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Effect of spacing and GA₃ on growth, flowering and yield of golden rod (*Solidago canadensis* L.)

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Abstract

An experiment entitled "Effect of spacing and GA₃ on growth, flowering and yield of golden rod" was carried out during *Kharif* season of the year 2019-2020 at Satpuda Botanical Garden, Horticulture Section, College of Agriculture, Nagpur, Dr. PDKV, Akola (M.S.). The treatments comprised of four spacing *viz.*, 30 x 10 cm, 30 x 20 cm, 30 x 30 cm and 30 x 40 cm and three levels of GA₃ *viz.* 0 ppm (control), 100 ppm and 150 ppm. Before planting suckers of golden rod were dipped in GA₃ solution of different concentrations as per the treatment for 6 hours. The experiment was laid out in Factorial Randomized Block Design with three replications. The results revealed that, in respect of growth parameters, plant height with panicle, number of leaves plant⁻¹ and plant spread were recorded significantly maximum with the spacing of 30 x 40 cm and suckers treatment with 150 ppm GA₃. In respect of flowering parameters, initiation of panicle and opening of first flower were registered significantly earliest when golden rod suckers planted at the spacing of 30 x 40 cm and treated with 150 ppm GA₃. The yield parameters like number of panicles plant⁻¹ and ha⁻¹ were also found significantly maximum with the spacing of 30 x 40 cm and the sucker's treatment with 150 ppm GA₃.

Keywords: Golden rod, gibberellic acid, growth, flowering, quality and yield

Introduction

'Solidago' commonly known as golden rod belongs to family Asteraceae. The genus comprises about 130 species, mostly native to North America. Few species like *Solidago canadensis*, *S. virgaurea* and *S. memorialis* are grown in beds, borders or rock gardens. Besides, they are also used as cut flowers for indoor decoration and bouquets. Golden rod (*Solidago canadensis* L.) is a perennial flowering plant which is grown for its attractive, long and straight flower stalk. It is commonly grown in beds, borders, rock gardens and also for cut flower in India. Because of its easy cultivation, adaptability to varying soil and climatic conditions and excellent keeping quality, there is a great scope for cultivation of golden rod in India. It is generally used as cut flower for indoor decoration as well as in bouquet making as a filler along with other flowers. It has a very good potential for dry flower industry.

This crop did not receive a much attention of researchers in the past under Vidharbha conditions and therefore, technological information for these areas is much scanty. Gibberellic acid plays a vital role in improvement of vegetative growth characters of the plant as it enhances the cell elongation and cell division by promoting the DNA synthesis in the cell. It reduces the juvenile phase due to an increase in photo-synthesis and respiration with enhanced carbon-di-oxide fixation in the plant. Keeping in view the potentialities of gibberellic acid, the present study was undertaken to find out the suitable spacing and concentration of GA₃ for the better growth, flowering and yield of golden rod.

Materials and Methods

Present experiment was carried out at Satpuda Botanical Garden, Horticulture Section, College of Agriculture, Nagpur during 2019-2020. The treatments comprised of four spacing *viz.*, 30 x 10 cm, 30 x 20 cm, 30 x 30 cm and 30 x 40 cm and three levels of GA₃ *viz.* 0 ppm (control), 100 ppm and 150 ppm. The experiment was laid out in Factorial Randomized Block Design (FRBD) replicated thrice. After preparation of the experimental field various plots were laid out as per the different spacing treatments. Golden rod suckers were dipped with three levels of gibberellic acid (0, 100 and 150 ppm GA₃) solution for 6 hours. Planting of GA₃ soaked

golden rod suckers was done in different plots at various spacing as per the treatment. Farmyard manure was applied @ 600g/m² to all the plots uniformly and incorporated in to the soil, whereas, the fertilizers were applied @ 150:100:100 kg/ha N, P₂O₅ and K₂O, respectively. Irrigation was applied thrice in a week for one month and twice in week afterwards. Hand weeding was carried out as and when required. Five plants were selected randomly from each plot for recording various growth parameters viz. plant height with panicle, number of leaves plant⁻¹ and plant spread, flowering parameters viz., days to initiation of panicle and days to

opening of first flower and yield parameters like number of panicles plant⁻¹ and hectare⁻¹. Various observations were recorded at proper stages and the data was statistically analyzed by the method suggested by Panse and Sukhatme (1995) [6].

