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Influence of integrated nutrient management and pinching on yield and quality of annual chrysanthemum (*Chrysanthemum coronarium* L.)

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Abstract
The present investigation was carried out at Instructional Farm, Jambuvadi, Department of Floriculture & Landscape Architecture, College of Horticulture, Junagadh Agricultural University, Junagadh (Gujarat) from October-2022 to March-2023. In the case of integrated nutrient management, the result revealed that the application of 60% RDF + Vermicompost (3 t/ha) + *Azotobacter* (5 ml/l) + PSB (5 ml/l) + KSB (5 ml/l) + Seaweed extract (1%) (I_5) was recorded maximum for all the flowering, yield and quality parameters. In respect to pinching, minimum days to first flower bud appearance (25.58), maximum flower diameter (6.84 cm), fresh weight of flower (5.88 g) and fresh weight of hundred flowers (499.53 g) was observed in no pinching (P_1). While, *in-situ* longevity of flower (11.64 days) was observed in single pinching (P_2). Whereas, the maximum number of flowers per plant (111.58), flowering span (53.66 days), flower yield per plant (351.12 g), flower yield per plot (3.16 kg), lower yield per hectare (25.97 t), vase life of flower (6.20 days) and shelf life of flower (4.22 days) were observed in double pinching (P_3). In case of interaction, the highest number of flowers per plant (117.36), flower yield per plant (444.90 g), flower yield per plot (4.08 kg) and flower yield per hectare (33.61 t) were observed in a treatment combination of 60% RDF + Vermicompost (3 t/ha) + *Azotobacter* (5 ml/l) + PSB (5 ml/l) + KSB (5 ml/l) + Seaweed extract (1%) with double pinching (I_5P_3). From the present study, it can be inferred that an application of 60% RDF + Vermicompost (3 t/ha) + *Azotobacter* (5 ml/l) + PSB (5 ml/l) + KSB (5 ml/l) + Seaweed extract (1%) with double pinching (I_5P_3) increased flower yield in annual chrysanthemum.

Keywords: Integrated nutrient management, pinching, yield, quality

Introduction

Chrysanthemum, a member of the Asteraceae family, encompasses approximately 160 species. The most widespread among them is *Chrysanthemum morifolium*, a modern perennial that predominantly blooms in autumn. This variety is commonly propagated through suckers. In contrast, annual chrysanthemums, which are propagated through seeds, consist of three distinct species: *Chrysanthemum segtum* (Corn marigold), *Chrysanthemum carinatum* (tricoloured chrysanthemum), and *Chrysanthemum coronarium* (Crown daisy or Garland chrysanthemum). The crown daisy or Garland chrysanthemum (*Chrysanthemum coronarium*) is indigenous to Southern Europe and possesses a chromosome number of 2n=4x=34. It is an annual plant with branching characteristics, finely cut foliage, and can reach heights of up to a meter. The flower size typically ranges from 2.5 to 4 cm, displaying shades of yellow and white, often with a cream zone at the center (Vishnu, 1967) [18]. This variety is known for its rapid growth and winter blooming capabilities. Crown daisy or Garland chrysanthemum serves various purposes, such as loose flowers, cut flowers, potted plants, decorative elements, and borders in gardens. Its leaves are commonly steamed or boiled and used as greens, particularly in Chinese cuisine. Additionally, yellow and white chrysanthemum flowers are boiled to create a sweet beverage referred to as 'chrysanthemum tea,' popular in certain parts of Asia. An economically significant aspect of the Crown daisy or Garland chrysanthemum lies in its natural insecticidal properties. The flowers are pulverized to extract an active component known as pyrethrin, which is utilized in insecticidal preparations. Pyrethrin exhibits potent insecticidal properties and serves as an effective means of pest control.

