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IMPROVEMENT OF SOME ECONOMIC CHARACTERS THROUGH VARIATION INDUCED VIA IRRADIATION IN CANOLA (*Brassica napus* L.)

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ABSTRACT

This work aims to induce genetic variation via irradiation to improve oil quality and quantity, yield and yield components in canola through selection. The canola cultivars Pactol, Serwo 4 and Serwo 6 were irradiated with 0, 200, 300, 400 and 500 Gy of ^{60}Co-gamma rays at a dose rate 5.94 Gy/min. The irradiated populations and non-irradiated cultivars were evaluated in the field at Giza Research station, ARC during 2001-2002 and 2002-2003 winter seasons. Significant differences were found between canola cultivars, gamma ray doses and the interaction between them for most studied characters in M_1 and M_2 generations. The increases in mean number of pods/plant as a result of applying the four irradiation doses caused significant increases in seed yield/ plant which finally will improve the yield production. Gamma ray doses had positive effect on oil percentage and negative effect on protein content in M_1 and M_2 generations. Most irradiation treatments decreased erucic acid ($C_{22:1}$) content in M_1 generation. In M_2 generation, most irradiated populations had traces of erucic acid. The variation of total unsaturated/total saturated fatty acids ratio, which found in irradiated populations, is a promising finding for breeders to improve canola oil quality. The increase in range, coefficient of variability and heritability estimates of irradiated populations in the M_2 generation indicated that the used doses of gamma ray might be useful for increasing genetic variation, which would be necessary for practicing selection. SDS-protein banding patterns showed that the number of bands as affected by increasing gamma ray doses depending on the analysed cultivar. The cluster analysis showed that the effect of gamma ray doses on the three canola cultivars resulted in variations which appeared in the different genetic distances among the irradiated populations and its control. Data indicated that Serwo 4 was the most sensitive cultivar to irradiation with gamma ray in M_1 and M_2 generation.

Key words: *Canola, Brassica napus, Gamma ray doses, Yield and yield components, Variability, Genetic parameters, Oil quantity and quality, Protein content, SDS-Protein patterns.*

INTRODUCTION

Rapeseed is not a word that can be used in the place of canola. Canola (*Brassica napus* L.) was derived from rapeseed using traditional breeding methods, both differ in their chemical composition. Canola is considered as one of the most important oil crops in the world. The major production regions are Canada, China, Northern Europe and the Indian subcontinent The *Brassica* oilseed species *B. napus*, *B. campestris* and *B. juncea* are the third most important source of edible vegetable oils after soybean and sunflower over the world (Stefanov and Gyurov 1985). Downey (1990) reported that the biosynthetic pathway of the undesirable fatty acid (erucic acid), as well as the deleterious aliphatic glucosinolates, the nutritional quality of the seed oil and meal has been greatly elevated by genetically blocking in the developing seed. Further modifications of the fatty acid composition of *Brassica* oils have been developed and are undergoing evaluation for specialty markets. Increased seed yields are expected from the development of hybrid varieties utilizing cytoplasmic male sterility and self-incompatibility systems, while the successful application of all biotechnologies to *Brassica* oilseed plants offers great promise for the future.

In Egypt, rape-seed is one of the winter oil crops that grow well in newly reclaimed lands. Its seed contains more than 40% of excellent edible semi dry oil. Consequently, rape-seed oil is considered a promising oil crop to decrease the gab between the production and the consumption. Accordingly, looking for high yielding rape varieties adapted to the local conditions is considered an important objective (Sharaan 1987). Gallab and Sharaan (2002) reported that the presence of double zero type of rapeseed (producing oil with less than 2% erucic acid and less than 30 μmol/g glucosinolate in dehfulled meal) encouraged its utility as a source of edible oil overall the world.

Ionizing radiation influencing different organisms causes physical, chemical and biochemical changes (Panojan 1971). Many investigators have used ionizing radiation such as gamma rays to induce useful mutations for developing new genetic variants (Gregory 1965 and Vranceanu *et al* 1991). Moreover, promising mutants in rape seed have been obtained by Rakow *et al* (1987). Two rape varieties were released in China between 1966 and 1983 following mutagenic treatments (FAO/IAEA 1986). Also, Thompson *et al* (1985) obtained a spontaneous mutation in oil seed rape. The elimination of both erucic acid and glucosinolates from oil-seed rape cultivars is an important goal of the rape seed breeders. Zero erucic mutation was the first step in this respect. Induced mutations of oil seed crops reflected the successful efforts of plant breeders in adjusting oil compositional characteristics to fit the consumer needs and more specifically to health conditions (Shrief 1998).

Therefore, the aims of this investigation were to induce new genetic variability in three commercial cultivars of canola (Pactol, Serwo 4 and Serwo 6) using gamma irradiation in an attempt to improve oil quantity and quality via a mutation and selection breeding program and to study the effect of irradiation on the yield and yield components, protein content and protein patterns.

MATERIALS AND METHODS

Dry seeds (10% moisture content) of three Canola cultivars: Pactol, Serwo 4 and Serwo 6, obtained from the Oil Crops Research Department, Field Crops Research institute, ARC, were exposed to 0, 200, 300, 400 and 500Gy of gamma rays at a dose rate of 5.94 Gy / min at the National Center for Radiation Research and Technology, Atomic Energy Authority. Irradiated seed lots and non-irradiated controls were grown (immediately after irradiation) on December 6, 2001 at Giza Research Station, ARC to give M_1 generation.

In M_2 generation, random samples of seeds from each treatment as well as controls were grown on December 16, 2002 to obtain M_2-plants.

In the two successive seasons, a Randomized Complete Block Design with four replications was used for each population. The irradiated and non-irradiated seeds were sown in plots; each plot consisted of six rows, 4 meters long, 60 cm apart and 10 cm between hills. Seeds of 40 plants of every treatment were bulked and sown to arise M_2 generation. Random samples of 16 individual plants per treatment were used to measure studied characters in M_1 and M_2 generations.

Statistical procedures

Data were statistically analyzed according to Steel and Torrie (1980). Means, ranges and coefficient of variation were determined for all traits in $M_1$and M_2 generations. In addition, phenotypic coefficient of variability (P.C.V. %), genotypic coefficient of variability (G.C.V. %), heritability in the broad sense (h^2) and expected genetic advance under 10% selection intensity (GS) were computed according to (Allard 1999) only in the M_2 generation.

Chemical analysis

Seed samples were used to determine oil percentage, fatty acid composition and crude seed protein content. Oil content was determined according to the AOAC (1990). Fatty acid compositions were determined by gas-liquid chromatography according to Marquard (1987). The crude protein was calculated by multiplying the total nitrogen by 6.25 (according to AOAC 1990).

Sodium dodesyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE)

For direct visual protein comparisons, proteins were size fractionated based on the molecular weight by SDS-PAGE performed as described by Laemmli (1970). 0.75 mm-thick vertical slab gels were cast and electrophoresed using the Bio Rad Mini-Protean II system. Gels were stained with commassie brilliant blue R-250 solution, photographed and scored using gel documentation system manufactured by Alpha Ease FC (Alphimager 2200), U.S.A. The dissimilarity matrices were done using Gel works 1D advanced software UVP-England Program. The relationships among the irradiated populations and their control as revealed by dendrograms were done using SPSS windows (Version 10) program.

RESULTS AND DISCUSSION

Effect of gamma ray Irradiation treatments

Morphological, yield and yield component characters

The mean values of studied characters for three canola cultivars in M_1 and M_2 generations after irradiated with gamma ray doses are illustrated in Tables (1) and (2), respectively.

In M_1 generation, significant differences were found between the three canola cultivars over the gamma ray doses for plant height, fruiting zone length, number of pods/plant, weight of pods/plant and seed index. These high variations reflect the direct effect of the mutagens applied. The statistical analysis indicated significant differences among irradiation doses on all studied characters, except the first branch height. The gamma ray treatments gradually decreased plant height, fruiting zone length by increasing dose and vice versa for number of branches, number of pods/ plant, weight of pods/plant, seed yield/plant and seed index. It seems that 500Gy treatment decreased the most of studied characters. McNaughton *et al* (1985) found no relationship between radiation dosage and seed set in *Brassiceae*.

