J. Agric. Sci. Mansoura Univ., 28 (3): 2317 - 2325 , 2003

SUSCEPTIBILITY OF CERTAIN IRRADIATED AND NON-IRRADIATED COWPEA VARIETIES TO INFESTATION WITH *Callosobruchus maculatus* (F.)

El- Degwi, Mai S.
National center for Radiation Research and Technology (NCRRT) P.O. Box 29, Nasr City, Cairo, Egypt.

ABSTRACT

Seeds of four irradiated and non- irradiated cowpea varieties were evaluated according to their susceptibility to infestation by *Callosobruchus maculatus* to determine the relationship between seed variety and susceptibility level, number of eggs laid, hatchability, failure of larval instars to penetrate the seed testa, duration of development, number of emerged adults and rate of survival, sex ratio, dead larvae within the cotyledon and impact of infestation on weight loss.

Obtained results indicated that there were different changes in the biological properties of this pest, among the irradiated and non- irradiated four cowpea varieties. The radiation doses causing remarkable increase in internal mortality in all varieties. The relatively resistant variety Balady showed the highest level of mortality, Azmerly and Dokki were less resistant while, Karem 7was moderately susceptible. However non- irradiated Balady and Dokki varieties showed moderately susceptible, Azmerly and Karem7 were susceptible. It could be concluded that the susceptible of cowpea varieties was radiation dependent.

INTRODUCTION

Pulses are grain legumes grown as important food crops in many countries of the world (Smartt, 1976). These seeds constitute an important protein source in the human and animal nutrition (El- Shazly, 1993 and Silim Nahdy *et al.*, 1998).

Bruchids are the most important post-harvest pests on legume seeds in Egypt. These beetles cause appreciable losses every year. Genus *callosobruchus* involves the largest number of pest species which cause the greatest damage to many economically important legume seeds. *Callosobruchus maculatus* is specific pest of many stored legume seeds. Its usual host plant cowpea *vigna unguiculata* many varieties of cowpea are liable to its attack and furnish suitable breeding source for it. The females oviposit on the pods or seeds in which the larvae develops consuming the reserve contained in the cotyledons, (Alzouma, 1981).

Selection of legumes varieties resistant to infestation with pulse beetles during storage has been the subject of many workers since a long time. Previous studies on the relative varietal resistance to infestation with *Callosobruchus* beetles in cowpea (Kitch *et al.*, 1991, Mbata, 1993; Desroches *et al.*, 1995 and El-Shazly 2001) reveald considerable differences.

Several investigators observed the relationship between certain morphological and chemical characters of pulse seeds and the level of their infestation with bruchid beetles. (Oigiangbe and Onigbinde, 1996; El-Shazly, 1998)

Host plant resistance is one of the relatively recent methods of the pest control. Therefore, this investigation was conducted to evaluate the effect of gamma radiation on the ability of *C.maculates* to infest and develop on some varieties of cowpea *V.unguiculata* cultivated in the same region in order to find out the relative resistance variety.

MATERIALS AND METHODS

Four varieties of cowpea seeds (*vigna unguiculata*) namely Azmerly, Dokki, Balady and Karem 7 were tested for their relative resistance against *C.maculatus*, tested varieties were obtained from the Crop Research Institute, Ministry of Agriculture. The cowpea varieties were irradiated through the model 220 Gamma Cell Irradiation Unit (Co) source installed in (NCRRT) with a dose rate (2.6 rad/ sec.). The irradiation doses used were 20, 40 and 60 Gy Irradiated and non-irradiated seeds of different varieties of cowpea were sown in sand loamy soil in green house of (NCRRT), seeds of each varieties were harvested when the plants reached maturity stage (F1).

The pulse beetles *Collosobruchus maculatus* (F.) were reared in the Insect and Pest Control Lab (NCRRT). Experiments were conducted under the conditions of 30 ± 2°C and 70 ± 5% R.H. Five pairs of newly emerged adults were introduced into 25 gm. Seeds each in small jars of each variety (Three times), then kept under experimental conditions for 4 days during which the majority of eggs were laid (El-Shazly, 1993). Seeds were examined and the number of eggs laid was counted. Hatched eggs, penetrated larvae, duration of development from egg oviposition to adult emergence, number of emerged adults and rate of survivals were estimated, adult were sexed and counted until emergence of adults in each jar ceased. At the end of the experiments seeds were weighted and the weighted loss for each cowpea variety was calculated.