Integrated nutrient management practices play a crucial role in reducing the reliance on inorganic fertilizers, mitigating soil pollution caused by excessive fertilizer use, and safeguarding natural resources. The major elements necessary for the growth, flower yield, and quality of annual chrysanthemums are Nitrogen, Phosphorus, and Potash. To meet these requirements, vermicompost serves as a nutrient-rich mixture comprising both major and minor plant nutrients. On average, vermicompost contains approximately 3% nitrogen, 1% phosphorus, and 1.5% potassium. Furthermore, vermicompost provides an ideal foundation for the establishment of beneficial free-living and symbiotic microbes. To enhance soil fertility, various biofertilizers are employed, including *Azotobacter*, PSB (phosphate-solubilizing bacteria), and KSB (potassium-solubilizing bacteria). These microbial inoculants consist of select microorganisms that aid in improving soil fertility by facilitating nutrient availability to plants. Additionally, biostimulants such as seaweed extract and humic acid offer valuable products that can reduce the dependency on fertilizers while simultaneously promoting plant growth and enhancing resistance to water and abiotic stresses. By utilizing these innovative practices, the overall sustainability and productivity of chrysanthemum cultivation can be enhanced while minimizing the environmental impact associated with excessive fertilizer usage.

Pinching is a vital horticultural technique that involves the removal of the terminal growth portion of a stem to stimulate branching and enhance bloom production. Apical dominance, a phenomenon where the main stem grows vertically, can be overcome through pinching. By removing the growth tips, the plant redirects its resources, known as assimilates, towards lateral buds, promoting the development of branching. This process of pinching has a direct impact on regulating flowering and optimizing the production of high-quality flowers.

Material and Methods

This experiment was conducted during 2022-23 located at Instructional Farm, Jambuvadi, Department of Floriculture & Landscape Architecture, College of Horticulture, Junagadh Agricultural University, Junagadh (21.5^0 N, 70.5^0 E; 60 m). The field experiment used a factorial Randomized Block Design with two factors, Factor A had six integrated nutrient management treatments *i.e.* 100% RDF (150:100:100 kg NPK/ha + 10 t/ha FYM) (I_1), 80% RDF + Vermicompost (2 t/ha) + *Azotobacter* (2.5 ml/l) + PSB (2.5 ml/l) + KSB (2.5 ml/l) (I_2), 80% RDF + Vermicompost (2 t/ha) + *Azotobacter* (2.5 ml/l) + PSB (2.5 ml/l) + KSB (2.5 ml/l) + Seaweed extract (0.5%) (I_3), 80% RDF + Vermicompost (2 t/ha) + *Azotobacter* (2.5 ml/l) + PSB (2.5 ml/l) + KSB (2.5 ml/l) + Humic acid (0.2%) (I_4), 60% RDF + Vermicompost (3 t/ha) + *Azotobacter* (5 ml/l) + PSB (5 ml/l) + KSB (5 ml/l) + Seaweed extract (1%) (I_5), 60% RDF + Vermicompost (3 t/ha) + *Azotobacter* (5 ml/l) + PSB (5 ml/l) + KSB (5 ml/l) + Humic acid (0.4%) (I_6) and Factor B had three pinching treatments *i.e*. no pinching (P_1), single pinching (P_2), double pinching (P_3) with three replications. The spacing was 45 cm × 30 cm in plant to plant and row to row.

The half dose of nitrogen was applied as a basal dose one day before transplanting and the remaining half dose was applied one month after transplanting. The entire dose of phosphorus, potassium and vermicompost as per the treatments was applied as a basal dose one day before transplanting. Biofertilizers were applied by the seedling dipping method. The roots of the seedlings were dipped for 30 minutes in the solution prepared before transplanting as per treatment allocation. Single pinching is done 30 DAT in which removal of the apical portion of the plant with 2-3 leaves. In double pinching, first by doing a single pinch followed by another pinching of all the shoots after 15 days of single pinching. Biostimulants were sprayed immediately after pinching.

Result and Discussion

The effect of integrated nutrient management treatments and pinching with their interaction effect flowering, yield and quality are depicted in Table 1, 2 and 3.

