www.hortflorajournal.com
HortFlora Research Spectrum, 4(3): 230-235 (September 2015) ISSN : 2250-2823

EFFECT OF NITROGEN LEVELS AND CUTTINGS (MAIN AND RATOON) ON GROWTH AND FLOWERING OF GOLDEN ROD (*Solidago canadensis* L.) DURING SUMMER AND RAINY SEASON PLANTING

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ABSTRACT : The recently introduced under cultivation plant species *Solidago canadensis* L. is commonly known as 'Goldenrod' belongs to family Asteraceae. It is a perennial in nature and unexploited flower crop cultivated in limited areas for its flower stalks. Now a day farmers are growing this crop commercially in a limited area. The trial was conducted to evaluate the nitrogen levels and type of cuttings during two seasons (summer and rainy) with six nitrogen levels (0, 50, 100, 150, 200 and 250 kg N/ha). The nitrogen was applied once during main harvest. Main harvest had pronounced effect on vegetative parameters during summer and rainy plantings except number of suckers and fresh weight of plant, which was higher during both plantings. While earliest flowering (80.20 days) was observed in ratoon harvesting during summer planting. While, under rainy planting the main harvest provided more number of panicles per plant and per hectare. The application of 250 kg N/ha had pronounced effect on vegetative growth parameters which had increased all vegetative growth parameters. Nitrogen at 250 kg N/ha produced highest longevity of inflorescence, yield of panicles per plant and per hectare during summer and rainy planting, respectively Earliest flowering was found at 200 kg N/ha (73.70 days) during summer and at 250 kg N/ha (98.10 days) during rainy season.

Keywords : *Golden Rod, miss-concepts, nutrients, harvesting, seasonal variation.*

Solidago canadensis L. is commonly known as 'golden rod', which belongs to family Asteraceae. Golden rod is perennial flower crop cultivated for its flower stalks. The genus *Solidago* comprises about 100 species, most of which native to North America, few of which are found in South America, temperate Europe and Asia. It is grown in beds, borders or rock garden and some of which produced yellow flowers and panicles for several months of a year, which are very attractive as cut flower and are used in bouquet and also for table decoration purpose. Now a day farmers are growing this crop commercially in a limited area. Still it is required to standardize the package of practices to grow it's economically. It is now locally popular as *sonasali* in Saurashtra region. Few species like *S. canadensis, S. virgourea, S. memeoralis* are grown in beds, borders or rock garden and some of which produced yellow flowers and panicles for several months of a year, which are very attractive as cut flower and are used in bouquet and also for table decoration purpose. Previously, it was considered as a perennial weed in United States of America. There was meagre importance given to the golden rod in past years because of its identification as fever spreading weed. There was a misconception in older days, that golden rod causes hay fever which having allergic reactions on the skin and respiration system on human body. But, a golden rod flower produces heavy pollen grains, which require dissemination by insects. Whereas, hay fever had been caused by lightweight and windblown pollens. Hence, it is cleared that hay fever is not caused by golden rod. But due to such misconceiving, the flowers have limited use in USA and ultimately its spread goes limited throughout the world and India.

MATERIALS AND METHODS

The present experiment was carried out at Horticulture Instructional Farm, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh during February 2004 to March 2005. The trial was carried out to evaluate the nitrogen levels and type of cuttings during two seasons (S_1-Summer and S_2-Rainy) with six nitrogen levels (N_1-0, N_2-50, N_3-100, N_4-150, N_5-200 and N_6-250 kg N/ha). The nitrogen was applied once during main harvest. Two seasons and six nitrogen levels were studied in the experiment where two cuttings taken of each season as a main crop and ratoon crop. The well decomposed farmyard manure was incorporated in the soil during preparation of soil at the rate of 10 t/ha and

Received : 05-08-2015 *Accepted : 30-08-2015*

phosphorus and potash were applied to the plots as per the recommendation rate of 150 kg/ha each. After detaching the suckers from mother plant immediately they were transplanted in each plot at the spacing of 30 cm × 30 cm on 2nd week of February for summer season. The second transplanting was done in Kharif on 2nd week of June. The gap filling was carried out within twenty days in both the seasons. Harvesting was done at the stage of few opened flowers on the top of the panicle, early in the morning at three to four days interval with sharp knife.

Table1: Effect of Nitrogen levels and planting seasons on vegetative parameters of goldenrod during both main harvest and ratoon harvest.