To estimate hatchability, penetration, survival and mortality, the following equations were used according to El-Shazly (1993).

Rate of hatchability = No. of hatched eggs / No. of eggs x 100
Rate of penetration = No. of penetrated larvae / No.of hatched eggs x 100
Rate of survival = No. of emerged adults / No. of penetrated larvae x 100
External mortality (EM) = 100 - Rate of penetration.
Internal mortality (IM) = 100 - Rate of survival.
Total rate of mortality (TM) = EM + IM.

Differences between the rates of mortality on each variety were calculated and used for the classification of the tested varieties into 5 arbitrary susceptibility group as, relatively resistant, less resistant, moderately susceptible, susceptible and highly susceptible according to the following equations (Desroches *et al.*, 1995).

Relatively resistant	(TM) < 80%
Less resistant	(TM) 60 - 80%
Moderately susceptible	(TM) 40 - 60%
Susceptible	(TM) 20 - 40%
Highly susceptible	(TM) 0 - 20%

RESULTS AND DISCUSSION

As shown in Table (1) the pulse beetle C.*maculatus* laid great number of eggs on non-irradiated Balady variety (132.67) and relatively more number on Azmerly (87.67), while moderate number on both Karem 7 and Dokki (69.30 and 65.70).

Table (1): Effect of gamma-irradiated and non-irradiated four varieties of cowpea on the production and hatchability of eggs laid by *C. maculatus*.

Irradiation dose (Gy)	Cowpea variety	Mean number of eggs/female	Mean number of hatched eggs	% Rate of hatchability
0	Azmerly	87.67	81.30	92.78
	Dokki	65.70	50.30	76.65
	Balady	132.67	117.00	88.19
	Karem 7	69.30	56.00	80.70
20	Azmerly	79.00	72.00	91.14
	Dokki	52.60	36.70	69.62
	Balady	105.70	87.00	82.33
	Karem 7	58.60	41.60	71.02
40	Azmerly	54.33	48.30	82.82
	Dokki	38.00	15.60	64.90
	Balady	81.33	68.01	83.61
	Karem 7	48.00	32.60	68.05
60	Azmerly	41.00	35.30	78.86
	Dokki	17.70	11.00	62.23
	Balady	57.60	43.30	75.14
	Karem 7	35.00	21.60	61.90

There was highly decreased in the mean number of eggs deposited by female on irradiated varieties with the increasing of radiation dose. The lowest number of eggs were on Dokki and Karem 7 (17.70 and 35.00) irradiated with 60 Gy. Regarding the highly difference between the mean number of hatched eggs deposited by female on the non-irradiated cowpea varieties and those deposited by female on irradiated ones. The mean number of hatched eggs was (117.0) on Balady (81.30) on Azmerly but it decreased to (56.0) on Karem 7 and (50.30) Dokki. The dose 40 and 60 Gy caused highly decreased in the number of hatched eggs, especially in Dokki (15.6, 11.0) and Karem 7 (32.60, 21.6) while, 20 Gy caused moderately decreased.

Data in table (2) clearly demonstrate that larvae showed a high rate of pentration on all non-irradiated and irradiated varieties. It should be noted that radiation doses did not often prevent the larvae penetration.

Concerning developmental period there were differences between tested varieties, it ranged between (24.3 and 27.6 days) on non-irradiated and prolonged with the increasing of radiation dose on all tested ones, it reached to (33.3 days) on irradiated Dokki with 60 Gy.

Table (2): Effect of gamma-irradiated and non-irradiated four varieties of cowpea on larvae, rate of penetration and developmental period of *C. maculatus*.

