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Improvement in Yield Attributing Traits of Cumin (*Cuminum cyminum*) Through Acute Exposure of Gamma Ray

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ABSTRACT

Cumin is an important seed spice of India and having very narrow range of genetic variability. Induced mutagenesis by gamma rays has been found to be a very useful technique for crop improvement. Therefore, a study was undertaken to know the effect of gamma rays in cumin cv. RZ- 209 to create genetic variability for essential traits. Dry seeds were exposed to different doses of gamma radiations using ^{60}Co as the radiation source at Bhabha Atomic Research Centre (BARC), Mumbai. The irradiated seeds along with control were kept for germination in petri dishes and also sown in the field. It was recorded that increased doses reduced the seed germination and survival of seedlings. The 48.4% survival of seedlings was recorded at the dose of 200Gy. This dose of gamma ray caused near about 50% reduction in root length, shoot length, seedling length and vigour index. The days to first flowering and days taken for fruiting to maturity was delayed as the doses were increased. The gamma rays dose 200Gy significantly increased the numbers of umbels per plant, 1000 seed weight (3.97g) and seed yield per plant (1.67g) over control.

Key words: *Cuminum cyminum, Mutagenesis, Gamma ray, Growth and yield*

INTRODUCTION

India is 'The Land of Spices' and the glories of Indian spices are known throughout the world. Total 109 spices are listed by ISO and 63 spices are grown in India and out of which 20 are being classified as seed spices. Out of spices, we categories seed spices which are annual, herbaceous, grown mostly during winter season and their seed used as spices. Seed spices are known as gold in arid and semi arid areas of India. In India seed spices are mostly grown in Rajasthan, Gujarat, besides these two states, seed spices are also grown in Uttar Pradesh, Madhya Pradesh, Punjab, Haryana and some parts of South India. India is the largest producer, consumer and exporter of seed spices in the world. The states, Rajasthan and Gujarat have together contributed more than 80 % of the total seed spices production of the country. The total area under cumin is around 701560 ha with the production of 372290 tonnes[20]. The chief cumin exporters are India, Syria, Pakistan and Turkey, while India and the USA are main cumin oil producers[9,17]. The total export of seed spices is worth of more than Rs 2800 crore annually out of which cumin alone contributed more than Rs 1500 crore[20].

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Cumin (*Cuminum cyminum* L.) is an annual herbaceous spice cum medicinal plant. It belongs to family apiaceae and has basic chromosome number 2n=14. Cumin is mentioned as an essential ingredient of many traditional dishes. In Ayurvedic system of medicine, dried cumin seeds are used for therapeutic purposes. It is known for its activities like enhancing appetite, taste perception, digestion, vision, strength and lactation. It is used to treat diseases like fever, loss of appetite, diarrhea, vomiting, abdominal distension, edema and puerperal disorders[13]. It is one of the oldest cultivated medicinal food herbs in Asia, Africa and Europe. Apart from India cumin is mostly grown in Morocco, Turkey, Syria, Greece, Egypt and the southern part of the Mashhad province, Iran[9].

Progress in breeding programme of any crops depends on the extent and nature of variability existing in the base population. Plant genetic diversity is created over thousands of years in nature to remain stable. Masses of native plants are germplasm for appropriate eugenics programs. It is imperative that researchers tirelessly work and provide information on gene banks collection, identification and evaluation for the protection of gene pool and plant masses. Conventional methods based on selection of desirable genotypes have modified crops during the past decades and this has created awareness of the diversity of population and the first prerequisite step in improve plants[1]. The plant breeding aspect of cumin is quite new due to limited research work conducted in that area.

