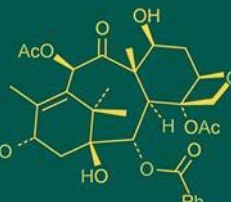
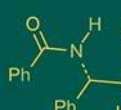
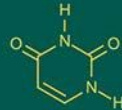
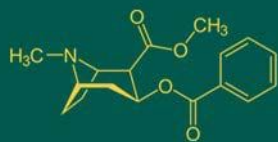


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Influence of gibberellic acid on primary metabolite accumulation in temperate [*Lycoris radiata* (L'Hér.) Herb.] grown in subtropical Terai region of West Bengal, India

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Abstract

This study aimed to evaluate the impact of various gibberellic acid concentrations on the accumulation of primary metabolites like carbohydrates, proteins and lipids under the Terai region of West Bengal in *Lycoris radiata*, a temperate bulbous ornamental, which is known for its unique flowering and complexity of growth. Results revealed the higher accumulation of carbohydrates in 250 ppm of GA₃ and 100 ppm of GA₃ in leaves and bulbs respectively. Protein content peaked at 125 ppm in leaves and 250 ppm in bulbs and lipid levels were highest at 300 ppm in leaves and 175 ppm in bulbs. Result helps to figure out how gibberellic acid modulate the metabolic pathways to influence source-sink dynamics and storage physiology of this temperate species in non-temperate region like Terai region of West Bengal.

Keywords: *Lycoris radiata*, gibberellic acid, protein and carbohydrate

Introduction

[*Lycoris radiata* (L'Hér.) Herb.], also called as Spider Lily (Chang *et al.*, 2009) [5] or Magic Lily or Hurricane Lily (Yang *et al.*, 2023) [17] is a temperate ornamental geophyte (Cai *et al.*, 2020) [4], belonging to the plant family Amaryllidaceae and native to Asian countries like Japan, China, Korea and Nepal (Cahlíkova *et al.*, 2020) [2]. It is widely naturalized in China (Liu *et al.*, 2016) [11] and introduced to Japan along with paddy cultivation as a companion crop (Hayashi *et al.*, 2005) [8]. The Netherlands, world leading producer of ornamental geophytes, also leads in the production of *Lycoris radiata*, where its cultivation is being practiced over 60ha (Cai *et al.*, 2019) [3]. Due to the peculiar growth pattern and attracting unique inflorescence (Cheng *et al.*, 2022) [6], it is gaining popularity in cut flower industry, as a potted plant and in landscape gardening. Since it is a temperate species, where it requires 13-22 °C for floral transition (Cai *et al.*, 2019) [3], it seems to be quite challenging to grow in subtropical regions like Terai plains of West Bengal. Among the different plant growth regulators, gibberellic acid (GA₃) has the potentiality to induce flowering in temperate ornamental geophytes, which is already proven in crops, like-Tulips, Liliums, Ornithogalum *etc.* (Gul *et al.*, 2020) [7]. Gibberellic acid interacts with DELLA protein, a negative regulator of floral transition and degrades it through ubiquitination pathway, thereby, allowing the phase shifting of plants from vegetative to reproductive (Wang and Deng, 2011) [15]. Gibberellic acid also known to increase the levels of primary metabolites, like-carbohydrates, proteins and lipids (Murcia *et al.*, 2017) [12], in geophytes and make them more metabolically active. An experiment was conducted in the Terai region of West Bengal to evaluate the effect of different concentrations of gibberellic acid on the accumulation of primary metabolites, like-carbohydrate, protein and lipid in both leaves as well as in bulbs of *Lycoris radiata*.

Materials and Methods

The experiment was conducted at the Instructional Farm of Department of Floriculture,

Medicinal and Aromatic Plants, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, CoochBehar, India in 2021-22 The experiment was laid in Completely Randomized Block Design, with three replications and thirteen treatments of gibberellic acid-*viz.*, T₁-0 ppm of GA₃, T₂-25 ppm, T₃-50 ppm, T₄-75 ppm of GA₃, T₅-100 ppm of GA₃, T₆-125 ppm of GA₃, T₇-150 ppm of GA₃, T₈-175 ppm of GA₃, T₉-200 ppm of GA₃, T₁₀-225 ppm of GA₃, T₁₁-250 ppm of GA₃, T₁₂-275 ppm of GA₃ and T₁₃-300 ppm of GA₃. The bulbs of *Lycoris radiata* were collected from ICAR-IARI Regional Station, Kalimpong and dipped in different concentrations of gibberellic acid for six hours before planting and also applied as foliar sprays at monthly interval. The estimation of carbohydrate content was performed by using Anthrone method (Yemm and Willis, 1954) ^[18], protein by Lowry's method (Waterborg and Matthews, 1994) ^[16] and Lipid content using Automatic Solven Extraction Apparatus (Schafer, 1998) ^[14] using petroleum ether as a solvent.

