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Response of INM and plant growth retardants on flowering and yield of golden rod (*Solidago canadensis* L.) cv. Local

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Abstract
The present experiment entitled under "Response of INM and plant growth retardants on flowering and yield parameters (*Solidago canadensis* L.) cv. Local" in Saurashtra region" was conducted at, Floriculture farm, Jambuvadi, College of Horticulture J.A.U., Junagadh, Gujarat, during two consecutive years 2023-24 and 2024-25. The experiment was assigned a Randomized Design with factorial concept with 18 treatment combinations arising from six levels of INM (with three replications). Results reveal While in case of flowering parameter minimum number of days for panicle iniation (72.22 days, 82.22 days and 77.22 days), maximum length of panicle (54.78 cm, 57.33 and 56.06 cm), maximum diameter of main flower stalk (6.42 mm, 6.47 mm and 6.44 mm) and maximum number of inflorescences per panicle (36.89, 36.11 and 36.50) was found in I_4 treatment during both the years as well as pooled. Whereas in yield parameter number of panicles per plant (2.60, 2.59 and 2.60) and number of panicles per hectare (2.88 lakh, 2.89 lakh and 2.86 lakh) was found in I_4 treatment during both the years as well as pooled.

Keywords: Golden rod, INM, PGR, growth, yield, quality

Introduction
Solidago canadensis L. is commonly known as 'golden rod', which belongs to the family Asteraceae. Golden rod is a perennial flower crop cultivated for its flower stalk. The genus *Solidago* comprises about 100 species, most of which are native to North America, a few of which are found in South America, temperate Europe and Asia. Golden rod is known as sonasali in the local language. A few species like *S. canadensis*, *S. virgourea*, *S. memeoralis* grow in beds, borders, or rock gardens. Yellow panicles are very attractive as cut flowers and are also used in bouquets and for table decoration purposes.

The crop does well in a tropical climate. Division of stools, suckers or seeds propagates golden rod. The plants are easy to grow. Though they are heavy feeder, the soil should be rich in nutrients to promote vegetative growth. The addition of organic manure to the soil is helpful to retain moisture in dry season. When the plant becomes root-bound, the growth and flowering are reduced at that time stools are lifted and divided for planting. In a moderate climate, planting can be done at any time, but the spring and rainy season are more favorable for growth.

Golden rod is an important flower crop at the international level, basically as a filler material in floral arrangements. It has promising and untapped export potential besides local demand. It looks very beautiful when used with flowers like roses, gerbera, gladiolus, as well as providing good support and framework to the overall flower arrangement, as the stalks are hardy. In golden rod, the behavior of flower opening is from top to bottom, which enhances the beauty of the floral display and, thus, provides a spectacular look to the flower arrangement. It is apparent from the meaning of the Latin word & quot; solido; that stands for "to make a hole". Cultivation of golden rod as filler material is preferred as compared to other filler plants and as a cut flower. Thus, along with low cost of cultivation and hardy nature, it has an additional benefit of providing good support in the flower arrangements and bouquets.

Integrated nutrient management (INM) refers to the maintenance of soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through

optimization of the benefits from all possible sources of plant nutrients in an integrated manner. INM helps in the improvement of the soil physical properties such as granulation, porosity, water holding and drainage capacity, aeration etc. It also leads to improvement in the organic matter content in the soil, making the soil healthy. The aim of integrated nutrient management is to integrate the use of natural and man-made soil nutrients to increase crop productivity and preserve soil productivity for future generations.

Second aspects of PGR used Maleic Hydrazide (MH) has been found to retard plant height by reducing intermodal length and also simultaneously it reduces the formation of lateral shoots, thereby the plant produces a greater number of flowers bearing shoots in chrysanthemum (Yewale *et al*. 1999) [12]. Cycocel is known to retard cell division and cell elongation in shoot tissues and thus regulate plant growth physiologically without malformation of leaves and stem the growth suppression by MH is due to its action as an antiauxin, dwarfing properties and nullification of the apical dominance (Crafts *et al*. 1970) [2]. Paclobutrazol reduces plant height by suppressing the apical dominance, increases the main and secondary branches and increases the flower number with a reduction of flower diameter.

