EFFECT OF RADIATION ON PEAS
(PISUM SATIVUM)

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THESIS

Submitted in Partial Fulfilment of the Requirements
for the Degree of

MASTER OF SCIENCE
in
GENETICS

Department of Genetics
Faculty of Agriculture
Ain Shams University

1971

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Date / / *1971*

A C K N O W L E D G E M E N T

The author wishes to express his sincere gratitude to Dr. Abdel-Aziz M. Omar, Emeritus Professor and Former Head of the Department of Genetics, Dr.Mohamad Abdel-Maksoud, Professor of Vegetable Crops, Department of Horticulture and Dr.Mahmoud Abdel-Rahim Marwan, Former Lecturer of Genetics, Faculty of Agriculture, Ain Shams University, for suggesting the problem, kind guidance and encouragement during the progress of the study.

He is also very gratefull to Dr.Ahmed Kamel Abdallah Selim, Professor of Genetics and Head of Genetics Department, Faculty of Agriculture, Ain Shams University who gave unspairingly of his time and advice for the accomplishment of this work.

The writer is greatly indebted to Dr.Amin Khalifa A. Okasha, Lecturer of Genetics, Faculty of Agriculture, Ain Shams University, for his immense effort and kind help during the preparation of the manuscript.

The author is also thankfull to the National Research Centre, U.A.R., for the award of a scholarship and the facilities provided.

Thanks are also due to the Atomic Energy Establishment Staff at Inshas for their help in exposing the material to the radioactive cobalt.

بسم الله الرحمن الرحيم

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I. INTRODUCTION

It was established by Muller and Stadler in the late 1920's that hereditary changes similar to those occurring naturally could be induced in animals and plants by radiation. Since that time, radiation has been applied extensively in genetic and plant breeding research. In spite of the great amount of work already done in this field, relatively few, however, have been reported on the beneficial effects of radiation in the improvement of plants. This could be due to the fact that most of the minute useful modifications could not be easily detected. Moreover, the unfavourable modifications which represent the majority of irradiation induced variants generally shift the means of the studied characters towards the negative direction. This led to the belief that radiation apparently causes only destructive genetic changes especially in quantitative characters.

From more recent work done by several investigators, especially in self-pollinated plants, it has now become clear that mutations in polygenic system do occur towards both positive and negative directions. The induced variability thus created could be fixed by selection and thereby serve to shift the means of homozygous lines favourably.

The present experiment was designed to study the effect of different doses of gamma-rays on some quantitative characters including the yield and its components as well as their interrelationships on peas (Pisum sativum). Besides, the physiological responses to irradiation treatments with respect to the pigment content of the seeds was studied. The two pea varieties Little Marvel and Lincoln were used. The variety Little Marvel was used to gain information on the effect of irradiation on the yield and its components whereas both of the two varieties were used for the study of pigmentation. Treated plants were followed through two generations.

II- REVIEW OF LITERATURE

1- Yield and Yield Components :

A- Yield :

The success of a breeding programme is dependent upon sufficient genetic variability among the genotypes to permit effective selection. Several investigators have utilized ionizing irradiation to increase the variability load in their populations (Gregory, 1955 (20), Offut, 1962 (30), Palenzona, 1963 (31), Disler, 1966 (9), Balint et al., 1968 (4) and Vasudevan et al., 1969 (46)). This increase in variability within populations gave them better basis for selection of improved types of plants.

Gelin (1954), obtained pea mutants that gave 2.5% higher yield than the original material by using seeds irradiated with 15 K rad of x-ray (13). In 1955, Gregory estimated the total genetic variance and measured the effect of selection on yield among progenies of randomly selected, normal appearing x-ray treated plants and in control populations of Virginia Bunch peanuts (20). He found that the estimated genetic variance of the irradiated groups was approximately four times that of the control. Several high yielding irradiation induced mutants were recovered from the populations studied.

Similar results were obtained by Rawlings *et al.* (1958) in Adams and Hawkeye soybeans (34). They utilized five x-ray doses ranging from 7,500 r to 20,000 r and seven doses of thermal neutrons ranging from 5.6×10^{12} N^{th}/cm^2. to 2.4×10^{13} N^{th}/cm^2. They found that the irradiation treatments significantly increased the genetic variability with respect to yield, plant height, maturity and seed size. The estimates of genetic variance in the irradiation treatments were about five times greater than those of the controls. The predicted genetic gains from selection indicated that an advance could be made within each population for all the characters studied except plant height.

