The Pharma Innovation Journal 2022; 11(6): 1388-1392

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(6): 1388-1392

www.thepharmajournal.com
Received: 08-02-2022
Accepted: 19-05-2022

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Identification and evaluation of productive mutants of Niger (*Guizotia abyssinica* (L. f.) Cass.) For different morphological Characters in subsequent generations

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Abstract
Niger is minor oilseed crop and important for many nutritious purposes. Niger can be grown with minimum agro inputs, it is considered to be a crop for resources poor farmers particularly in developing countries like India. India is the chief producer of Niger seeds which ranks second and fourth position in the world for its average and annual production respectively. Mutation breeding is one of the important tools to create variability and is being widely used for the improvement of various plant characters in different groups of crops. It is an effective and powerful tool in the hands of breeders especially for crops with narrow genetic base. The present experiment comprising of four genotypes of Niger with five doses of γ rays *viz*., 12, 16, 20, 24and 28 Kr. Morpho-physiological data were taken and analysed. Evaluation was done from Kharif 2016 to Kharif 2018. Mutation dose of 16 and 20Kr was noticed to be suitable for Niger crop. The mutation dose of 24 and 28 Kr was noticed least seed yield (50 & 120 kg/ha in M1, 60 & 50 Kg/ha in M2) but in M3 generation after selection achieved a good seed yield i.e. 550 & 450 Kg/ha) while dose of 16 and 20Kr recorded maximum seed yield in all the three generations i.e. (620 and 750 kg/ha respectively in M1 generation. Various beneficial and effective mutants were also identified for different characters like early maturity, short stature, No. of branches per plant and Capitula per plant like N-244-M-11-1, N-244-M-18-2, ONS-171-M-08-01, ONS-171-M-02-02, ONS-150-M-13-01, GA-27-M-10-01, GA-27-M-03-02, ON-1-M-07-01, ON-1-M-06-02, ON-1-M-01-03.

Keywords: Niger, mutation, doses, productive mutants, generations, selection

Introduction
Niger [*Guizotia abyssinica* (L.f.) Cass] is minor oilseed crop and it is important for Indian tribal communities, which contains edible oil 38–43%, protein 20% and sugar 12%. Niger can be grown with minimum agro inputs, it is considered to be a crop for resources poor farmers particularly in developing countries like India. India is the chief producer of Niger seeds which ranks second and fourth position in the world for its average and annual production respectively (Dalei *et al*., 2014) [1]. It is grown in the states of Madhya Pradesh, Chhattisgarh, Odisha and Maharastra and to a lesser extent in Karnataka, Bihar, Jharkhand, Gujarat and Andhra Pradesh. The Niger seed has nearly 40% of oil which is used in foods, paints, soft soaps, lighting, lubrication and cosmetics (DOR). In India about 75% of the harvested seeds are used for oil extraction and the rest is exported for bird food. Roasted or fried seeds are eaten as snacks or used as a condiment. The press cake after oil extraction contains 31–40% protein and is used as cattle feed. (Dalei *et al.*, 2014) [1].

Niger is an minor oilseed crop which has been under cultivation in Ethiopia India and many other countries. The earliest name given to this plant was *Verbesina oleifera*. The first botanical description of Niger was *Polymniaabyssinica* L. The Linnaean herbarium in London holds a specimen matching the description with the name *Polymnia bidentis* with a note *abyssinica*. Another description by Cassini (1821) was *Heliopsis platyglossa*, probably based on samples of Bruce. Eight years later, Cassini (1829) realized that *Heliopsis platyglossa* and *Polymniaabyssinica* were identical and designated a new name, *Guizotia abyssinica* Cass. The name *Guizotia* is from the French historian François Pierre Guillaume Guizot. A. (Getinet and S.M. Sharma) [2].

Niger (*Guizotia abyssinica* (L.f.) Cass.) the important oilseed crop in most hardy and drought tolerant occupying a prominent place where moisture is the limiting factor and soils are sub-marginal to marginal in several parts of the country.

It is grown in India in an area about 2.99 lakh ha with a production of 0.98 lakh tones and a productivity of 327 kg/ha. In the state of Odisha, it covers an area of 53.18 thousand ha with a production of 19.51 thousand MT and productivity of 367kg/ha. (Odisha Agriculture Statistics 2018-19) [3].

Niger is cultivated in many countries for its edible oil which is mainly used for cooking, lightening, painting, cleaning of machinery (Patil and Patil, 1981).