Results and Discussion

The effect of gibberellic acid on various biochemical

parameters of *Lycoris radiata* showed statistically significant results and it was found that the accumulation was higher in bulbs than the leaves. Among the different treatments of gibberellic acid, application of 250 ppm of GA₃ showed the maximum carbohydrate content (7.93 g/100 g) in leaves, while in bulbs, the higher accumulation (23.61 g/100 g) was observed with the application of 100 ppm of GA₃. The least amount of carbohydrate was estimated in control (0 ppm of GA₃) (2.93 g/100 g) in leaves and in 275 ppm of GA₃ (13.76 g/100 g) in bulbs. In the protein content, highest accumulation (0.212 g/100 g) in leaves was observed in 125 ppm of GA₃, whereas, the least content (0.154 g/100 g) was showed in control. In the bulbs, higher protein content (0.792 g/100 g) was observed in 250 ppm of GA₃ and least content (0.337 g/100 g) in 75 ppm of GA₃. Regarding the lipid content, higher concentration (300 ppm of GA₃) resulted more amount of lipid accumulation in leaves (0.373 g/100 g), while in the bulbs, 175 ppm of GA₃ showed the highest lipid content (5.02 g/100 g), on the other hand, the lower amount of lipid content resulted in control plants in both the leaves (0.177 g/100 g) as well as in bulbs (1.08 g/100 g).

Table 1: Effect of GA₃ on accumulation of primary metabolites in leaves and bulbs of *Lycoris radiata*

Treatments	Carbohydrate content (g/100 g)		Protein content (g/100 g)		Lipid content (g/100 g)	
	Leaves	Bulbs	Leaves	Bulbs	Leaves	Bulbs
T ₁	2.93 ^d	17.03 ^{cd}	0.154 ^f	0.531 ^b	0.177 ^{ef}	1.08 ^f
T ₂	6.80 ^{abc}	20.86 ^{abc}	0.200 ^{abc}	0.554 ^b	0.253 ^d	1.38 ^f
T ₃	7.54 ^a	18.27 ^{bc}	0.189 ^{bcd}	0.586 ^b	0.263 ^d	1.19 ^f
T ₄	3.59 ^d	23.25 ^a	0.167 ^{def}	0.377 ^c	0.140 ^g	1.40 ^f
T ₅	4.61 ^{cd}	23.61 ^a	0.202 ^{ab}	0.494 ^{bc}	0.207 ^e	4.09 ^b
T ₆	3.53 ^d	13.90 ^d	0.212 ^a	0.584 ^b	0.320 ^c	4.00 ^b
T ₇	4.14 ^d	18.57 ^{bc}	0.202 ^{ab}	0.511 ^b	0.187 ^e	4.27 ^b
T ₈	5.03 ^{bcd}	21.17 ^{abc}	0.165 ^{ef}	0.522 ^b	0.253 ^d	5.02 ^a
T ₉	6.66 ^{abc}	19.72 ^{abc}	0.181 ^{bcd}	0.521 ^b	0.320 ^c	2.18 ^{de}
T ₁₀	7.22 ^{ab}	21.79 ^{ab}	0.174 ^{def}	0.560 ^b	0.150 ^{fg}	2.44 ^{cd}
T ₁₁	7.93 ^a	18.74 ^{bc}	0.180 ^{cde}	0.792 ^a	0.363 ^{ab}	2.44 ^{cd}
T ₁₂	7.77 ^a	13.76 ^d	0.182 ^{bcd}	0.596 ^b	0.330 ^{bc}	2.62 ^c
T ₁₃	6.85 ^{abc}	22.05 ^{ab}	0.184 ^{bcd}	0.591 ^b	0.373 ^a	1.95 ^c
SE(m)±	0.721	1.356	0.007	0.041	0.012	0.136
CD at 5%	2.105	3.958	0.020	0.120	0.035	0.397

