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EFFECT OF GAMMA RAYS ON SEED GERMINATION AND SEEDLING GROWTH OF SOME TIMBER TREES

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ABSTRACT

Two irradiation trials were conducted during two successive seasons of 2001/2002 and 2002/2003 to study, the effect of gamma irradiation doses ranging from 0 to 25 k. rad on seeds germination and seedling growth of (*Pinus pinea, Cupressus sempervirens, Khaya senegalensis, Azaderachta indica and Jatropha curcas*).

The results were summarized as follows:

1 The exposed treatments at 5 and 10 k.rad doses were caused the best values in seed germination percentages and seedling height as of vegetative growth also total carbohydrate contents and total protein percentages were significantly increased at all seedling in both seasons.

2 Seed germination percentage and seedling height decreased by using dose up to 10 k. rad specially in *Cupressus sempervirens, Khaya senegalensis*, and *Pinus pinea*. But *Azaderachta indica* and *Jatropha curcas* tolernated the radiation up to 15 k. rad compared with control.

3 The worest influence of gamma rays was observed at 25 k.rad dose at which there was no germination in all seeds. In this concern, 20 k.rad dose caused a significant decrease at all recorded values.

4 *Khaya senegalensis* seeds had the most sensitive gamma rays doses. Where low levels of 1, 2 and 5 k.rad doses were caused a significant increase in seed germination, carbohydrates content and total protein.

5 Germination percentage of seeds and total protein content of seedling increased significantly in linear as the increasing gamma rays doses had been raised from 1 to 10 k.rad compared with control in all species, whereas the values decreased at 15 k.

INTRODUCTION

Gamma rays play a great role in inducing the genetic changes in DNA in different crop plants and chemical composition of plants. It seems that the sensitivity to gamma rays differs from variety to another. Therefore, the experiments must be conducted to detect the radio sensitivity of different developed cultivar, Yanuklov (1979, Dobrev (1986), Syamsuwida (1986), Molotkov *et al* (1988), Sharma *et al.* (1990), Littvay, (1994). El-Esawy (1995)

and El-Shouny *et al.* (2001), reported that the effect of gamma rays is differed according to the different doses of gamma rays and the growth and chemical composition were increased by application of low doses and decreased with high doses of gamma rays while bad influences were exhibited at 20 k. rad doses.

The present study was carried out to investigate the influence of wide range of gamma rays doses on seed germination, seedling growth and chemical composition (carbohydrates and protein).

MATERIALS AND METHODS

This study was conducted at the Experimental Area of Horticultural Research Station at El-Kanater region, Qalyoubia Governorate through two successive seasons of 2001/2002 and 2002/2003.

The objectives of this study are to investigate the effect of gamma rays on seed germination, seedling growth and chemical composition of some timber trees (*Pinus pinea, Cupressus sempervirens, Khaya senegalensis, Azaderachta indica and Jatropha curcas*). Seeds were collected from Horticultural Research Station at EL-Kanater region and Botanical Garden in Asswan. Both the seeds of (*Khaya senegalensis, Cupressus sempervirnes*) were cultivated on March 1st 2001 and 2002 on the first and second seasons, respectively but the seeds of (*Azaderachta indica, Pinus pinea* and *Jatropha curcas*) were sown on September 1st 2001 and 2002 in the first and second season, respectively. The seeds were sown in pots of 40 cm diameter.

Treatments of irradiation:

The dry seeds were backed in paper bags and exposed to different doses of gamma rays namely 1, 2, 5, 10, 15, 20, 25 k. rad from a 60 co source at rate of 316 rad/min at the middle Eastern Regional Radiosotope Center for the Arab Countries at Dokki, Giza.

Soil used:

The loamy soil is used in these experiments which was analyzed physically and chemically before beginning of the experiment according to the pipette method described.

Procedures:

Seeds which were exposed to radiation were sown in pots (20 seed/pot) covered by 1 cm soil, and irrigated with tap water twice weekly and germinated seeds (%) had been recorded. The procedures continued for 10 months in both seasons.

The layout of the experiment:

The pots were distributed in a split plot design in which the different doses of rays were the main plot, while the species were the sub-plot. Three replicate were included in each treatment and each replicate was represented with three pots.

The following vegetative growth parameters were recorded:

1- Germination percentage was calculated in each treatment using the following formula.

$$\frac{\text{No. of germinated seeds}}{\text{No. of total seeds}} \times 100$$

2- Seedling height was measured in cm at the terminal of experiment.

Chemical composition:

1-Determination of total carbohydrates:

Total carbohydrates percentages in whole plant were determined according to Smith *et al.* (1956).

Total nitrogen and crude protein:

Total nitrogen content in dried whole plant samples was estimated by the modified micro-kjeldahl method as described by Pregl (1954). The crude protein percentage was collected by multiplying the total organic nitrogen by 6.25.

Statistical analysis:

The obtained data were analyzed statistically by using Duncan's Multiple Range Test according to Snedecor and Cochran (1974).

