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Full Length Research Paper

Effect of exposure time of fast neutron irradiation on growth and yield parameters of *Capsicum annum* and *Capsicum frutescens*

Olamide Ahmed Falusi [1]*, Oladipupo Abdulazeez Yusuf Daudu[1] and Jaime A. Teixeira da Silva[2]

[1]Department of Biological Sciences, Federal University of Technology, Minna, Niger State, Nigeria.
[2]Faculty of Agriculture and Graduate School of Agriculture, Kagawa University, Miki cho, Kita Gun, Ikenobe, 761-0795, Japan.

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In order to assess the effect of fast neutron irradiation (FNI) on growth and yield parameters of *Capsicum annum* and *Capsicum frutescens*, 400 dry seeds of each species were exposed to FNI from an Americium Beryllium source with a flux of 1.5×10^4 n.cm^2/s for five irradiation exposure periods (IEPs): 0, 30, 60, 90 and 120 min (100 seeds per treatment). Plant grown parameters (percent germination, plant height and number of leaves/plant) and yield parameters (number of fruit/plant, number of seeds/fruit, length of fruit and weight of fruit) from each FNI treatment and control were measured. Highly significant differences were observed in plant height and number of leaves/plant in both species. Different irradiation exposure periods tend to favour different yield parameters in *C. annum* in which the number of fruits/plant and number of seeds/fruit were improved by 90 min IEP, the width and length of fruit were favoured by 60 min IEP and the weight of fruit by 120 min IEP. The values obtained in *C. frutescens* showed a reduction in fruit length and weight with an increase in irradiation exposure period (IEP). However, 90 min IEP resulted in more fruits/plant and wider plants. FNI serves as a valuable tool for the improvement of peppers (both *C. annum* and *C. frutescens*).

Key words: *Capsicum annum*, *Capsicum frutescens*, fast neutron, irradiation exposure period.

INTRODUCTION

Capsicum belongs to the Solanaceae family (GRIN, 2009). The genus consists of over 100 species and even more botanical varieties (Ado, 1999; Falusi, 2007), including five domesticated species (*Capsicum annum*, *Capsicum frutescens*, *Capsicum baccatum*, *Capsicum chinense* and *Capsicum pubescens*) all believed to have originated from the New World (McLeod et al., 1982; Bosland, 1994). *C. annum* and *C. frutescens* are the most recognized species grown in commercial quantities all over Nigeria (Falusi and Morakinyo, 2001; Mady et al., 2005). These two species form an important ingredient in people’s diet around the world (GRIN, 2009) due to the pungency properties of the fruits resulting from their high concentration of capsaicinoid alkaloid (Bosland and Vostava, 2000; Anonymous, 2010).

Mutation technology has been used to produce many cultivars with improved economic value and to advance the study of plant genetics and development (Bertagne-Sagnard et al., 1996; Adamu and Aliyu, 2007; Poornananda and Hosakatte, 2009; Ranalli, 2012). Genetic variability for desired characters can be induced successfully through mutations, with high practical value in plant improvement programs (Fahad and Salim, 2009). Mutation breeding employing fast neutron irradiation (FNI) has been used to develop new varieties (Sodkiewicz and Sodkiewicz, 1999) and is widely used for the induction of mutations (Zhang et al., 2002) resulting in a significant increase in the yield of major

* Corresponding author. E-mail:falusiolamide@gmail.com.

Table 1. Description of pepper (*C. annum* and *C. frutescens*) plants used in this study.

Source	Local name	Botanical name	Description
Minna	Ata Wewe	*C. frutescens* L.	Large perennial shrub, small pointed fruit with very hot taste, 2-4 pedicels per node
Minna	Ata Rodo	*C. annum* var. *abbreviatum* Fingerh	Medium sized annual plant, small oblong and wrinkled fruits with hot taste, one pedicel per node

crops, including chilli (Swaminathan, 1998). However, the main difficulty in chilli cultivation in Nigeria is the unchanged yield level, which is an important problem from a breeder's perspective. According to Sodkiewicz and Sodkiewicz (1999), one of the ways to supplement an existing germplasm with additional variation and to improve cultivars is by inducing mutations. Since FNI-induced mutations in pepper could be useful as a new source of altered germplasm, our objective was to assess the impact of FNI on growth and yield parameters of *C. annum* and *C. frutescens*, extending results achieved more recently (Falusi et al., 2012).

