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Sunflower germination and growth behavior under various gamma radiation absorbed doses

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ABSTRACT

Gamma radiation, various absorbed doses (0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5 krad) effects were evaluated on sunflower (*Helianthus annus*. L.) germination and growth characteristics. Sunflower healthy seeds were exposed to gamma radiation source Co^{60} at nuclear institute for food and agriculture and exposed seeds were grown under controlled laboratory conditions. In comparison to control, gamma radiation absorbed doses affected the measured response positively i.e., radical length, plumule length, number of roots, seedling fresh weight, seedling dry weight, germination percentage, time of germination and diameter of hypocotyl of sunflower enhanced up to 83.15%, 70.32%, 73.03%, 4.80%, 3.26%, 72.0%, −18.88% and 12.58%, respectively. The time of germination, fresh weight and percent moisture contents enhanced insignificantly, however, the response was higher than control. All gamma radiation absorbed doses showed a stimulatory effect on sunflower germination and seedling growth characteristics. The low gamma radiation absorbed doses were found to be more effective versus higher doses for enhancing the germination and growth characteristics of sunflower. In view of positive effect of gamma radiation of sunflower germination and growth characteristics, it is concluded that this techniques could possibly be used for the enhancement of germination, growth and ultimately yield in sunflower in areas where germination is low due to unfavorable conditions.

1. Introduction

Sunflower was first introduced as an oilseed crop in 1960s in Pakistan. Extensive research work on different aspects of this crop has been undertaken. In 1970–71, about 6664 ha of sunflower was gown in Punjab and Sindh, respectively, with a total production of 482 tones. In 1987–88, the area under sunflower cultivation increased to 33,122 ha in Punjab, 9648 ha in Sindh and 342 ha in NWFP, with a total production of 42,531 tones. On average, of the total production, 76% is produced in Punjab, 21% in Sindh and 3% in NWFP. Sunflower has been accommodating between the two major crops, cotton and rice [1–4]. Nutritive value of sunflower oil is equal to that of olive oil, like other vegetable oils, it consists of saturated fatty acids, the saturated fatty acids have been found associated with coronary diseases by increasing cholesterol level of the blood serum, which create fatty lining inside the blood vessels, resulting clog, and obstruct the flow of blood [5]. Evolution of sunflower varieties passing high field performance and better oil contents one of the most important steps in solving the edible oil problems of the country. In the recent past, techniques have been successfully employed for the improvement of many important field crops, which are simple and less time consuming means of adding the new genetic variation in the production or desired crops [4,6,7].

The past few decades have witnessed a lot of research dealing with the application of ionizing radiation in agriculture along with other useful application [8–10] and in view of environmental issue, clean technologies are suggested [11–32]. To date, many improved varieties were developed of wheat, oat, barley, maize, flax, many legumes and other field crops by the use of ionizing radiation. Gamma radiation could be used as a source of creating new heredity regarding morphological characters for the improvement of crops [33]. Previous studies revealed that

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gamma radiation enhanced the plant characteristics i.e., *Plodia interpunctella* [34], tomato [35] and cowpea [36] showed positive response to gamma radiation absorbed doses.

In view of importance of sunflower crop, nevertheless, the effect of gamma radiation on sunflower germination and seedling growth was studied in sunflower native to Pakistani soil and environment. Therefore, the principal adjective of present study was to appraise the gamma radiation pre-sowing seed treatment effect on germination and seedling growth characteristics of various absorbed doses of gamma radiation.

2. Material and methods

The $HgCl_2$ was purchased from Sigma-Aldrich and sunflower seed (variety S-278) were obtained from NIFA. The effects of different doses of gamma (Co^{60}) radiations were studied for different genetic parameters of Sunflower. Under laboratory conditions, these parameters were studied by placing 50 seeds for each dose, on filter paper with distilled water (10 ml/petri dish) in sterilized petri dishes, which were kept at 25 °C for 72 h. There were ten radiation doses along with control. Five replications were run for each treatment. After 72 h, germination percentage, radical length, plumule length, diameter of Hypocotyl, number of roots, time of germination, Fresh weight, dry weight and moisture content were measured for each dose.

Germination %age was calculated by multiplying the total number of grains germinated with 100 and divided by the total number of grains sown. Radical length and plumule length was calculated on calibrated scale in cm after 72 h. The diameter of hypocotyle was determined by vernier caliper after 72 h. The number of roots was obtained by counting the roots of each grain. Time of germination was calculated by daily observation of each petri dish. The fresh weight of the replicates was determined by placing the seedling of each replicate in envelops and measuring their weight on digital balance. The dry weight of seedling was determined by placing the fresh weight in an oven for 72 h at 70 °C. The moisture content percentage was obtained by subtraction of dry weight from fresh weight and then by dividing dry weight and multiplication with 100.

3. Results and discussion

3.1. Germination and related parameters

The sunflower seeds were irradiated to gamma radiation at different absorbed doses and effect was evaluated on the basis of germination, seedling growth and physiological attributes. The germinated seed under the effect of different absorbed doses are shown in Fig. 1, whereas germination and growth parameters responses are shown in Tables 1–9 and statistical analysis is given in Table 10. Statistical analysis revealed that germination percentage enhanced significantly in response of gamma radiation exposure. Germination percentage increased under all the radiation doses applied and ranged between 46% at 5 krad and 82% at 0.5 krad. The germination percentages showed insignificant difference among replicates (Table 1). Radical length showed highly significant difference in comparison to control under various doses of gamma irradiation (Table 2). Time of germination in response radiation pre-sowing seed treatment also decreased and up to 18.88% time of germination reduced, which indicates that exposed seed took less time for germination versus un-exposed seeds (Table 2). Least significant difference test revealed that the radical length was minimum (0.700) at 5 krad and maximum (2.730) at 1.5 krad and enhancement in radical length observed up to 83.15% at 1.5 krad (Table 3). Plumule length also showed highly significant response in response of different irradiation doses (Table 4). Statistical analysis revealed that plumule length was maximum under 0.5 krad. Plumule length showed a maximum increase of 70.12% at 1.5 krad.

3.2. Growth characteristics

The number of roots showed highly significant difference under gamma radiation different doses exposure (Table 5). LSD analysis showed that the number of roots were maximum at 1.5 krad and minimum (8.840) at 2.5 krad. The number of roots increased up to 73.03% at 1.5 krad versus control (Table 5). Diameter of hypocotyle also found to be different at different absorbed doses (Table 6). The diameter of hypocotyle was found in the range of 1.780 to 1.130 cm for 0.5 to 5 krad. The increment in hypocotyle diameter was 26.66% versus

Fig. 1. Gamma radiation treated seed of sunflower (*Helianthus annus L.*) at various absorbed doses; A-0.5 Krad, B-1 Krad, C-1.5 Krad, D-2.0 Krad, E-2.5 Krad, F-3.0 Krad, G-4.0 Krad and H-5.0 Krad.