RESULTS AND DISCUSSION

1. Effect of gamma rays on seed germination percentage:

Data presented in Table (1) and Fig. (1) cleared obviously that gamma irradiation was more effective on seed germination as it significantly increased gradually in positive linear with the increases of irradiation as the doses were raised up to 10 k. rad. then the values decreased at high doses in spite of, the dose of 15 k. rad was better than those of control. This trend was pronounced with the used species in the two seasons. The best treatment was found for species of *Cupressus sempervirens, Pinus pinea, Azaderachta indica* and *Jatropha curcas,* while the best dose was 5 k. rad exhibited with *Khaya senegalensis.* It can be concluded also that the dose of 25 k.rad gamma rays did not give any seed germination. These results were in harmony with the finding of Sharma *et al.,* (1990) they showed that the effect of gamma rays by using doses ranging from 0 to 1, 2, 4, and 8 k.rad) decreased slightly seed germination percentage with increasing radiation dose Pandy *et al.* (1998) show that the dry seeds of *Jatropha curcas* irradiated by gamma rays at 6, 12, 18 and 24 k.rad, they found that the seed germination and growth had been influenced positively by increasing irradiation dose.

2. Influence of gamma rays on seedling height:

Data presented in Table (2) and Fig. (2) show that gamma irradiation dose from 1 k. rad to 10 k.rad caused an increase in seedling height by about 29.23, 32.0, 28.0, 20.33 cm. and 28.0, 33.0, 36.0, 24.0 cm for *Cupressus sempervirens,* while 17.0, 16.67, 19.33, 20.67 and 17.33, 17.33, 20.00 for *Pinus pinea,* in both season.

Table (1): Effect of gamma rays doses on seed germination (%) *of Cupressus sempervirens., Pinus pinea., Khaya senegalensis Azaderachta indica., and Jatropha curcas.*

Seeds germination (%)										
Season 2001										
Treatments	*C. sempervirens*		*P. pinea*		*K. senegalensis*		*A. indica*		*J. curcas*	
	%	S. G. ch. %*	%	S. G. ch. %*	%	S. G. ch. %*	%	S. G. ch. %*	%	S. G. ch. %*
Control	69.67C	100.00	64.33E	100.00	52.22D	100.00	64.33C	100.00	69.45E	100.00
1 k.rad	80.33B	115.30	70.67CD	109.86	65.56C	125.55	65.83C	102.33	75.00D	107.99
2 k.rad	82.00B	117.70	74.33C	115.54	66.67C	127.67	73.17B	113.74	82.78C	119.19
5 k.rad	86.33A	123.91	82.33B	127.98	91.94A	176.06	86.33A	134.20	89.00B	128.15
10 k.rad	88.50A	127.03	89.00A	138.35	85.52B	163.77	90.50A	140.68	94.44A	135.98
15 k.rad	69.50C	99.76	68.67D	106.75	54.42D	104.21	75.67B	117.63	80.56C	116.00
20 k.rad	52.83D	75.83	60.67E	94.31	46.11E	88.30	53.17D	82.65	52.78F	76.00
25 k.rad	N.G.		N.G.		N.G.		N.G.		N.G.	
L.SD at 0.05	2.64		4.26		4.77		4.59		4.23	
Season 2002										
Control	66.00E	100.00	52.00E	100.00	51.00D	100.00	63.67F	100.00	67.33E	100.00
1 k.rad	71.00D	107.58	65.17D	125.33	58.33C	114.31	76.00D	119.37	71.67D	106.45
2 k.rad	79.00B	119.70	74.00C	142.31	77.33B	151.63	84.33B	132.45	81.00C	120.30
5 k.rad	80.50B	121.97	87.00B	167.31	89.00A	174.51	90.00A	141.35	88.00B	130.70
10 k.rad	88.67A	134.35	91.67A	176.29	79.00B	154.90	93.67A	147.12	92.33A	137.13
15 k.rad	76.17C	115.41	74.33C	142.94	61.00C	119.61	80.33C	126.17	88.67B	131.69
20 k.rad	51.67F	78.29	50.17E	96.48	43.00E	84.31	70.33E	110.46	71.67D	106.45
25 k.rad	N.G.		N.G.		N.G.		N.G.		N.G.	
L.SD at 0.05	2.36		2.85		3.45		3.95		2.60	

This analysis was carried out using Duncan's Multiple Range Test.

The values have the same letter are not significant different at 0.05 probability level.