Table 1. Effect of gamma ray doses on mean values of morphological, yield and yield component characters for irradiated three canola cultivars in M_1 generation.

Characters	Cultivar	Gamma ray doses					Mean	L.S.D. 5%		
		Control	200Gy	300Gy	400Gy	500Gy		C	R	C x R
First branch height (cm)	Pactol	49.75	43.54	43.75	57.29	53.50	49.57	N.S.	N.S.	N.S.
	Serwo 4	47.54	43.67	50.13	55.54	62.88	51.95			
	Serwo 6	57.06	53.92	60.25	54.33	50.54	55.22			
	Mean	51.45	47.04	51.38	55.72	55.64				
Plant height (cm)	Pactol	111.25	121.13	120.83	125.00	119.19	119.48	9.23	9.70	16.80
	Serwo 4	133.17	137.21	133.38	127.21	120.06	130.20			
	Serwo 6	134.38	122.50	108.92	107.33	93.09	113.24			
	Mean	126.26	126.94	121.04	119.85	110.78				
Fruiting zone length (cm)	Pactol	60.94	77.17	75.79	67.83	66.06	69.56	9.63	11.52	N.S.
	Serwo 4	85.63	96.50	83.13	71.67	57.19	78.82			
	Serwo 6	77.31	69.31	48.67	53.00	43.67	58.39			
	Mean	74.63	80.99	69.19	64.17	55.64				
No. of branches	Pactol	4.94	6.63	7.29	7.50	8.04	6.88	N.S.	0.94	1.63
	Serwo 4	6.17	7.00	7.88	5.92	5.19	6.43			
	Serwo 6	5.81	6.56	6.58	6.50	5.96	6.28			
	Mean	5.64	6.73	7.25	6.64	6.40				
No. of Pods/plant	Pactol	128.08	164.25	189.79	197.94	139.38	163.89	43.82	49.61	85.93
	Serwo 4	232.04	318.34	549.21	320.42	312.71	346.54			
	Serwo 6	192.84	199.54	200.75	207.63	194.13	198.98			
	Mean	184.32	227.38	313.25	241.99	215.40				
Weight of pods / plant (gm)	Pactol	23.02	22.83	23.89	26.68	23.17	23.92	5.53	4.12	7.13
	Serwo 4	32.46	38.60	54.59	34.36	33.32	38.67			
	Serwo 6	28.62	35.61	36.35	36.71	28.70	33.20			
	Mean	28.03	32.35	38.28	32.58	28.39				
Seed yield/plant (gm)	Pactol	15.21	15.87	17.33	17.33	16.40	16.43	N.S.	2.16	3.73
	Serwo 4	17.32	18.00	24.24	18.43	18.34	19.26			
	Serwo 6	16.49	17.56	18.24	22.50	15.43	18.04			
	Mean	16.34	17.14	19.94	19.42	16.72				
Seed index (gm)	Pactol	1.98	2.95	3.39	3.47	3.56	3.09	0.33	0.30	N.S.
	Serwo 4	2.50	3.59	4.04	3.80	3.71	3.53			
	Serwo 6	2.16	3.27	3.34	3.57	2.91	3.05			
	Mean	2.21	3.27	3.59	3.61	3.43				

C= Cultivars R= Irradiation dose treatment C x R= Interaction between cultivars and doses.

Table 2. **Effect of gamma ray doses on mean value of morphological, yield and yield component characters for irradiated three canola cultivars in M_2 generation**

Characters	Cultivars	Gamma ray doses					Mean	L.S.D. 5%		
		Control	200Gy	300Gy	400Gy	500Gy		C	R	C x R
First branch height (cm)	Pactol	78.80	61.98	58.09	53.06	49.82	60.35	1.51	5.14	8.91
	Serwo 4	71.18	69.47	50.25	39.75	45.04	55.14			
	Serwo 6	72.31	64.24	61.46	60.30	52.07	62.08			
	Mean	74.10	65.23	56.60	51.04	48.98				
Plant height (cm)	Pactol	144.91	139.53	140.11	144.21	147.20	143.19	4.76	N.S.	N.S.
	Serwo 4	133.91	129.29	129.38	125.97	125.25	128.76			
	Serwo 6	135.09	133.65	122.87	127.10	124.69	128.68			
	Mean	137.97	134.16	130.79	132.43	132.38				
Fruiting zone length (cm)	Pactol	63.66	77.71	82.02	90.98	97.26	82.32	5.96	5.55	9.62
	Serwo 4	63.29	64.90	79.78	87.04	80.21	75.04			
	Serwo 6	62.78	69.42	64.80	66.80	72.63	67.28			
	Mean	63.24	70.67	75.53	81.60	83.37				
No. of branches	Pactol	6.91	8.91	10.50	10.28	9.73	9.26	N.S.	1.17	N.S.
	Serwo 4	6.55	7.26	8.47	8.44	9.58	8.06			
	Serwo 6	7.44	8.23	8.40	8.48	11.27	8.76			
	Mean	6.97	8.13	9.12	9.06	10.19				
No. of Pods/plant	Pactol	156.60	157.48	168.65	207.12	223.74	182.72	34.98	31.37	N.S.
	Serwo 4	111.94	121.26	153.12	143.24	158.65	137.64			
	Serwo 6	120.22	128.58	124.72	137.42	145.47	131.28			
	Mean	129.59	135.77	148.83	162.59	175.95				
Weight of pods/ plant (gm)	Pactol	27.10	37.28	33.22	36.75	37.06	34.28	2.55	2.90	5.02
	Serwo 4	23.92	25.12	33.07	30.94	29.75	28.59			
	Serwo 6	22.40	23.41	26.00	25.59	23.29	24.14			
	Mean	24.47	28.60	30.76	31.09	30.03				
Seed yield/plant (gm)	Pactol	16.38	22.05	20.73	22.88	22.14	20.84	1.40	1.72	2.98
	Serwo 4	15.66	17.47	18.68	19.79	19.43	18.21			
	Serwo 6	17.05	18.34	18.07	16.24	17.04	17.35			
	Mean	16.36	19.29	19.16	19.64	19.54				
Seed index (gm)	Pactol	2.07	3.44	2.76	4.00	2.86	3.02	0.21	0.38	0.66
	Serwo 4	3.26	3.47	4.42	4.58	3.63	3.87			
	Serwo 6	2.15	4.57	5.12	3.64	5.04	4.10			
	Mean	2.49	3.83	4.09	4.07	3.84				

C= Cultivars R=Irradiation dose treatment C x R= Interaction between cultivars and doses.

Increasing number of pods/plant and seed yield/plant of the three cultivars in M_1 by increasing gamma ray doses may be attributed to the stimulating physiological effect of gamma rays. Similar results were reported by Cebrat *et al* (1995). Chen *et al* (1997) observed wide differences between lines with different genetic backgrounds and between different irradiation doses.

In M_1 generation (Table 1), the first branch height had no significant change. Similar results were obtained by Hussein and Dissouki (1976) on *Phaseolus vulgaris*, Sorour (1989) on *Arachis hypogaea* and Sorour and Keshta (1994). The latter authors treated oil rape seed with 4 gamma ray of gamma doses on most studied traits were in the same line with Bors and

Fredrik (1983), who observed a gradual decrease in trait values as radiation dose increased, although in some cases the 100 Gy dose produced stimulatory effect.

The interaction of cultivars x dose treatments was significant for plant height, number of branches, number of pods/plant, weight of pods/ plant and seed yield/ plant, indicating various responses of the studied cultivars to the applied gamma ray doses. Similar results were stated by Sorour and Keshta (1994) who reported that the high levels of gamma irradiation probably affect on early development stages of the plant.

