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Effect of integrated nutrient management on growth, flowering and yield of spider lily (*Hymenocallis littoralis* L.) Cv. Local

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Abstract
A field experiment was carried out to study the effect of integrated nutrient management on growth, flowering and yield of spider lily (*Hymenocallis littoralis* L.) cv. Local at Instructional farm, Jambuvadi, Department of Floriculture and Landscape Architecture, College of Horticulture, Junagadh Agricultural University, Junagadh (Gujarat) during the years 2021-22 and 2022-23. The experiment was laid out in RBD with 10 treatment combinations replicated thrice to assess the effect of organic, inorganic, biofertilizers and biostimulants. Results reveal that the application of 80% RDF + *Azotobacter* + PSB + KSB (each at 2 l/ha) + Castor cake 0.5 t/ha (T_5) was recorded maximum plant height, number of leaves per plant, width of leaves, length of leaves and leaf area during both the years as well as in pooled. Among the flowering and yield parameters, application of 80% RDF + Novel 1.0% + Seaweed 2% + Panchgavya 3% (T_8) recorded minimum number of days to first stalk emergence, minimum days taken for flower emergence and earlier floret opening. Significantly highest number of flower stalks per plant, maximum perianth diameter, flower stalk length, number of flowers per stalk, longer duration of flowering in stalk, maximum number of flowers per plant and higher yield were recorded in the application of 80% RDF + *Azotobacter* + PSB + KSB (each at 2 l/ha) + Castor cake 0.5 t/ha (T_5).

Keywords: Spider lily, *Azotobacter*, PSB, KSB, novel, seaweed, panchgavya

Introduction
Spider lily (*Hymenocallis littoralis* L.) is native to South America and belongs to the family Amaryllidaceae. It is a bulbous herbaceous perennial ornamental plant which is 60-70 cm tall. The diameter of the bulb is 7 to 10 cm. With age, the bulb develops a neck that reaches 4-5 cm in diameter. It has long, broad and strap-shaped light green leaves. It is relatively hardy and free from infestation of pests, diseases and other physiological disorders. The flowers are large, white, vanilla-scented and sessile. The tepals are attached to the stamina cup. Each flower's tube is 14 to 17 cm (5 to 7 inches) long. An umbel produced 9-10 flowers on its head. 2-3 flower umbels are produced at a time on a single well developed plant. They have six long, delicate, narrow segments united at the base by a thin membranous cup or corona.

It is used as a loose flower as offered to the God, garland making, veni, gajra, bridal car decoration and pergolas stages in various social functions. Flowers are in great demand during marriages and social ceremonies. Therefore, it has a year-round market and has gained common importance. There is no specific cultivar but generally two types of spider lily, one is narrow and dark green leaved which flowers only in the rainy season and another type is broad and medium green leaved which produces flowers around the year. Generally, unopened flower buds are harvested from the stalk during morning or evening hours every day. Bundles of 50 buds are prepared by tying them with fibers or rubber bands and are kept in wet jute bags for transportation.

Agriculture, which largely depends on continuous use of chemical fertilizer is not only a burden for the farmer's or growers but is also responsible for the depletion of soil fertility which often affects productivity. Hence, efficient and judicious use of chemical fertilizers along with organic manure, biofertilizers, biostimulants are imperative not only for obtaining more yields per unit area on a sustainable basis but also to conserve the energy and to avoid

the problem of environmental quality.