* S. G. Ch. = Seed germination changes % as relation to the control

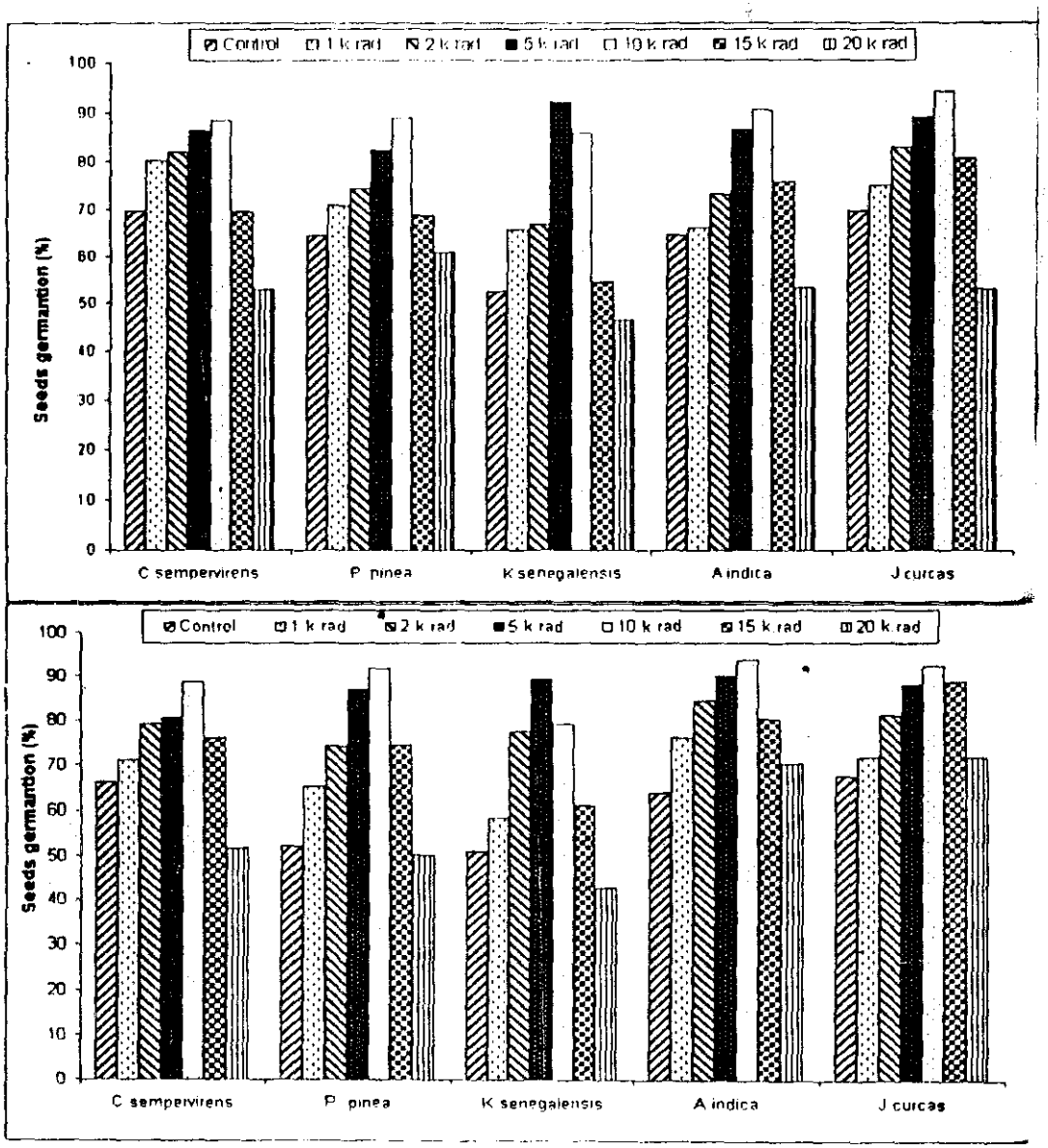

Fig (1). Effect of gamma rays dòses on seed germination (%) of *Cupressus sempervirens., Pinus pinea., Khaya senegalensis., Azaderachta indica., and Jatropha curcas*

Table (2): Effect of gamma rays doses on seedling height (Cm) of Cupressus sempervirens., Pinus pinea., Khaya senegalensis *Azaderachta indica., and Jatropha curcas.*

Seedling height (Cm)										
Season 2001										
Treatments	*C. sempervirens*		*P. pinea*		*K. senegalensis*		*A. indica*		*J. curcas*	
	Cm.	S. G. ch. %*	Cm.	S. G. ch. %*	Cm.	S. G. ch. %*	Cm.	S. G. ch. %*	Cm.	S. G. ch. %*
Control	15.67D	100.00	16.33B	100.00	15.67B	100.00	25.33EF	100.00	16.00C	100.00
1 k.rad	29.33AB	187.17	17.00B	104.10	17.33B	110.59	27.00DE	106.59	17.00C	106.25
2 k.rad	32.00A	204.21	16.67B	102.08	17.33B	110.59	28.67CD	113.19	19.67B	122.94
5 k.rad	28.00B	178.69	19.33A	118.37	20.00A	127.63	44.33B	175.01	20.00B	125.00
10 k.rad	20.33C	129.74	20.67A	126.58	16.00B	102.11	55.67A	219.78	23.00A	143.75
15 k.rad	17.00D	108.49	16.00B	97.98	12.67C	80.86	31.00C	122.38	23.00A	143.75
20 k.rad	9.33E	59.54	5.68C	34.78	10.00D	63.82	23.33F	92.10	17.00C	106.25
L.SD at 0.05	2.81		1.83		1.35		3.16		2.43	
Season 2002										
Control	21.00E	100.00	15.67B	100.00	21.67CD	100.00	27.00D	100.00	15.33D	100.00
1 k.rad	28.00C$_e$	133.33	17.33B	110.59	23.33C	107.66	27.67D	102.48	17.67CD	115.26
2 k.rad	33.00B	157.14	17.33B	110.59	28.33B	130.73	31.00C	114.81	20.00BC	130.46
5 k.rad	36.00A	171.43	20.00A	127.63	31.67A	146.15	38.67B	143.22	21.00B	136.99
10 k.rad	24.00D	114.29	16.00B	102.11	20.00D	92.29	50.33A	186.41	24.67A	160.93
15 k.rad	17.67F	84.14	12.67C	80.86	15.00E	69.22	26.00DE	96.30	27.00A	176.13
20 k.rad	11.67G	55.57	10.00D	63.82	10.67F	49.24	24.00E	88.89	15.00D	97.85
L.SD at 0.05	1.46		1.87		1.74		2.42		2.57	

This analysis was carried out using Duncan's Multiple Range Test.