Differences in accumulation of primary metabolites have been observed with the exogenous application of gibberellic acid in *Lycoris radiata*. Among the various concentrations, 250 ppm of GA₃ in leaves and 100 ppm of GA₃ in bulbs showed the maximum accumulation of carbohydrate content and these specific concentrations might have increased the photosynthetic activity leading to higher accumulation of carbohydrate in leaves (Yuan and Xu, 2001) ^[19]. Interestingly, the lower concentration, like-100 ppm showed more accumulation in bulbs, possibly due to high phloem loading and translocation of photoassimilates from source (leaves) to sink (bulbs) (Murcia *et al.*, 2016) ^[13]. GA₃ has the ability to influence nitrogen metabolism and protein biosynthesis by regulating key enzymes like nitrate reductase and glutamine synthetase (Higgins *et al.*, 1982). Intermediate concentration like 125 ppm of GA₃ might

have elevated the amino acid synthesis and thereby increasing the protein content in leaves. However, higher concentration, like-250 ppm of GA₃ might have delayed the accumulation in leaves, but increased the deposits of nitrogenous compounds in storage tissues. Lipids are the energy-dense biomolecules and are essential for membrane synthesis (Byrnes *et al.*, 2022) ^[1] that serves as a long-term energy source in most of the geophytes. The elevated lipid content at highest concentration (300 ppm of GA₃) in leaves, might be due to upregulation of acetyl-coA carboxylase enzyme, which involved in fatty acid biosynthesis (Kresnawaty *et al.*, 2023) ^[10]. Whereas, moderate concentration (175 ppm of GA₃) showed more accumulation of GA₃ in bulbs and this suggests that increased concentrations prioritize vegetative growth over the storage accumulation.

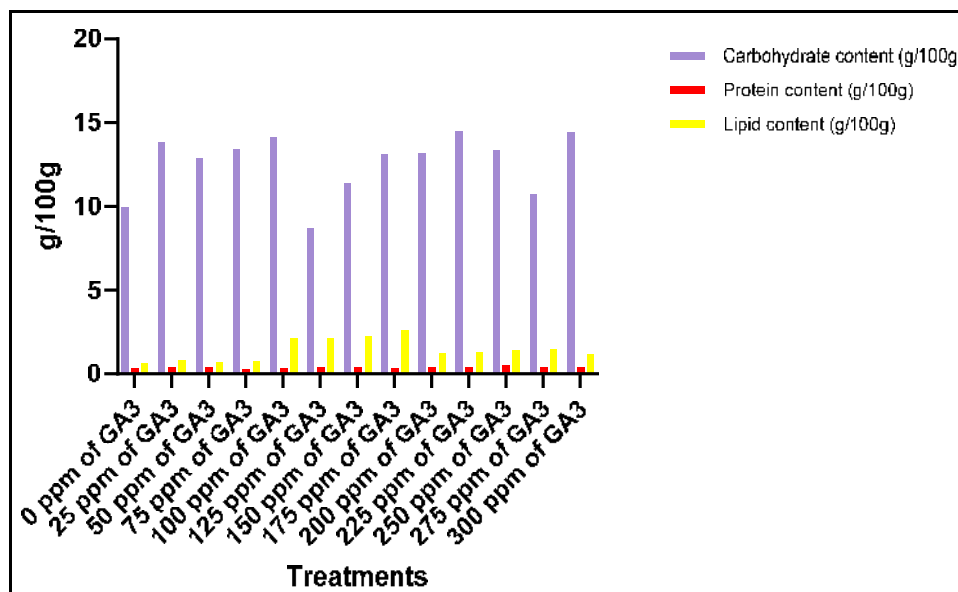


Fig 1: Accumulation of primary metabolites across the treatments

Conclusion

The differential accumulation of primary metabolites across the leaf and bulb tissues of *Lycoris radiata*, shows the concentration specific response of exogenous application of gibberellic acid. 250 ppm of GA₃ enhanced the carbohydrate and protein content in leaves and bulbs respectively, while lipid accumulation was more in 300 ppm in leaves and 175 ppm in bulbs. These findings revealed the role of GA₃ in partitioning of primary metabolites to finetune the vegetative growth and storage functions and paved a way to understand the physiological behaviour of this temperate species to various concentrations of gibberellic acid under the Terai region of West Bengal.

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