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Effect of recurrent irradiation on the improvement of a variant line of wild tomato (*Solanum pimpinellifolium*)

J. Nunoo [a,*], *E.K. Quartey* [a], *H.M. Amoatey* [b], *G.Y.P. Klu* [b]

[a] *Biotechnology and Nuclear Agriculture Research Institute (BNARI), P.O. Box LG 80, Legon, Accra, Ghana*
[b] *School of Nuclear and Allied Sciences (SNAS) of University of Ghana, Legon P.O. Box AE 1, Atomic Energy, Accra, Ghana*

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ABSTRACT

Solanum pimpinellifolium L. a breed of wild tomato is rich in lycopene. It possess traits which can be transferred to cultivated varieties. Its fruit size is a major hindirance to its domestication. This breed of tomato is very small and thus this work was carried out to improve the size and other desirable traits of the variety. A variant line, SP 300/30.4.2.4, selected from second generation (M2) following irradiation of seeds of *S. pimpinellifolium* L. at 300 Gy was used for the work. 2000 seeds were re-irradiated at 150 Gy and 300 Gy for each treatment and nursed immediately. Plant height at first flowering was highest among the control plants reaching a maximum of 47 cm compared to plants irradiated at 150 Gy and 300 Gy which reached 37 cm and 36 cm respectively. Irradiation therefore led to a reduction in plant height of treated plants. Irradiated materials produced bigger fruits than the controls. The highest mean fruit weight recorded for 300 Gy treated plants was higher than those for 150 Gy and the controls. Variations were observed in the fruit size, shape, colour, plant architecture, number of days to 50% fruiting and flowering. The variations observed could be used selected for and used in subsequent breeding work.

1. Introduction

Wild tomato (*Solanum pimpinellifolium* L.) belongs to the family Solanaceae. It is a close relative of the commercial variety, *Solanum lycopersicon* L. (Cox, 2000) and may have originated from Western South or Central America (Taylor, 1986). Selection over many generations presumably led to increased fruit size and higher ratio of fruit weight and seed content, characteristics that are typical of the modern day tomato. It is useful for its drought and disease. It has the better ability to grow under dry conditions than the commercial tomato (*S. lycopersicon* L.), because it naturally grows in places with less water.

The fruits of *S. pimpinellifolium* L. are red, round (Tanksley, 2004) tastes sweet but small, weighing only a few grams, compared to the cultivated varieties which are bigger (Cox, 2000). The fruits contain lycopene, one of the most powerful natural antioxidants. Lycopene is responsible for the deep red colour in tomato fruits (Cox, 2000). In cooked tomatoes, lycopene has been found to help prevent prostate cancer (Clinton et al., 2007) and improve the skin's ability to protect it against

* *Corresponding author*. Tel.: +233 243015436.
E-mail address: joenunoo85@yahoo.co.uk (J. Nunoo).
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harmful Ultra Violet (UV) rays. *S. pimpinellifolium* L. contains over 40 times more lycopene than domesticated tomatoes (Cox, 2000).

It is grown by plant breeders and used to improve flavours of commercial varieties of tomatoes. The narrow genetic base of cultivated tomato has resulted in breeders and plant pathologists relying on closely related wild species for allelic variation and thus, the wild relatives of tomato have been used extensively as sources of alleles to improve cultivated tomato germplasm (Osborn, Alexander, & Fobes, 1987).

The use of mutations can result in changes in the growth habit, plant height, oil content, flower colour and leaf shape. Additionally, traits such as leaf shape, texture and colour of a crop may be observed. The floral morphology, fruit size, shape and colour can also be enhanced. In a review, Rick (1976) summarized a number of improvements obtained through breeding to include increase yields by way of larger fruit size and increased fruit number. It also included improvement in fruit quality involving shape, texture, colour and flavour. Plant habit was also modified to facilitate cultural and harvest operations; particularly exploitation of determinate growth habit conditioned by the *SP* gene (Rick, 1976). There was improvement in handling and storage durability (but sometimes to the detriment of culinary quality). Pest resistance to various species of insects, viral and fungal parasites and nematodes was also improved.

