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Effect of Low Dosage Gamma Irradiation on Emergence, Growth, Yield, and Sugar and Protein Content of Potato[1]

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Abstract. **'Russet Burbank' and 'Nampa' seed potatoes (*Solanum tuberosum* L.) were irradiated with gamma rays at 328 rads/minute for ¾, 1½, and 3 minutes for greenhouse studies and 167 rads/minute for 2, 4, and 7 minutes for field trials. The higher rates of irradiation delayed plant emergence and decreased tuber yield and tended to increase reducing sugar content of tubers. Total sugar content was variable depending on cultivar and culture. Number of stems and tubers, tuber size, and soluble protein of tubers produced by plants from irradiated seed pieces were unaffected by irradiation.**

Stimulation of higher plants by low dose radiation was noted following atomic bomb tests. Since that time considerable effort has been made to assess the possible value of this stimulation to agricultural crop production (1, 6).

Gamma ray irradiation effects sprouting and chemical composition of potato tubers (7, 8, 9, 10, 11). Recent studies revealed that low dosage gamma irradiation of seed pieces resulted in an increase in yield and vigor of the potato (2) and yam (3). We present here the effects of low dosage irradiation on growth and yield of potato plants grown from irradiated seed pieces and sugar and protein content of the tubers produced by these plants.

Foundation seed pieces of 'Russet Burbank' weighed 30-40 g and were not cut, while those of 'Nampa' weighed about 100 g and were halved longitudinally. Seed pieces were dusted with captan prior to planting and those used in the field study were desprouted before irradiation.

Uniform-sized seed pieces were irradiated with gamma rays from a cobalt-60 source; the sample container was rigged for continuous rotation to provide uniform exposure. The seed potatoes were planted immediately after irradiation.

Greenhouse study. After irradiation at 328 rads/min for ¾, 1½, and 3 min (246, 492 and 984 rads) the seed potatoes were planted in 25 cm plastic pots containing a 1 peat:1 sand:1 perlite mix. This soil mix also contained adequate Osmocote 14-14-14 for 90 days of culture, as well as lime and micronutrients. The potatoes were grown in a cooled greenhouse under natural light. Night temp in the greenhouse was maintained at 18.3°C. Stem emergence and growth of the plants was measured. After 90 days of growth the vines were cut off at soil level and the tubers remained in the soil for 10 days before harvest. Tuber wt, size, and number were measured at harvest and then subjected to chemical analysis.

Emergence of the plants of 'Russet Burbank' potato was delayed by irradiation of the seed with 492 and 984 rads, while emergence of 'Nampa' was delayed by irradiation of the seed with 984 rads of gamma rays when grown in the greenhouse (Table 1). The no. of stems per plant was not significantly influenced by irradiation.

Plants produced from seed pieces irradiated with 492 and 984 rads of gamma rays were shorter than the controls 14 days after planting. No significant differences in plant height among treatments were present after 52 and 87 days. No significant differences in tuber wt, number, or size were found.

Reducing sugars content of both cultivars was higher in tubers produced by plants grown from irradiated seed pieces (Table 1). Total sugar content was significantly increased in 'Nampa' but not in 'Russet Burbank'. Other investigators (5, 6) have noted an increase in reducing sugars immediately following irradiation of the tubers. Some of the elevated sugar content may be due to the younger tubers from plants grown from irradiated seed which were delayed in emergence. However, all of the tubers were harvested after a relatively short growing season of 90 days when sugar concn and metabolism are relatively stable (4, 5).

Soluble protein content of tubers was not affected by irradiation treatment applied to the seed (Table 1).

Field study. Seed potatoes irradiated at 167 rads/min for 2, 4, and 7 min (334, 668, and 1169 rads) were planted in the field using a randomized complete block design. Each treatment was replicated in each of 5 blocks. An appli-

Table 1. Effect of irradiation of the seed piece with gamma rays on growth, yield, and sugar content of 'Russet Burbank' and 'Nampa' potatoes grown in the greenhouse.