Available literature indicates that the problem in the improvement of cumin includes, genetic base in the available germplasm particularly for economic traits viz. yield, quality (volatile oil content) and reaction to different biotic and abiotic stresses is narrow[9]. Crop also suffer from lack of usable variation for important yield traits and disease resistance in the germplasm collection and even if present may not be used with ease on account of very small size of their flower, thus restricting the crop improvement programs. The chromosomes of the different varieties have morphological similarities and there is no distinct variation in length and volume[16]. Genetic enhancement of cumin is possible only by the methods of hybridization or induced mutation. Since, the variability naturally present in this crop is very low, so, induced mutation can be an option for improvement of this crop. Gamma rays have been used for induced variation for different traits like days to flowering, days to maturity and individual plant weight etc. in cumin[7]. Mutagenic efficacy and efficiency varied between crops, species and mutagens used. Gamma rays were relatively more potent mutagen on cumin as compared to other mutagens[12]. Efficient mutagens more often yielded superior progenies in cumin i.e. progenies having significantly higher yield than their parent. The growth parameters including percent seed germination, seedling growth and plant growth are used to decide mutagenic sensitivity in a particular crop and variety[10]. Therefore, objective of this research was comprehensive study the effect of ionizing radiation on cumin to find out the effect of gamma rays plant growth and yield characters.

MATERIALS AND METHODS

An experiment was conducted to evaluate the effect of gamma rays on cumin cultivar RZ-209 at ICAR- National Research Centre on Seed Spices, Ajmer, Rajasthan. ^{60}Co was used as a source of gamma rays in the present investigations to induce mutations in cumin to achieve genetic variability. The dry seed of cumin cultivar RZ-209 was irradiated with 150, 175, 200, 225 and 250Gy of gamma rays at gamma chamber, Bhabha Atomic Research Centre, Trombay, Mumbai, India. The irradiated seed sown along with non irradiated seeds in petri plates over moistened germination paper. The treated seeds also sown in the field with control. Seed germination was considered when the plumule emerged out from the seed. Seed germination and seedling growth parameters were recorded. The seedling length was measured with the help of scale after 30 days of germination. The optimum dose was determined based on seedling survivability and percentage reduction in seedling after treatment with different doses of gamma rays with control (untreated). The plants from each treatment were selected and bagged before flowering to avoid cross pollination. In the M_1 generation the plant growth and flowering parameters were recorded. Observations were recorded for growth parameters viz., root length (cm), shoot length (cm), vigour index, plant height (cm), days to first flowering, days taken to maturity, number of umbel per plant, number of umbellate per plant. The M_2 seeds were harvested only from the bagged M_1 plants. The Experiment was laid out in Completely Randomized Design (CRD) for controlled condition (seed germination) and Randomized Block Design (RBD) for field level study. Data obtained were subjected to analysis of variance (ANOVA) having significant level of 5% (P=0.05). All data are presented as the mean ± standard deviation (SD) from five independent. The graphs were drawn using Excel software.

RESULTS DISCUSSION

Effect of gamma irradiation on seed germination, seedling survival and seedling growth

The data presented in Fig. 1 shows reduction in seed germination and plant survival with the increase in dose of gamma rays. Seed germination was 100% in control and among the different doses of gamma rays, the maximum seed germination was noticed at 150Gy (78.8%) whereas the minimum seed germination was recorded at highest dose 250Gy (52.6%). The survival of seedlings was also found to be decreasing with increase in dose of gamma rays. The seedlings survival was decreased as the dose of gamma rays were increased from 150 to 250Gy. The 50% seedlings did not survive if the dose was increased beyond 200Gy. The dose of 200Gy recorded 68.4% seed germination and 48.4% seedlings survival. The highest dose recorded the lowest (31.80%) seedlings survival as compared to the untreated plants. From the data recorded, it was observed that gamma ray had a highly significant impact on root length, shoot length, fresh weight per plant and vigour index (Table 1). The maximum roots length (4.14), shoots length (8.56 cm), fresh weight per plant (0.0.51g) was observed at lowest dose of 150Gy. The trends in these parameters were decreased as the doses were increased. The plant vigour was highest (1000.76) at lowest dose 150Gy of gamma rays and vice versa. Plant vigour was decreased with the increased in the irradiation doses. The reduction in roots length (82%), shoots length (87%), fresh weight (74%) and plant vigour (59%) were recorded on 200Gy of gamma ray when compared to control.