N (Kg/ha)	Plant height(cm)					Plant spread					No. of suckers per plant				
	Summer Planting			Rainy Planting		Summer Planting			Rainy Planting		Summer Planting			Rainy Planting	
	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean
N_1-00	21.92	11.15	16.54	19.38	18.29	18.83	235.47	105.70	170.59	234.25	95.45	164.85	1.60	3.10	2.35	1.55	2.55	2.05
N_2-50	24.18	13.20	18.69	21.43	21.63	21.53	254.44	115.25	184.85	265.20	119.80	192.50	2.75	4.15	3.45	2.20	3.15	2.68
N_3-100	25.61	15.35	20.48	22.60	22.22	22.41	282.91	130.90	206.90	297.65	129.90	213.78	3.20	6.00	4.60	2.75	3.70	3.23
N_4-150	26.62	17.15	21.89	23.78	23.30	23.54	297.56	189.50	243.53	322.20	145.35	233.78	3.55	7.40	5.48	3.55	4.55	4.06
N_5-200	28.05	19.30	23.68	27.10	29.17	28.14	321.24	185.98	253.61	329.35	159.55	244.45	4.30	8.40	6.35	4.05	4.55	4.30
N_6-250	27.99	20.98	24.48	31.55	30.55	31.05	366.62	220.90	293.76	342.05	188.50	265.28	4.85	9.90	7.38	4.70	5.30	5.00
Mean	25.73	16.19	——	24.31	24.19	——	293.64	158.04	——	298.45	139.76	——	3.38	6.49	——	3.13	3.97	——
Harvest (Main and Ratoon)																		
CD (P=0.05)	1.333			NS			15.09			12.14			0.33			0.89		
Nitrogen																		
CD (P=0.05)	2.309			1.972			26.13			21.029			0.58			0.50		

RESULTS AND DISCUSSION

Effect of nitrogen on growth attributes

The different growth parameters of golden rod showed an increasing trend with increase in levels of nitrogen (Table 1). The highest level of nitrogen N_6 (250 kg/ha) recorded significantly maximum plant height (24.48 cm), plant spread (293.76 cm^2) and number of suckers per plant (7.38), during summer planting. Also during rainy planting, the highest level of nitrogen @ 250 kg N/ha resulted significantly in maximum plant height (31.05 cm), plant spread (265.28 cm^2) and number of suckers per plant (5.00). The beneficial effect of nitrogen on promoting growth was mainly due to enhanced synthesis and accumulation of proteins, amino acids and enzymes, which are responsible for cell division and cell elongation; hence growth of the plant was increased (Wadleigh, 20). An increase in plant height with increasing the levels of nitrogen also reported by Sodha and Dhaduk (15) in golden rod and Jubb and Johnson (6) in chrysanthemum, and Arulomozhiyan and Pappaiah (2) in marigold.

Maximum plant spread obtained under highest level of nitrogen (N_6) might be due to formation of new cells at localized region called meristem and increased in size and more of cells produced (Verma, 18). It is in close conformity with findings of Kumar *et al.* (7) in chrysanthemum, Singatkar *et al.* (12) in gaillardia and Singh and Sangama (14) in china aster.Significantly maximum number of suckers were recorded from the highest level of nitrogen (250 kg/ha). This might be due to luxuriant vegetative growth of plant, which translocated more food material and stored in stem part, which made it available for multiplication of suckers. Bose and Jana (3) in gerbera and Singatkar *et al.* (12) in gaillardia reported that nitrogenous compounds resulted luxurious growth of plant. The highest

level of nitrogen was also resulted in significantly maximum fresh weight and dry weight of plant. These might be due to conservation of maximum dry matter at highest level of nitrogen, which helped to increase in weight. Similar findings were also reported by Sodha and Dhaduk (15) in golden rod.

Table 2: Effect of Nitrogen levels and planting seasons on flowering parameters of goldenrod during both main harvest and ratoon harvest.

N (Kg/ha)	No. of days to early flowering						Length of panicle at harvest						No. of inflorescence branches per panicle					
	Summer Planting			Rainy Planting			Summer Planting			Rainy Planting			Summer Planting			Rainy Planting		
	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean
N_1-00	112.60	98.95	105.78	119.90	124.60	122.25	52.51	48.90	50.71	51.50	53.80	52.65	32.90	22.75	27.83	32.80	31.75	32.28
N_2-50	105.80	86.45	96.13	113.30	112.40	112.85	65.43	54.33	59.88	60.85	61.95	61.40	34.95	23.65	29.30	38.80	33.40	36.10
N_3-100	97.20	80.70	88.95	110.15	106.60	108.38	67.74	58.60	63.17	65.35	66.52	65.94	38.05	24.70	31.38	43.85	34.00	38.93
N_4-150	78.20	75.35	76.78	108.65	105.65	107.15	69.80	63.13	66.46	70.00	68.70	69.35	42.00	29.00	35.50	48.55	38.35	43.45
N_5-200	77.90	69.50	73.70	100.25	103.95	102.10	70.17	66.56	68.66	90.05	71.60	80.83	45.40	31.50	38.45	51.50	41.45	46.48
N_6-250	77.65	70.25	73.95	92.85	103.35	98.10	72.93	69.99	71.46	93.65	73.55	83.60	47.60	35.90	41.75	52.20	44.35	48.28
Mean	91.56	80.20	——	107.52	109.43	——	66.53	60.25	——	71.90	66.02	——	40.15	27.92	——	44.62	37.22	——
Harvest (Main and Ratoon)																		
CD (P=0.05)		3.32			NS			2.815			2.04			2.80			1.80	
Nitrogen																		
CD (P=0.05)		5.74			4.58			4.95			3.53			4.85			3.12	