Flowering & yield parameters

Influence of integrated nutrient management

The data from the investigation reported that the application of integrated nutrient management treatments have significant influence on flowering and yield parameters *viz*., flower diameter, fresh weight of flower, fresh weight of hundred flowers, number of flowers per plant, flowering span, flower yield per plant, flower yield per plot and flower yield per hectare. However, the days to first flower bud appearance was noted non-significant.

The maximum flower diameter (6.11 cm), fresh weight of flower (5.09 g), fresh weight of hundred flowers (442.28 g), number of flowers per plant (88.39), flowering span (52.63 days), flower yield per plant (391.74 g), flower yield per plot (3.57 kg) and flower yield per hectare (29.36 t) were reported in 60% RDF + Vermicompost (3 t/ha) + *Azotobacter* (5 ml/l) + PSB (5 ml/l) + KSB (5 ml/l) + Seaweed extract (1%) (I_6) at 90 DAT as compare to other treatments. Is might be because the balanced application of fertilizers resulted in increased carbohydrate assimilation leading to increased vegetative growth. These carbohydrates when translocated to reproductive organs underwent hydrolysis and got converted into reducing sugars which ultimately helped in increasing flower size, weight and number of flowers per plant. These findings corroborate results obtained by Nethra *et al.* (1999) [10] and Kumar *et al.* (2009) [7] in China aster and Gadagi *et al.* (2004) [4] and Parmar (2006) [12] in gaillardia, Kapadiya *et al.* (2008) [5] in marigold.

Influence of pinching

The pinching treatments were found significant in flowering and yield parameters such as days to first flower bud appearance, flower diameter, fresh weight of flower, fresh weight of hundred flowers, number of flowers per plant, flowering span, flower yield per plant, flower yield per plot and flower yield per hectare.

The data showed that significantly minimum days to first flower bud appearance (25.58), maximum flower diameter (6.84 cm), fresh weight of flower (5.88 g) and fresh weight of hundred flowers (499.53 g) were observed in no pinching (P_1). The decrease in flower diameter in pinched plants might be due to the fact that in pinched plants energy was shared by the developing side branches, while in the case of unpinched plants, the energy sharing was limited to the flower developing in the main branch only. That is why un-pinched plants have a more fresh weight of flower. The similar findings have been reported by Khobragade *et al.* (2012) [6] in China aster and Nain *et al.* (2017) [9] in marigold. While, a significant maximum number of flowers per plant (111.58), flowering span (53.66 days), flower yield per plant (351.12 g), flower yield per plot (3.16 kg) and flower yield per hectare (25.97 t) were observed in double pinching (P_3). The increase in the number of flowers due to the pinching treatment may be correlated with vegetative growth characteristics like a number of branches. Due to the pinching treatment, more side branches were formed below the pinched portion of the main stem of the plant. This more vegetative growth obtained in pinched plants resulted in the production of a maximum number of flowers per plant. A similar result was also recorded by Maharnor *et al.* (2011) [8] in African marigold and Akshay *et al.* (2020) [2] in annual chrysanthemum.

Table 1: Influence of integrated nutrient management and pinching on flowering parameters of annual chrysanthemum

Treatments	Days to first flower bud appearance	Flower diameter (cm)	Fresh weight of flower (g)	Fresh weight of hundred flowers (g)	Flowering span (days)
Factor A – Integrated nutrient management					
I_1	30.69	5.42	4.46	369.26	44.60
I_2	30.31	5.54	4.56	384.50	49.36
I_3	29.32	5.80	4.81	410.36	50.87
I_4	29.67	5.65	4.68	396.25	48.00
I_5	28.61	6.11	5.09	442.28	52.63
I_6	28.87	5.97	4.96	426.19	47.20
S.Em.±	0.615	0.164	0.137	11.969	1.369
C.D. at 5%	NS	0.47	0.39	34.40	3.93
Factor B - Pinching					
P_1	25.58	6.84	5.88	499.53	43.76
P_2	29.56	5.87	4.78	407.08	48.92
P_3	33.59	4.54	3.61	307.81	53.66
S.Em.±	0.435	0.116	0.097	8.463	0.968
C.D. at 5%	1.25	0.33	0.28	24.32	2.78
Interaction: I × P					
S.Em.±	1.066	0.284	0.237	20.731	2.371
C.D. at 5%	NS	NS	NS	NS	NS
C.V. %	6.24	8.55	8.63	8.87	8.42