Some morphological variations induced via irradiation with different gamma ray doses were observed such as decreasing the first branch height, increasing the fruiting zone length and pod size as displayed in Fig. (1).

In M_2 generation, results in Table (2) showed that the first branch height was significantly decreased by all doses, which resulted in a significant beneficial effect of irradiation dose treatments on fruiting zone length. On the other hand, fruiting zone length, number of branches, number of pods/plant, weight of pods/plant, seed yield/plant and seed index were significantly increased. The increments in mean number of pods/plant as a result of applying gamma ray treatments (200, 300, 400 and 500 Gy) consequently increased number and seed yield/plant which finally improved seed yield. These results are in agreement with those obtained by El-Sayed (1966), MacDonald and Aslam (1986), Rajendra and Basudeo (1986) and Sorour and Keshta (1994).

The increments in mean number of pods/plant as a result of applying gamma ray treatments (200, 300, 400 and 500 Gy) consequently increased number and seed yield/plant which finally improved seed yield.

The results concluded that almost all studied characters were increased with all gamma ray treatments in both generations. These results were in the same line with Amer and El-Mohandes (1992), who reported that, mean seed yield/plant was increased at the dose of 100 Gy for all cultivars in M_2 generation. On the contrary, Bors and Fredrik (1983) mentioned that there was a reduction in the yield of winter rape in M_2 generation. Zhou-YongMing *et al* (1998) investigated eight quantitative traits in the M_1 and M_2 generations and observed significant inhibition of plant height and biomass production in the M_2 generation.

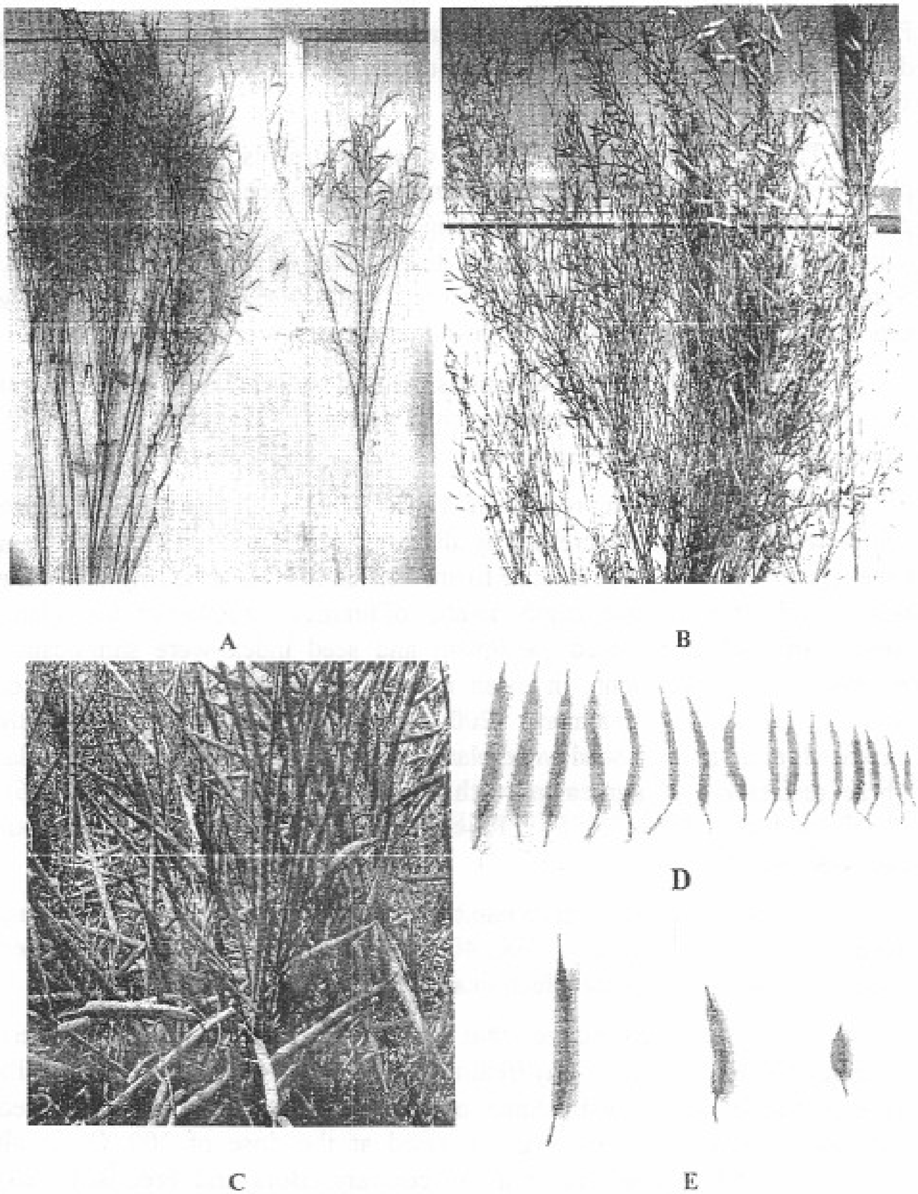


Fig.1. Some morphological variations induced via irradiation with different gamma ray doses in M_1 generation (A,B and C) variation in plant height and first branch height, and high yielding ability, while (D and E) showing high variation in pod size.

The interaction between cultivars and gamma ray doses was significant for most studied traits except plant height, fruiting zone length and number of pods/plant, reflecting different response of the three studied cultivars to gamma ray doses. These results are in agreement with those obtained by El-Sayed (1966), MacDonald and Aslam (1996), Rajendra and Basudeo (1986) and Sorour and Keshta (1994).

Oil and protein content

Means of seeds oil percentage and protein content for the three canola cultivars: Pactol, Serwo 4 and Serwo 6 in M_1 and M_2 generations are presented in Table (3). Gamma ray doses had positive effect on oil percentage and negative effect on protein content, where over the three cultivars, oil percentage was significantly increased by all doses, and vice versa for protein content in M_1 and M_2 generations. The mean value of protein content in M_2 generation for Pactol cultivar surpassed Serwo 4 and Serwo 6 over all gamma ray treatments, but for oil percentage, there were insignificant differences between the three canola cultivars.

In the M_1 and M_2 generations, the interaction between cultivars and gamma rays was significant for oil percentage and protein content. Moreover, 200 Gy gamma ray treatments were given the highest oil percentages and the lowest protein content with almost all studied cultivars in both generations.

Azzam (1993) obtained similar results after treating sunflower with 100, 200 and 300 Gy gamma ray doses in sunflower, while Bors and Fredrik (1983) obtained different results in rapeseed. They mentioned that there was no significant effect of irradiation on seed quality. Hu and Chen (1993) reported that dosage had no significant effect on oil content but differences existed between individuals ranging from 37.33 to 44.21% when they irradiated 3 cultivars with 100, 130, 150, 170, 190 and 210 Kr of ^{60}Co-gamma rays with the aim of inducing a mutation for high oil content and suggesting that it would be effective to select for higher oil content in early generations. The oil content of the parent seed showed a marked influence on its mutant progenies. A few stable mutant lines with oil content 5-7 % higher than the commercially cultivated cultivars were obtained. Also Das *et al* (1999) improved the oil content by using high dosages of gamma ray (700-900 Gy).

Table 3. Effect of gamma ray doses on mean value of oil % and protein content for three canola cultivars in M_1 and M_2 generations.