Results and Discussion

The data presented in Table 1 revealed that, different spacing and levels of GA₃ had significant effect on growth, flowering and yield parameters of golden rod.

Table 1: Effect of spacing and levels of GA₃ on growth, flowering and yield of golden rod

| Treatments | Plant height with panicle (cm) | Number of leaves plant ⁻¹ | Plant spread (cm) | Days for initiation of panicle (days) | Days for opening of first flower (days) | Yield of panicles plant ⁻¹ | Yield of panicles hectare ⁻¹ (Lakh) |
|---|--------------------------------|--------------------------------------|-------------------|---------------------------------------|---|---------------------------------------|--|
| A. Spacing (S) | | | | | | | |
| S ₁ - 30 x 10 cm | 64.28 | 33.07 | 22.40 | 40.93 | 84.03 | 4.04 | 2.97 |
| S ₂ - 30 x 20 cm | 65.98 | 33.33 | 22.65 | 39.63 | 83.17 | 4.16 | 3.09 |
| S ₃ - 30 x 30 cm | 68.24 | 33.65 | 24.39 | 38.07 | 79.76 | 4.24 | 3.16 |
| S ₄ - 30 x 40 cm | 73.49 | 35.44 | 25.84 | 35.02 | 78.48 | 4.80 | 3.50 |
| F test | Sig. | Sig. | Sig. | Sig. | Sig. | Sig. | Sig. |
| SE (m) ± | 1.11 | 0.60 | 0.42 | 1.21 | 1.21 | 0.08 | 0.06 |
| CD at 5% | 3.26 | 1.75 | 1.23 | 3.56 | 3.55 | 0.23 | 0.18 |
| B. GA₃ Concentrations (G) | | | | | | | |
| G ₁ - 0 ppm GA ₃ | 64.99 | 32.42 | 22.34 | 41.84 | 84.20 | 4.15 | 3.06 |
| G ₂ - 100 ppm GA ₃ | 67.32 | 33.33 | 24.28 | 38.26 | 81.47 | 4.32 | 3.23 |
| G ₃ - 150 ppm GA ₃ | 71.68 | 35.86 | 24.83 | 35.14 | 78.43 | 4.47 | 3.26 |
| F test | Sig. | Sig. | Sig. | Sig. | Sig. | Sig. | Sig. |
| SE (m) ± | 0.96 | 0.51 | 0.36 | 1.05 | 1.05 | 0.07 | 0.05 |
| CD at 5% | 2.82 | 1.52 | 1.06 | 3.08 | 3.08 | 0.20 | 0.16 |
| C. Interaction (D x G) | | | | | | | |
| F test | Sig. | N.S. | Sig. | N.S. | N.S. | N.S. | N.S. |
| SE (m) ± | 2.36 | 1.27 | 0.89 | 2.57 | 2.56 | 0.17 | 0.13 |
| CD at 5% | 6.92 | - | 2.61 | - | - | - | - |

Table 2: Interaction effect of spacing and levels of GA₃ on plant height and spread in golden rod

