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Effect of Integrated Nutrient Management on Post-Harvest Traits of Italian Aster (*Aster amellus* L.) cv. 'Purple Multipetal

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Abstract
Post-harvest quality is a crucial factor determining the market value and consumer preference of cut flowers. Integrated Nutrient Management (INM) offers a sustainable approach to improve flower quality by enhancing nutrient availability and physiological efficiency. The present study was conducted to assess the effect of integrated nutrient management on post-harvest traits of Italian aster (*Aster amellus* L.) cv. 'Purple Multipetal'. The experiment was carried out at the Floricultural Research Station, Agricultural Research Institute, Rajendranagar, Hyderabad, during September 2017 to January 2018, following a Randomized Block Design with eight treatments and three replications. Treatments consisted of combinations of inorganic fertilizers, organic manures (vermicompost and farmyard manure), and bio-fertilizers (*Azospirillum* and phosphate-solubilizing bacteria). Post-harvest parameters such as fresh weight of spike, transpirational loss of water, fresh weight change during vase life, and vase life were recorded.

The results revealed that integrated nutrient management significantly influenced all post-harvest traits. The highest fresh weight of spike (90.71 g), maximum fresh weight retention (100.68%), and longest vase life (8.03 days) were recorded in treatment T_7 (50% RDF + 50% RDF through vermicompost + *Azospirillum* + PSB). In contrast, the lowest values were observed under sole application of inorganic fertilizers (100% RDF). The enhanced post-harvest performance under INM may be attributed to improved nutrient uptake, better water relations, delayed senescence, and enhanced cellular integrity due to the synergistic effects of organic manures and bio-fertilizers. The study concludes that INM is an effective strategy for improving post-harvest quality and vase life of Italian aster.

Keywords: Italian aster, integrated nutrient management, post-harvest traits, vase life, vermicompost, bio-fertilizers

Introduction
Floriculture has emerged as a dynamic and high-value segment of horticulture, contributing significantly to income generation, employment opportunities, and export earnings. In India, rapid urbanization, changing lifestyles, and increasing demand for aesthetic products have led to a substantial rise in the consumption of cut flowers for decorative, ceremonial, and commercial purposes. Among quality attributes, post-harvest performance of flowers such as vase life, freshness, colour retention, and physiological stability plays a crucial role in determining market acceptability and economic returns to growers.

Italian aster (*Aster amellus* L.), commonly known as daisy, belongs to the family Asteraceae and is valued as an important cut and filler flower in floral arrangements. The cultivar 'Purple Multipetal' is especially preferred due to its attractive colour, profuse flowering, sturdy spikes, and adaptability to diverse agro-climatic conditions. Besides its ornamental appeal, Italian aster is gaining commercial importance owing to its suitability for off-season production, longer flowering duration, and comparatively good post-harvest keeping quality. However, post-harvest traits such as vase life, flower longevity, fresh and dry weight, and spike durability are highly influenced by pre-harvest cultural practices, particularly nutrient management (Krushnaiah, et al., 2019) [9].

In commercial floriculture, emphasis has traditionally been placed on enhancing yield and flower size through chemical fertilizers. Although inorganic fertilizers supply nutrients in readily available forms, their continuous and unbalanced use often leads to nutrient imbalance, deterioration of soil health, and adverse effects on flower quality and post-harvest performance. Excessive nitrogen fertilization, for instance, may promote luxuriant vegetative growth but can reduce tissue strength, increase respiration rate, and shorten vase life of cut flowers. Therefore, sustainable nutrient management strategies that improve both yield and post-harvest quality are essential (Chaupoo, and Kumar, 2022) [3].

Integrated Nutrient Management (INM), which involves the combined use of inorganic fertilizers, organic manures, and bio-fertilizers, has been recognized as an effective approach to enhance nutrient use efficiency, soil fertility, and crop quality. Organic manures such as farmyard manure and vermicompost improve soil structure, water-holding capacity, microbial activity, and availability of macro- and micronutrients, which collectively influence flower quality and post-harvest longevity. Vermicompost, in particular, is rich in humic substances, enzymes, and plant growth regulators that enhance nutrient uptake and physiological efficiency of plants (Krushnaiah, et al., 2018) [8].