Character	generatio	Cultiva	Gamma ray doses			Mean			L.S.D. 5%		
			Contro	200Gy	300Gy	400Gy	500Gy		C	R	C x R
Oil %	M1	Pactol	38.66	40.00	39.14	37.47	39.18	38.89	0.22	0.14	0.23
		Serwo 4	37.45	39.63	39.22	38.02	38.60	38.58			
		Serwo 6	39.11	36.84	40.45	40.88	38.00	39.06			
		Mean	38.41	38.82	39.60	38.79	38.59				
	M2	Pactol	38.09	42.56	41.66	40.15	41.70	40.83	N.S.	1.07	1.85
		Serwo 4	36.65	42.44	41.74	40.48	41.32	40.53			
		Serwo 6	39.28	40.76	43.29	43.52	40.45	41.46			
		Mean	38.01	41.92	42.23	41.38	41.16				
Protein	M1	Pactol	28.35	22.58	28.04	29.30	28.33	27.32	0.48	0.39	0.68
		Serwo 4	29.14	29.07	29.30	29.15	28.34	29.00			
		Serwo 6	30.10	30.37	22.20	21.39	29.41	26.69			
		Mean	29.20	27.34	26.51	26.61	28.69				
	M2	Pactol	29.06	21.21	21.51	22.38	21.33	23.10	0.56	0.31	0.54
		Serwo 4	29.88	20.14	21.14	21.74	21.60	22.90			
		Serwo 6	28.56	21.86	19.51	19.71	21.98	22.32			
		Mean	29.16	21.07	20.72	21.28	21.64				

C= Cultivars R=Irradiation dose treatment C x R= Interaction between cultivars and doses.

Fatty acids composition

Fatty acids composition for irradiated populations and non-irradiated three canola cultivars in M_1 and M_2 generations are presented in Table (4). Data showed that the major fatty acids were $C_{18:1}$, $C_{18:2}$ and $C_{18:3}$. It is clear that Oleic acid was the prevalent unsaturated fatty acid followed by linoleic acid. Linolenic content was decreased by all gamma ray treatments in all studied cultivars. Oram *et al* (1993) produced mutants with low linolenic acid content in *Brassica juncea* similar to canola (rape) oil by using gamma ray doses. Palmitic acid ($C_{16:0}$) was the predominant saturated fatty acid in all populations.

Concerning the erucic acid ($C_{22:1}$) contents, the data showed that, Most irradiation treatments decreased erucic acid (C22:1) content in M_1 generation. In M_2 generation, most irradiated populations had traces of erucic acid. These results clarify that conducting pedigree selection program in the advanced generations of irradiated populations could produce lines that have zero erucic acid.

Total saturated fatty acids (Palmitic, Stearic and Arachidic acid) ranged in M_1 from 5.52 to 13.24% for Pactol at 200 Gy and Serwo 4 at 400 Gy, respectively, but in M_2 the range was from 7.98 to 15.55 % for Pactol at 300 Gy and Serwo 4 at 400 Gy, respectively. On the other hand, total unsaturated ones (Oleic, linoleic, linolenic and erucic acid) ranged from 86.76 to 94.48% in M_1 for Serwo 4 at 400 Gy and Pactol at 200 Gy gamma ray treatments, while in M_2 the amount ranged from 84.45 to 92.02% for Serwo 4 control and Pactol at 300 Gy, respectively.

Data in Table (4) indicated that the high oil quality (the highest TU/TS value) was produced after treating Pactol cultivar with 200 Gy in M_1, while in M_2 generation the highest TU/TS value was obtained after treating Pactol cultivar with 300 Gy gamma ray dose. Nevertheless, the increased variation of TU/TS ratio found in irradiated populations is a promising finding for breeders to improve canola oil quality.

These results are in agreement with those obtained by Azzam (2000) and Ahmed (2004). While, Auld *et al* (1992) used chemical mutagenesis (5% v/v of -ethyl methanesulfonate-EMS) to induce mutations. They found that reduced levels of polyunsaturated fatty acids and increased levels of oleic acid could increase both the utility and value of the oil of both tetraploid (*Brassica napus*) and diploid *B. rapa* (*B. campestris*) rapeseed. The M_2 generations were screened to identify mutants with low levels of

Table 4. Fatty acids composition for irradiated populations and non-irradiated three canola cultivars in M_1 and M_2 generations.

Generation	Cultivars	Fatty acids							TS	TU	TU/TS
		Pl. acid	St. acid	Ol. acid	Lin. acid	Linn. acid	Ar. acid	Er. acid			
M_1	Pactol control	2.70	2.44	60.00	23.53	9.61	1.08	0.64	6.22	93.78	15.08
	200 Gy	2.20	1.80	61.24	24.11	9.13	1.52	tr	5.52	94.48	17.12
	300 Gy	2.81	2.11	61.98	23.95	8.05	1.10	tr	6.02	93.98	15.61
	400 Gy	4.05	3.51	60.09	22.46	8.42	1.46	0.01	9.02	90.98	10.09
	500 Gy	4.31	3.14	59.97	22.00	9.14	1.33	0.11	8.78	91.22	10.39
	Serwo 4 control	5.69	1.62	58.53	21.94	9.05	1.90	0.43	10.05	89.95	8.95
	200 Gy	6.25	3.59	60.32	19.21	8.81	1.72	0.10	11.56	88.44	7.65
	300 Gy	6.70	2.05	62.99	14.22	12.72	1.30	0.02	10.05	89.95	8.95
	400 Gy	6.90	4.79	61.35	14.10	11.30	1.55	0.01	13.24	86.76	6.55
	500 Gy	7.45	3.50	58.01	18.12	10.44	2.23	0.25	13.18	86.82	6.59
	Serwo 6 control	4.92	3.30	62.58	15.95	12.66	0.39	0.20	8.61	91.39	10.61
	200 Gy	4.75	3.56	62.48	18.16	9.90	1.05	0.10	9.36	90.64	9.68
	300 Gy	7.82	2.33	62.19	19.87	6.93	0.86	tr	11.01	88.99	8.08
	400 Gy	8.71	1.81	64.51	15.67	8.39	0.91	tr	11.43	88.57	7.75
	500 Gy	3.89	4.91	63.95	14.58	10.55	2.11	0.01	10.91	89.09	8.17
M_2	Pactol control	4.24	3.93	58.07	23.06	9.42	1.06	0.22	9.23	90.77	9.83
	200 Gy	4.64	3.16	62.49	18.21	9.95	1.49	0.06	9.29	90.71	9.76
	300 Gy	3.37	3.53	60.64	23.47	7.89	1.08	0.02	7.98	92.02	11.53
	400 Gy	4.86	4.21	60.11	21.14	8.25	1.43	tr	10.50	89.50	8.52
	500 Gy	5.17	3.77	59.24	21.56	8.96	1.30	tr	10.24	89.76	8.77
	Serwo 4 control	6.83	3.69	57.25	20.97	8.87	1.86	0.53	12.38	87.62	7.08
	200 Gy	7.50	4.31	59.04	18.83	8.63	1.69	tr	13.50	86.50	6.41
	300 Gy	8.04	2.46	61.82	13.94	12.47	1.27	tr	11.77	88.23	7.50
	400 Gy	8.28	5.75	59.09	13.82	11.07	1.52	0.47	15.55	84.45	5.43
	500 Gy	6.94	3.20	62.68	15.76	10.23	1.19	tr	11.33	88.67	7.83
	Serwo 6 control	5.90	3.96	55.63	21.39	12.41	0.38	0.33	10.24	89.76	8.77
	200 Gy	5.70	4.27	61.50	17.80	9.70	1.03	tr	11.00	89.00	8.09
	300 Gy	7.35	3.80	61.94	19.28	6.79	0.84	tr	11.99	88.01	7.34
	400 Gy	6.23	2.17	67.13	15.36	8.22	0.89	tr	9.29	90.71	9.76
	500 Gy	4.67	4.63	64.00	14.29	10.34	2.07	tr	11.37	88.63	7.80

Pl. acid = Palmitic acid $C_{16:0}$ St. acid = Stearic acid $C_{18:0}$
Ol. acid = Oleic acid $C_{18:1}$ Lin. Acid= Linoleic acid $C_{18:2}$
Linn. Acid= Linolenic acid $C_{18:3}$ Ar. Acid = Arachidic acid $C_{20:0}$
Er. Acid = Erucic acid $C_{22:1}$ tr = Traces TU/TS= TU/TS ratio
TS= Total saturated fatty acids TU= Total unsaturated fatty acids

polyunsaturated fatty acids (PUFA) using a modified thiobarbituric acid procedure. They mentioned that the development of commercial cultivars with reduced levels of polyunsaturated fatty acids, in both *B. rapa* and *B. napus* could develop new markets for both industrial rapeseed and edible canola oil. Also Morice (1983) and Das *et al* (1999) improved the fatty acid composition by using high dosage of gamma ray doses (700-900 Gy). On the other hand, Rakow *et al* (1987) treated *B. napus* cv. Tower with EMS and the selected seed from a low-linolenic acid M_3 line was again treated with EMS and with X rays. Further selection stabilized low linolenic acid content and the lines thus derived were crossed with the high-linoleic acid mutant M_{11}. Plants selected in the F_2 for low glucosinolate and linolenic acid content and high linoleic acid content were further selected to give lines suitable for yield tests. However, all the lines tested were lower in seed yield and oil content than current Canadian canola cultivars.