| Treatment combinations | Plant height with panicle(cm) | Plant spread (cm) |
|---|-------------------------------|-------------------|
| S ₁ G ₁ (30 x 10 cm spacing + no sucker treatment with GA ₃ i. e. control) | 62.61 | 21.40 |
| S ₁ G ₂ (30 x 10 cm spacing + sucker treatment with GA ₃ 100 ppm) | 64.36 | 23.29 |
| S ₁ G ₃ (30 x 10 cm spacing + sucker treatment with GA ₃ 150 ppm) | 65.86 | 22.51 |
| S ₂ G ₁ (30 x 20 cm spacing + no sucker treatment with GA ₃ i. e. control) | 64.91 | 21.69 |
| S ₂ G ₂ (30 x 20 cm spacing + sucker treatment with GA ₃ 100 ppm) | 65.79 | 23.32 |
| S ₂ G ₃ (30 x 20 cm spacing + sucker treatment with GA ₃ 150 ppm) | 67.23 | 22.95 |
| S ₃ G ₁ (30 x 30 cm spacing + no sucker treatment with GA ₃ i. e. control) | 65.54 | 22.86 |
| S ₃ G ₂ (30 x 30 cm spacing + sucker treatment with GA ₃ 100 ppm) | 67.71 | 25.05 |
| S ₃ G ₃ (30 x 30 cm spacing + sucker treatment with GA ₃ 150 ppm) | 71.48 | 25.27 |
| S ₄ G ₁ (30 x 40 cm spacing + no sucker treatment with GA ₃ i. e. control) | 66.88 | 23.42 |
| S ₄ G ₂ (30 x 40 cm spacing + sucker treatment with GA ₃ 100 ppm) | 71.41 | 25.26 |
| S ₄ G ₃ (30 x 40 cm spacing + sucker treatment with GA ₃ 150 ppm) | 82.16 | 28.83 |
| F test | Sig. | Sig. |
| SE (m) ± | 2.36 | 0.89 |
| CD at 5% | 6.92 | 2.61 |

Growth parameters

Effect of spacing

Significantly maximum plant height with panicle (73.49 cm), number of leaves plant⁻¹ (35.44) and plant spread (25.84 cm) were recorded when the golden rod suckers planted at the spacing of 30 x 40 cm and it was followed by 30 x 30 cm (68.24 cm, 33.65 and 24.39 cm, respectively), whereas, minimum values were recorded with the closer spacing of 30 x 10 cm (64.28 cm, 33.07 and 22.40 cm, respectively).

From the above results, it has been noticed that, wider planting distance of 30 x 40 cm was superior than other spacing treatments in respect of growth parameters. An

increase in vegetative growth parameters due to wider planting might be due to the availability of more nutrient, moisture and light which ultimately increased the photosynthetic rate and enhanced the metabolic activities which reflected in to maximum vegetative growth of plants. These results are in close conformity with the findings of Tingare *et al.* (2007) [9] in golden rod.

Effect of GA₃ concentrations

The plant height with panicle (71.68 cm), number of leaves plant⁻¹ (35.86) and plant spread (24.83 cm) were observed significantly highest when the golden rod suckers treated with

150 ppm GA₃ which was closely followed by 100 ppm GA₃ in respect of plant height and number of leaves plant⁻¹ (67.32 cm and 33.33, respectively) and it was found at par with 100 ppm GA₃ (24.28 cm) in respect of plant spread. However, minimum plant height with panicle (64.99 cm), number of leaves plant⁻¹ (32.42) and plant spread (22.34 cm) were reported in the control treatment. The increase in growth parameters with GA₃ treatment over control might be because of the fact that GA₃ promotes vegetative growth by inducing active cell division and cell elongation, which might have resulted in increasing the growth parameters. These findings are also supported by Bharathi *et al.* (2009)^[1] in tuberose, Nandre *et al.* (2009)^[4] in China aster and Osman and Sewedan (2014)^[5] in golden rod.

Interaction effect

The interaction effect of spacing and levels of GA₃ on growth parameters *viz.* plant height with panicle and plant spread in golden rod was found statistically significant. However, in respect of number of leaves plant⁻¹ the interaction effect was found non-significant.

The treatment combination S₄G₃ (30×40 cm + 150 ppm GA₃) significantly recorded maximum plant height with panicle (82.16 cm) and plant spread (28.83 cm) which was closely followed by S₃G₃ *i.e.* 30×30 cm + 150 ppm GA₃ (71.48 cm and 25.27 cm, respectively) and S₄G₂ *i.e.* 30×40 cm + 100 ppm GA₃ (71.41 cm and 25.26 cm, respectively). However, minimum plant height with panicle (62.61 cm) and plant spread (21.40 cm) was observed in treatment combination S₁G₁ (30×10 cm + 0 ppm GA₃). This increase in vegetative growth in respect of plant height and spread might have been due to the combined effect of wider spacing and treatment of golden rod suckers with gibberellic acid. These results are in close agreement with the findings of Pavagadhi, H.N. (2001)^[7] in golden rod.