Biofertilizers more appropriately called 'microbial inoculants' are the preparations containing live or latent cells of efficient strains of microorganisms. These may be biological nitrogen fixers, P-solubilising, mineralization of nitrogen and transformation of several elements like sulphur and iron into available forms. These biofertilizers benefit agricultural production by supplying nutrients. *Azotobacter* is an aerobic free living, heterotrophic N-fixing bacterium (fixes about 10-25 kg N/ha/season). Nitrogen fertilizer demand can be reduced up to 50 percent, through the application of *Azotobacter* inoculation with FYM. These bacteria are also known to produce plant growth substances which have beneficial effects on crop growth. Phosphate solubilizing bacteria otherwise called phosphobacteria, plays a major role in the solubalization and uptake of native and applied soil phosphorus requirements of plant. Several soil bacteria and fungi notably species of *Bacillus, Psudomonas, Asperigillus and Penicillium* secrete organic acids such as formic, acetic, propionic, lactic, glycolic, fumaric and succinic acids, which contribute about 10-15 kg P_2O_5/ha/season (Reddy, 2008) [20]. Potassium-solubilizing bacteria (KSB) can be used as a promising approach to increase K availability in soils, thus playing an important role in crop establishment under K-limited soils, owing to the naturally available source of potassium in soil and the high price of synthetic potassium fertilizers.

Novel liquid organic fertilizer is extracted from banana pseudostem was evaluated as liquid fertilizer and has found to contain a fair amount of nutrient in it. This contains a high amount of essential plant nutrients, which are being lost. By utilizing such waste plant material, many useful by-products like fiber, paper, fabrics, organic manure, etc. can be prepared. While separating fibers from the banana pseudostem, the liquid available is known as sap which contains a good amount of essential macro and micronutrients as well as growth boosters. Salukhe (2010) [21] analyzed the samples of banana pseudostem for its elemental composition and found that banana pseudostem contained macro elements in the range of 1.00 to 1.12% N, 0.50 to 0.71% P, 2.39 to 2.62% K and micro nutrients in the range of 259 to 323.2 mg/kg Fe, 47.3 to 241.3 mg/kg Mn, 10.1 to 107.4 mg/kg Zn and 13.4 to 83.6 mg/kg Cu.

Seaweed extract is the macroscopic marine algae found at the bottom of relatively shallow coastal waters. Seaweed extract contains organic matter (55-65%), nitrogen (0.5-0.8%), potassium (17-20%), calcium (0.6-1.8%), magnesium (0.42%), sodium (1.5-2.2%), alginic acid (10-12%), iron (0.15-0.30%), copper (0.42%) and iodine (350 ppm). It also contains vitamins, amino acids and plant growth regulators like auxins, cytokinins and gibberellins that exhibit growth stimulating activities (Hong *et al.* 2007) [9].

Materials and Methods

The present inspection titled “Effect of integrated nutrient management on growth, yield and quality of spider lily (*Hymenocallis littoralis* L.) cv. Local” was conducted at Instructional Farm, Department of Floriculture and Landscape Architecture, College of Horticulture, Junagadh Agricultural University, Junagadh during the years 2021-22 and 2022-23. The experiment was laid out in randomized block design with three replications and consisting of ten treatments *viz*., 100% RDF (400:200:100 NPK kg/ha) (T_1), 80% RDF + FYM (8 t/ha) (T_2), 60% RDF + FYM (16 t/ha) (T_3), 100% RDF + *Azotobacter* + PSB + KSB (each at 1 l/ha) (T_4), 80% RDF + *Azotobacter* + PSB + KSB (each at 2 l/ha) + Castor cake 0.5 t/ha (T_5), 60% RDF + *Azotobacter* + PSB + KSB (each at 3 l/ha) + Castor cake 1 t/ha (T_6), 100% RDF + Novel 0.5% + Seaweed 1% + Panchgavya 2% (T_7), 80% RDF + Novel 1.0% + Seaweed 2% + Panchgavya 3% (T_8), 60% RDF + Novel 1.5% + Seaweed 3% + Panchgavya 4% (T_9) and Control (Absolute) (T_{10}).

The plants were two years old and the deleafing was done for ratooning in the month of November for experiment. Biostimulants like novel, seaweed and panchgavya applied by spraying with 15 and 45 days after deleafing. Biofertilizers like *Azotobacter*, PSB and KSB applied by drenching with 15 and 45 days after deleafing.