Knowledge on the nature and magnitude of the genetic variation governing the inheritance of quantitative character like yield and its components is essential for effecting genetic improvement (Rakesh Kumar Dhanwani *et al*., 2013) [4], Genetic variability for agronomic characters therefore, is a key component of breeding programmes for broadening gene pool of crops (Ahmad *et al.*, 2011) [5].

Among the different breeding methods used, mutation induction has been used as an important tool to supplement existing variability and to create additional variability for qualitative as well as quantitatively inherited traits in niger especially various degrees of resistance to biotic and abiotic stress, seed yield and oil content. Mutations are known to enhance the genetic variability of crop plants as the variability at species level has reached the ceiling due to high breeding intensity and rapid erosion of genetic resources. Since spontaneous mutations occur at very low frequency, induced mutations facilitate the development of improved varieties at a swifter rate (Maluszynski, 1990) [6]. The biological effect of ionizing radiation like gamma rays depends primarily on the amount of energy that will be absorbed by the biological system of which of course, the chromosomes are the most important target (Van Harten, 1998) [9]. Induced mutations have been used to generate genetic variability and have been successfully utilized to improve yield components of various crops like *Oryza sativa* (Awan *et al*., 1980; Singh *et al*., 1998), *Hordeum vulgare* (Ramesh *et al*., 2001), *Triticum durum* (Sakin and Yildirim, 2004) [10], *Cicerarietinum* (Wani and Anis, 2001) [11], *Vigna mungo* (Misra *et al*., 2001) [12], *Cajanus cajan* (Srivastava and Singh, 1996; Ravikesavan *et al*., 2001), *Arachis hypogaea* (Venkatachalam *et al*., 1999) [14], *Sesame indicum* (Mensah *et al*., 2007), *Helianthus annuus* (Elangovan, 2001) [13], *Guizotia abyssinic* These reportsshow that mutagenesis is a potential tool to be employed for crop improvement. The present study deal with the effects of mutagens like gamma rays on some of the agronomical and yield characters of Niger **(**Prashant. K. Jagtap) [7].

Breaking of yield barriers in crops has become hard task to breeders. Genetic variability is a pre-requisite for any breeding programme. Without adequate variability, selection would be ineffective. Induction of variability can be brought about by the use of mutagens (mutation causing agents). Mutation breeding is one of the important tools to create variability and is being widely used for the improvement of various plant characters in different groups of crops. It is an effective and powerful tool in the hands of breeders especially for crops with narrow genetic base. Mutagenic agents have been used to induce useful variations in plants for more than seventy decades. Many varieties through the use of mutation breeding has been released in 50 countries all over the world including cereals, oilseeds, pulses, vegetables, fruits, fibers and ornamentals. Selection of an effective and efficient mutagen is very essential to produce a high frequency of desirable mutation in any mutation breeding programme.

It is highly reported that mutagens cause genetic changes in an organism, break linkages and produce many new promising traits for improvement of crop plants. Among the chemical mutagens, EMS is reported to be the most effective and powerful mutagen, whereas, gamma rays are known to influence plant growth and development by inducing cytological, genetically, biochemical, physiological and morphogenetic changes in cells and tissues reported that gamma rays and EMS could be fruitfully applied to develop new varieties with higher yield and other improved traits. In comparison to gamma rays, EMS induces a high rate of mutations and sometimes, they exceed those obtained by radiations

Materials and Methods

The present experiment was carried out at AICRP on Niger scheme, Regional Research and Technology Transfer Station (OUAT), Semiliguda of Koraput district under Eastern Ghat High Land zone of Odisha during from *kharif-2016* to *Kharif* 2018.Five genotypes of Niger *viz*. N-244, ONS-171, ONS-150, GA-27, ON-1 were irradiated with gamma radiation at Bhabha. Atomicc Research Centre, Mumbai, India. The gamma radiation was derived from a Cobalt-60 (60Co) source with admeasured dose rate of about 4.07 Gy/min. The seeds were treated with gamma radiation with 12, 16, 20, 24 & 28Kr.The experiment comprising of 25 treatment combinations was laid out in completely randomized block design during *kharif*, 2016-17 to Kharif-2018-19 at AICRP on Niger scheme, Regional Research and Technology Transfer Station (OUAT), Semiliguda, Koraput India. All other agronomical/breeding and cultural practices were followed. The data were collected on the important morpho-physiological aspects of Niger crop.

Table 1: Number of Genotypes selected with respective doses.