Bio-fertilizers such as *Azospirillum* and phosphate-solubilizing bacteria (PSB) further contribute to sustainable flower production by fixing atmospheric nitrogen, solubilizing unavailable phosphorus, and synthesizing growth-promoting substances like auxins, gibberellins, and cytokinins. These beneficial effects not only improve plant vigor but also strengthen cellular integrity, delay senescence, and enhance post-harvest traits such as vase life and flower longevity.

Although several studies have reported the positive influence of integrated nutrient management on growth and yield of ornamental crops, systematic information on its effect on post-harvest attributes of Italian aster, particularly under Indian conditions, is limited. Considering the increasing demand for high-quality cut flowers with extended shelf life, it is imperative to evaluate the role of INM in improving post-harvest performance (Gupta, 2021) [4]. Therefore, the present investigation was undertaken to assess the effect of integrated nutrient management on post-harvest traits of Italian aster (*Aster amellus* L.) cv. 'Purple Multipetal', with the objective of identifying sustainable nutrient combinations that enhance flower quality, longevity, and market value.

Materials and Methods

The experiment was conducted at the Floricultural Research Station, Agricultural Research Institute (ARI), Rajendranagar, Sri Konda Laxman Telangana State Horticultural University, Hyderabad, India, during September 2017 to January 2018. The experimental site is situated in a subtropical climatic region at an altitude of 542.3 m above mean sea level (17.90° N latitude and 78.23° E longitude) and receives an average annual rainfall of approximately 800 mm. Healthy, uniform, and disease-free suckers of Italian aster (*Aster amellus* L.) cv. 'Purple multipetal' were used as planting material.

The experimental field soil was sandy clay loam with good drainage and uniform topography. Pre-plant soil analysis indicated a pH of 7.7 and electrical conductivity of 0.43 dS m^{-1}. The soil was medium in available nitrogen (165 kg ha^{-1}), phosphorus (36.1 kg ha^{-1}), and potassium (144 kg ha^{-1}). Meteorological data on temperature, rainfall, and relative humidity were recorded throughout the crop growth period. The experiment was laid out in a Randomized Block Design with eight treatments and three replications. Each plot measured 1.5 m × 1.5 m, and plants were spaced at 30 cm × 30 cm. The recommended fertilizer dose for Italian aster was 150:100:60 kg $N:P_2O_5:K_2O$ ha^{-1}. Treatments comprised combinations of inorganic fertilizers, organic manures, and bio-fertilizers. These included 100% RDF (T_1); 50% RDF + 50% RDF through vermicompost (T_2); 50% RDF + 50% RDF through vermicompost + *Azospirillum* (T_3); 50% RDF + 50% RDF through vermicompost + phosphate-solubilizing bacteria (PSB) (T_4); 50% RDF + 50% RDF through farmyard manure (FYM) (T_5); 50% RDF + 50% RDF through FYM + PSB (T_6); 50% RDF + 50% RDF through vermicompost + *Azospirillum* + PSB (T_7); and 50% RDF + 50% RDF through FYM + *Azospirillum* + PSB (T_8).

Chemical fertilizers were applied through urea, diammonium phosphate, and muriate of potash. Half of the nitrogen and the full dose of phosphorus and potassium were applied at planting, while the remaining nitrogen was top-dressed later. Organic manures were incorporated into the soil 15 days prior to planting as per treatment. Bio-fertilizers were applied by root dipping. A slurry was prepared using 200 g of *Azospirillum* or PSB in one litre of jaggery solution (100 g L^{-1}). For combined treatments, 100 g each of *Azospirillum* and PSB were used. Rooted suckers were dipped in the slurry for 30 minutes before transplanting, following standard procedures. Data has been take 5 random selected plant with the traits Fresh weight of spike (g), Fresh weight change of spike (FWC), Transpiration loss of water (TLW), and Vase life.