Materials and Methods

"Response of INM and plant growth retardants on flowering and yield parameters (*Solidago canadensis* L.) cv. Local" in Saurashtra region" was conducted at, Floriculture farm, Jambuvadi, College of Horticulture J.A.U., Junagadh, Gujarat, during two consecutive years 2023-24 and 2024-25. The experiment was assigned a Randomized Design with factorial concept with 18 treatment combinations arising from six levels of INM (with three replications). *viz*., 100% (T_1), 80% RDF + FYM (8 t/ha) (T_2), 75% RDF + FYM 5 t/ha + *Azotobacter* 2 L/ha + PSB 2 L/ha + KSB 2 L/ha (T_3), 75% RDF + VC 2 t/ha + *Azotobacter* 2 L/ha + PSB 2 L/ha + KSB 2 L/ha (T_4), 50% RDF + FYM 5 t/ha + *Azotobacter* 3 L/ha + PSB 3 L/ha + KSB 3 L/ha (T_5), 50% RDF + VC 2 t/ha + *Azotobacter* 3 L/ha + PSB 3 L/ha + KSB 3 L/ha (T_6) and second factor three levels PGR MH-700 mg/l (P_1), CCC-2000 mg/l (P_2) and PCB-0.5 ml/l (P_3).

Results

Flowering and yield parameters

Flowering parameter minimum number of days for panicle iniation (72.22 days, 82.22 days and 77.22 days), maximum length of panicle (54.78 cm, 57.33 and 56.06 cm), maximum diameter of main flower stalk (6.42 mm, 6.47 mm and 6.44 mm) and maximum number of inflorescences per panicle (36.89, 36.11 and 36.50) was found in I4 treatment during both the years as well as pooled. Whereas in yield parameter number of panicles per plant (2.60, 2.59 and 2.60) and number of panicles per hectare (2.88 lakh, 2.89 lakh and 2.86 lakh) was found in I4 treatment during both the years as well as pooled.

Discussion

Flowering and yield parameters

Length of panicle may also be attributed to the supply of macro and micro nutrients, enzymes, and growth hormones by vermicompost. This, in turn, helped in reducing 50 percent of the recommended NPK. The similar effects of *Azotobacter* and PSB were noted on China aster (Chaitra and Patil 2006) [1]. The positive effect of vermicompost in increasing the length of the panicle has been reported in gladiolus (Gangadharan and Gopinath 2000) [6]. The positive effect of vermicompost and bio-fertilizers on flower diameter has been reported in roses by Kolambe (2008) [8]. Whereas in yield parameters Narasimha and Haripriya (2001) [11] reported higher flower yield in crossandra with the combination of *Azospirillium* and PSB with 100% NPK. Mital *et al*. (2010) [9] in marigold and Deshmukh *et al*. (2008) [5] in gaillardia have obtained similar results.

In case of PGR for flowering parameters a similar result was obtained by Dalve *et al*. (2009) [4] for the gladiolus flower and Jagdale *et al*. (2017) [7] in chrysanthemum. For yield parameters the greater number of branches and maximum plant spread in this treatment had accumulated more carbohydrates through photosynthesis, which were directly used for increasing the number of flowers and flower yield. These results are in agreement with results obtained by Navale *et al*. (2010) [10] in chrysanthemum and Joshi and Reddy (2006) [13] in china aster and Dani *et al*. (2010) [3] in marigold.