Different manures like FYM and castor cake were applied as per the treatment to respective plots. The RDF of chemical fertilizers for spider lily is 400:200:100 kg NPK per hectare. Fertilizers like NPK in suitable sources were applied as per the treatment. Nitrogen was applied in the form of Urea in three split application. Phosphorus and Potash were applied in the form of Single Super Phosphate and Muriate of Potash, respectively. Promptly the experimental field was irrigated to ensure efficient uptake and avoid nutrient loss.

Results

Growth parameters

The statistical analysis of data (Table-1) revealed that the growth parameters were influenced significantly due to the various combinations of integrated nutrient management during both years of the experiment. The perusal of the data reveals that the maximum plant height (80.33, 81.27 and 80.80 cm), number of leaves per plant (80.18, 81.85 and 81.01), width of leaves (7.32, 7.66 and 7.49 cm), length of leaves (76.33, 77.20 and 76.77 cm) and leaf area (247.32, 248.67 and 247.99 cm^2) were recorded with an application of 80% RDF + *Azotobacter* + PSB + KSB (each at 2 l/ha) + Castor cake 0.5 t/ha (T_5) during both the years as well as in pooled.

Flowering and yield parameters

Data pertaining to flowering parameters *viz*., days to first stalk emergence, flower emergence and floret opening were influenced by different nutritional treatments (Table 2).

Minimum number of days to first stalk emergence (17.13, 17.42 and 17.28 days), days taken for flower emergence (22.92, 23.55 and 23.24 days) and early floret opening (24.09, 24.67 and 24.38 days) were observed with an application of 80% RDF + Novel 1.0% + Seaweed 2% + Panchgavya 3% (T_8) during both the years as well as in pooled.

Significantly highest number of flower stalks per plant (11.47, 11.37 and 11.42), maximum perianth diameter (24.00, 24.71 and 24.35 cm), flower stalk length (75.00, 75.53 and 75.27 cm), duration of flowering in the stalk (12.00, 12.23 and 12.12 days), maximum number of flowers per stalk (23.20, 23.93 and 23.57), per plant (183.47, 184.12 and 183.79) and per hectare (135901.23, 136385.19 and 136143.21 bundles/ha) were recorded in the application of 80% RDF + *Azotobacter* + PSB + KSB (each at 2 l/ha) + Castor cake 0.5 t/ha (T_5) during both the years as well as in pooled.

Discussion

Growth parameters

This might be due to the beneficial effect of more availability of nitrogen and other nutrient elements. Nitrogen is a main constituent of chlorophyll, protein and amino acids and plays an important role in cell division, protein synthesis and metabolite transport that help to build the plant tissues. The increased growth of plant may also be attributed to the favorable effects of phytohormon like auxin and gibberellins produced by *Azotobacter*, PSB and KSB which might have improved the root system of the plant, which in turn might have helped in better nutrient uptake and this might have enhanced the plant growth (Gupta *et al.*, 2004) [7]. These results confirmed well with Hadwani *et al.* (2013) [8] in tuberose; Kant *et al.* (2021) [11] and Paikra *et al.* (2022) [13] in marigold; Patokar *et al.* (2022) [17], Choudhary and Sailendri (2023) [4] and Swaroop *et al.* (2023) [26] in gladiolus; Arasu *et al.* (2023) [2] in tuberose and Gawade *et al.* (2019) [6] and Dobariya *et al.* (2023) [5] in chrysanthemum.

Flowering and yield parameters

This might be due to the ability of seaweed to benefit the plant to receive directly naturally balanced nutrients (major and minor) and plant growth substances because of its unique composition leading to early bud break. Hence, early production of florigen and other flower inducing substances in seaweed treated plants resulted in early flowering. These results align with the findings of Sathyanarayana *et al.* (2018) [22] in gladiolus and Kumar *et al.* (2022) [12] and Veeresh *et al.* (2024) [27] in China aster.

