significant increases as the gamma radiation dose was increased up to 60 Gy, but was decreased at the highest tested dose (80 Gy). On the other hand, all the FYM application rates significantly increased the dry weight of shoots, compared to the control, with the highest FYM application rate (40 m^3/fed.) giving the highest values in both seasons. Regarding the interaction between the effects of gamma radiation and FYM application, the data in Table (4) show that most of the plants receiving different combinations of these two factors showed a significant increases in their shoots dry weight, compared to the control, with the highest value (in both seasons) resulting from gamma irradiation at 60 GY, combined with application of FYM at 40 m^3/fed.

Similar increases in vegetative growth parameters as a result of gamma ray treatments have been reported by Youssef and Moussa (1998), who observed that gamma irradiation doses up to 15 k-rad significantly increased the fresh weight of chamomile plants. Also, Abd-El-Wahab (2000) showed that average dry weight of coriander shoots was gradually increased as the dose of gamma rays was raised from 0 up to 40 Gy, but declined at 80 Gy. Noby (2002) stated that gamma ray doses of 25 and 50 gray significantly increased leaves dry weight in *Delphinium* and *Mathiola*, whereas the dose of 100 gray significantly generally decreased leaves dry weight of the two plants. Nassar *et al.* (2004) found that pre-sowing gamma irradiation at 10 k-rad. caused an increase in dry weight of chamomile shoots. The favorable effect of FYM treatments on the vegetative growth of lovage plants is in agreement with the findings of El-Ghadban (1998), who reported that organic fertilizers (farm yard manure and poultry manure) increased fresh and dry weight of *Origanum majorana* herb, and Sakr (2001), who showed that the highest dose of different organic manures increased herb dry weight of *Mentha piperita* plants.

Table (4): Effect of gamma radiation and/ or farm yard manure on shoots dry weight (gm) of lovage plant.

FYM (m^3/fed.)	Shoots dry weight (gm)					
	Gamma Rays (Gy)					Mean
	0	20	40	60	80	
	First season					
0	51.8	54.5	57.0	61.2	55.2	55.9
20	59.8	64.8	65.8	71.8	63.2	65.1
30	61.4	72.1	72.9	76.8	64.1	69.5
40	63.5	76.8	76.5	90.1	65.7	74.5
Mean	59.1	67.1	68.0	74.9	62.1	
L.S.D. at 5%: Gamma Rays	1.756					
F.Y.M	1.963					
Interaction	3.926					
	Second season					
0	48.5	61.8	64.4	70.4	41.1	57.2
20	50.1	64.8	66.8	74.2	44.4	60.1
30	57.6	67.2	70.8	77.8	56.9	66.1
40	72.8	76.4	77.5	94.1	67.8	77.7
Mean	57.3	67.5	69.9	79.1	52.5	
L.S.D. at 5%: Gamma Rays	1.849					
F.Y.M	2.067					
Interaction	4.135					

CONCLUSION

From the results recorded in the two seasons, it could be concluded that a marked stimulation of the different vegetative growth parameters of lovage plants (plant height, number of branches/plant, stem thickness and shoots dry weight) could be achieved by raising the doses of pre-sowing gamma irradiation of seeds (up to 60 Gy, which gave the maximum effect), and/or by application of FYM fertilization (especially at 40 m^3/fed.). This trend could be attributed to the stimulation caused by low gamma doses and FYM of the physiological and biochemical processes in the plant, viz., activation of enzymatic systems, sustaining the action of plant hormones, and enhancement of the metabolism of different components in the plant.

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تأثير الإشعاع والتسميد العضوى على نمو نبات اللوفاج

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أجرى هذا البحث خلال موسمين متتاليين ٢٠٠٣/٢٠٠٤، ٢٠٠٤/٢٠٠٥ بمزرعة النباتات الطبية - مركز البحوث النووية بأنشاص لدراسة تأثير كل من تشعيع بذور اللوفاج بأشعة جاما قبل الزراعة بجرعات (صفر، ٢٠، ٤٠، ٦٠، ٨٠ جراى) و التسميد العضوى بسماد الماشية للتربة بمعدل (صفر، ٢٠، ٣٠، ٤٠ متر مكعب للفدان) و التأثير المتداخل بينهما على نمو نبات اللوفاج. وقد أظهرت النتائج حدوث زيادة معنوية فى طول النبات، عدد الأفرع، سمك الساق الرئيسية والوزن الجاف للنبات نتيجة لمعاملات الإشعاع فى كلا الموسمين وكان أفضل معاملة للإشعاع هى تشعيع البذور قبل الزراعة بأشعة جاما بجرعة ٦٠ جراى. أما بالنسبة لسماد الماشية فقد أوضحت النتائج حدوث زيادة فى القياسات السابقة بزيادة معدل التسميد العضوى بسماد الماشية وكانت أفضل معاملة هى ٤٠ متر مكعب للفدان قبل الزراعة وذلك فى كلا الموسمين.

وبالنسبة للتأثير المتداخل لكلا العاملين فقد أوضحت النتائج أنه كان له تأثير إيجابى على نمو نباتات اللوفاج وكانت أفضل معاملة هى (٦٠ جراى x ٤٠ متر مكعب سماد عضوى) وذلك فى كلا الموسمين.