Sl. No.	Name of the Genotypes	Doses in Kr
1	N-244	12
2	ONS-171	16
3	ONS-150	20
4	GA-27	24
5	ON-1	28

Result and Discussion

The experiment was carried out at AICRP on Niger scheme, Regional Research and Technology Transfer Station (OUAT), Semiliguda of Koraput district under Eastern Ghat High Land zone of Odisha during from *kharif-2016* to *Kharif* 2018.The experiment was conducted and various observations were taken to determine the effects of the mutagen doses on various characters like survival, plant height/short stature, branches per plant, capsules per plant, seed yield and others for M^1 generation. The present experiment comprising of four genotypes of Niger with five doses of **γ** rays *viz*., 12, 16, 20, 24 and 28 Kr. Morpho-physiological traits datas were taken and analysed. First the M^1 generation was harvested in *Kharif* 2016 and only beneficial mutants were selected and sown during *Kharif* 2017 than again only beneficial and stable mutants were selected and again sown in *Kharif* 2018 and observations were taken. The germination data were taken after 15 days of sowing in the field and other agronomical observations were taken at each stage of the Niger crop. Mutagen dose reduce the survival percentage and it was observed in all the five genotypes of Niger due to mutagenic treatment. It was also observed that mutation dose above 20Kr

showed drastically reduction in survival of Niger crop. Mutation dose of 16 and 20Kr was noticed to be suitable for Niger crop. The initiation of flower, 50% flowering and days to maturity were found to delay as the dose of mutation increases from 20Kr and more days to flowering and maturity was recorded by mutation dose of 28 Kr. Similar findings were also observed by (P.K. Jagtap 2015) [15]. The mutants of ONS-150 & ONS-171 were observed as late maturing among all the genotypes tested. The similar findings were also noticed by Naik and Murthy (2009) [8]. The plant height found to be decrease due to increase in mutation dose. Some of the dwarf mutants in GA-27 were also noticed during the M1 generation study. The branches and capsules per plant were reduced in number as the mutation dose goes beyond 20Kr where as very slight change had been noticed in the number of seeds per capsule (Naik and Murthy, 2009) [8]. The mutation dose of 24 and 28 Kr was noticed least seed yield (50 & 120 kg/ha in M1, 60 & 50 Kg/ha in M2) but in M3 generation after selection achieved a good seed yield i.e. 550 & 450 Kg/ha) while dose of 16 and 20Kr recorded maximum seed yield in all the three generations i.e. (620 and 750 kg/ha respectively in M1 generation, 640 & 730 Kg/ha respectively in M2 and 650 & 760 Kg/ha respectively in M3 generation which clearly shows that mutagen doses 16 and 20 kr perform well on yield aspects and and they can be considered optimum doses for achieving higher yield on mutation ground. The overall study indicates that the mutation dose of 16 and 20Kr found to be most productive and suitable for creation of variability in Niger crop which were also found to be beneficial in producing some of the desirable mutants during *kharif*, 2016 to2018. Similar findings were also observed by (P.K. Jagtap 2015) [15]. Various beneficial and effective mutants were also identified for different characters like early maturity, short stature, No. of branches per plant and Capitulla per plant like N-244-M-11-1, N-244-M-18-2, ONS-171-M-08-01, ONS-171-M-02-02, ONS-150-M-13-01, GA-27-M-10-01, GA-27-M-03-02, ON-1-M-07-01, ON-1-M-06-02, ON-1-M-01-03 given in below tables. 3, 4, 5, 6. Mutants name was given on the basis of their source germplasm and selection

These individual useful mutants were harvested separately and it will be evaluated for further performance and utilized in the various breeding programme.

Table 2: Germination % and further survival % in M1 generation

Genotypes	Mutation doses	Germination %	Further survival % after germination
1. N-244	12	80	95
	16	75	100
	20	90	100
	24	40	90
	28	30	80
2. ONS-171	12	73	95
	16	81	98
	20	85	99
	24	32	80
	28	22	70
3. ONS-150	12	82	96
	16	78	100
	20	87	98
	24	30	85
	28	22	70
4. GA-27	12	72	92
	16	82	95
	20	90	99
	24	45	85
	28	30	75
5. ON-1	12	87	90
	16	72	98
	20	85	100
	24	38	75
	28	25	65

Table 3: Mutants showing early maturity in successive generation (M1 to M3)