Irradiation dose (Gy)	Cowpea variety	Mean number of penetrated larvae	% rate of penetration	Developmental period in (days)
0	Azmerly	71.67	88.11	24.3
	Dokki	39.00	77.48	27.6
	Balady	96.67	82.62	26.0
	Karem 7	48.60	86.90	26.3
20	Azmerly	60.60	84.20	25.6
	Dokki	27.00	73.64	29.3
	Balady	68.66	78.92	26.7
	Karem 7	55.00	84.00	28.3
40	Azmerly	34.60	77.03	26.70
	Dokki	17.30	70.00	30.6
	Balady	49.33	72.55	28.6
	Karem 7	26.60	81.63	30.6
60	Azmerly	24.30	75.25	31.33
	Dokki	7.60	69.70	33.3
	Balady	27.66	63.85	32.7
	Karem 7	18.00	83.07	32.3

Results in Table (3) revealed that the mean number of adult emergence decreased by irradiated in all varieties compared to their corresponding non-irradiation ones. The data show that survival rate were 86.97%, 75.21%, 74.83% and 83.56% on non-irradiated Azmerly, Dokki, Balady and Karem 7, respectively. Moreover, radiation showed no great affect on the rate of survival of penetrated larvae in all dose levels except dose 60 Gy where the rate was 55.42% on Balady. While, the percentage of males were more than females on non-irradiated Azmerly and Dokki (52.4%, 51.41%). However, the percentage of males were produced from irradiated varieties in all dose levels were less than females except in irradiated Azmerly with 40 Gy (54.69%).

Table (4) indicated that the first larval instars perforated the seed coat and reached the cotyledon whatever the tested variety. Therefore, external mortality (EM) was less than (15%) of hatched eggs on non-irradiated Azmerly and Karem 7, while this rate of mortality was between (15-23%) on Balady and Dokki. The percentage of mortality was affected by irradiation especially at dose 60 Gy., where the percentage was increased to (36.15%) on Balady. The internal mortality (IM), was higher than (EM) in all irradiated and non-irradiated varieties. The radiation doses causing remarkable increase in (IM), in all varieties, it reached (35.62%) on Azmerly compared to (13.03%) in the control and reached the highest level (44.58%) in Balady while, ranged between (25%-35%) in rest tested varieties with 60 Gy. The total level mortality (TM), was higher than (20%) on non-irradiated Azmerly and Karem 7 while they ranged between (42.55% and 47.31%) on Balady and Dokki. On the other hand the dose level 20, 40 and 60 Gy caused highly increase in (TM) especially in Balady which was (62.59%, 80.73%) with 40 and 60 Gy. Results in Table (4) refer to general conduction that (IM) was higher than (EM) in all tested varieties except for Dokki with 20 and 40 Gy.

Table (3): Effect of gamma-irradiated and non-irradiated four varieties of cowpea on adult emergence and survival rate of *C. maculatus*.

Irradiation dose (Gy)	Cowpea variety	Mean number of emerged adults	% rate of survival	Sex ratio (% males)
0	Azmerly	62.30	86.97	52.41
	Dokki	29.3	75.21	51.41
	Balady	72.33	74.83	45.62
	Karem 7	40.60	83.56	43.31
20	Azmerly	50.30	82.96	44.38
	Dokki	20.00	74.07	45.0
	Balady	52.33	76.21	46.50
	Karem 7	32.00	81.90	48.84
40	Azmerly	28.60	61.53	54.69
	Dokki	12.30	71.15	45.95
	Balady	32.00	64.86	41.70
	Karem 7	20.30	76.25	49.18
60	Azmerly	15.60	64.38	46.81
	Dokki	5.00	65.22	40.0
	Balady	15.30	55.42	45.67
	Karem 7	13.30	74.07	40.00

Table (4): Effect of gamma-irradiated and non-irradiated four varieties of cowpea on mortality of *C. maculatus* larvae.