The values have the same letter are not significant different at 0.05 probability level.

* S. G. Ch. = Seed germination changes % as relation to the control.

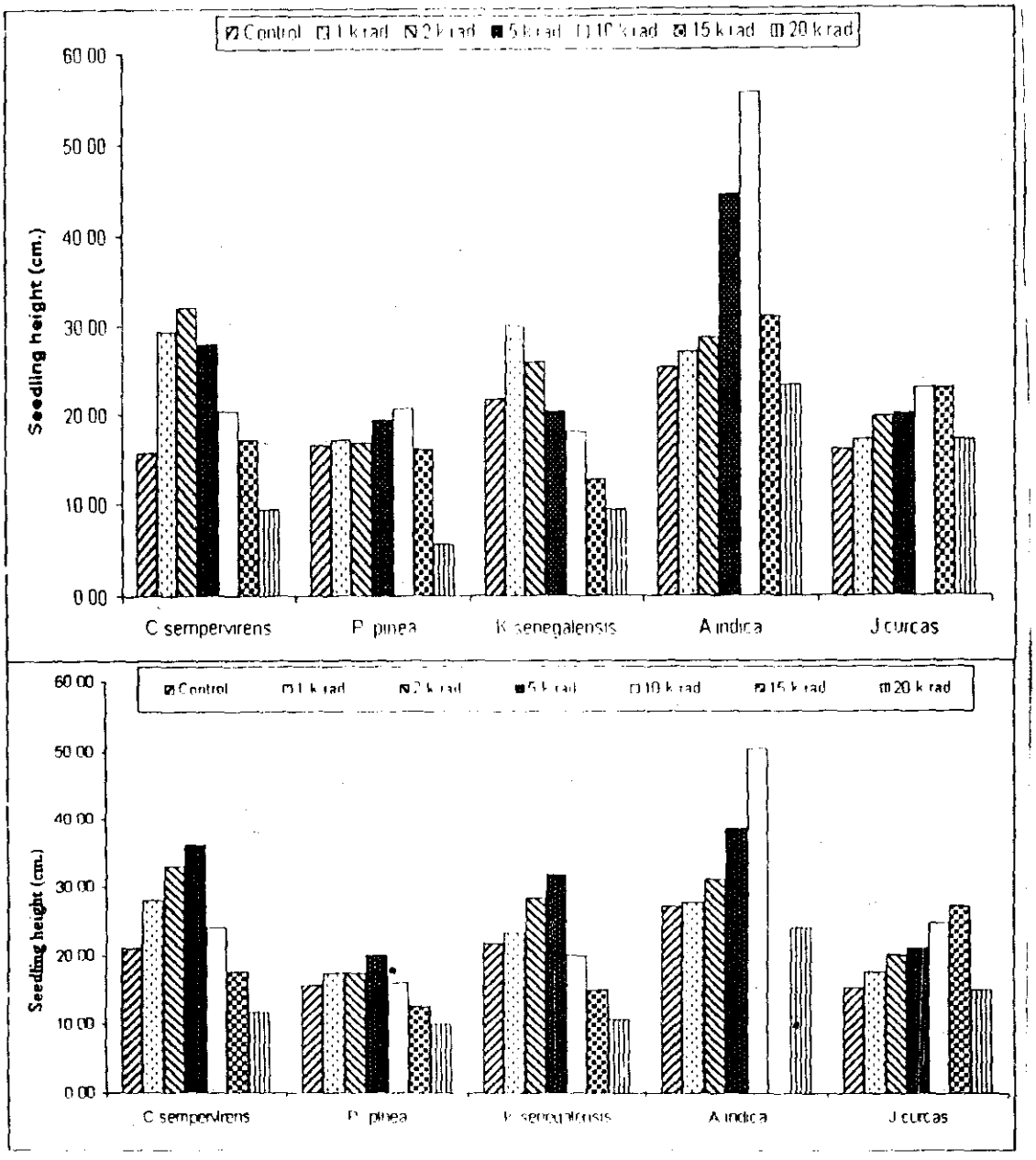

Fig (2). Effect of gamma rays doses on seedling height (Cm) of *Cupressus sempervirens., Pinus pinea., Khaya senegalensis., Azaderachta indica., and Jatropha curcas.*

However, seedling height of, Jatropha curcas increased by increase doses from 1 to 15 k.rad where the values were 17, 15.67, 20, 23, 23 cm and 17.67, 20, 12, 24.67, 27 cm in both seasons respectively, as this in *Azaderachta indica*, by the doses from 1 to 15 k.rad in the first season resulted the values of 27, 28.67, 44.33, 55.67, 31 cm and 27.67, 31, 38.67, 50.33 cm in the second season.