Recurrent irradiation provides an even greater range of genetic variability than would a single irradiation (Khadr & Frey, 1965). Results from various reports present contradicting values of the effect of additional variability induced by recurrent irradiation. Oat (*Avena sativa*) populations developed by recurrent irradiation with thermal neutrons showed expanded variability for quantitative traits over either the original or the pedigree population although the second irradiation cycle did not generate as much variability as the first (Khadr & Frey, 1965). It has been documented that several early examples of chrysanthemum cultivars have been obtained as a result of recurrent irradiation (Broertjes, Koene, & van Veen, 1980; Micke, Donini, & Maluszynski, 1990).

The results of application of radiation include the reduction in yielding capacity of early maturing mutants in barley (Gaul & Mittelstenscheid, 1960; Gustafsson, Hagberg, & Lundqvist, 1960). Early maturing mutants especially slightly early maturing ones with yield capacities equivalent to or higher than their original varieties have been induced in several crops (Aastveit, 1965; Kawai, 1963; Porsche, 1963). Plant height changes in early maturing mutants and significant correlations between the two characters have also been reported in rice (Abrams & Frey, 1964).

The objective of the study was to determine the effect of recurrent irradiation on the improvement of fruit quality (fruit colour, shape and size) and plant architecture of a variant of wild tomato (*S. pimpinellifolium* L.).

2. Materials and method

2.1. Study site

The study site was the experimental farms of the Biotechnology and Nuclear Agriculture Research Institute (BNARI) of the Ghana Atomic Energy Commission (GAEC). The work was conducted between August 2009 and August, 2010. The farms is located about 20 km north of Accra (05° 40' 60 N and 0° 13' 0 W), with an elevation of 76 m above sea level. The vegetation is Coastal Savannah, and characterized by a bimodal rainfall pattern. The mean annual rainfall is 810 mm distributed over less than 80 days, and temperatures are moderate with maxima rarely exceeding 32 °C while the minimum does not fall below 17 °C.

2.2. Planting materials

Dried seeds of SP 300/30.4.2.4, a variant line selected from second generation (M_2) following irradiation of seeds of *S. pimpinellifolium* L. at 300 Gy from a ^{60}Co gamma source were used. SP 300/30.4.2.4 had an increased fruit size of 2.84 g in relation to the wild parent (Quartey, 2010). The seeds were re-irradiated at 150 Gy and 300 Gy from a ^{60}Co gamma source at 11.88 Gy per hour at position 50 from a radiation source. Irradiation was done at the Radiation Technology Centre (RTC) of the Ghana Atomic Energy Commission, (GAEC) Kwabenya. Non irradiated seeds were used as control (parents).

2.3. Raising of M_2M_1 and M_2M_2 generation

Two thousand (2000) seeds were irradiated for each treatment and nursed immediately after radiation to raise M_2M_1 population. The seedlings were transplanted onto the field after 21days. The experimental design used was complete randomised design with four replications. Each plot had 210 seedlings with 70 plants of each of the seedlings irradiated at 150

Table 1 – Plant height at first flowering and days to 50% flowering in M_2M_1 and M_2M_2 generation of *S. pimpinellifolium* L. variant line (SP 300/3.4.2.4) following recurrent irradiation.

Trait	Range		Mean ± SE	
	M_2M_1 population	M_2M_2 population	M_2M_1 population	M_2M_2 population
Plant height at 1st flowering				
0	20.4–47.0	40.3–60.5	27.7 ± 3.1b	47.4 ± 5.7a
150	28.3–37.0	38.4–50.7	32.4 ± 2.7a	43.5 ± 3.5b
300	26.5–36.0	38.3–47.4	31.1 ± 3.2a	42.3 ± 3.3b
Days to 50% flowering				
0	43.0–54.0	45–60	48.7 ± 4.9a	44.4 ± 18.9a
150	41.0–50.0	47–55	46.2 ± 3.2a	51.7 ± 2.4a
300	40.0–52.0	36–43	43.6 ± 6.0a	40.0 ± 2.4a