Irradiation dose (Gy)	Cowpea variety	Mortality		
		EM	IM	TM
0	Azmerly	11.89	13.03	24.92
	Dokki	22.52	24.79	47.31
	Balady	17.38	25.17	42.55
	Karem 7	13.1	16.44	29.54
20	Azmerly	15.80	17.04	32.84
	Dokki	26.36	25.93	52.29
	Balady	21.08	23.79	44.87
	Karem 7	16.00	18.1	34.10
40	Azmerly	22.97	38.47	61.144
	Dokki	29.97	28.85	58.82
	Balady	27.45	35.14	62.59
	Karem 7	18.37	35.62	42.12
60	Azmerly	24.75	35.62	60.37
	Dokki	30.30	34.78	65.08
	Balady	36.15	44.58	80.73
	Karem 7	16.93	25.93	42.80

The tested irradiated and non-irradiated varieties could be classified according to their susceptibility to infestation with *C.maculatus* in 4 arbitrary different groups shown in Table (5). Relatively resistant, less resistant, moderately susceptible and susceptible. Balady variety appeared relatively

resistant with 60 Gy and was less resistant with 40 Gy while, was moderately susceptible in control and 20 Gy. Simultaneously, Azmerly and Karem 7 were susceptible with the same dose levels. increasing gamma irradiation doses to 40 and 60 Gy Azmerly was less resistant while, Karem 7 appeared moderately susceptible in control, 20 and 40 Gy while, was less resistant with 60 Gy.

Table (5): Tested cowpea varieties in ascending order according to evaluation parameters.

Resistant group	Irradiation dose (Gy)			
	0	20	40	60
Relatively Resistant	-	-	-	Balady
Less resistant	-	-	Azmerly Balady	Azmerly Dokki
Moderately susceptible	Dokki Balady	Dokki Balady	Dokki Karem 7	Karem 7
Susceptible	Azmerly Karem 7	Azmerly Karem 7	-	-

As shown in the Table (6) percentage of weight loss was related to the number of emerged adults Table (3). *C.maculatus* caused the highest level of loss on non-irradiated Azmerly variety (49.69%). Balady showed the lowest percentage of loss (31.48%) and reached only (6.68%) when seeds irradiated with 60 Gy, thus this rate reached (16.01%, 7.06% and 11.8%) on Karem 7, Dokki and Azmerly varieties, respectively with the same dose of radiation.

Table (6) : The prcentages of weight loss caused by *C. maculates* on irradiated and non-irradiated four varieties of cowpea.

Irradiation dose (Gy)	Cowpea varieties							
	Karem 7		Dokki		Azmerly		Balady	
	weight(g) ± S.E	% loss	weight(g) ± S.E	% loss	Weight(g) ± S.E	% loss	weight (g)± S.E	% loss
0	44.43± 0.7203	40.76	56.10± 0.1193	25.2	39.23± 0.2521	47.69	51.39± 0.1804	31.48
20	53.51± 0.3507	28.65	62.33± 0.6707	16.89	52.86± 0.3470	29.52	56.51± 0.3568	24.65
40	57.68± 0.7261	23.09	66.8± 0.3737	10.93	59.94± 0.4223	20.94	65.68± 0.5154	12.43
60	62.99± 0.7261	16.01	69.70±. 0.0899	7.06	66.09± 1.0160	11.88	69.99± 0.3690	6.68

Generally, the lowest weight loss was radiation dose dependent. In the present study, there were markable changes in the biological properties of this pest, among the non-irradiated four cowpea varieties. This may be due to some morphological and chemical seed characters. Janzen (1997 a,b)

observed the importance of the seed coat in the relationships between the bruchids and their host plants the seed coat prevented of larvae in the seed tested.

Desroches *et al.* (1995) reported that presence of tannins in seed coat may affect larval penetration.

In this study the seed coat did not influence the larval penetration This result goes in line with the finding of Thiery (1981) who recorded that larvae may avoid the toxic defense mechanisms in the seed coat by boring through it without ingesting toxins, El-Shazly,(2001).

In all tested varieties larvae were able to develop. Impact of seed testa on development was discussed by several authors (El-Shazly, 1993; Desroches et, al., 1995, El-Shazly, 1998, El-Shazly and El-Shabrawy, 2000), who stated that the texture of seed coat, its hardness or presence of toxic compounds could explain these.