MATERIALS AND METHODS

Fresh fruit of two pepper accessions (50 fruits each) were bought from a local farmer in Minna, Niger State, Nigeria. They were identified as *C. annum* var. *abbreviatum* Fingerh and *C. frutescens* (Table 1) using a taxonomic aid provided by Simmond (1976), as well as morphological descriptions of Hutchinson and Dalziel (1963), Schippers (2000) and Abdullahi et al. (2003). Each fruit of the *Capsicum* accessions was cut open; the seeds were removed, kept separately and sun-dried for 8 h. The sun-dried seeds were tested for viability using the floatation method before FNI treatment. They were later irradiated at the Centre for Energy and Research Training (CERT), Ahmadu Bello University, Zaria with FNI using an Americium-Beryllium source with a flux of 1.5×10^4 n.cm^2/s for five different irradiation exposure periods (IEPs): 0, 30, 60, 90, and 120 min. The equipment used was a miniature neutron source reactor (MNSR) designed by the China Institute of Atomic Energy (CIAE) and licensed to operate at a maximum power of 31 kW (SAR, 2005).

Treated seeds (100 from each treatment) were then planted in nursery trays to obtain seedlings, which were transplanted into 3.5 L plastic pots containing garden soil, at a rate of three seedlings/pot after 4 weeks in the nursery. No fertilizer was applied although, when the crop began to flower, an insecticide (pyrethroid cypermethrin at a rate of 10 to 15 L/ha with controlled droplet application using spinning disc sprayers) was applied to prevent insect-borne diseases. The planted seeds were watered once daily between 5.00 and 6.30 pm using bore-hole water. Each treatment was replicated four times using a completely randomized design (CRD).

Plant grown parameters (percent germination, plant height (cm) and number of leaves/plant at maturity) and yield parameters (number of fruit/plant, number of seeds/fruit, length (cm) and weight (g) of fruit, and yield/plant) from each FNI treatment and control were measured. Plant height and number of leaves/plant were measured at 2, 4 and 8 weeks, and at maturity. Data, which was collected from 15 plants/accession, was analyzed using analysis of variance (ANOVA) and Duncan's multiple range test was used to separate the means with significant differences detected at $P = 0.05$.

RESULTS AND DISCUSSION

The response of *C. annum* and *C. frutescens* differed depending on the period of exposure to FNI. There was a negative correlation between irradiation period and percent germination in both accessions (Table 2), implying that as irradiation time increased, percent germination decreased. The late germination of the irradiated seeds could therefore be the effect of FNI. Adamu (2004) and Amjad et al. (2008) reported similar negative effects of irradiation on chickpea seed germination but Poornananda and Hosakatte (2009) reported 100% germination and survival when niger (*Guizzotia abyssinica*) seeds were treated with gamma irradiation. Highly significant differences were observed in plant height and number of leaves/plant in both *Capsicum* species (Tables 2 and 3). Asmahan and Nada (2006), Fahad (2009) and Hegazi and Hamideldin (2010) also reported that an increase in irradiation exposure period tended to increase certain morphological traits such as plant height.

However, Poornananda and Hosakatee (2009) reported a decrease in plant height of niger treated with gamma rays and sodium azide. Adamu (2004) also reported a decrease in the height of plants (pop-corn maize) as the exposure period of thermal neutron and gamma irradiation increased. FNI generally increased the vegetative growth of both pepper species as shown by the number of leaves/plant (Table 3). This result differs completely from the findings of Poornananda and Hosakatee (2009) on niger, Adamu and Aliyu (2007) on tomato and Adamu (2004) on pop-corn maize. In all three cases, the authors reported a decrease in the number of leaves/plant due to exposure to different irradiation sources.