Tselishchev and Moglevkin (1958), found a decrease in seed yield of some crop plants as a result of seed treatments with 2.2×10^{12} to 66.0×10^{12} neutrons/cm^2 and gamma-radiation intensities from 1.5×10^3 to 45×10^3 (44). The plants varied in their radiosensitivity as determined by the decrease in seed yield in the following ascending order; mustard, radish, millet, soybean, oats, wheat, beans, peas. Nevertheless, Svejda (1961), reported that the average yields of x_3 and x_4 bulks resulting from x-ray irradiated pea seeds of the variety Chancellor were considerably higher than that of the control (41). Their average increase in yield over the untreated variety was attributed to a large number of higher yielding types in the x_3 and

x_4 bulks. However, no consistent relationship between x-ray doses and yield was detected.

Offut (1962), studied the effect of gamma-ray dosages ranging from 40 to 80 Kr. and the effects of the exposure to thermal neutrons for 1-8 hours on some characters of Korean Lespedeza including yield (30). All dosages reduced seed yield of R_1 progenies as compared with their controls. Seed yields of six of the R_4 lines were significantly higher than that of the control, and nine were significantly lower. The range of variability of all characters studied has fluctuated above as well as below that of the control, indicating that worth-while advances in the improvement of this crop can be made through the use of irradiation.

Debelyj (1963), selected some lines of the pea variety Nemcinovka 51 treated with thermal neutrons that exceeded the untreated controls in total yield in the R_1 and later generations (5). He recommended carrying out selection for higher yield in the R_1 generation. Consequently in (1964), he was able to introduce high-yielding mutants of the pea Moscow 572 and Nemcinovka 51 which were obtained by means of gamma-irradiation (6).

In wheat, Palenzona (1963) studied 14 quantitative characters in the R_2 and R_3 of plants treated with 10 kr of x-ray (31). A significant increase was found in the variability of R_3 as compared with the untreated controls. Nevertheless, no increase was detected in the R_2. These results led Palenzona to conclude that the increase in variability was due to mutations in a multifactorial system rather than in the major genes. In Lupinus termis, Amer and Hakeem (1964) found that the 12 Kr treatment of gamma-rays resulted in more fruits than the control (1).

Gottschalk (1964), mentioned that air dry pea seeds variety Dippes Gelbe Victoria, subjected to x-ray doses of 5-15 Kr gave an increase in seed yield of 19.1%, higher than the untreated controls (16). Nevertheless, he found that higher x-ray doses caused reduction in seed yield. On the other hand, Heringa (1964), found that the yield of pea plants was reduced as a result of dry seed treatment with x-rays and neutrons (23).

Vlk (1964), reported that varieties of peas and Vicia faba were found to be very susceptible to gamma-rays and that the low doses produced some mutants of economic use (47). These included a mutant of the pea Raman, which was characterised by its dwarf growth, earliness and high yield. In 1965, Dubinin and Hvostova reported a number of radiomutants in different plant species which were suitable for direct introduction and hybridisation for improvement of existing varieties (10). In haricot bean, two gamma-ray induced mutants outyielded the original varieties by 60-90%. Meanwhile, the radiomutants Universal and Gudo Grust in soybean gave 850 kg. and 1160 kg. increase in yield per hektar over the recommended varieties.

Several high-yielding mutants of garden pea were obtained by Hangildin in 1965 by irradiating seeds of six different cultivars with 10 Kr. of x-rays (21). One of the mutants exceeded the parental variety Ciminsky Ranny by 13% in seed yield, although the parent was the most productive local variety.

Sidorova _et al_. (1965), used chemical mutagenics and gamma-rays in separate treatments on the two pea varieties Torsdag and Falenki 24 (27). They were able to select 26 mutants from Torsdag and 14 from Falenki 24 which exceeded the parental variety by 5-25% in seed yield. Tedorads (1965), obtained 18 A_2 plants from seeds of three cultivars of French bean treated with doses of gamma-rays ranging from 5 to 30 Kr (42). These plants showed an increase of about 747 kg. per hectar over their controls. One mutant of Canva 3 gave a yield of 1640 kg. per hectar whereas the control gave only 893 kg.

Teresenko (1965), reported that the 5 Kr. treatment of gamma-rays gave the greatest number of plants with promising agronomic features in the pea variety Konkursnyj (43). He isolated six families from the R_2 that exceeded the control by 26-100%.