Effect of nitrogen on flowering attributes and flower yield

Number of days taken for flowering was reduced to 73.95 days and 98.10 days during summer and rainy planting, respectively under highest level of nitrogen (Table 2). Reduction in days taken for flowering was due to high level of nitrogen as reported by Singatkar *et al.* (12) in gaillardia. The results are in consonance with Sodha and Dhaduk (15) in golden rod. Maximum length of panicle (71.46 cm and 83.60 cm), number of inflorescence branches per panicle (41.75 and 48.28), and length of rachis (42.78 cm and 46.36 cm) were observed under the 250 kg N/ha during summer and rainy planting, respectively. The improvement in all above parameters was caused by drawing of photosynthate to the flower as consequence of intensification of sink. Also it might be due to the improved vegetative growth of plant under the highest level of nitrogen, which resulted in more storage and subsequent utilization of carbohydrates and thus improved various flower characters.

Maximum numbers of panicles (3.33 and 3.68) per plant were resulted from the highest level of nitrogen @ 250 kg per hectare during summer and rainy planting, respectively. Similarly, maximum numbers of panicles per hectare (3.69 lakhs and 4.08 lakhs) were resulted from the highest nitrogen level (250 kg/ha) during summer and rainy planting, respectively. Yield of flower crop depends on the amount of vegetative growth (Singatkar *et al.,* 12), Vedavatti *e al.,* 17). These findings are in close conformity with those of Arora and Khanna (1), Arulmozhiya and Pappaiah (2) in marigold, Lodhi *et al.* (8) in chrysanthemum and Gangwar *et al.,* 4) in tuberose with respect to maximum cut flowers per plant with highest level of nitrogen. Similar results for yield of flowers per hectare was also reported by Jubb and Jhonson (6), Vijaykumar and Shanmugavelu (19), Kumar *et al.* (7) and Rao *et al.* (11) in chrysanthemum.

Effect of harvestings on growth attributes

There was higher plant height in main harvest (25.73 cm) during summer planting as compared to ratoon harvest (16.19 cm). Increase in plant height was recorded in main harvest during summer season and also the increased plant spread in main harvest during both summer and rainy planting was noted over ratoon harvest. This may be due to ratoon have a shallower root system than the plant crop as far as the absorbing parts is concerned. Also the old stubble roots were less efficient for absorbing nutrients (Hunsuingi, 5). Higher the number of suckers per plant (6.49 and 3.97) was obtained in ratoon harvest as compared to main harvest during both summer and rainy planting, respectively. The increase in number of suckers in ratoon harvest might be due to spreading habit of golden rod.

There was significant increase in dry weight of plant in main crop during both summer and rainy planting as compared to ratoon harvest. Van Dilewijn (16) has alluded to the rope system of ratoon stubble roots, which are less efficient in absorbing nutrients. Several investigations led to the convincing conclusion that the absorption of major and minor element at the critical stage is restricted during ratoon (Hunsungi, 5). Hence due to less absorption of water and nutrients in ratoon due to inactive roots and more absorption of nutrients in main harvest and there was more conservation of dry matter.

Effect of harvesting on flowering and flower yield attributes

Number of days taken for flowering was reduced in ratoon harvest (80.20 days) during summer planting. It might be due to reason that ratoon crop did not required establishment period and hence required less days to flower (Table 2). While number of inflorescence branches were maximum in main harvest (40.15 and 44.62) during summer and rainy planting, respectively. Also maximum length of panicle (66.53 cm and 71.90 cm) and length of rachis (44.65 cm and 43.16 cm) were during main harvest as compared to ratoon harvest during summer and rainy planting respectively. Other flowering parameters like number of inflorescence branches, length of panicle and length of rachis were found higher in main harvest than ratoon harvest. It might be due to active and developing roots in main harvest than ratoon harvest, which help to absorb more water and nutrients and translocate it to the sink. It was supported by Wilkins (21) that the ability of the root cells to absorb water was partially diminished with age and older parts of the roots become suberized.