Table 1: Effect of INM and PGR on the number of days for panicle initiation and length of panicle golden rod cv. Local

Treatments	Number of days for panicle initiation			Length of panicle (cm)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
INM (I)						
I_1	84.44	91.00	87.72	31.89	34.22	33.06
I_2	78.33	87.44	82.89	38.00	43.56	40.78
I_3	76.11	86.56	81.33	43.78	47.00	45.39
I_4	72.22	82.22	77.22	54.78	57.33	56.06
I_5	77.11	84.11	80.61	45.78	47.33	46.56
I_6	70.22	85.44	77.83	44.56	46.11	45.33
S.Em.±	2.52	1.72	1.53	1.05	1.00	0.73
C.D. at 5%	7.26	4.96	4.31	3.03	2.89	2.06
PGR (P)						
P_1-MH:-700 mg/l	78.44	85.78	82.11	42.33	46.39	44.36
P_2-CCC:-2000 mg/l	73.72	85.22	79.47	43.00	45.72	44.36
P_3-PBZ:-0.5 ml/l	77.06	87.39	82.22	44.06	45.67	44.86
S.Em.±	1.78	1.22	1.08	0.75	0.71	0.51
C.D. at 5%	NS	NS	NS	NS	NS	NS
I x P						
S.Em.±	4.37	2.99	6.22	1.83	1.74	1.59
C.D. at 5%	12.57	8.59	17.57	5.25	NS	NS
Y x I						
S.Em.±	-	-	2.16	-	-	1.03
C.D. at 5%	-	-	NS	-	-	NS
Y x P						
S.Em.±	-	-	1.53	-	-	1.63
C.D. at 5%	-	-	NS	-	-	NS
Y x I x P						
S.Em.±	-	-	3.74	-	-	1.78
C.D. at 5%	-	-	NS	-	-	NS
C.V.%	9.90	6.00	7.97	7.33	6.56	6.93

Table 2: Effect of INM and PGR on the number of diameter of main flower stalk and number of inflorescences per panicle golden rod cv. Local

Treatments	Diameter of main flower stalk (mm)			Number of inflorescences per panicle		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
INM (I)						
I_1	4.53	5.04	4.78	32.78	28.11	30.44
I_2	5.14	5.20	5.17	35.89	30.78	33.33
I_3	5.72	5.98	5.85	34.78	34.56	34.67
I_4	6.42	6.47	6.44	36.89	36.11	36.50
I_5	5.64	5.94	5.79	35.00	33.89	34.44
I_6	5.58	5.89	5.73	32.33	30.00	31.17
S.Em.±	0.07	0.16	0.09	0.93	1.27	0.78
C.D. at 5%	0.21	0.45	0.24	2.67	3.64	2.22
PGR (P)						
P_1-MH:-700 mg/l	5.23	5.57	5.40	34.67	30.28	32.47
P_2-CCC:-2000 mg/l	5.55	5.71	5.63	34.61	33.00	33.81
P_3-PBZ:-0.5 ml/l	5.72	5.98	5.85	34.56	33.44	34.00
S.Em.±	0.05	0.11	0.06	0.66	0.89	0.55
C.D. at 5%	0.15	0.32	0.17	NS	2.57	NS
I x P						
S.Em.±	0.13	0.27	0.18	1.61	2.19	2.15
C.D. at 5%	NS	NS	NS	NS	NS	6.08
Y x I						
S.Em.±	-	-	0.12	-	-	1.13
C.D. at 5%	-	-	NS	-	-	NS
Y x P						
S.Em.±	-	-	0.09	-	-	0.78
C.D. at 5%	-	-	NS	-	-	NS
Y x I x P						
S.Em.±	-	-	0.21	-	-	1.92
C.D. at 5%	-	-	NS	-	-	NS
C.V.%	3.97	8.08	6.46	8.04	11.78	9.96

Table 3: Effect of INM and PGR on the number of panicles per plant and number of panicles per hectare