Table 2: Influence of integrated nutrient management and pinching on yield parameters of annual chrysanthemum

Treatments	Number of flowers per plant	Flower yield per plant (g)	Flower yield per plot (kg)	Flower yield per hectare (t)
Factor A – Integrated nutrient management				
I_1	73.25	251.66	2.30	18.91
I_2	78.33	282.09	2.57	21.11
I_3	82.23	321.28	2.93	24.08
I_4	80.69	301.23	2.74	22.55
I_5	88.39	391.74	3.57	29.36
I_6	85.96	349.02	3.14	25.87
S.Em.±	2.124	7.967	0.072	0.596
C.D. at 5%	6.10	22.90	0.21	1.71
Factor B - Pinching				
P_1	55.46	277.55	2.55	21.02
P_2	77.38	319.84	2.91	23.95
P_3	111.58	351.12	3.16	25.97
S.Em.±	1.502	5.634	0.051	0.421
C.D. at 5%	4.32	16.19	0.15	1.21
Interaction: I × P				
S.Em.±	3.689	13.800	0.125	1.032
C.D. at 5%	10.60	39.66	0.36	2.97
C.V. %	7.82	7.56	7.56	7.56

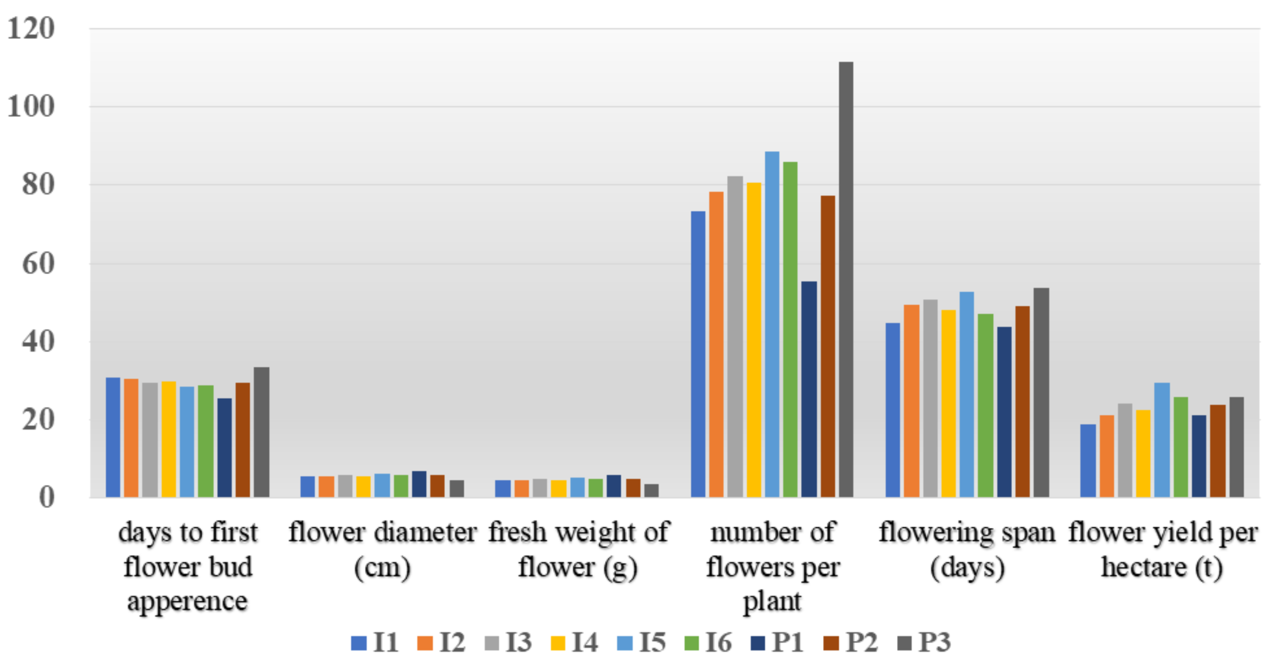

Fig 1: Effect of integrated nutrient and pinching on flowering & yield parameters