Planting was done on 9 September 2017 during the Rabi season. Irrigation was provided at 4-6 day intervals, and manual weeding was carried out as needed. Uniform plant protection measures were followed throughout the experiment. Data were analyzed statistically using ANOVA for RBD, and treatment means were compared using the critical difference test at the 5% level of significance, Panse and Sukhatme (1985).

Results and Discussion

Fresh weight of spike (g)

Fresh weight of spike at harvest was significantly influenced by integrated nutrient management treatments in Italian aster (Table 1; Fig. 1). The highest spike fresh weight (90.71 g) was recorded in treatment T_7 (50% RDF + 50% RDF through vermicompost + *Azospirillum* + PSB), which was statistically superior to all other treatments and was closely followed by T_8 (50% RDF + 50% RDF through FYM + *Azospirillum* + PSB), registering a fresh weight of 85.25 g. In contrast, the lowest fresh weight of spike (60.60 g) was observed in T_5 (50% RDF + 50% RDF through FYM), which remained on par with T_2 (50% RDF + 50% RDF through vermicompost). The remaining treatments produced intermediate values.

The improvement in spike fresh weight under integrated application of organic manures and bio-fertilizers may be attributed to enhanced biological nitrogen fixation and phosphorus solubilization in the rhizosphere, resulting in improved nutrient uptake and assimilation. Inoculation with *Azospirillum* plays a vital role not only in nitrogen fixation but also in the synthesis of plant growth-promoting substances such as indole-3-acetic acid (IAA), gibberellins, and cytokinins, which collectively enhance vegetative growth, cellular expansion, and biomass accumulation. Additionally, the presence of vermicompost improves nutrient availability and physiological efficiency, thereby contributing to higher fresh weight of flower spikes. These findings are in agreement with earlier reports by Rajesh et al. in carnation and Harish et al. (2015) [5] in gladiolus, who also observed increased flower fresh weight with the combined application of bio-fertilizers and organic nutrient sources, Khanna, et al., 2016). Similar as reported (Harish et al., 2018) [5].

Transpirational loss of water (g spike^{-1})

The transpirational loss of water (TLW) during the vase life of Italian aster spikes was significantly influenced by integrated nutrient management practices (Table 2; Fig. 2). Cut spikes maintained in 3 per cent sucrose solution exhibited significant variation in TLW among treatments. The highest TLW (10.58 g spike^{-1}) was observed in treatment T_7 (50% RDF + 50% RDF through vermicompost + *Azospirillum* + PSB), whereas the lowest TLW (7.70 g spike^{-1}) was recorded in T_2 (50% RDF + 50% RDF through vermicompost). Transpirational loss varied significantly across different days of the vase life period. TLW showed a declining trend from the second day (10.90 g) to the eighth day (6.41 g), with significant differences observed at each interval. The interaction between treatments and days was also significant. Treatment T_7 consistently recorded the highest TLW on the 2nd, 4th, 6th, and 8th days (13.52, 11.26, 9.33, and 8.23 g, respectively). In contrast, minimum TLW on the 2nd day (9.22 g) was observed in T_5 (50% RDF + 50% RDF through FYM), while on the 4th, 6th, and 8th days, the lowest values (8.14, 6.21, and 5.14 g, respectively) were recorded in T_1 (100% RDF). Other treatments showed intermediate responses. Higher TLW in certain treatments may be attributed to increased water uptake by the spikes to avoid temporary water stress, resulting in enhanced transpiration. The limited water retention capacity of flowers eventually leads to wilting. Inoculation with *Azospirillum* enhances nitrogen fixation and stimulates the production of growth regulators such as auxins, gibberellins, and cytokinins, which increase cellular metabolic activity and membrane permeability, thereby contributing to higher transpirational loss. These results corroborate the findings of Rekha et al. (2001) [12] in gladiolus, Tang et al. (2004) [13] in gerbera, and Harish et al. (2015) [5] in gladiolus.