On the other hand, the application of 20 k.rad dose of gamma rays produced bad influence on seedling height of all species specially in *Pinus pinea* and *Khaya senegalensis*, where the reduction was 62.22% and 50.76 for the two plants, respectively compared with the control. These results were in accordance with the findings of Syamsuwid (1986). He studied the influence of gamma rays on *Acacia mangium* and *Pinus merkusii* and found that seedlings increased and vegetative growth was progressively reduced in both species by increasing doses of irradiation from 1 to 5 k.rad Molotkov *et al.* (1988) stated that treating dry seeds with gamma rays at 200-600 rad have a stimulating effect on seedling height and growth of *Pinus sylvestris*, El-Kholy (1987) planted irradiated seeds of *Hyoscyamus nuticus*, and found that doses up to 15 k.rad increased the seedling height. On the other hand, irradiation of *Datura innoxia* with gamma rays at 0.5-1 k.rad reduced the seedling height. This result agreed also with Hussein et al. (1955), El-Esawy (1955) found that the seedling height increased percentages by low gamma doses (5-20 Gy).

3. Effect of gamma rays doses on carbohydrates content:

Data concerning the effect of gamma irradiation on carbohydrate contents is presented in Table (3) and Fig. (3), the collected data show that carbohydrates content increased significantly with application of the high used doses of gamma irradiation on *Jatropha curcas, Pinus pinea, Azaderachta indica* and *Khaya senegalensis,* in the first and second season respectively, but there was no significant increase of carbohydrates content in *Cupressus sempervirens,* seedling with the exclusion of the dose 2 k.rad in the second season which pronounced an increase of 8% and 9% respectively as compared with the control. Concerning *Cupressus sempervirens* seedlings resulted in the highest percentages (26.36 and 27.91) with the treatment of 2 k.rad and 5 k.rad respectively. But the lowest percentages were 18.56 and 20.27 were obtained from using 20 k.rad dose in both seasons respectively.

Concerning the seedling of *Khaya senegalensis*, which exposed to gamma irradiation at 2 and 1 k.rad giving the highest values i.e 28.64 and 27.69 whereas, the lowest carbohydrates content (21.51 and 19.92) had bean found for the treated with 20 k.rad at the first and second seasons, respectively. But the seedlings of *Azaderachta indica* has been affected by increase the irradiation doses 1, 2, 5, 10 and 15 k.rad containing 24.68, 25.30, 25.55, 28.29 and 31.44 for these doses respectively in the second season. Whereas, in the first season, the highest values (31.15 and 30.30) were determined for the application with 5 and 10 k.rad, respectively. These results were in the same line of Sharma *et al.* (1990)they showed that using gamma rays at doses of (0, 1, 2, 4 and 8 k.rad) decreased carbohydrates with increasing radiation dose Pandy *et al.* (1998) showed that the seedling of *Jatropha curcas* irradiated with gamma rays at 6, 12,

18 and 24 k.rad and found that the carbohydrates content and growth had been influenced positively by increasing irradiation dose. Syamsuwid (1986) studied the influence of gamma rays on *Acacia mangium* and *Pinus merkusii*, and found that the carbohydrates content was progressively increased in both species by increasing doses of irradiation from 1 to 5 k.rad Molotkov *et al.* (1988) stated that treating dry seeds with gamma rays at 200 – 600 rad have a stimulating effect on total carbohydrates content of *Pinus sylvestris*, El-Kholy (1987) planted irradiated seeds of *Hyoscyamus nuticus*, and found that doses up to 15 k. rad increased the carbohydrates content. On the other hand, irradiation of *Datura innoxia* with gamma rays at 0.5-1 k.rad reduced the total carbohydrates this conclusion agreed with the result obtained by Hussein *et al.* (1995) also, El-Esawy (1995) found that carbohydrates content were increased at low gamma doses (5 – 20 Gy).

4. Influence of gamma rays on protein content of seedling:

Data presented in Table (4) and Fig. (4), revealed significant increase in total protein as a result of gamma rays ranging from 1 to 10 k.rad for the five species. In particular, a slight increase had been exhibited for *Cupressus sempervirens*, *Pinus pinea*, and *Azaderachta indica* in both seasons. On the other hand, the values of protein content for all species were significantly decreased by 20% lower than the control at the dose of 20 k.rad of gamma rays treatment. It is clear from the application irradiation doses ranged from 1 to 15 k.rad increased the protein content of the seedlings for all species. These results were in accordance with the finding of Sharma *et al.* (1990) showing that the effect of gamma rays by using doses (0, 1, 2, 4 and 8 k.rad) caused reduction protein content with increasing radiation dose Pandy *et al.* (1998) showed that the dry seeds of *Jatropha curcas* irradiated by gamma rays at 6, 12, 18 and 24 k.rad and found that the protein content had been affected positively by increasing irradiation dose. Syamsuwida (1986) studied that influence of gamma rays on *Acacia mangium* and *Pinus merkusii*, he found that the protein content was progressively increased by increasing doses of irradiation from 1 to 5 k.rad Molotkov *et al.* (1988) stated that treating dry seeds with gamma rays at 200-600 rad have a stimulating effect on total protein content of *Pinus sylvestris*. On the other hand, irradiation of *Datura innoxia* with gamma rays at 0.5-1 k.rad reduced the total protein this agreed with the result obtained by Hussein *et al.* (1995) also, El-Esawy (1995) found that protein content increased at low gamma doses (5-20 Gy).