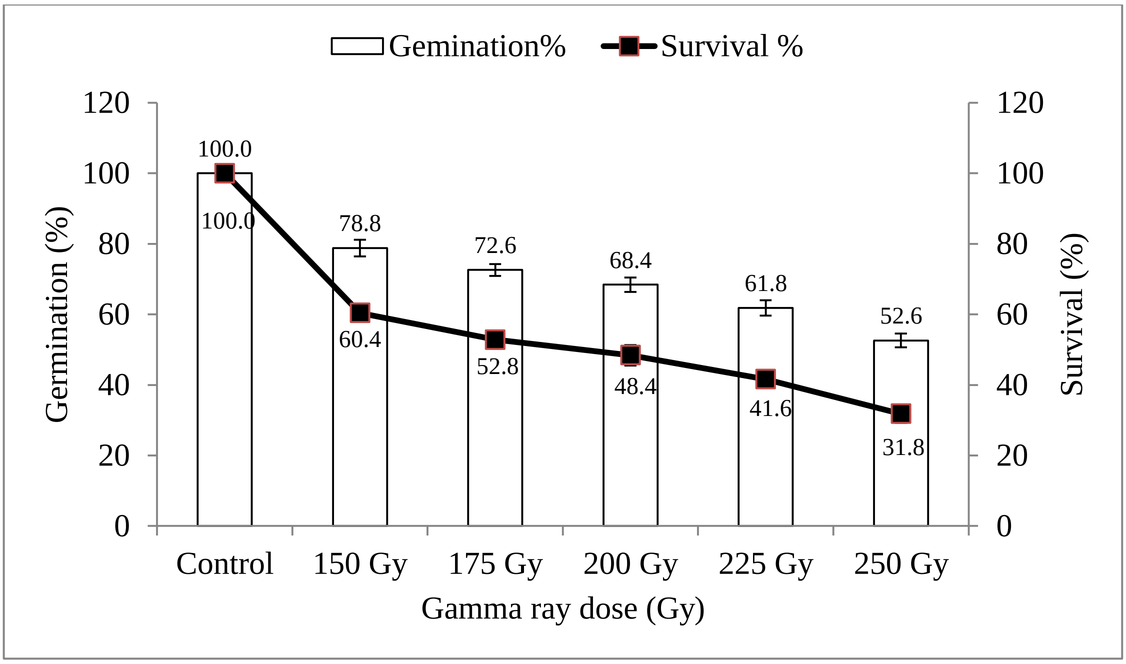

Fig. 1: Effect of different doses of gamma irradiation on seed germination and seedling survival

Table 1: Effect of different doses of gamma irradiation on seedling growth at 30 DAS

Dose (Gy)	Root length (cm)	Shoot length (cm)	Fresh weight per plant (gm)	Vigour index (VI)
0 (Control)	4.52+0.38	9.06+0.46	0.532+0.06	1349.60+69.93
150	4.14+0.26	8.56+0.43	0.514+0.05	1000.76+47.94
175	3.92+0.61	8.36+0.67	0.458+0.15	896.34+59.75
200	3.72+0.19	7.94+0.34	0.394+0.12	799.70+36.21
225	3.5+0.28	7.42+0.16	0.348+0.36	668.84+26.85
250	3.16+0.17	7.20+0.21	0.333+0.11	550.01+25.90
CD (*P*=0.05)	0.49	0.50	0.09	62.58

The decrease in seed germination induced by mutagenic treatments may be the result of damage of cell constituents at molecular level or altered enzyme activity[6]. Coriander germination was reduced in all the treatments of the mutagens with increase in dose of mutagens. More reduction was observed at higher doses indicating dose dependency reduction due to mutagenic treatment[14]. The reduction in the plant growth characters as well as induced polygenic variability was reported in lentil by induced mutation[19]. Gamma rays were drastically reduced the length of root, shoot, fresh weight and vigour index at higher doses in sunflower[4,5].