Mortality inside seeds may be due to the chemical components in the cotyledons. Desroches *et al.* (1995), reported that the important of vicine content for C. *maculatus* larvae and the variation in convicine content had little effect. Recent studies emphasize the precence of certain non-nutrient proteins on the seeds of resistant varieties and C. *maculatus* larvae can't be able to detoxify secondary chemical component (Macedo *et al.*, 1993, Desroches *et al.*, 1995 and El-Shazly, 1998). Oigiangbe and Onigpinde (1996) and El-Shazly (1998) explained that the high rate of weigh loss may be due to some morphological and chimecal seed characters.

Also there were different changes in the biological aspects of the *C.maculatus* fed on the irradiated four cowpea varieties compared to non-irradiated ones. The reasons of these changes seem to depend on the susceptibility of this pest to the differences in the structure between the four varieties before and after irradiation. Sowden (1981) studies the biochemical effects of gamma radiation on proteins, lipids and carbohydrates of fruit and vegetable products and found that high and low doses prolonged the storage life and modified the quality. Irradiation may be affected in the physical, physiological and microbiological characters, also chemical constituents. The present results are agreement with those reported on other insects fed on different irradiated diets. Arthur *et al.* (1993) on *Sitophilus granarium* by irradiated wheat, Mansour and Al. Bachir (1994) on *Bruchus detipes, B. ervi* and *B. lentis* by irradiated lentil and faba bean, Prasad and Roy (1995) on *Tribolium castanium* and *Sitophilus oryzae* by irradiated rice, and Haiba (2000) on *Phthorimaea operculella* by irradiated potato tubers.

According to the evaluation parameters, Balady variety appeared relatively resistant, Azmerly and Dokki were less resistant and Karem 7 was moderately susceptible, no variety observed as susceptible or highly susceptible, it can be concluded that the susceptible of cowpea varieties was radiation dose dependent.

REFERENCES

Al Zouma, I. (1981). Observation on the ecology of *Bruchidius atrolineatus* Pic and *Callosobruchus maculatus* (Coleoptera, Bruchidae) in Niger. In the Ecology of Bruchids Attaching Legumes (Pulses) (*Edited by Labeyrine* V.), pp. 205-213. Junk, the Hangue.

Arthur, V.; M. Wiendle and S.S.H. Franco (1993). The influence of irradiated wheat on longevity and reproduction of the grain weevil *Sitophilus granarius* Linne. Acta-Agriculturae, Ncleata-Sinica., 7(4): 223-226.

Desroches, P.; E. El-Shazly; N. Mandon; G. Due and J. Hugnard (1995). Development of *Callosobruchus chinensis* and *Callosobruchus maculatus* in seed of *Vicia faba* differing in their tannin vicine and convicine contents. J. Stored prod. Res., 31(1): 83-89.

El-Shazly, E.A. (1993). Studies on the relationships between two bruchus species, *Bruchus refimanus* and *Callosobruchus Chinensis* and their host plants. Unpublished, Ph. D.Thesis Cairo Univ. Fac. Agric. pp. *165.*

El-Shazly, E.A. (2001). Susceptibility of certain broad bean varieties to infestation with *Callosobruchus maculatus* (F.) and *Callosobruchus chinensis* (L.) *(Col: Bruchidae) Bull.* Fac. Agric. Cairo, Univ., 2: 149 - 154.

El-Shazly, E.A. and H.A. El-Shabrawy (2000). The impact of certain pulse seeds on the development of *Callosobruchus maculatus* (F.) and *Callosobruchus chinensis* (L.) (Coleoptera:Bruchidae). Bull. Ent. Soc. Egypte, 78: 53-61.

Haiba, I. M. (2000). Integration of ash and gamma- irradiation for controlling the potato tuber moth, *Phthorimaea operculella Zeiller* (Lipidoptera - Gelechildae)in storage. Bull. Ent. Soc. Egypt, Econ. Ser., 27: 87-107.

Janzen, D.H. (1997a). The interaction of seed predators and seed chemistry. Coll. Int. C.N.R.S., 265: 412-420.

Janzen, D.H.(1997b).How southern cowpea weevil larvae *Callosobruchus maculates* die on non host seeds. Ecology 58, 921-927.