Fresh weight change (% of initial weight)

Fresh weight change (FWC), expressed as a percentage of initial weight, was significantly affected by integrated nutrient management during the vase life of Italian aster (Table 2; Fig. 3). The fresh weight of spikes increased from the first day, reached a maximum on the second day, and thereafter gradually declined until the end of the vase life period. Overall, fresh weight increased from 100.00 per cent on the first day to a peak of 105.05 per cent on the second day, followed by a progressive reduction.

Significant variation in FWC was observed among treatments. The highest mean fresh weight (100.68%) was recorded in T_7 (50% RDF + 50% RDF through vermicompost + *Azospirillum* + PSB), while the lowest value (91.64%) was observed in T_1 (100% RDF). Fresh weight also differed significantly across observation days, increasing significantly from day 1 (100.00%) to day 2 (103.11%) and then decreasing from day 4 (100.44%) to day 8 (89.70%). The interaction between treatments and days was significant. Treatment T_7 maintained the highest fresh weight on the 2nd, 4th, 6th, and 8th days (105.05, 103.42, 99.82, and 94.39%, respectively). Conversely, on the 2nd day, the lowest fresh weight (101.51%) was observed in T_5 (50% RDF + 50% RDF through FYM), while on the 4th, 6th, and 8th days, minimum values (93.42, 86.41, and 82.52%, respectively) were recorded in T_1 (100% RDF). The improved fresh weight retention under integrated nutrient management, particularly with vermicompost and bio-fertilizers, may be attributed to the presence of humic substances and micronutrients that stimulate enzymatic activity, enhance metabolic processes, and delay senescence during vase life. These results are in conformity with the findings of Angadi and Airadevi (2014) [2] in chrysanthemum, Harish et al. (2015) [5] in gladiolus, and Verma (2010) [14] in chrysanthemum.

Vase life (days)

Vase life of Italian aster spikes was significantly influenced by integrated nutrient management practices (Table 1; Fig. 1). Among the treatments, the longest vase life (8.03 days) was recorded in T_7 (50% RDF + 50% RDF through vermicompost + *Azospirillum* + PSB), which was statistically superior to all other treatments. This was followed by T_4 (50% RDF + 50% RDF through vermicompost + PSB), which recorded a vase life of 7.06 days. In contrast, the shortest vase life (6.03 days) was observed in T_1 (100% RDF). The remaining treatments (T_3, T_8, T_6, T_2, and T_5) were statistically on par with each other.

The extended vase life observed under integrated nutrient management, particularly in treatments involving vermicompost and bio-fertilizers, may be attributed to improved water retention within floral tissues, reduced cellular desiccation, and delayed senescence. The presence of bio-fertilizers enhances nutrient uptake efficiency and physiological activity, while vermicompost supplies humic substances and micronutrients that help maintain membrane integrity and metabolic balance during the post-harvest period. These factors collectively contribute to improved post-harvest longevity of cut flowers. The present findings are in agreement with earlier reports by Verma (2010) [14] in chrysanthemum, Anand et al. (2016) in orchid, Angadi (2014) [2] in chrysanthemum, and Harish et al. (2015) [5] in gladiolus.

Table 1: Effect of Integrated Nutrient Management on Fresh weight of the spike (g) and vase life (days) of Italian Aster

Treatments	Fresh weight of the spike (g)	Vase life (Days)
T_1=100% RDF	78.78	6.03
T_2=RDF 50%+RDF 50% through VC	64.33	6.26
T_3=RDF 50% +RDF 50% through VC + Azo	68.29	6.73
T_4=RDF 50%+ RDF 50% through VC + PSB	76.4	7.06
T_5=RDF 50% + RDF 50% through FYM	60.6	6.18
T_6 =RDF 50% + RDF 50% through FYM + PSB	72.3	6.36
T_7= RDF 50% + RDF 50% through VC + Azo + PSB	90.71	8.03
T_8 = RDF 50% + RDF 50% through FYM + Azo + PSB	85.25	6.4
Mean	74.58	6.63
S.Em ±	1.32	0.17
CD at 5%	3.99	0.51