Yield might be attributed to the availability of three major nutrients that may lead to enhanced growth as a result of increased cell division, cell enlargement and maximum conservation of photosynthesis to plant growth. Similar findings were reported by Suhashi *et al.*, 2021 [25] in golden rod. Yield was positively affected by organic manure because chemically, organic manures add an organic compound to the soil while going under decomposing. Biologically, organic manures provide food for the beneficial soil microorganisms which increase the availability of nutrients. The experimental soil was low in available N_2 and medium in available P_2O_5 and therefore the addition of organic manures might have helped in the supply of these nutrients and in creating a congenial atmosphere in the root rhizosphere in overall improvement of spider lily yield. Whereas, biofertilizer may be due to *Azotobacter*, PSB and KSB an associative living diazotroph have been certified as potential microbial inoculants for increasing the productivity of various non-legume crops. These organisms besides fixation synthesize and secrete many amino acids, which influence flowering and yield (Patel *et al.* 2017) [16]. Similarly, Akhter *et al.* (2023) [1] and Chirukuri *et al.* (2023) [3] in marigold; Pithiya *et al.* (2016) [18], Sri *et al.* (2022) [24] and Pandey *et al.* (2023) [14] in China aster; Pansuriya *et al.* (2018) [15] and Pukhram *et al.* (2023) [19] in gladiolus; Shivkumar *et al.* (2020) [23] in dahlia and Indhumathi *et al.* (2023) [10] in gaillardia.

Table 1: Effect of integrated nutrient management on growth parameters of spider lily cv. Local

S. N.	Treatments	Plant height (cm)			No. of leaves per plant			Width of leaves (cm)			Length of leaves (cm)			Leaf area (cm^2)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T_1	100% RDF	67.33	67.67	67.50	61.53	61.67	61.60	5.80	5.73	5.77	62.26	63.53	62.90	213.70	215.33	214.52
T_2	80% RDF + FYM (8 t/ha)	69.07	68.73	68.90	62.79	62.92	62.85	5.87	5.97	5.92	63.67	64.22	63.94	216.81	218.14	217.47
T_3	60% RDF + FYM (16 t/ha)	70.33	70.02	70.18	64.00	64.52	64.26	5.93	6.17	6.05	64.93	65.37	65.15	220.10	220.85	220.47
T_4	100% RDF + *Azo.* + PSB + KSB (each at 1 l/ha)	71.17	70.74	70.96	66.89	67.00	66.94	6.27	6.30	6.28	67.25	67.92	67.59	223.21	226.30	224.76
T_5	80% RDF + *Azo.* + PSB + KSB (each at 2 l/ha) + CC 0.5 t/ha	80.33	81.27	80.80	80.18	81.85	81.01	7.32	7.66	7.49	76.33	77.20	76.77	247.32	248.67	247.99
T_6	60% RDF + *Azo.* + PSB + KSB (each at 3 l/ha) + CC 1 t/ha	75.33	75.83	75.58	76.08	76.42	76.25	7.06	7.10	7.08	71.66	72.33	72.00	237.36	238.33	237.85
T_7	100% RDF + Novel 0.5% + Seaweed 1% + Panchgavya 2%	71.67	72.90	72.28	70.87	70.63	70.75	6.23	6.58	6.41	68.34	69.05	68.70	227.28	228.03	227.65
T_8	80% RDF + Novel 1.0% + Seaweed 2% + Panchgavya 3%	75.19	76.00	75.59	74.73	75.13	74.93	7.10	7.13	7.12	72.50	72.83	72.67	232.39	233.63	233.01
T_9	60% RDF + Novel 1.5% + Seaweed 3% + Panchgavya 4%	71.81	71.81	71.81	69.18	69.54	69.36	6.40	6.49	6.45	68.22	68.85	68.53	229.28	231.28	230.28
T_{10}	Control (Absolute)	63.33	63.00	63.17	59.51	58.90	59.21	5.33	5.41	5.37	60.52	59.97	60.24	204.81	208.14	206.47
	S.Em.±	2.696	2.608	1.876	2.862	3.158	2.137	0.250	0.248	0.172	2.685	2.886	1.964	7.493	7.411	5.270
	C.D. at 5%	8.01	7.75	5.38	8.50	9.35	6.11	0.74	0.71	0.49	7.95	8.54	5.64	22.26	22.02	15.13
	C.V.%	6.53	6.20	6.41	7.23	7.79	7.58	6.83	6.26	6.60	6.86	7.21	7.09	5.76	5.61	5.71