Genetic parameters

Data of phenotypic (P.C.V. %), genotypic (G.C.V.%) coefficient of variability, broad sense heritability (h^2) and genetic advance under selection (Gs) for growth, yield and yield component characters of irradiated populations and non-irradiated three canola cultivars in M_2 generation are presented in Table (5).

The estimates of P.C.V.% and G.C.V.% were increased with all gamma ray doses for the three irradiated canola cultivars, but the trend of dose effects displayed trivial differences. In most characters, P.C.V.% values of irradiated population were higher than non-irradiated for all varieties in M_2 generation. The high magnitude of phenotypic variability given in the mutagenic treatments increased the genetic variance and consequently practicing selection within these mutated materials is possible.

The estimates of h^2 and Gs were increased with almost gamma ray doses for the three irradiated canola cultivars. These increases in heritability estimates of irradiated populations in the M_2 generation indicates that the used doses of gamma ray are useful for increasing genetic variation which would be necessary for practicing selection to improve rapeseed characters.

Knowledge of the magnitude of genetic variance and broad sense heritability estimates may provide a basis for real gain from selection.

Table 5. Phenotypic coefficient of variation (P. C. V. %), genotypic coefficient of variation (G.C. V. %), broad sense heritability (h^2%) and expected genetic advance (Gs %) for the characters of three canola cultivars in M_2 generation.

Entries	First branch height (cm)				Plant height (cm)				No. of branches				Fruiting zone length (cm)			
	P.C.V %	G.C.V. %	h 2 %	Gs %	P.C.V %	G.C.V %	h 2 %	Gs %	P.C.V %	G.C.V %	h 2 %	Gs %	P.C.V %	G.C.V %	h 2 %	Gs %
Pactol control	24.30	-	-	-	10.15	-	-	-	25.65	-	-	-	25.40	-	-	-
200 Gy	33.78	14.10	17.42	12.65	11.16	3.99	12.79	3.07	28.75	20.83	52.47	32.43	27.66	18.57	45.08	26.81
300 Gy	39.83	23.04	33.44	28.64	11.55	4.84	17.65	4.39	26.77	20.77	60.18	34.64	25.80	16.48	40.79	22.63
400 Gy	48.36	31.52	42.50	44.18	10.44	1.97	3.56	0.80	25.77	19.12	55.04	30.50	26.89	20.21	56.45	32.64
500 Gy	46.00	26.06	32.09	31.74	11.23	5.01	19.96	4.82	28.55	22.01	59.40	36.47	30.54	25.47	69.56	45.67
Serwo 4 control	21.74	-	-	-	11.14	-	-	-	28.35	-	-	-	23.32	-	-	-
200 Gy	24.71	10.05	16.55	8.79	13.64	7.25	28.27	8.29	37.58	28.89	59.08	47.74	36.04	27.91	59.98	46.47
300 Gy	46.58	35.23	57.18	57.27	14.29	8.31	33.80	10.38	45.77	40.45	78.12	76.87	34.89	29.56	71.78	53.85
400 Gy	49.18	30.57	38.63	40.84	13.37	6.03	20.30	5.84	43.75	38.24	76.38	71.85	26.62	20.48	59.17	33.87
500 Gy	41.20	24.25	34.65	30.69	13.85	6.93	25.06	7.46	46.20	41.89	82.21	81.66	34.72	29.30	71.26	53.18
Serwo 6 control	17.32	-	-	-	11.94	-	-	-	22.78	-	-	-	24.88	-	-	-
200 Gy	26.79	18.53	47.81	27.54	13.19	5.37	16.56	4.69	35.05	28.31	65.22	49.15	30.70	20.82	45.99	30.35
300 Gy	28.50	20.06	49.52	30.35	15.79	8.77	30.86	10.47	40.93	35.44	74.99	65.99	36.29	27.11	58.81	43.55
400 Gy	28.83	20.01	48.15	29.85	15.15	8.11	28.68	9.34	40.88	35.70	76.2[illegible]	[illegible]	[illegible]	31.78	64.17	54.73
500 Gy	37.62	26.94	59.20	[illegible]	[illegible]	14.69	[illegible]	[illegible]	[illegible]	62.39	94.43	130.34	42.77	36.93	74.64	68.64

Entries	No. of pods/plant				Weight of [illegible]				[illegible]				[illegible]			
	P.C.V %	G.C.V %	h 2 %	Gs %	P.C.V %	G.C.V %	h 2 %	Gs %	P.C.V %	G.C.V %	h 2 %	Gs %	P.C.V %	G.C.V %	h 2 %	Gs %
Pactol control	56.59	-	-	-	31.97	-	-	-	24.64	-	-	-	3.87	-	-	-
200 Gy	61.01	23.94	15.40	20.20	35.85	27.43	58.52	45.11	23.51	21.98	59.44	36.43	27.15	27.05	25.13	14.67
300 Gy	75.80	51.87	46.83	76.32	42.62	33.47	61.67	56.51	33.15	27.00	66.32	47.27	25.12	24.95	17.16	9.26
400 Gy	74.53	61.87	68.91	110.43	44.23	37.29	70.92	67.52	42.56	38.66	82.50	75.49	20.44	20.34	16.61	7.30
500 Gy	64.05	51.27	64.07	88.23	57.82	53.13	84.13	104.98	36.37	31.58	75.40	58.96	18.45	18.23	9.50	3.77
Serwo 4 control	57.93	-	-	-	32.01	-	-	-	26.13	-	-	-	6.91	-	-	-
200 Gy	57.86	24.16	17.44	21.69	31.91	8.63	7.32	5.02	30.73	18.94	37.99	25.10	21.20	20.15	14.12	6.44
300 Gy	65.20	50.00	58.82	82.44	44.28	37.93	73.38	69.85	31.49	22.43	50.74	34.35	15.90	15.03	9.97	3.41
400 Gy	58.66	38.84	43.84	55.29	45.34	38.15	70.80	69.01	34.97	28.11	64.62	48.58	14.87	13.97	8.78	2.81
500 Gy	100.10	91.78	84.07	180.93	74.72	70.40	88.77	142.61	56.29	52.23	86.12	104.22	19.93	18.93	13.15	5.64
Serwo 6 control	41.01	-	-	-	31.60	-	-	-	25.22	-	-	-	3.13	-	-	-
200 Gy	64.94	52.28	64.82	90.50	38.09	23.20	37.08	30.37	33.31	23.50	49.76	35.64	15.65	15.58	11.10	3.74
300 Gy	70.64	58.12	67.69	102.80	49.49	41.06	68.84	73.24	36.20	27.30	56.86	44.26	17.76	17.71	16.34	6.24
400 Gy	67.77	56.08	68.47	99.76	42.22	30.89	53.53	48.59	30.44	15.18	24.87	16.28	17.27	17.19	11.98	4.45
500 Gy	72.40	64.15	78.53	122.23	46.29	34.93	56.92	56.65	42.18	33.85	64.40	58.40	17.58	17.53	15.45	5.84

Similar results were observed by Sorour (1989) who found high amount of phenotypic coefficient of variation in peanut seed yield and most of its contributing traits following the treatment with wide range of gamma ray dosages.