Interaction effect of integrated nutrient management and pinching

The result noted that the interaction effect of integrated nutrient management and pinching was reported significant in the number of flowers per plant, flower yield per plant, flower yield per plot and flower yield per hectare. Meanwhile, it was noted as non-significant for days to first flower bud appearance, flower diameter, fresh weight of flower, fresh weight of hundred flowers and flowering span.

Significantly maximum number of flowers per plant (117.36), flower yield per plant (444.90 g), flower yield per plot (4.08 kg) and flower yield per hectare (33.61 t) were observed in treatment combination of 60% RDF + Vermicompost (3 t/ha) + *Azotobacter* (5 ml/l) + PSB (5 ml/l) + KSB (5 ml/l) + Seaweed extract (1%) with double pinching. This might be due to proper nutrient management and double pinching were more effective in bringing improvement in the number of primary and secondary branches as well as leaves per plant which might have increased the flower production per plant. This result is in close approximately with the finding of Singh *et al.* (2010) [15] in marigold and Tanzeela *et al.* (2021) [16] in gomphrena.

Quality parameters

Effect of integrated nutrient management

The data showed that the application of integrated nutrient management treatments exerted a significant influence on quality parameters like the *in-situ* longevity of flower. While, vase the life of flower and the shelf life of flower was found non-significant.

Significant maximum *in-situ* longevity of flowers (11.37 days) was obtained in 60% RDF + Vermicompost (3 t/ha) + *Azotobacter* (5 ml/l) + PSB (5 ml/l) + KSB (5 ml/l) + Seaweed extract (1%) (I_6) as compare to other treatments. It might be the role of NPK, biofertilizers and seaweed extract in increasing growth parameters, translocation and accumulation of more photosynthates and delaying the senescence might be the reason for increased in-situ longevity of flowers. These results are in accordance with Airadevi (2012) [1], Anjali *et al.* (2020) [3] in annual chrysanthemum and Parsana *et al.* (2023) [13] in custard apple.

Effect of pinching

The data from the investigation reported that pinching treatments exerted to be a significant influence on the vase life of a flower, shelf life of the flower and *in-situ* longevity of flower. The result revealed that the maximum vase life of flower, (6.20 days) and shelf life of flower (4.22 days) were observed in double pinching (P_3). While, *in-situ* longevity of flower (11.64 days) was observed in single pinching (P_2). Variation in vase life, shelf life and *in-situ* longevity of flower could be attributed to the fact that the variation in ability to produce ethylene and sensitivity to it among different pinching treatments maximum evident in double pinching. The size of the pedicel full of stored food material maintained firmness for long. These results are agreed with the findings of Ryagi *et al.* (2007) [14] in carnation, Pakhale (2011) [11] in African marigold and Vasava *et al.* (2023) [17].