Table (3): Effect of gamma rays doses on Carbohydrates contant (%) of Cupressus sempervirens., Pinus pinea., Khaya senegalensis *senegalensis., Azaderachta indica., and Jatropha curcas.*

Carbohydrates contants (%)										
Season 2001										
Treatments	*C. sempervirens*		*P. pinea*		*K. senegalensis*		*A. indica*		*J. curcas*	
	%	S. G. ch. %*	%	S. G. ch. %*	%	S. G. ch. %*	%	S. G. ch. %*	%	S. G. ch. %*
Control	24.47B	100.00	21.30E	100.00	26.71E	100.00	26.22F	100.00	16.46E	100.00
1 k.rad	21.41E	87.70	22.60B	106.10	28.03B	104.94	27.43E	104.61	18.07D	109.78
2 k.rad	26.36A	108.03	22.35C	104.93	28.64A	107.23	27.98D	106.71	22.75B	138.21
5 k.rad	21.99D	90.12	23.23A	109.06	27.79C	104.04	31.15A	118.80	24.28A	147.51
10 k.rad	22.74C	93.20	22.07D	103.62	27.36D	102.43	30.30B	115.56	20.62C	125.27
15 k.rad	20.47F	83.89	20.59F	96.67	23.15F	86.67	29.29C	111.71	15.83F	96.17
20 k.rad	18.56G	76.07	16.75G	78.64	21.51G	80.53	23.32G	88.94	13.92G	84.57
L.SD at 0.05	0.056		0.113		0.080		0.124		0.292	
Season 2002										
Control	25.50C	100.00	22.37D	100.00	25.24B	100.00	16.59D	100.00	18.43E	100.00
1 k.rad	25.93C	101.69	23.62C	105.59	27.69A	109.71	24.68C	148.76	21.18D	114.92
2 k.rad	26.74A-C	104.86	25.33B	113.23	27.60A	109.35	25.30BC	152.50	24.21B	131.36
5 k.rad	27.91A	109.45	28.00A	125.17	25.92B	102.69	25.55BC	154.01	26.58A	144.22
10 k.rad	27.66AB	108.47	27.67A	123.69	25.05B	99.25	28.29B	170.52	25.95A	140.80
15 k.rad	26.41BC	103.57	21.79D	97.41	22.82C	90.41	31.44A	189.51	22.27C	120.84
20 k.rad	20.27D	79.49	20.24E	90.48	19.92D	78.92	19.00D	114.53	17.58E	95.39
L.SD at 0.05	0.416		0.823		1.127		0.994		1.024	

This analysis was carried out using Duncan's Multiple Range Test.

The values have the same letter are not significant different at 0.05 probability level.

* S. G. Ch. = Seed germination changes % as relation to the control.