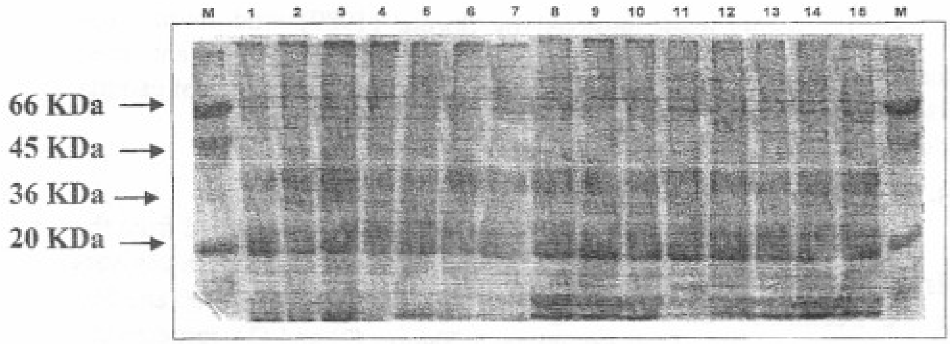
SDS-PAGE protein banding patterns

The electrophoretic banding patterns of proteins extracted from the seeds of the irradiated populations and non-irradiated three canola cultivars after the treatment with different gamma ray doses (200, 300, 400 and 500 Gy) in M_1 and M_2 generations are shown in Figures (2) and (3), respectively, and their densitometric analysis are illustrated in Tables (6) and (7), respectively, where the presence and absence of bands were assessed with (1) and (0), respectively.

The results of SDS-PAGE revealed a total number of 35 bands with molecular weights (MW) ranging from about 2.00 to 89.00 KDa in M_1, and from 4.00 to 98.00 KDa in M_2 generation, which were not necessarily present in all irradiated populations and non-irradiated cultivars. Data showed some common bands (monomorphic), while the remaining bands were polymorphic with polymorphism in the irradiated populations in both generations. There is no resemblance between any irradiated populations and non-irradiated cultivars and each was characterized by a unique fingerprint followed by Serwo 6 and then Pactol based on the dissimilarity index in M_1 generation. In addition, The highest dissimilarity index between the irradiated populations and their control (0.89) was observed between

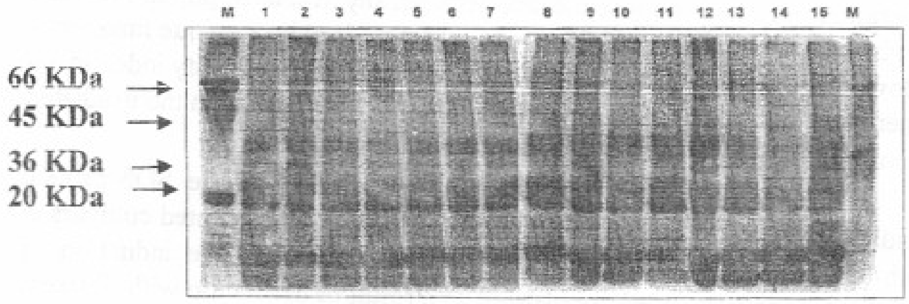
The densitometric analysis (Tables 6 and 7) of the SDS-protein banding patterns of the irradiated populations and non-irradiated cultivars in both generations was found to be useful in identifying the induction of variations in the irradiated populations as a result of irradiation with different gamma ray doses based on the protein level.

Dissimilarity index among the irradiated populations and non-irradiated three canola cultivars after the treatments with the 4 gamma ray doses based on protein analysis in M_1 and M_2 generations, carried out using UPGMA computer program, are presented in Tables (8) and (9).



M= Protein marker	1= Pactol (control)	2= Pactol (200 Gy)	3= Pactol (300 Gy)
4= Pactol (400 Gy)	5= Pactol (500 Gy)	6=Serwo4 (control)	7= Serwo 4 (200 Gy)
8= Serwo 4 (300 Gy)	9= Serwo 4 (400 Gy)	10= Serwo 4 (500 Gy)	11= Serwo 6 (control)
12= Serwo 6 (200 Gy)	13= Serwo 6 (300 Gy)	14= Serwo 6 (400 Gy)	15= Serwo 6 (500 Gy)

Fig. 2. SDS-protein banding patterns for seed proteins of the irradiated populations and non-irradiated three canola cultivars in M_1 generation.



M= Protein marker	1= Pactol (control)	2= Pactol (200 Gy)	3= Pactol (300 Gy)
4= Pactol (400 Gy)	5= Pactol (500 Gy)	6= Serwo 4 (control)	7= Serwo 4 (200 Gy)
8= Serwo 4 (300 Gy)	9= Serwo 4 (400 Gy)	10= Serwo 4 (500 Gy)	11= Serwo 6 (control)
12= Serwo 6 (200 Gy)	13= Serwo 6 (300 Gy)	14= Serwo 6 (400 Gy)	15= Serwo 6 (500 Gy)

Fig. 3. SDS-protein banding patterns for seed proteins of the irradiated populations and non-irradiated three canola cultivars in M_2 generation.

Table 6. Densitometric analysis for SDS seed storage protein (water soluble fraction) of the irradiated populations and non-irradiated three canola cultivars in M_1 generation..

Band No	MW (KDa)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	89	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0
2	87	0	0	0	1	1	1	0	0	0	0	1	0	0	0	1
3	84	0	1	1	0	1	1	1	0	0	0	0	1	1	1	1
4	82	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
5	80	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0
6	77	0	1	1	0	1	1	1	0	0	0	0	1	1	1	0
7	75	1	1	1	1	0	0	0	0	0	0	1	0	1	1	0
8	73	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0
9	70	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1
10	69	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
11	67	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
12	64	0	0	0	0	1	1	1	0	1	1	1	1	1	1	1
13	62	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1
14	56	0	0	0	0	0	0	1	0	1	0	0	1	1	1	1
15	55	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
16	51	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
17	43	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
18	38	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
19	36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	35	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0
21	34	1	1	1	1	1	1	1	0	0	0	0	1	0	1	1
22	33	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0
23	32	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1
24	27	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
25	26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	24	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
27	23	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
28	21	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
29	18	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
30	17	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
31	14	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
32	11	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
33	8	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
34	6	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
35	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Total No. of bands		13	16	16	18	18	18	16	15	19	18	22	21	21	21	20

1= Pactol (control) 2= Pactol (200 Gy) 3= Pactol (300 Gy)
4= Pactol (400 Gy) 5= Pactol (500 Gy) 6= Serwo 4 (control) 7= Serwo 4 (200 Gy)
8= Serwo 4 (300 Gy) 9= Serwo 4 (400 Gy) 10= Serwo 4 (500 Gy) 11= Serwo 6 (control)
12= Serwo 6 (200 Gy) 13= Serwo 6 (300 Gy) 14= Serwo 6 (400 Gy) 15= Serwo 6 (500 Gy)

Table 7. Densitometric analysis for SDS seed storage protein (water soluble fraction) of the irradiated populations and non-irradiated three canola cultivars in M_2 generation.