Disler (1966), found that the range of spontaneous variability in plant height and number of pods and seeds per plant has increased in a mutated cultivar of field bean by means of irradiation with gamma-rays (9). He pointed out that 0.5 Kr. gamma-rays was more effective than 1.0 or 3.0 Kr. He selected some R_3 plants which showed 34% increase in the number of seeds per plant over the controls.

Weber and Fehr (1967), compared some quantitative characters of soybean in untreated lines derived from the cross Mandarin x A_4-3159 and lines derived from the same cross irradiated with 1.62 x 10^{13} thermal neutrons per cm^2 (48). They found that seed yield was significantly lower in the irradiated populations and averaged 118 pounds per acre less than the control.

Badr (1968), reported that the low doses of gamma-rays (from 1 to 5 Kr) had a stimulative effect on the total yield of the pea variety Little Marvel whereas higher doses (from 10 to 30 Kr) were depressive (2). He attributed the decrease in yield at the higher doses to the suppressive effect of radiation on yield components, which depended on the level of the dose. He further reported that the stimulative effect of the low doses could be attributed to the increase in the number of bacterial nodules on the roots of such plants and to the increase of leaf area.

Balint *et al*. (1968), found that x-ray treatments at 700 r has increased the phenotypic variability for some characters in the R_3 generation in the variety Pitit Provencal of *Pisum sativum* (4). They also recorded an increase in variability of some characters of the irradiated plants which otherwise showed little or no genetic variability in the untreated controls.

Hanna (1969), in a study of the effect of post-irradiation storage on *Vicia faba* seeds variety Giza 1, found that the low doses (1 Kr) of gamma-rays had a stimulative effect on yield whereas the higher doses were depressive (22).

In 1969, Vasudevan *et al*. irradiated barley seeds of the variety C. 138-2 with x-ray doses ranging from 4,000r to 16,500 r (46). They found that the coefficient of variation for grain yield increased from 20% in the control population to 28.65 and 27.35% in the R_2 of plants treated with 8,250 and 16.500 r respectively.

B- Yield components

1- Number of branches

In 1958, Lamprecht produced an x-ray mutant in peas which had an average of 10 branches per plant compared with the nonirradiated normals that had only 3 or 4 branches (25). Similarly, Hangildin (1965) selected several mutants with greater number of branches from the progeny of six different varieties of garden peas irradiated with 10 Kr of x-ray (21).

Badr (1968), reported that gamma-irradiation increased the number of branches per plant in the pea variety Little Marvel (2). Nevertheless, he found that the increase in the number of branches was not linear with the increase in the level of the given doses.

In wheat, El-Barhamtoushy (1964), found that the number of tillers per plant in the variety Einoorn increased with the increase in the radiation dose from 5000 r to 30,000 r of gamma rays (11). Meanwhile, Hanna (1969) , showed that the relatively low doses of gamma-rays (1 and 3 Kr) increased the number of branches per plant in Vicia faba variety Giza 1, whereas higher doses (5 and 10 Kr) reduced the number of branches per plant (22).

2- Number of pods

Sidorova (1965), reported mutations with increased pod number resulted from gamma-ray treatments of the pea variety Torsdag (37).

By irradiating seeds with gamma-ray dosages ranging from 5 to 30 Kr, Tedoradze (1965) was able to obtain a mutant of the variety Canava 3 of French bean that had 14-18%

more pods per plant than the untreated stock (42). On the other hand. Pinchinat and Adams (1966), found that neutron irradiation at 739 rep. for 30 minutes had no marked effect on the number of pods per plant in the sare crop (32).

Disler (1966), reported mutants in *Vicia faba* that had up to 100% higher increase in the number of pods per plant as a result of irradiation treatments with gamma-ray dosages of 0.5, 1.0 and 3.0 Kr (9).

Balint *et al*. (1968), found that the mean values for the number of pods per plant increased in the R_1 and R_2 progenies of the pea variety Pitit Provencal which was treated with 7000 r x-ray (4).

Debelyj (1968), selected a plant which surpassed the parent variety in number of pods from an R_2 family of Nemcinovsky 766 pea treated with 7 Kr of gamma-rays (7).

Hanna (1969), reported that gamma-ray treatments of the seeds of the variety Giza 1 with doses of 1 or 3 Kr had no effect on the number of pods per plant, whereas the treatment with 5 and 10 Kr decreased the number of pods by 22 and 39% relative to the control respectively (22).

3- Number of seeds per pod

In 1965, Tedoradze obtained a bean mutant which had 1-2 more seeds per pod resulting from seed irradiation with