Treatments	Number of panicles per plant			Number of panicles per hectare (Lakh)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
INM (I)						
I_1	1.24	1.21	1.23	1.38	1.34	1.99
I_2	1.80	1.99	1.89	1.99	2.21	2.15
I_3	2.32	2.37	2.35	2.58	2.63	2.56
I_4	2.60	2.59	2.60	2.88	2.89	2.86
I_5	1.89	2.02	1.96	2.10	2.24	2.17
I_6	2.02	2.14	2.08	2.24	2.38	2.30
S.Em.±	0.07	0.06	0.05	0.07	0.07	0.05
C.D. at 5%	0.19	0.18	0.13	0.20	0.21	0.14
PGR (P)						
P_1-MH:-700 mg/l	1.90	2.08	1.99	2.10	2.31	2.21
P_2-CCC:-2000 mg/l	2.02	1.95	1.99	2.24	2.16	2.20
P_3-PBZ:-0.5 ml/l	2.02	2.13	2.08	2.25	2.37	2.30
S.Em.±	0.05	0.05	0.07	0.05	0.05	0.07
C.D. at 5%	NS	0.13	NS	NS	0.15	NS
I x P						
S.Em.±	0.11	0.11	0.10	0.12	0.23	0.10
C.D. at 5%	NS	NS	NS	NS	NS	NS
Y x I						
S.Em.±	-	-	0.06	-	-	0.12
C.D. at 5%	-	-	NS	-	-	NS
Y x P						
S.Em.±	-	-	0.05	-	-	0.05
C.D. at 5%	-	-	NS	-	-	NS
Y x I x P						
S.Em.±	-	-	0.11	-	-	0.12
C.D. at 5%	-	-	NS	-	-	NS
C.V.%	9.87	9.38	9.62	9.87	9.38	9.62

Table 4: Interaction effect of INM and PGR on the number of days for panicle initiation and number of inflorence per panicle

Treatment combination	Number of days for panicle initiation			Number of inflorescences per panicle		
INM ×PGR (Interaction)	**2023-24**	**2024-25**	**Pooled**	**2023-24**	**2024-25**	**Pooled**
I_1P_1	88.33	86.67	87.50	32.33	25.67	29.00
I_1P_2	81.67	91.67	86.67	36.67	30.33	33.50
I_1P_3	83.33	94.67	89.00	29.33	28.33	28.83
I_2P_1	73.33	86.67	80.00	37.00	23.33	30.17
I_2P_2	76.67	86.67	81.67	34.67	30.25	32.46
I_2P_3	85.00	89.00	87.00	36.00	34.33	35.17
I_3P_1	71.67	83.33	77.50	30.32	32.33	31.82
I_3P_2	76.67	85.67	81.17	30.67	33.67	32.17
I_3P_3	80.00	90.67	85.33	35.33	37.67	37.50
I_4P_1	88.50	91.22	89.86	36.00	34.33	35.17
I_4P_2	60.00	76.67	68.33	38.00	36.33	37.17
I_4P_3	65.00	78.33	71.67	36.67	37.67	37.17
I_5P_1	71.67	87.33	79.50	37.00	33.67	35.33
I_5P_2	82.33	85.00	83.67	32.33	32.33	32.33
I_5P_3	77.33	80.00	78.67	35.67	35.67	35.67
I_6P_1	74.00	79.00	76.50	32.33	32.33	32.33
I_6P_2	65.00	85.67	75.33	32.33	30.67	31.50
I_6P_3	71.67	91.67	81.67	32.33	25.67	29.67
S.Em.±	4.37	2.99	6.22	1.61	2.19	2.15
C.D. at 5%	12.57	8.59	17.57	NS	NS	6.08
C.V.%	9.90	6.00	7.97	8.04	11.78	9.96

Conclusion

The present investigation clearly demonstrated that integrated nutrient management (INM) significantly influenced the flowering and yield parameters of golden rod (*Solidago canadensis* L.) under Saurashtra conditions. Among the treatments, INM level I_4 consistently recorded superior performance in terms of flowering parameters and overall yield. Plant growth retardants, on the other hand, exhibited a limited effect, with significant influence observed only on the days to panicle initiation and inflorescence number of panicles. Overall, the findings suggest that adoption of I_4 level of INM is most effective for enhancing the growth, yield, and quality of golden rod in the Saurashtra region. Integration with appropriate plant growth retardant treatments, particularly P_3.

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