Band No	MW (KDa)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	98	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
2	95	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
3	92	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
4	91	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0
5	87	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
6	84	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
7	81	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
8	78	0	1	1	1	0	0	0	0	0	0	1	1	1	0	0
9	77	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0
10	74	1	1	1	0	1	0	1	0	0	1	0	1	1	0	1
11	73	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
12	72	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0
13	70	1	1	1	0	1	1	1	1	1	0	0	0	1	1	1
14	67	0	0	0	1	0	0	0	1	1	1	1	0	0	0	1
15	64	0	1	1	0	0	0	0	0	0	1	1	1	1	1	1
16	61	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0
17	60	0	0	0	0	0	0	0	1	0	1	1	1	0	0	1
18	56	0	0	0	0	1	1	1	0	1	0	0	1	1	1	0
19	53	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
20	49	0	1	0	0	0	0	0	1	1	1	0	0	1	0	1
21	47	1	0	0	0	1	1	1	0	0	1	1	1	1	0	0
22	44	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0
23	42	1	1	0	0	0	1	1	0	1	0	0	0	0	0	0
24	39	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0
25	38	1	1	1	1	1	1	1	0	0	0	0	1	0	0	1
26	37	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1
27	36	1	1	0	1	1	1	1	0	0	1	1	1	1	1	1
28	35	1	1	1	1	0	1	1	0	0	0	0	0	1	0	1
29	34	0	1	1	0	1	1	1	1	1	1	1	1	0	1	0
30	33	1	0	0	0	0	1	0	1	1	1	1	1	0	0	0
31	32	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
32	31	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0
33	30	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0
34	28	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
35	26	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
36	24	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0
37	22	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
38	20	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0
39	18	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
40	17	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1
41	13	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1
42	11	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0
43	7	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
44	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
45	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total No. of bands		22	26	22	22	25	29	29	22	21	24	23	24	18	11	17

1= Pactol (control) 2= Pactol (200 Gy) 3= Pactol (300 Gy)
4= Pactol (400 Gy) 5= Pactol (500 Gy) 6= Serwo 4 (control) 7= Serwo 4 (200 Gy)
8= Serwo 4 (300 Gy) 9= Serwo 4 (400 Gy) 10= Serwo 4 (500 Gy) 11= Serwo 6 (control)
12= Serwo 6 (200 Gy) 13= Serwo 6 (300 Gy) 14= Serwo 6 (400 Gy) 15= Serwo 6 (500 Gy)

Table 8. Dissimilarity index (pair wise comparison) of SDS-protein data among irradiated populations and non-irradiated three canola cultivars in M_1 generation.

Cases	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0														
2	0.17	0													
3	0.38	0.33	0												
4	0.41	0.43	0.36	0											
5	0.52	0.54	0.48	0.33	0										
6	0.48	0.50	0.36	0.31	0.25	0									
7	0.46	0.56	0.50	0.44	0.39	0.36	0								
8	0.79	0.80	0.88	1.00	1.00	0.89	0.88	0							
9	0.90	0.91	0.89	1.00	0.89	0.80	0.79	0.33	0						
10	0.91	0.92	0.90	0.91	0.90	0.82	0.90	0.57	0.37	0					
11	0.91	0.91	0.90	0.81	0.89	0.81	0.90	0.54	0.47	0.18	0				
12	0.82	0.83	0.70	1.00	1.00	0.90	0.90	0.38	0.47	0.65	0.62	0			
13	0.82	0.74	0.80	1.00	0.89	0.81	0.80	0.69	0.47	0.65	0.75	0.37	0		
14	1.00	0.78	0.87	1.00	1.00	0.87	0.87	0.75	0.80	0.83	0.82	0.64	0.45	0	
15	0.89	0.79	0.75	1.00	1.00	0.88	0.87	0.56	0.64	0.68	0.67	0.50	0.50	0.43	0

1= Pactol (control) 2= Pactol (200 Gy) 3= Pactol (300 Gy)
4= Pactol (400 Gy) 5= Pactol (500 Gy) 6= Serwo 4 (control) 7= Serwo 4 (200 Gy)
8= Serwo 4 (300 Gy) 9= Serwo 4 (400 Gy) 10= Serwo 4 (500 Gy) 11= Serwo 6 (control)
12= Serwo 6 (200 Gy) 13= Serwo 6 (300 Gy) 14= Serwo 6 (400 Gy) 15= Serwo 6 (500 Gy)

Table 9. Dissimilarity index (pair wise comparison) of SDS-protein data among irradiated populations and non-irradiated three canola cultivars in M_2 generation.

Cases	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0														
2	0.25	0													
3	0.33	0.29	0												
4	0.50	0.56	0.29	0											
5	0.62	0.67	0.65	0.67	0										
6	0.53	0.58	0.56	0.68	0.05	0									
7	0.62	0.67	0.65	0.78	0.33	0.26	0								
8	0.86	0.87	0.87	0.87	0.87	0.88	0.87	0							
9	0.87	0.89	0.88	0.89	0.78	0.79	0.78	0.25	0						
10	0.75	0.89	0.76	0.78	0.89	0.89	0.89	0.37	0.22	0					
11	0.79	0.81	0.70	0.81	0.90	0.91	0.90	0.47	0.33	0.14	0				
12	0.80	0.91	0.81	0.82	0.73	0.74	0.73	0.50	0.45	0.27	0.28	0			
13	0.81	0.91	0.82	0.83	0.74	0.75	0.74	0.52	0.48	0.30	0.38	0.11	0		
14	0.81	0.91	0.82	0.83	0.74	0.75	0.74	0.52	0.48	0.30	0.38	0.11	0	0	
15	0.79	0.81	0.90	0.90	0.81	0.82	0.81	0.47	0.33	0.33	0.42	0.36	0.23	0.23	0

1= Pactol (control) 2= Pactol (200 Gy) 3= Pactol (300 Gy)
4= Pactol (400 Gy) 5= Pactol (500 Gy) 6= Serwo 4 (control) 7= Serwo 4 (200 Gy)
8= Serwo 4 (300 Gy) 9= Serwo 4 (400 Gy) 10= Serwo 4 (500 Gy) 11= Serwo 6 (control)
12= Serwo 6 (200 Gy) 13= Serwo 6 (300 Gy) 14= Serwo 6 (400 Gy) 15= Serwo 6 (500 Gy)

The highest dissimilarity index (0.90) was recorded between Serwo 4 after irradiation with 200 Gy and the same cultivar after irradiation with 500 Gy gamma ray dose. The dissimilarity relationships between the irradiated and Serwo 6 populations and the control ranged from 0.82 to 0.62 between the irradiated population with 400 Gy and the control (non-irradiated) and between the irradiated population with 200 Gy and non-irradiated, respectively. The lowest dissimilarity index (0.37) was recorded between Serwo 6 after irradiation with 200 Gy and the same cultivar after irradiation with 300 Gy gamma ray dose. Data in Table (8) indicated that Serwo 4 is the most sensitive cultivar to irradiation with gamma rays. Serwo 4 irradiated population with 200 Gy and Serwo 4 irradiated population with 500 Gy dose in M_2 generation (Table 9). The lowest dissimilarity index (0.11) was recorded between Serwo 6 after irradiation with 200 Gy

The dendrogram of the irradiated populations and non-irradiated three canola cultivars showing the genetic relationships in M_1 generation is present in Figure (4). The cultivars were separated into two clusters; cluster 1 included all Pactol populations, Serwo 4 control and Serwo 4 population after treatment with 200 Gy gamma ray dose, but the rest of the studied populations are appeared in cluster 2. Cluster 1 included two subclusters, the first subcluster included Pactol control, Pactol 200 Gy and Pactol 300 Gy populations, while the second subcluster included Pactol 500 Gy, Serwo 4 control, Pactol 400 Gy and Serwo 4 at 200 Gy. Cluster 2 included two subclusters, the first subcluster included Serwo 4 at 500 Gy, Serwo 6 control, Serwo 4 at 300 Gy and Serwo 4 at 400 Gy populations, while the second subcluster included Serwo 6 at 200 Gy, at 300 Gy, at 400 Gy and at 500 Gy. More over in M_2 generation (Fig. 5), the cultivars were separated also into two clusters. The dendrogram (Figs. 4 and 5) showed that the effect of gamma ray doses on the genetic relationships of three canola cultivars resulted in variations appeared in the different genetic distances among the irradiated populations and their control (non-irradiated cultivars).