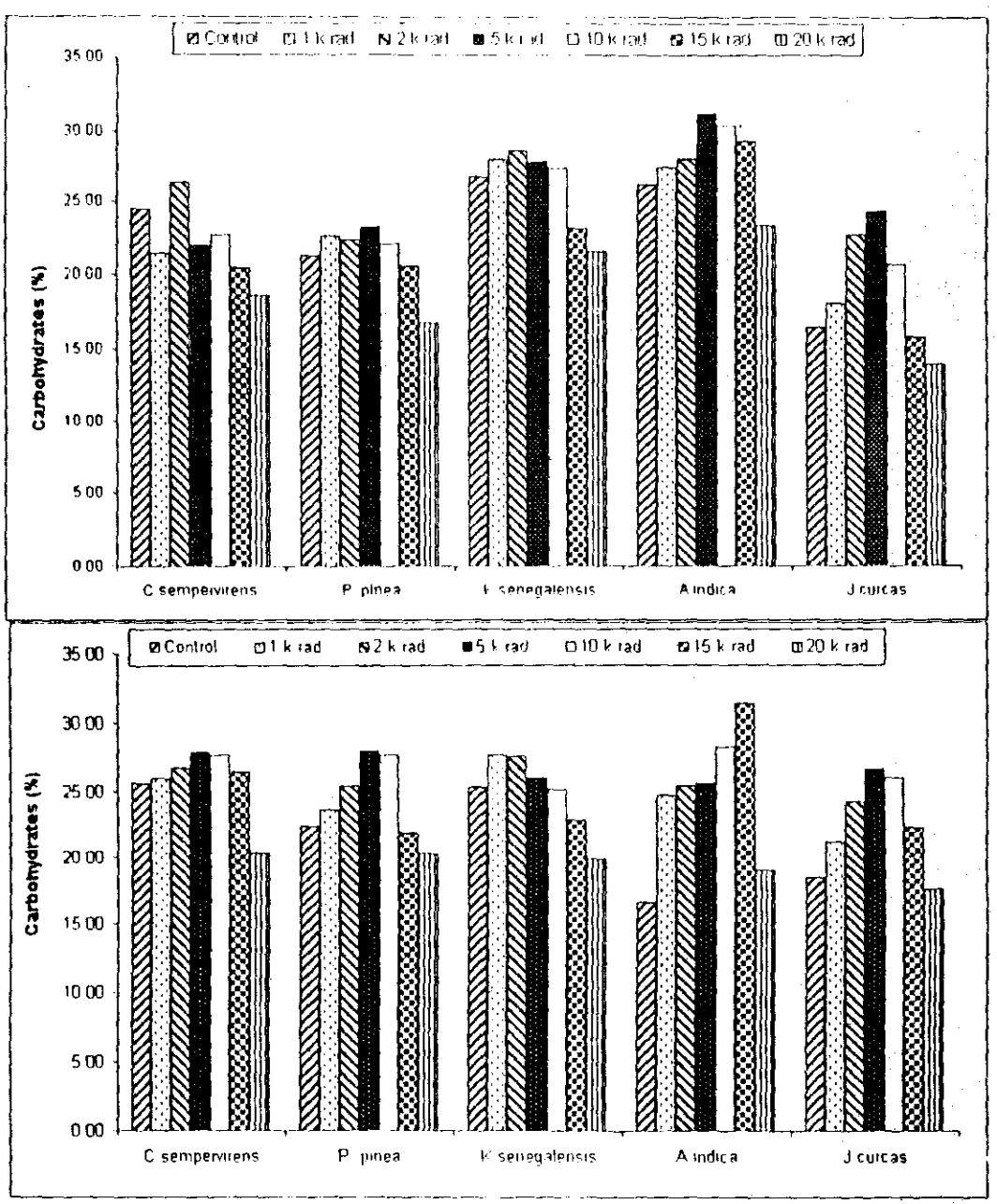

Fig (3). Effect of gamma rays doses on carbohydrates (%) of *Cupressus sempervirens., Pinus pinea., Khaya senegalensis., Azaderachta indica., and Jatropha curcas.*

Table (4): Effect of gamma rays doses on Total proten (%) of Cupressus sempervirens., Pinus pinea., Khaya senegalensis *Azaderachta indica., and Jatropha curcas.*

Total protein (%)										
Season 2001										
Treatments	*C. sempervirens*		*P. pinea*		*K. senegalensis*		*A. indica*		*J. curcas*	
	%	S. G. ch. %*	%	S. G. ch. %*	%	S. G. ch. %*	%	S. G. ch. %*	%	S. G. ch. %*
Control	0.50C	100.00	0.70C	100.00	0.78BC	100.00	0.72D	100.00	0.90B	100.00
1 k.rad	0.44C	88.00	0.82B	117.14	0.78BC	100.00	0.86C	119.44	0.86BC	95.56
2 k.rad	0.50C	100.00	0.90B	128.57	0.92A	117.95	1.04B	144.44	0.78CD	86.67
5 k.rad	0.78C	156.00	1.06A	151.43	0.88AB	112.82	1.08B	150.00	0.82B-D	91.11
10 k.rad	0.86A	172.00	1.14A	162.86	0.90A	115.38	1.20A	166.67	1.10A	122.22
15 k.rad	0.72B	144.00	0.80B	114.29	0.74C	94.87	0.78CD	108.33	0.74A	82.22
20 k.rad	0.42C	84.00	0.66C	94.29	0.60D	76.92	0.54E	75.00	0.66E	73.33
L.SD at 0.05	0.080		0.097		0.113		0.026		0.032	
Season 2002										
Control	0.46D	100.00	0.68C	100.00	0.80C	100.00	0.80C	100.00	0.88BC	100.00
1 k.rad	0.50CD	108.70	0.72C	105.88	0.80C	100.00	0.82C	102.50	0.94B	106.82
2 k.rad	0.56C	121.74	0.84BC	123.53	0.90B	112.50	1.08B	135.00	0.88BC	100.00
5 k.rad	0.74B	160.87	1.08A	158.82	0.98A	122.50	1.08B	135.00	0.94B	106.82
10 k.rad	0.84A	182.61	0.96AB	141.18	0.86BC	107.50	1.16A	145.00	1.14A	129.55
15 k.rad	0.76B	165.22	0.84BC	123.53	0.80C	100.00	0.76C	95.00	0.82CD	93.18
20 k.rad	0.56C	121.74	0.72C	105.88	0.66D	82.50	0.48D	60.00	0.74D	84.09
L.SD at 0.05	0.069		0.187		0.071		0.025		0.028	

This analysis was carried out using Duncan's Multiple Range Test.

The values have the same letter are not significant different at 0.05 probability level.

* S. G. Ch. = Seed germination changes % as relation to the control.