Days after planting	Cultivar	Treatment (rads) 0	246	492	984
				Emergence (%)	
14	Russet Burbank	90[z]	100	40**	30**
	Nampa	100	100	90	10**
				Stems per plant	
14	Russet Burbank	1.7	1.8	1.3	1.5
	Nampa	2.2	2.6	2.5	2.3
				Plant ht (cm)	
14	Russet Burbank	18.9	19.6	16.7*	14.3*
	Nampa	20.6	19.1	15.8*	13.1**
52	Russet Burbank	75.4	75.3	78.4	77.6
	Nampa	62.4	62.8	60.0	59.4
87	Russet Burbank	122.3	116.5	124.0	127.1
	Nampa	95	98.1	97.5	97.1
Days after harvest				*Yield per plant (g)*	
90	Russet Burbank	581.3	571.9	562.3	533.3
	Nampa	381.2	379.8	398.5	379.4
				Tuber no. per plant	
90	Russet Burbank	13	12	13	10
	Nampa	9	9	8	8
				Tuber size (g)	
90	Russet Burbank	44.7	47.6	43.2	53.3
	Nampa	42.4	42.2	49.8	47.4
				Reducing sugar mg/g (dry (wt)	
90	Russet Burbank	20[y]	29.6**	29.6**	25.2**
	Nampa	40.4	68.0**	56.2**	60.0**
				Total sugar g/g (dry wt)	
90	Russet Burbank	62.0[y]	65.6	87.6	61.2
	Nampa	76.4	116.0**	96.2**	108.0**
				Soluble protein mg/g (dry wt)	
90	Russet Burbank	37[y]	34	35	31
	Nampa	33	45	38	42

[z]Avg of 10 plants for each treatment.
[y]Avg of 4 determinations.
*,**Significant at the 5% and 1% probability level, respectively.

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cation of 48 kg/ha N, P_2O_5, and K_2O had been incorporated into the soil prior to planting. The soil was irrigated as required using overhead sprinklers. Emergence and growth of the plants were measured. Ninety days after planting the vines were cut at soil level. The tubers were allowed to remain for 10 days in the soil, then harvested. Yield and tuber number were measured at harvest. The tubers were stored for 10 days at 21°C and for a week at 7.2°C prior to chemical analysis.

The field study produced similar results to those of the greenhouse study. The plants from seed pieces treated with 665 and 1164 rads emerged very slowly (Table 2). 'Nampa' appeared to be more susceptible to delayed emergence by irradiation than was 'Russet Burbank'. Some of the plants did not emerge until after July 8 or 38 days after planting. However, only two plants failed to emerge.

Plants from untreated seed pieces were taller than those from treated seed pieces at 35, 42, 49, and 56 days after planting (Fig. 1). However, after 66 days all of the plants were the same height. The growth curves for the 'Russet Burbank' were similar for all treatments. The growth curve for 'Nampa', however, became more linear as the dose increased. Yield of 'Russet Burbank' was significantly decreased by treatment of the seed pieces with 665 and 1164 rads (Table 3). Tuber no. was decreased by the 1164 rad dose on 'Russet Burbank'. No statistical difference in tuber no. occurred due to treatment in the cultivar 'Nampa'.

Analysis of sugar and protein. A sample of 10 tubers of equal size was selected from each treatment and replication of the field study. These tubers were quartered longitudinally and one quarter of each tuber was used to make up the sample for chemical analysis. The sample was cubed, frozen at −25°C and then freeze-dried. The freeze-dried cubes were ground to pass a 60 mesh sieve in a Wiley Mill.

For sugar analysis, a 1 g sample of the freeze-dried powder was extracted with 80% ethanol and the reducing sugars determined. A 5 ml portion of the extract was acidified with 2N HCl and heated in boiling water for 10 min to achieve inversion. A 1 ml aliquot of the neutralized extract was taken for total sugar analysis.

Water soluble protein was extracted and determined by the method of Waddell (12).

'Russet Burbank' potatoes produced from plants which were grown from irradiated seed pieces had higher reducing and total sugars than did the control (Table 4). No significant difference was found in either reducing sugar or total sugar in 'Nampa'.