Flowering parameters

Effect of spacing

Days required for initiation of panicle and opening of first flower in golden rod were recorded significantly minimum with the spacing of 30 x 40 cm (35.02 and 78.48 days, respectively) which was found statistically at par with 30 x 30 cm spacing (38.07 and 79.76 days, respectively). However, maximum days for initiation of panicle (40.93 days) and opening of first flower (84.03 days) were noted with the closer spacing of 30 x 10 cm. Thus, the flowering was delayed with closer spacing which might have been due to non-availability of sufficient nutrients, light, water etc. due to heavy competition between the plants of golden rod due to which the juvenile phase of the plant might have been extended. The results are in close agreement with the findings of Osman and Sewedan (2014)^[5] in golden rod who also reported delay in flowering due to increased planting density.

Effect of GA₃ concentration

Significantly minimum days were required for initiation of panicle (35.14 days) and opening of first flower (78.43 days) when the suckers of golden rod treated with 150 ppm GA₃ which was closely followed by the treatment of 100 ppm GA₃ (38.26 and 81.47 days, respectively), whereas, significantly late initiation of panicle (41.84 days) and opening of first flower (84.20 days) were reported with the control treatment. Earlier initiation of panicle and opening of first flower due to the treatment of GA₃ might be due to the fact that, GA₃ is quite effective in reducing the juvenile period of plants. More

or less similar results are reported by Bharathi *et al.* (2009)^[1] in tuberose, Dalal *et al.* (2009)^[2] in gerbera and Dogra *et al.* (2012)^[3] in gladiolus.

Interaction effect

The interaction effect of planting dates and levels of GA₃ on flowering parameter *viz.* days for initiation of panicle and days for opening of first flower in golden rod was found statistically non-significant.

Yield parameters

Effect of spacing

Significantly maximum number of panicles plant⁻¹ (4.80) and ha⁻¹ (3.50 lakh) were harvested with the spacing of 30 x 40 cm which was followed by 30 x 30 cm (4.24 and 3.16 lakh). However, minimum number of panicles plant⁻¹ (4.04) and ha⁻¹ (2.97 lakh) were noted with the closer spacing of 30 x 10 cm. The plants planted at wider spacing of 30 x 40 cm produced good vegetative growth, thereby proper development of required photosynthetic system which might have helped to increase the production of flowers which in turn resulted in maximum number of panicles plant⁻¹ and ha⁻¹. Similar results have also been reported by Osman and Sewedan (2014)^[5] in golden rod.

Effect of GA₃ concentrations

The number of panicles plant⁻¹ (4.47) and hectare⁻¹ (3.26 lakh) were registered significantly maximum when the golden rod suckers treated with 150 ppm GA₃ and it was found statistically at par with 100 ppm GA₃ (4.32 and 3.23 lakh). Whereas, minimum number of panicles plant⁻¹ (4.15) and ha⁻¹ (3.06 lakh) were reported in the control treatment. This increase in number of panicles per plant and per hectare due to GA₃ application over control might be due to increased vegetative growth in respect of plant height and spread and number of leaves, which is essential for production of carbohydrates in the plants. These carbohydrates are translocated towards the reproductive parts of the plants for higher production of flowers. These results are in conformity with the findings of Nandre *et al.* (2009)^[4] in China aster and Rajput *et al.* (2011)^[8] in golden rod.

Interaction effect

The interaction effect due to spacing and GA₃ levels on the yield of panicles plant⁻¹ and ha⁻¹ was found non-significant. Thus, it can be inferred from the present investigation that, maximum growth and flower yield with earliest flowering was recorded in golden rod when the suckers planted at wider spacing of 30 x 40 cm and treated with 150 ppm GA₃.

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