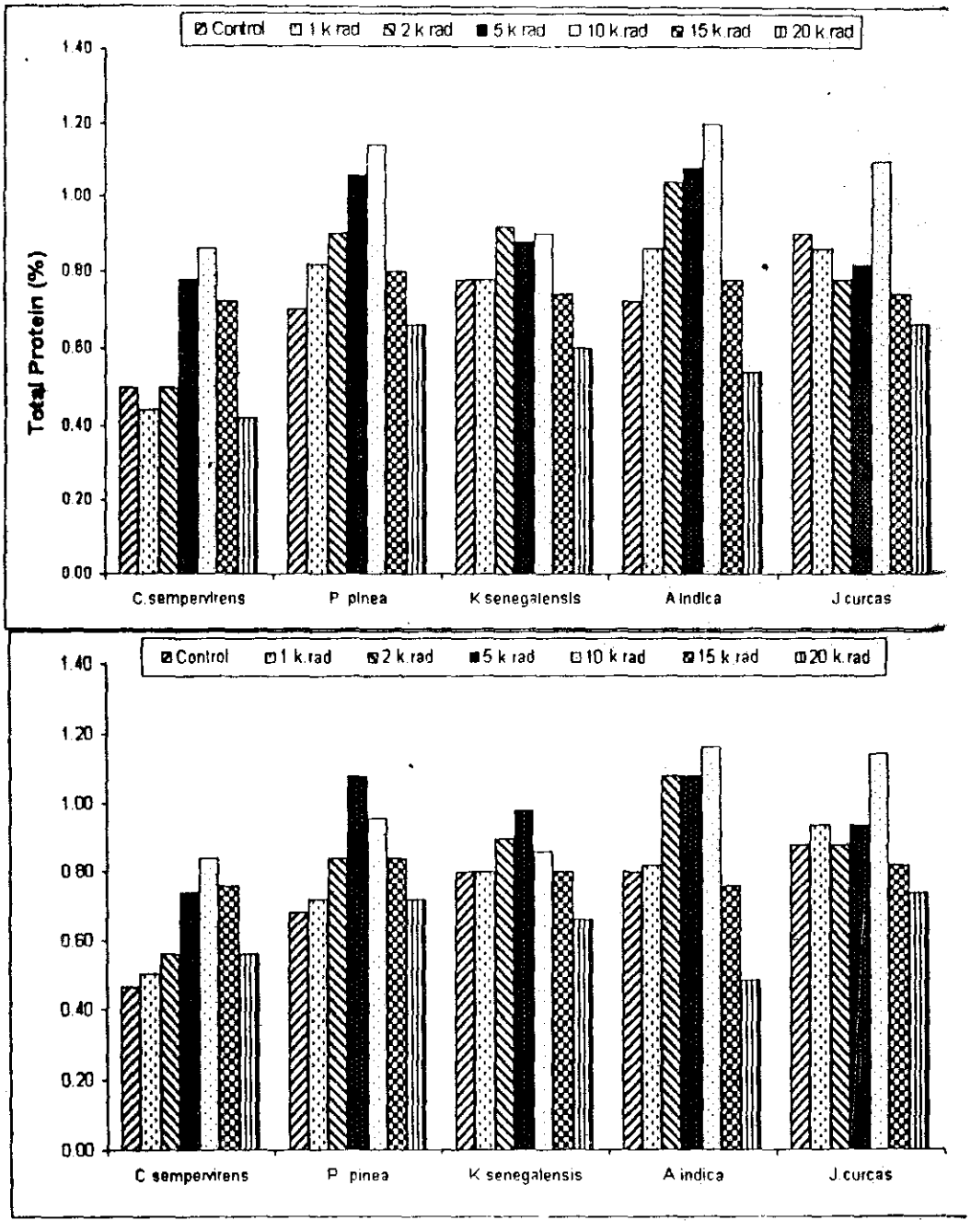

Fig (4). Effect of gamma rays doses on total protein (%) of *Cupressus sempervirens., Pinus pinea., Khaya senegalensis., Azaderachta indica., and Jatropha curcas.*

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تأثير أشعة جاما على إنبات البذور ونمو شتلات بعض أنواع الأشجار الخشبية

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فى خلال موسمين متتاليين ٢٠٠١/٢٠٠٢، ٢٠٠٢/٢٠٠٣ تم زراعة البذور المعرضة لجرعات من أشعة جاما صفر، ١، ٢، ٥، ١٠، ١٥، ٢٠، ٢٥ كيلوراد لكل من السرو والصنوبر والكايا والنيم والجاتروفا مقارنة بالكنترول وكانت النتائج كما يلى:ــ

١. أدت المعاملة بأشعة جاما بالجرعتين ٥، ١٠ كيلوراد الى الحصول على أفضل القيم فى النسبة المئوية للإنبات وارتفاع الشتلات كمؤشر للنمو الخضرى وكذلك ارتفاع نسبة الكربوهيدرات والبروتين فى معظم الشتلات المعاملة بذورها بأشعة جاما فى كلا الموسمين.

٢. إنخفضت نسبة الإنبات وطول الشتلات بزيادة جرعة الإشعاع لأكثر من ١٠ كيلوراد وخاصة فى السرو والصنوبر والكايا وحدث ذلك أيضا مع الجرعات الأكثر من ١٥ كيلوراد مع الجاتروفا والنيم.

٣. ظهر التأثير الضار لأشعة جاما بالجرعة ٢٥ كيلوراد متمثل فى عدم إنبات جميع بذور الأنواع المشععة، كما أدت الجرعة ٢٠ كيلوراد الى خفض معنوى فى كل من نسبة الإنبات وطور الشتلات ونسبة الكربوهيدرات والبروتين فى كل الأنواع.

٤. بذور الكايا كانت أكثر حساسية لجرعات الإشعاع حيث أدت الجرعات البسيطة ١، ٢، ٥ كيلوراد الى زيادة معنوية فى نسبة الإنبات ومحتوى الشتلات من الكربوهيدرات والبروتين.

٥. زادت النسبة المئوية للإنبات وكذلك البروتين زيادة تدريجية كلما زادت جرعة الإشعاع من ١ الى ١٥ كيلوراد على التوالى، وانخفض مع الجرعة ٢٠ كيلوراد ولكنها فى جميع الحالات أكبر من محتويات الشتلات التى لم تشعع بذورها.