S. No.	Mutants	Derived from the genotype	Mutation dose	Maturity duration (Days)		
				M1	M2	M3
1	N-244-M-11-1	N-244	16 Kr	100	98	105
2	N-244-M-18-2	N-244	20Kr	102	105	100
3	ONS-171-M-08-01	ONS-171	12Kr	102	103	105
4	ONS-171-M-02-02	ONS-171	20Kr	105	100	107
5	ONS-150-M-13-01	ONS-150	20Kr	108	105	110
6	GA-27-M-10-01	GA-27	24Kr	102	99	103
7	GA-27-M-03-02	GA-27	16Kr	100	105	103
8	ON-1-M-07-01	ON-1	12Kr	104	102	105
9	ON-1-M-06-02	ON-1	16Kr	108	106	108
10	ON-1-M-01-03	ON-1	20Kr	103	100	105

Table 4: Mutants showing short stature plant (M1 to M3)

S. No.	Mutants	Derived from the genotype	Mutation dose	Plant height (cm)		
				M1	M2	M3
1	N-244-M-11-1	N-244	16 Kr	116	115	118
2	N-244-M-18-2	N-244	20Kr	108	112	110
3	ONS-171-M-08-01	ONS-171	12Kr	115	118	119
4	ONS-171-M-02-02	ONS-171	20Kr	115	119	118
5	ONS-150-M-13-01	ONS-150	20Kr	118	125	121
6	GA-27-M-10-01	GA-27	24Kr	109	110	113
7	GA-27-M-03-02	GA-27	16Kr	112	117	115
8	ON-1-M-07-01	ON-1	12Kr	115	112	117
9	ON-1-M-06-02	ON-1	16Kr	120	118	123
10	ON-1-M-01-03	ON-1	20Kr	120	115	120

Table 5: Mutants showing more no. of branches per plant (M1 to M3)

S. No.	Mutants	Derived from the genotype	Mutation dose	No. of branches/plant		
				M1	M2	M3
1	N-244-M-11-1	N-244	16 Kr	6	7	6
2	N-244-M-18-2	N-244	20Kr	7	7	6
3	ONS-171-M-08-01	ONS-171	12Kr	8	7	7
4	ONS-171-M-02-02	ONS-171	20Kr	6	7	7
5	ONS-150-M-13-01	ONS-150	20Kr	8	8	7
6	GA-27-M-10-01	GA-27	24Kr	6	7	7
7	GA-27-M-03-02	GA-27	16Kr	7	7	6
8	ON-1-M-07-01	ON-1	12Kr	8	7	8
9	ON-1-M-06-02	ON-1	16Kr	6	7	7
10	ON-1-M-01-03	ON-1	20Kr	8	7	7

Table 6: Mutants showing more no. of Capitula per plant (M1 to M3)

S. No.	Mutant	Derived from the genotype	Mutation dose	No. of Capitulla/plant		
				M1	M2	M3
1	N-244-M-11-1	N-244	16 Kr	48	45	50
2	N-244-M-18-2	N-244	20Kr	45	48	42
3	ONS-171-M-08-01	ONS-171	12Kr	40	42	46
4	ONS-171-M-02-02	ONS-171	20Kr	50	52	50
5	ONS-150-M-13-01	ONS-150	20Kr	55	58	60
6	GA-27-M-10-01	GA-27	24Kr	48	44	46
7	GA-27-M-03-02	GA-27	16Kr	49	51	52
8	ON-1-M-07-01	ON-1	12Kr	51	55	56
9	ON-1-M-06-02	ON-1	16Kr	44	48	44
10	ON-1-M-01-03	ON-1	20Kr	48	50	53

Table 7: Mean performances of different morphological characters

S. No.	Genotypes/Mutants	DIF	DFF	PH	NBP	NCP	SPC	MD	SY (Kg/ha)
1	N-244-M-11-1	51.2	62.3	118	6	50	27.3	105	650
2	N-244-M-18-2	45.3	55.6	110	6	42	25.2	100	680
3	ONS-171-M-08-01	43.8	52.9	122	7	46	28.6	105	730
4	ONS-171-M-02-02	47.3	60.2	118	7	50	22.1	107	695
5	ONS-150-M-13-01	52.9	64.3	130	7	60	26.9	110	700
6	GA-27-M-10-01	49.3	58.1	113	7	46	26.3	103	550
7	GA-27-M-03-02	51.9	62.7	115	6	55	28.2	103	670
8	ON-1-M-07-01	53.5	62.3	166	8	56	24.5	105	640
9	ON-1-M-06-02	55.2	63.2	125	7	44	22.6	108	600
10	ON-1-M-01-03	51.8	62.3	120	7	53	27.1	105	620

DIF-Days to initiation of flowering, DFF-Days to fifty % flowering, PH-Plant height, NBP-Number of branches/ plant, NCP-Number of capitula/plant, SPC-Seeds per capitula, MD-Maturity duration, SY-Seed yield

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