Effect of gamma radiation on flowering and number of branches

The results presented in Fig. 2 indicate that irradiation significantly delayed the days required for flowering and days required for maturity. The plants in control (58.2 days) flowers first followed by treated plants. The lowest dose (150Gy) required 60.6 days while highest dose (250Gy) required 69.4 days for flowering. There was significant difference observed between different doses of gamma rays (175, 200, 225 and 250Gy) and non significance difference was observed between 150 and 175Gy. The observation revealed that higher dose of gamma rays has significant effect on delaying the flowering. Data pertaining to number of days required for maturity revealed that, days required for maturity increased as irradiation doses increased. Among the different doses of gamma rays early maturity observed at 150Gy (115.4 days) followed by 175Gy (117.8 days) 200Gy (119.2 days), 225 (121.4 days) and 250Gy (124 days). The application of gamma rays had delayed the crop maturity. The Fig. 3 revealed that the numbers of primary branches were decreased in irradiated plant when compared to control. Control recorded highest number of primary branch followed by 200 (6.6), 250 and 150 (6.4), 225 (6.2) and 175Gy (5.8). The number of secondary branches at maturity was increased in some of the irradiated plants (Fig. 3). An increase in the numbers of secondary branches was recorded in 150 (11.8), 200 (12.4) and 250Gy (12.4) as compared to control (11.2). Macro mutants were created in coriander by induced mutantion[3]. Delayed in first flowering was observed by the irradiated the seeds with different dose of gamma rays viz., 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50kR in ashwagandha[2]. Our result was also same as we also found delayed in flowering in gamma rays irradiated plants. Increasing the concentration of chemical mutagens led to gradual reductions in the number of days to flower by stimulating early initiation of flower bud[11].

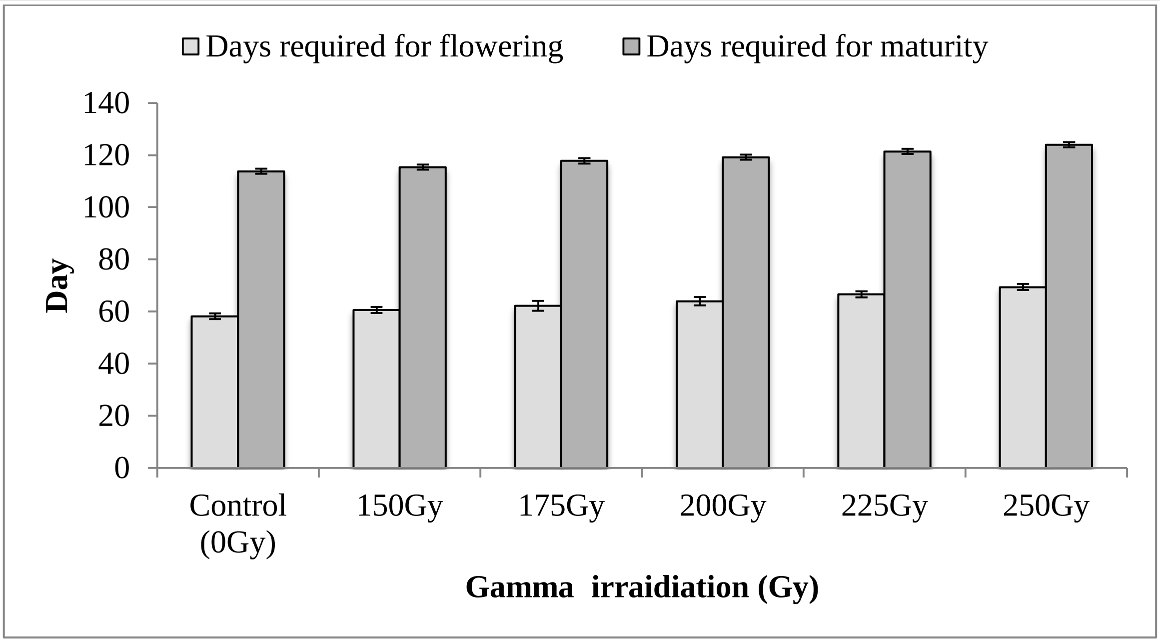

Fig. 2: Effect of different doses of gamma irradiation on number of days required for flowering and maturity