According to yield parameters numbers of panicles per plant (2.74) and per hectare (3.05

Table 3: Effect of Nitrogen levels and planting seasons on yield parameters of goldenrod during both main harvest and ratoon harvest.

N (Kg/ha)	No. of panicles per plant					Length of rachis (cm)					Yield of panicles (Number/Hectare)				
	Summer Planting			Rainy Planting		Summer Planting			Rainy Planting		Summer Planting			Rainy Planting	
	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean	Main Harvest (S_1)	Ratoon Harvest (S_2)	Mean
N_1–00	1.25	1.35	1.30	1.85	1.20	1.53	38.24	25.80	32.02	33.85	33.20	33.53	1.39	1.50	1.44	2.06	1.33	1.69
N_2–50	1.45	1.70	1.58	2.30	1.40	1.85	42.05	27.75	34.90	38.10	34.90	36.50	1.61	1.89	1.75	2.56	1.56	2.06
N_3–100	1.65	2.40	2.03	3.20	1.60	2.40	44.49	29.65	37.07	42.75	36.08	39.41	1.83	2.67	2.25	3.56	1.78	2.67
N_4–150	2.20	3.10	2.65	4.05	1.75	2.90	45.01	31.20	38.11	46.00	37.45	41.73	2.44	3.44	2.94	4.50	1.94	3.22
N_5–200	2.20	3.65	2.93	4.75	2.15	3.45	47.05	32.60	39.82	46.70	38.70	42.70	2.44	4.06	3.25	5.28	2.39	3.83
N_6–250	2.40	4.25	3.33	5.00	2.35	3.68	51.06	34.50	42.78	51.55	41.18	46.36	2.67	4.72	3.69	5.56	2.61	4.08
Mean	1.86	2.74	——	3.53	1.74	——	44.65	30.25	——	43.16	36.92	——	2.06	3.05	——	3.92	1.94	——
Harvest (Main and Ratoon)																		
CD (P=0.05)		0.11			0.34			1.29			0.99			0.3823			0.3823	
Nitrogen																		
CD (P=0.05)		0.19			0.59			2.23			1.72			0.2159			0.6607	

lakhs) were found higher in ratoon harvest during summer planting (Table 3). But were found higher in main harvest with respect to number of panicles per plant (3.53) and per hectare (3.92 lakhs) during rainy planting. Yield parameters showed significant increase in ratoon harvest as compared to main harvest during summer planting, but it was higher in main harvest during rainy planting. The increase in number of panicles per hectare during ratoon harvest was correlated with increasing number of suckers during ratoon harvest. Ratoon harvest produced good vegetative growth in terms of number of suckers, which enabled them to synthesize good amount of photosynthates, which in turn resulted in increased flower yield. Same trend was noted in chrysanthemum by Singh and Dadlani (13) that when chrysanthemum crop was left in field the plants gave increased yield (number of flowers). But in rainy planting it was controversial to results in summer planting. In rainy planting increase in yield during main harvest might be due to active absorption of water and nutrient from young roots in main crop. It was supported by Marschner (9) that nutrient uptake by maize plants in the soil was associated with highest volumetric water content. When soil water content is low, mechanical impedance of soil increases and root elongation and growth is inhibited, which further limits nutrient supply to root surface by diffusion. Under many climatic conditions nutrient availability in the topsoil declines more or less steeply during growing season, because low soil water content becomes a limiting factor for nutrient declines to the root surface. Because of which, during summer in main harvest and during in rainy planting in ratoon harvest the yield might be reduced.

Conclusions

Main harvest had profound influence on vegetative growth parameters during summer and rainy planting. During summer planting ratoon harvest caused earliest flowering, highest number of panicles per plant and per hectare. While, under rainy planting the main harvest provided maximum number of panicles per plant and per hectare. The application of 250 kg N/ha had pronounced effect on vegetative growth parameters. Nitrogen at 250 kg N/ha produced highest longevity of inflorescence, yield of panicles per plant and per hectare during summer and rainy planting, respectively. Earliest flowering was due to 200 kg N/ha during summer and 250 kg N/ha during rainy planting. Thus, It could be inferred that the suckers of golden rod should be planted during rainy season and the crop should be fertilized with 250 kg N/ha.

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Citation : Barad A.V., Bhosale N. and Maheta P. (2015). Effect of nitrogen levels and cuttings (main and ratoon) on growth and flowering of golden rod (*Solidago canadensis* L.) during summer and rainy season planting. *HortFlora Res. Spectrum* **4**(3) : 230-235