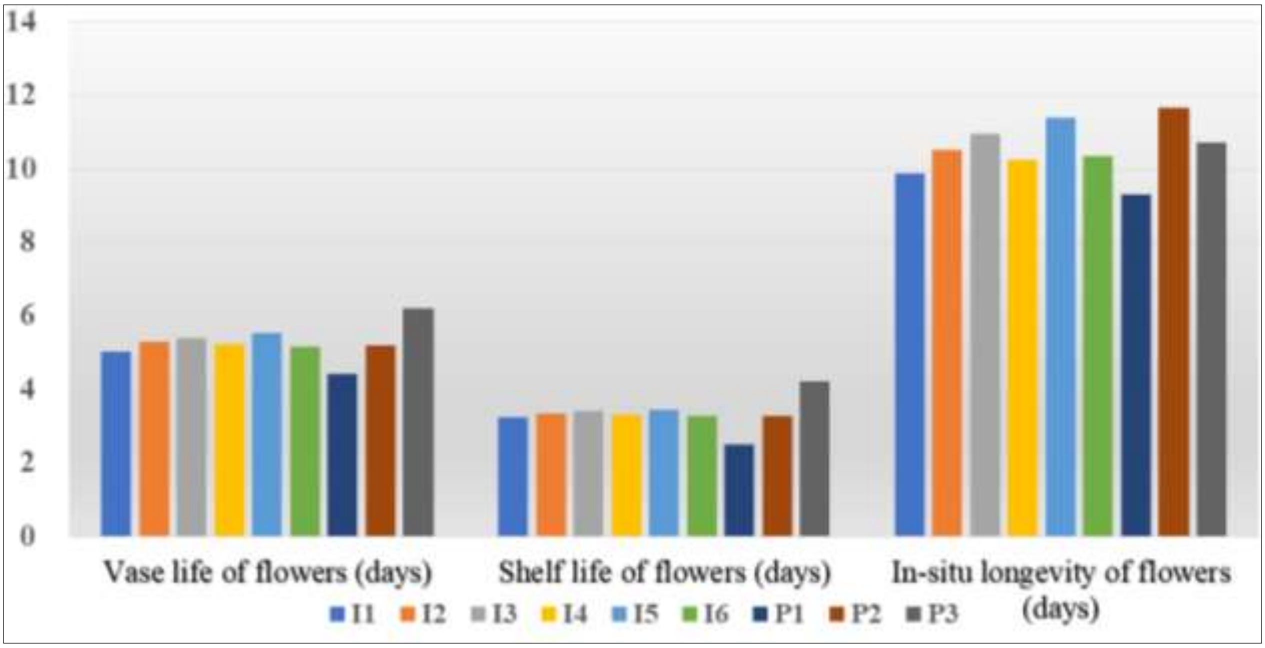

Fig 2: Effect of integrated nutrient and pinching on quality parameters

Table 3: Influence of integrated nutrient management and pinching on quality parameters of annual chrysanthemum

Treatments	Vase life of flower (days)	Shelf life of flower (days)	*In-situ* longevity of flower (days)
Factor A – Integrated nutrient management			
I_1	5.01	3.23	9.88
I_2	5.29	3.33	10.52
I_3	5.38	3.40	10.93
I_4	5.21	3.31	10.24
I_5	5.54	3.44	11.37
I_6	5.17	3.28	10.34
S.Em.±	0.127	0.077	0.288
C.D. at 5%	NS	NS	0.83
Factor B - Pinching			
P_1	4.41	2.50	9.29
P_2	5.19	3.28	11.64
P_3	6.20	4.22	10.71
S.Em.±	0.090	0.055	0.204
C.D. at 5%	0.26	0.16	0.59
Interaction: I × P			
S.Em.±	0.219	0.134	0.499
C.D. at 5%	NS	NS	NS
C.V. %	7.22	6.95	8.19

Interaction effect of integrated nutrient management and pinching

Interaction effect of integrated nutrient management and pinching was observed non-significant for all quality parameters.

Conclusion

From the result of field experiment, it appears reasonable to infer that there were notable differences in the outcomes of various treatments for flowering, yield and quality parameters. Almost all the, flowering, yield and quality parameters were found maximum with the application of 60% RDF + Vermicompost (3 t/ha) + *Azotobacter* (5 ml/l) + PSB (5 ml/l) + KSB (5 ml/l) + Seaweed extract (1%). While, maximum value of quality parameters are noted in double pinching. From the present investigation, it is concluded that application of Vermicompost (3 t/ha) + *Azotobacter* (5 ml/l) + PSB (5 ml/l) + KSB (5 ml/l) + Seaweed extract (1%) with double pinching is a successful strategy for enhancing the yield of flowers.

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