Soluble protein content of the tubers produced by plants from irradiated seed pieces was not different from that of the controls in the field study.

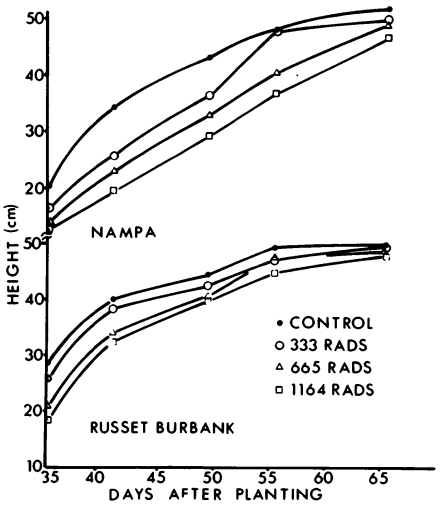

Fig. 1. Effect of irradiation of the seed piece on vine growth of 'Russet Burbank' and 'Nampa' potatoes grown in the field.

Gamma radiation of seed pieces delayed emergence of potatoes grown from treated seed pieces. This in turn decreased top growth early in the growing season but did not affect the ultimate height of the plants. Growth of 'Nampa' plants was more severely retarded than was 'Russet Burbank'. Gamma radiation generally increased reducing and total sugar content of the tubers. Further investigations are needed to determine the effects of low dosage ionizing irradiation on enzymes involved in carbohydrate metabolism.

Yield increases were not found due to low dosage gamma irradiation treatment of seed potatoes. This is contrary to some reported results and in accordance with others (1, 6, 8). Studies on seeds (Boe, unpub.) indicate that rate

Table 2. Effect of irradiation of seed piece with gamma rays on emergence of potatoes grown in the field.

	Emergence (%)							
	Russet Burbank				Nampa			
	Dose (rads)				Dose (rads)			
Date	0	333	665	1164	0	333	655	1164
June 24	4[z]	2	4	2	0	2	0	4
27	62	20**	10**	6**	66	24**	0**	8**
July 1	96	86	18**	10**	96	64**	8**	14**
4	100	100	96	66**	98	90	78*	58**
8	100	100	98	92	100	94	94	78*

[z]Avg of 5 reps each containing 10 plants.
*,**Significant at the 5% and !% probability levels, respectively.

Table 3. Effect of irradiation of the seed piece with gamma rays on the yield, tuber no. and tuber size of 'Russet Burbank' and 'Nampa' potatoes grown in the field.

Treatment (rads)	Yield/plant (kg)	Tubers/ plant	Tuber size (g)
		Russet Burbank	
0	2.1[z]	9.6	222.5
333	2.0	8.5	204.3
665	1.7*	8.7	186.1
1164	1.5*	7.3*	186.1
		Nampa	
0	2.0	12.2	167.1
333	1.7	11.5	147.1
665	1.5	12.5	129.8
1164	1.4	12.5	119.9

[z]Avg of 5 reps each containing 10 plants.
*,**Significant at the 5% and 1% probability levels respectively.

Table 4. Effect of irradiation of the seed piece with gamma rays on the reducing sugar, total sugar, and soluble protein of 'Russet Burbank' and 'Nampa' potatoes grown in the field.

Treatment (rads)	Reducing sugar (mg/g)	Total sugar (mg/g)	Soluble protein (mg/g)
		Russet Burbank	
0	11.5[z]	31.4	47.3
333	14.5*	37.3	52.0
665	30.8**	49.5**	52.5
1164	22.6**	49.5**	53.0
		Nampa	
0	44.5	83.4	58.0
333	27.0	69.8	57.8
665	35.9	87.0	61.8
1164	57.5	81.2	58.8

[z]Avg of 4 determinations.
*,**Significant at the 5% and 1% probability levels, respectively.

of irradiation is very important. The authors recommend that future research on the effects of low dosage irradiation on seeds should be done with high intensity sources. Treatments should be of very short duration.