FYM - Farm yard manure	CC - Castor cake
Azo. – Azotobacter	Novel - Banana pseudostem sap
PSB - Phosphate solubilizing bacterium KSB - Potash solubilizing bacteria	RDF- Recommended dose of fertilizers (400:200:100 NPK Kg/ha)

Table 2: Effect of integrated nutrient management on flowering parameters of spider lily cv. Local

S. N.	Treatments	Days to emergence of flower stalk (days)			Days to first flower emergence (days)			Days to opening at first floret (days)			Number of flower stalk per plant			Diameter of perianth (cm)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T_1	100% RDF	25.28	24.90	25.09	30.80	31.47	31.13	32.00	32.33	32.17	6.01	6.04	6.02	20.07	20.47	20.27
T_2	80% RDF + FYM (8 t/ha)	24.87	25.10	24.98	30.22	30.83	30.53	30.58	31.75	31.17	6.55	6.52	6.53	20.95	21.14	21.05
T_3	60% RDF + FYM (16 t/ha)	23.00	23.52	23.26	29.23	29.56	29.40	30.20	30.97	30.58	8.05	7.99	8.02	20.87	21.20	21.03
T_4	100% RDF + *Azo.* + PSB + KSB (each at 1 l/ha)	22.00	22.41	22.21	27.97	28.51	28.24	28.67	29.85	29.26	7.80	7.78	7.79	21.18	21.73	21.45
T_5	80% RDF + *Azo.* + PSB + KSB (each at 2 l/ha) + CC 0.5 t/ha	20.67	20.93	20.80	26.77	26.75	26.76	27.93	28.03	27.98	11.47	11.37	11.42	24.00	24.71	24.35
T_6	60% RDF + *Azo.* + PSB + KSB (each at 3 l/ha) + CC 1 t/ha	18.17	18.33	18.25	24.26	24.49	24.38	25.29	25.63	25.46	9.54	9.51	9.52	23.63	24.11	23.87
T_7	100% RDF + Novel 0.5% + Seaweed 1% + Panchgavya 2%	21.91	22.41	22.16	28.07	28.48	28.27	29.17	29.68	29.42	9.25	9.17	9.21	22.92	23.43	23.18
T_8	80% RDF + Novel 1.0% + Seaweed 2% + Panchgavya 3%	17.13	17.42	17.28	22.92	23.55	23.24	24.09	24.67	24.38	10.98	10.87	10.92	23.67	24.51	24.09
T_9	60% RDF + Novel 1.5% + Seaweed 3% + Panchgavya 4%	21.63	21.75	21.69	27.63	27.97	27.80	28.75	29.27	29.01	8.44	8.36	8.40	21.67	22.00	21.83
T_{10}	Control (Absolute)	26.89	27.56	27.22	32.57	33.24	32.90	33.70	34.47	34.08	5.48	5.44	5.46	18.00	18.52	18.26
	S.Em.±	1.182	1.305	0.880	1.182	1.247	0.859	1.335	1.225	0.906	0.402	0.383	0.277	0.909	0.986	0.671
	C.D. at 5%	3.51	3.87	2.52	3.51	3.70	2.47	3.97	3.64	2.60	1.19	1.14	0.80	2.70	2.93	1.92
	C.V.%	9.24	10.33	9.67	7.30	7.72	7.44	7.97	7.29	7.56	8.32	7.67	8.16	7.26	7.54	7.49

FYM - Farm yard manure	CC - Castor cake
Azo. – Azotobacter	Novel - Banana pseudostem sap
PSB - Phosphate solubilizing bacterium KSB - Potash solubilizing bacteria	RDF- Recommended dose of fertilizers (400:200:100 NPK Kg/ha)