Kitch, L.W.; R. Shade; L.L. Emad Murdick (1991). Resistance to cowpea weevil *Callosobruchus maculatus* larvae in pods of cowpea *vigna unguiculata*. Entomologia Experimentais et Applicata, 60: 183-192.

Macedo, M.L.R.; L.B.S. Andrade; R. A. Morales and J. Xavier-fitho (1993). Viclin variants and the resistance of cowpea *vigna unguculata* to the cowpea weevil *Callosobruchus maculatus*. Comparative Biochemisty and Physiology, 105: 89-94.

Mansour, M. and M. Al-Bachir (1994). Feasibility for disinfestation of pulses and cereal grains by irradiation. (Food irradiation in the Middle East and Europe Proceedings of the final research coordination meeting held in Cadarche, France pp. 133-144.

Mbata, G.N. (1993). Evaluation of susceptibility of varieties of cowpea to *Callosobruchus maculatus* and C. *subinnotatus*. J. Stored Prod. Res., 29:201-213.

Oigiangbe, N.O. and A.O. Onigbinde (1996). Association between some physico-chemical characteristics and susceptibility of cowpea *vigna unguiculata* (L.) to *Callosobruchus maculatus* (F) J. Stored prod .Res., 32:7-11.

Prasad, H.H. and M.K. Roy (1995). Efficacy of gamma radiation against important insects of export quality rice. Indian Food Packer., 40(2): 25-30.

Silim Nahdy, M.; R.H. Ellis; S.N. Silim and J. Smith (1998). Field infestation of pigeonpea *(Cojanus cajan* (L.) Millsp.) by *Callosobruchus chinensis* (L.) in Uganda. J. Stored prod. Res., 34: 207-216.

Smartt, J. (1976). Tropical pulses, longman, London, 348 pp.

Sowden, R.E. (1981). Biochemical effects of gamma radiation on fruit and vegetable products. Process Biochem., 16 (5): 43-49.

Thiery, Y.D. (1981). "Etude du comportemont des larves neonated de *Acanthoscelides obtectus* Say (Col: bruchidae) en presence de grain de leure: plant hote *Phaseolus vulgaris"* (these de 3 cycle pp. 185 Univ. de Tours, France).

قابلية بعض أصناف اللوبيا غير المعاملة والمعاملة بأشعة جاما للإصابة بخنفساء اللوبيا .

مي صلاح الدجوي

المركز القومي لبحوث وتكنولوجيا الإشعاع .

تم تقييم أربعة أصناف مختلفة من اللوبيا (أزميرلي – دقي – بلدي – كريم٧) ، والمعاملة بجرعات مختلفة من أشعة جاما ، والمزروعة في نفس التربة من حيث قابليتها للإصابة بخنفساء اللوبيا وذلك على أساس كمية البيض الموضوع ، نسبة الفقس ، قدرة اليرقات على الاختراق وإكمال فترات النمو ، نسل الجيل الأول والنسبة الجنسية ، نسبة الموت وأيضا نسبة الفاقد للتعرف على العلاقة بين كل صنف ودرجة الإصابة .

أظهرت النتائج اختلافا ملحوظا في الصفات البيولوجية للحشرة لأصناف اللوبيا سواء المعاملة أو غير المعاملة بالإشعاع .

كان هناك علاقة بين نسبة الموت ودرجة مقاومة الأصناف للإصابة .

أثبتت الدراسة أن جرعات الإشعاع أحدثت زيادة ملحوظة في نسبة الموت وبذلك يمكن القول أن هناك علاقة بين جرعات الإشعاع المستخدمة ودرجة مقاومة الأصناف للإصابة .

وقد أظهر الصنف بلدي مقاومة نسبة ، والصنف أزميرلي ودقي أقل مقاومة للإصابة ، بينما الصنف كريم٧ قد كان متوسط القابلية للإصابة ، في حين أظهرت الأصناف غير المعاملة بالإشعاع قابلية للإصابة في كل من الصنف (أزميرلي وكريم٧) . أما الصنف (بلدي – دقي) فد أظهرا قابلية متوسطة للإصابة .