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Evaluation of Herbicides for Container-grown Citrus[1]

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Abstract. **Three applications granular formulations of herbicides were applied broadcast over a 7-month period to budded citrus trees growing in 7.6 liters (4-gal) containers with a soil mix containing equal parts of peat, bark, and sand. Materials and rates at each application were alachlor + simazine 4.48 + 2.24 and 8.96 + 2.24 kg/ha; oryzalin 5.60 and 11.20 kg/ha; trifluralin 5.60, 11.20 and 22.40 kg/ha; oxadiazon 4.48 and 8.96 kg/ha; napropamide 11.20 and 22.40 kg/ha; and alachlor 11.20, 22.40 and 44.80. Good to excellent weed control was obtained at all rates of all herbicides used with no phytotoxicity to citrus trees observed.**

Of the 2.5 million citrus nursery trees produced annually in Florida, about 150,000 are container-grown with an estimated wholesale value of about $700,000 and a retail value of $1,200,000. Demand is expected to double in 5 years. Production techniques and conditions for container-grown citrus are similar to container-grown woody ornamentals and some nurseries produce both types of plants. Many of these citrus trees are marketed through retail garden centers as home landscape plants and contribute to the expected increase in demand. Weed control is considered a major production problem and the competitive effects of weeds growing with container-grown plants have been shown (1). In the woody ornamental industry the cost of weed control has been said to account for 20% of the total wholesale dollar volume of sales each year (3). Currey (unpublished data) has estimated that the cost of hand-weeding in container-grown plants may exceed $8,800/ha per year in Florida where no herbicides are used. Although a few herbicides are used on container-grown woody ornamentals and citrus, information on their use is limited. Product registration is difficult to obtain due to the high dollar value per unit area of the crop in relation to the potential low product sales and high risk.

Although a number of herbicides have been evaluated for use in field-grown citrus nursery stock, such results should not be transferred to container-grown stock because of the differences in conditions which affect herbicide activity and plant growth. Container media differs in composition and structure from field soil. Roots are confined within containers and much higher volumes of irrigation water are applied per unit area. Based on previous work in Florida ornamentals (2 and 4) we evaluated granular formulations of 2-chloro-2^1, 6^1-diethyl-N-(methoxymethyl) acetanilide + 2-chloro-4, 6-bis (ethylamino)s-triazine (alachlor + simazine); 3,5-dinitro N^4, N^4-dirpopylsulfanilamide (oryzalin); α,α,α-trifluoro-2, 6-dinitro-N, N-dipropyl-p-toluidine (trifluralin); 2-tert-butyl-4-(2,4-dichloro-5-isopropoxyphenyl) -Δ^2-1,3,4-oxadiazolin-5-one(oxadiazon); 2-(α-napthoxy)-N-N-diethylpropionamide (napropamide); and 2-chloro-2^1, 6^1diethyl-N-(methoxymethyl) acetanilide (alachlor) for weed control in container-grown citrus nursery stock. The experiment was conducted in full sun at a large commercial citrus nursery in Central Florida and initial treatments were applied in May 1975 under climatic conditions favoring active growth. Objectives of the experiment were to determine: 1) efficacy of several herbicides in controlling weeds which commonly compete with citrus trees, 2) satisfactory application rates, and 3) phytotoxicity of the herbicides to citrus.

Nursery plant material used was 'Hamlin' orange [*Citrus sinensis* (L.) Osbeck] on sour orange (*Citrus aurantium* L.) rootstock which had been transplanted from field to 7.6 liters (4-gal) containers with a 1 peat:1 bark:1 sand (v/v) mix.

Initial treatments were applied 1 month after transplanting from the field at which time trees had become established. A Casoron-type cyclone granular applicator, which gave uniform coverage of herbicides on container surfaces was used. Each of the 16 granular herbicide treatments was applied on May 7, 1975, to 30 single tree replicates in a completely randomized experimental design at application rates shown in Table 1. Containers were weed-free at the time of application. Irrigation was provided immediately after herbicide application and 2-3 times per week by a permanent overhead sprinkler system at the rate of 1.27

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