Different IEPs favoured different yield parameters in *C. annum*: number of fruits/plant and number of seeds/fruit were improved by 90 min, fruit width and length by 60 min and fruit weight by 120 min (Table 4). In contrast, fruit length and weight of *C. frutescens* decreased as IEP increased although a longer IEP resulted in more fruits/plant and wider plants. Similar results were obtained by Muhammad et al. (2005) on *C. Arientinum,*

Table 2. Effects of fast neutron irradiation on germination percentage and plant height at four periods after germination of *C. annum* and *C. frutescens*.

Irradiation time (min)	Germination % in pot	Plant height (cm)			
		2 weeks	4 weeks	8 weeks	Maturity
		C. annum			
Control	100.00[c]	5.43 ± 1.56[a]	7.15 ± 1.84[a]	11.14 ± 2.95[a]	21.68 ± 3.68[a]
30	50.00[b]	7.85 ± 1.19[b]	10.60 ± 2.87[b]	16.59 ± 2.88[b]	29.94 ± 7.67[b]
60	51.00[b]	7.92 ± 1.17[b]	10.80 ± 1.33[b]	17.81 ± 1.40[c]	32.79 ± 5.11[b]
90	51.00[b]	7.43 ± 1.73[b]	9.84 ± 2.62[b]	17.95 ± 2.58[b]	29.32 ± 7.05[b]
120	37.00[a]	7.95 ± 2.36[b]	11.05 ± 3.68[b]	19.90 ± 3.63[c]	33.70 ± 10.62[b]
		r = -0.8736			
		C. frutescens			
Control	100.00[d]	9.58 ± 2.40[a]	13.44 ± 3.92[a]	19.61 ± 3.87[a]	41.50 ± 9.46[b]
30	44.00[c]	11.04 ± 1.72[a]	15.84 ± 3.14[ab]	22.88 ± 3.14[ab]	37.77 ± 9.01[ab]
60	13.00[a]	9.72 ± 1.50[a]	14.69 ± 2.30[ab]	21.83 ± 2.31[ab]	38.84 ± 7.62[ab]
90	26.00[b]	9.79 ± 1.08[a]	15.94 ± 2.03[ab]	22.96 ± 2.02[ab]	34.84 ± 7.29[a]
120	40.00[c]	11.34 ± 1.34[a]	17.84 ± 3.20[b]	24.88 ± 3.27[b]	45.85 ± 10.41[b]
		r = -0.6525			

Values are mean ± SD; Means followed by the same superscript letter(s) within the same column and for each *Capsicum* species do not differ statistically at 5% level tested by DMRT. n = 100 per treatment (total 400/accession).

Table 3. Effects of fast neutron irradiation on the number of leaves/plant at four periods after germination of *C. annum* and *C. frutescens*.

Irradiation time (min)	Number of leaves/plant			
	2 weeks	4 weeks	8 weeks	Maturity
		C. frutescens		
Control	10.80 ± 2.15[a]	13.80 ± 3.22[a]	38.10 ± 13.62[a]	112.00 ± 33.06[a]
30	12.90 ± 2.42[a]	18.00 ± 5.68[ab]	52.80 ± 11.34[bc]	103.80 ± 44.44[a]
60	10.82 ± 2.14[a]	14.64 ± 3.07[abc]	48.18 ± 7.59[ab]	105.64 ± 24.40[a]
90	12.10 ± 1.66[a]	19.60 ± 3.47[bc]	53.50 ± 8.02[bc]	100.10 ± 34.83[a]
120	12.50 ± 0.97[a]	20.80 ± 5.55[c]	63.40 ± 13.41[c]	156.90 ± 57.26[b]
		C. annum		
Control	7.08 ± 2.64[a]	10.50 ± 2.81[a]	16.67 ± 4.23[a]	67.08 ± 19.08[a]
30	8.90 ± 3.00[a]	13.10 ± 3.25[a]	21.40 ± 3.84[ab]	99.20 ± 32.8[b]
60	9.45 ± 1.81[a]	13.45 ± 1.81[a]	28.00 ± 5.25[c]	113.00 ± 2.12[b]
90	9.09 ± 2.66[a]	11.82 ± 2.44[a]	23.09 ± 5.41[bc]	99.09 ± 32.31[b]
120	9.90 ± 2.88[b]	13.20 ± 4.26[a]	26.60 ± 8.47[bc]	120.10 ± 52.95[b]

Values are mean ± SD; Means followed by the same superscript letter(s) within the same column and for each *Capsicum* species do not differ statistically at the 5% level tested by DMRT. n = 100 per treatment (total 400/accession).