Table 3: Effect of integrated nutrient management on flowering and yield parameters of spider lily cv. Local

S. N.	Treatments	Length of flower stalk (cm)			Number of flowers per stalk			Duration of flowering in stalk (days)			Number of flowers per plant			Yield of flowers bundles per ha		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T_1	100% RDF	63.33	63.26	63.30	17.00	17.27	17.13	9.82	9.75	9.78	96.13	97.80	96.97	71209.88	72444.44	71827.16
T_2	80% RDF + FYM (8 t/ha)	67.27	67.33	67.30	16.67	16.99	16.83	10.00	10.05	10.03	104.84	105.54	105.19	77659.26	78180.25	77919.75
T_3	60% RDF + FYM (16 t/ha)	69.00	69.67	69.33	17.00	17.13	17.07	10.12	10.19	10.16	128.83	129.50	129.17	95432.10	95925.93	95679.01
T_4	100% RDF + *Azo.* + PSB + KSB (each at 1 l/ha)	68.67	69.51	69.09	17.53	18.24	17.89	10.39	10.54	10.47	124.77	125.97	125.37	92419.75	93308.64	92864.20
T_5	80% RDF + *Azo.* + PSB + KSB (each at 2 l/ha) + CC 0.5 t/ha	75.00	75.53	75.27	23.20	23.93	23.57	12.00	12.23	12.12	183.47	184.12	183.79	135901.23	136385.19	136143.21
T_6	60% RDF + *Azo.* + PSB + KSB (each at 3 l/ha) + CC 1 t/ha	70.33	70.74	70.54	20.67	20.93	20.80	10.67	10.78	10.73	152.67	154.00	153.33	113086.42	114074.07	113580.25
T_7	100% RDF + Novel 0.5% + Seaweed 1% + Panchgavya 2%	70.67	71.19	70.93	19.00	19.30	19.15	10.28	10.38	10.33	148.00	148.53	148.27	109629.63	110024.69	109827.16
T_8	80% RDF + Novel 1.0% + Seaweed 2% + Panchgavya 3%	72.52	72.99	72.75	21.52	21.86	21.69	11.38	11.39	11.38	175.63	176.04	175.84	130096.30	130400.00	130248.15
T_9	60% RDF + Novel 1.5% + Seaweed 3% + Panchgavya 4%	71.81	72.02	71.92	18.00	18.67	18.33	10.53	10.60	10.57	135.00	135.50	135.25	100000	100370.37	100185.19
T_{10}	Control (Absolute)	62.00	61.61	61.81	16.00	16.53	16.27	8.64	8.69	8.67	87.71	88.13	87.92	64970.37	65283.95	65127.16
	S.Em.±	2.332	2.215	1.608	0.938	1.067	0.710	0.364	0.367	0.259	6.423	6.207	4.466	4758.019	4598.036	3308.348
	C.D. at 5%	6.93	6.58	4.61	2.79	3.17	2.04	1.08	1.09	0.74	19.09	18.44	12.82	14137.32	13661.97	9496.85
	C.V.%	5.85	5.48	5.69	8.71	9.50	9.22	6.08	5.97	6.08	8.32	7.67	8.16	8.32	7.67	8.16

FYM - Farm yard manure	CC - Castor cake
Azo. – Azotobacter	Novel - Banana pseudostem sap
PSB - Phosphate solubilizing bacterium KSB - Potash solubilizing bacteria	RDF- Recommended dose of fertilizers (400:200:100 NPK Kg/ha)

Conclusion

From the present studies, it is concluded that the best integrated nutrient management schedule for growth and flower production in spider lily with an application of 80% RDF + *Azotobacter* + PSB + KSB (each at 2 l/ha) + Castor cake 0.5 t/ha (T_5) as it resulted in improvement for most of the parameter of economic importance. However, with respect to a minimum number of days taken for stalk emergence, flower emergence and opening first floret was

recorded in treatment (T_8) 80% RDF + Novel 1.0% + Seaweed 2% + Panchgavya 3%.

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