These results are in agreement with Kempthorne (1957), Mohan *et al* (1997), Kasarada *et al* (1998), Jaramillo *et al* (1999) and Gadalla (2004), who reported that SDS-PAGE was widely used to separate proteins, which are directly related to genetic background and can be used to certify the genetic makeup of wild cultivars, or newly derived cereal plants.

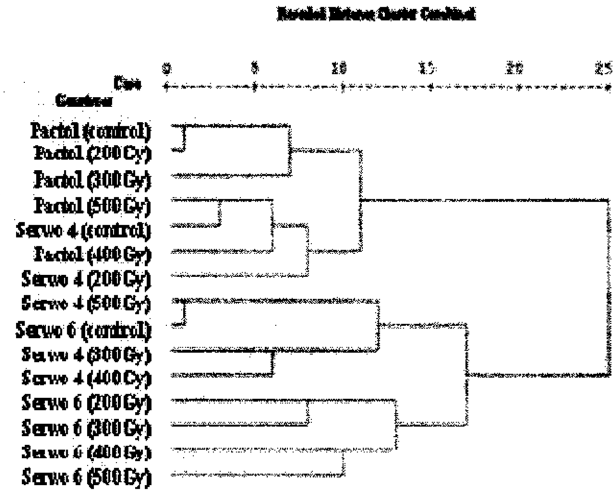


Fig. 4. **A dendrogram showing the genetic distance among the irradiated populations and non-irradiated three canola cultivars in M_1 generation using SDS- protein data.**

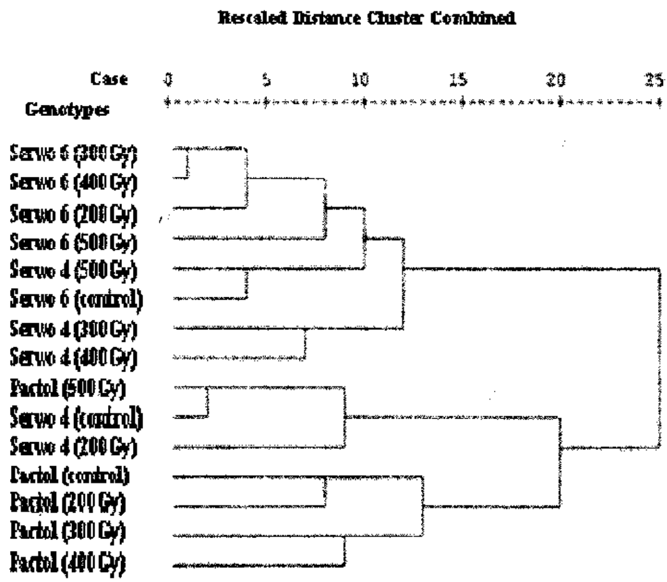


Fig. 5. **A dendrogram showing the genetic distance among the irradiated populations and non-irradiated three canola cultivars in M_2 generation using SDS- protein data.**

Luczkiewicz (1987) derived winter rapeseed mutants with decreased tendency to shattering. Kamala *et al* (1989) induced a long podded mutant in Toria (*Brassica napus* L.). Sorour and Keshta (1994) selected some mutants in the M_2 generation which could be of breeding and economic value, including mutants with high yielding ability, pod quality, early maturation and semi shattering pods. Sorour (1998) reported that the semi-shattering mutant was superior to the other cultivars in number of branches, number of siliquas and seed weight/plant in two seasons. However, this mutant showed some shattering resistance reducing the losses in seed yield.

Some of M_2 elite variants characterized by high yielding ability, early maturation, semi-shattering pods, as well as high oil percentage and quality were selected from M_2 populations derived after gamma ray treatments, where the genetic variation among individuals was greater than that derived after treatments with other gamma ray doses. These selected variants will be further studied in the next generations for incorporation in breeding programs of rape seed improvement.

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تحسين بعض الصفات الاقتصادية من خلال التباين المستحدث عن طريق الإشعاع في الكانولا

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تم تشعيع البذور الجافة لثلاثة أصناف من الكانولا(باكتول، سرو٤ ، سرو٦ (بخمسة جرعات إشعاعية من أشعة جاما : صفر, ٢٠٠, ٣٠٠, ٤٠٠ و٥٠٠ جراى (بمعدل تشعيع ٥,٩٤ جراى/دقيقة)، بهدف إستحداث تباين وراثى والانتخاب لتحسين الكانولا و دراسة تأثيرأشعة جاما على التباين الوراثي و كفاءة التوريث و التقدّم الوراثي المتوقع نتيجة للإنتخاب (بنسبة ١٠%) بالنسبة للصفات المورفولوجية، مكونات المحصول والمحصول وكميةِ و نوعيةِ الزيت ومحتوى البروتين والحزم البروتينة وذلك أثناء الموسمين الشتويين ٢٠٠١-٢٠٠٢ و٢٠٠٢ – ٢٠٠٣ فى مزرعة

مركز البحوث الزراعية بالجيزة . أشارت النتائج بأنه فى الجيل الاشعاعى الاول والثانى وجدت إختلافات معنوية بين أصناف الكانولا والجرعات الاشعاعية والتفاعل بينهما لكل الصفات المدروسة تقريبا. إن زيادة عدد القرون لكل نبات نتيجة للتشعيع فى أصناف الكانولا الثلاثة المدروسة أدت لزيادة معنوية فى محصول البذرة / نبات والتى ستؤدى لتحسين إنتاجية المحصول.

جرعات الاشعاع كان لهاا تأثير إيجابي على نسبة الزيت و تأثير سلبي على محتوى البروتين فى الجيل الاشعاعى الاول والثانى. زادت نسبة الزيت زيادة معنوية مع كل الجرعات الاشعاعية مقارنة بالكنترول والعكس بالعكس بالنسبة لمحتوى البروتين. أدت معظم الجرعات الاشعاعية لنقص محتوى الحامض الدهنى إيروسيك فى الجيل الاشعاعى الاول. فى الجيل الاشعاعى الثانى، معظم العشائر المشععة إحتوت فقط على كميات ضئيلة للغاية من الحامض الدهنى إيروسيك. التباين الذى لوحظ فى العشائر المشععة بالنسبة لمجموع الاحماض الدهنيةالكلية غير المشبعة/الاحماض الدهنية الكلية المشبعة يعتبر نتيجة مبشرة للمربين لتحسين نوعية زيت الكانولا. الزيادة فى المدى، معامل الاختلاف، كفاءة التوريث و التقدم الوراثي المتوقع نتيجة للإنتخاب فى الجيل الاشعاعى الثانى تشير الى ان الجرعات الاشعاعية المستخدمة كانت مفيدة فى إستحداث التباين الوراثى الضرورى لإجراء الانتخاب.

وجد أن تقنية التفريد الكهربي بطريقة الصوديوم ديدوسيل سلفيتSDS-PAGE للبروتينات الذائبة المستخلصة من بذرة الكانولا للعشائر المشععة وغير المشععة للاصناف المستخدمة فى كلا من الجيلين الاشعاعيين الاول و الثانى مفيدة لتوضيح التباين المستحدث على مستوى الحزم البروتينية فى العشائر المشععة كنتيجة للتشعيع بجرعات مختلفة من أشعة جاما. وقد ظهرت بعض الحزم البروتينية التى لم تتواجد فى المقارنة وغابت حزم بروتينية أخرى ذات أوزان جزيئية مختلفة. إعتمدت الزيادة أو النقص فى عدد الحزم البروتينية بزيادة جرعات جاما الاشعاعية على الصنف المستخدم. أستخدم برنامج الحاسوب UPGMA لتوضيح التباعد الوراثى فى العشائر المشععة وغير المشععة. أظهر ال dendrogram أن تأثير جرعات أشعة جاما على اصناف الكانولا الثلاثة أنتج إختلافات ظهرت في المسافات الوراثية المختلفة بين العشائر المشععة والكنترول (العشائر غير المشععة). تشير البيانات بأن الصنف سرو ٤ كان الأكثر حساسية إلى التشعيع باشعة جاما فى الجيلين الاشعاعيين.