Aslam and Siddiqui (1979) on Pennisetum *americanna* and by Asmahan and Nada (2006) and Jabeen and Mirza (2002) on pepper treated with sodium azide and ethyl methyl sulphonate, respectively. FNI at certain IEPs can be used to increase select growth and yield characters and induce variability in peppers through the isolation of beneficial mutants and can thus be used in pepper improvement programmes. Since both *C. annum* and *C. frutescens* were both responsive to FNI treatment, either species could serve as the parent plant in breeding and improvement programmes, or though mass propagation *in vitro*.

Table 4. Differences between agronomic traits of *C. annum* and *C. frutescens* following fast neutron irradiation for 5 periods of time.

Agronomic traits	Irradiation time (min)				
	0	30	60	90	120
			C. annum		
Plant height (cm)	21.68 ± 3.68[a]	29.94 ± 7.67[b]	32.79 ± 5.11[b]	29.32 ± 7.05[b]	33.70 ± 10.62[b]
Number of leaves/plant	67.08 ± 19.68[a]	99.20 ± 32.80[b]	113.00 ± 2.12[b]	99.09 ± 32.31[b]	120.10 ± 52.95[b]
Number of fruits/plant	15.90 ± 7.56[a]	17.80 ± 12.85[a]	19.00 ± 7.58[a]	19.70 ± 8.55[a]	17.50 ± 9.11[a]
Number of seeds/fruit	54.90 ± 21.22[a]	66.10 ± 11.08[ab]	71.90 ± 16.64[b]	73.5 ± 19.76[b]	72.00 ± 23.87[ab]
Length of fruit (cm)	3.95 ± 0.86[a]	4.28 ± 0.65[ab]	5.31 ± 0.67[c]	4.32 ± 1.09[ab]	4.89 ± 1.16[bc]
Width of fruit (cm)	2.99 ± 0.71[a]	3.59 ± 0.43[b]	3.86 ± 0.29[b]	3.72 ± 0.54[b]	3.67 ± 0.32[b]
Weight of fruit (g)	10.10 ± 3.81[ab]	9.60 ± 3.17[a]	11.00 ± 1.70[ab]	12.20 ± 3.55[ab]	12.90 ± 2.42[b]
			C. frutescens		
Plant height (cm)	41.50 ± 9.46[b]	37.77 ± 9.01[ab]	38.84 ± 7.62[ab]	34.84 ± 7.29[a]	45.85 ± 10.41[b]
Number of leaves/plant	112.00 ± 33.06[a]	103.80 ± 44.44[a]	105.64 ± 24.40[a]	100.10 ± 34.83[a]	156.90 ± 57.26
Number of fruits/plant	30.46 ± 17.77[a]	40.80 ± 21.71[a]	33.90 ± 13.54[a]	53.00 ± 28.42[a]	48.10 ± 16.45[a]
Number of seeds/fruit	31.00 ± 12.05[a]	32.70 ± 15.91[a]	24.00 ± 9.98[a]	35.80 ± 15.24[a]	32.40 ± 10.01[a]
Length of fruit (cm)	5.21 ± 1.60[a]	5.33 ± 1.27[a]	5.73 ± 1.22[a]	5.25 ± 1.22[a]	4.45 ± 1.76[a]
Width of fruit (cm)	0.80 ± 0.11[a]	0.88 ± 0.40[a]	0.80 ± 0.14[a]	0.89 ± 0.16[a]	0.99 ± 0.44[a]
Weight of fruit (g)	1.3 ± 0.48[a]	0.90 ± 0.34[a]	1.01 ± 0.49[a]	1.00 ± 0.44[a]	1.15 ± 0.75[a]

Values are mean ± SD; Means followed by the same superscript letter(s) within the same column and for each *Capsicum* species do not differ statistically at 5% level tested by DMRT. n = 100 per treatment (total 400/accession).

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