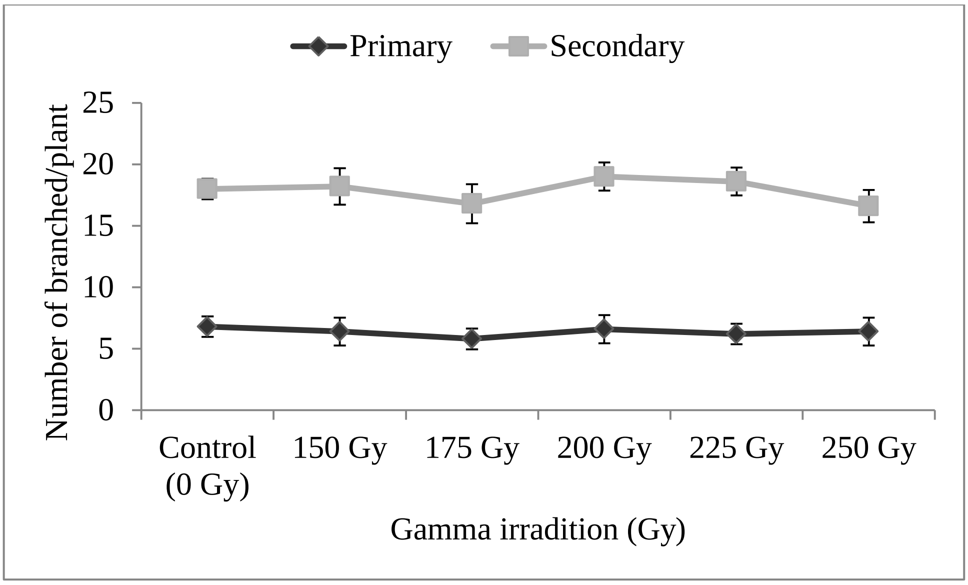

Fig. 3: Effect of different doses of gamma irradiation on primary and secondary branches

Effect of gamma radiation on yield attributes

A glance of results presented in Table 2 revealed that the gamma rays significantly affect the yield attributing characters in cumin. The maximum number of umbel per plant was recorded at the gamma rays doses of 200Gy (33.2) and maximum umbellate per umbel (5.6) in control. The number of seeds per umbellate was maximum (5.8) at 175Gy. The maximum number of seed per umbel was recorded in 225Gy. In some of the irradiated doses 1000 seed weight was increased and in some doses it was decreased when compared control. 1000 seed weight was recorded highest in 200Gy (3.97g) followed by 175Gy (3.90g). The maximum seed yield per plant was recorded in 200Gy (1.67g) followed by 175Gy (1.63g). Quantitative and qualitative crop increase is one of the most important basic and fundamental objectives in plant breeding. The yield is a multicative result of many yield attributing characters and these characters were not improved in all doses of gamma rays. Although, we found the increase in yield attributes character in many gamma rays irradiated plants of cumin. A very high magnitude of genetic coefficient of variability for grain yield per plant followed by number of pods per plant and leaf area in black gram was recorded after gamma rays irradiation[10]. In a study on fennel, it was recorded that the gamma rays degraded sodium alginate on the performance of growth and yield. They observed that foliar spray of radiation degraded alginate improved the yield attributing characters like umbels per plant, umbellate per umbel, hundred seed weight and seed yield[15]. The gamma rays induced genetically variability for different essential traits such as seed weight and seed number in coriander[18] and nigell[8]as compared to control.

Table 2: Effect of different doses of gamma irradiation on number of umbels per plant, number of umbellates per umbel, number of seeds per umbellate, number of seeds per umbel, 1000 seed weight and seed yield per plant

Dose (Gy)	No. of umbels/ plant	No. of umbellates/umbel	No. of seeds/ umbellate	No. of seeds/ umbel	1000 seed weight (g)	Seed yield/ plant (g)
0 (Control)	32.2+1.64	5.6+0.55	5.4+0.55	34.8+1.30	3.71+0.17	1.54+0.02
150	32.4+1.95	5.6+0.55	5.6+0.55	34.2+1.30	2.61+0.15	1.51+0.04
175	31.2+2.39	5.2+0.84	5.8+0.45	32.2+1.30	3.90+0.10	1.63+0.09
200	33.2+1.79	5.4+1.14	5.2+0.45	33+1.22	3.97+0.19	1.67+0.03
225	29+3.32	5.2+0.45	5.6+0.55	35.4+1.52	2.33+0.08	1.33+0.04
250	27.8+1.30	5.4+0.89	5.4+0.55	32.4+1.82	3.35+0.32	1.51+0.04
CD (*P*=0.05)	2.89	NS	NS	1.88	0.18	0.06

CONCLUSIONS

The dose 200Gy gamma rays was found more effective and showed LD_{50}. The gamma rays had stimulatory effect on yield attributing characters as compared to control. Hence, genetically improved plants for production of high yield attributing characters can be achieved through induced mutation by gamma rays.

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