Where, **DAP:** Days after planting, **FYM:** Farm Yard Manure, **Azo:** *Azospirillum* sp. **VC:** Vermicompost **PSB:** Phosphate solubilizing bacterium **RDF:** Recommended dose of fertilizers

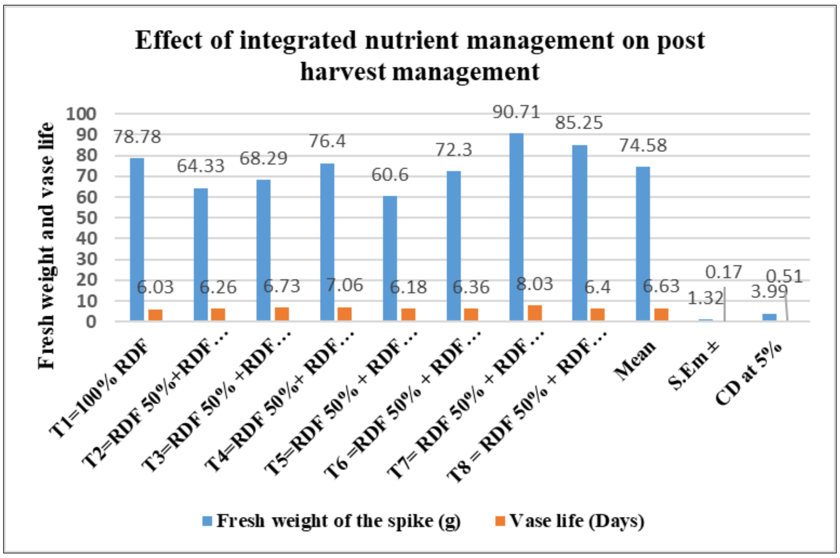

Fig 1: Effect of Integrated Nutrient Management on fresh weight of the spike (g) and vase life (days)

Table 2: Effect of Integrated Nutrient Management on Transpirational loss of water (TLW) (g/spike) and Fresh weight change (% of initial weight) of Italian Aster

	Transpirational loss of water (TLW) (g/spike)					**Fresh weight change (% of initial weight)**				
	Days (D)				**Treatments mean**	**Days (D)**				**Treatments mean**
Treatments	**2**	**4**	**6**	**8**		**2**	**4**	**6**	**8**	
T_1=100% RDF	12.33	8.14	6.21	5.14	7.95	104.2	93.42	86.41	82.52	91.64
T_2=RDF 50%+RDF 50% through V.C	9.52	8.73	6.83	5.73	7.7	101.91	100.31	92.43	88.34	95.75
T_3=RDF 50% +RDF 50% through V.C + Azo	10.83	9.92	7.02	6.93	8.68	103.08	101.92	96.12	92.9	98.5
T_4=RDF 50%+ RDF 50% through V.C + P.S.B	11.54	10.62	8.74	7.64	9.63	103.7	102.61	97.33	93.12	99.19
T_5=RDF 50% + RDF 50% through FYM	9.22	8.33	6.43	5.35	7.33	101.51	100.21	91.56	86.74	95
T_6 =RDF 50% + RDF 50% through FYM + P.S.B	9.93	8.82	6.93	5.86	7.89	102.6	100.65	93.31	89.42	96.49
T_7= RDF 50% + RDF 50% through V.C + Azo + P.S.B	13.52	11.26	9.33	8.23	10.58	105.05	103.42	99.89	94.39	100.68
T_8 = RDF 50% + RDF 50% through FYM + Azo + P.S.B	10.33	9.43	7.57	6.43	8.44	102.8	100.97	94.76	90.21	97.18
Days mean	10.9	9.41	7.38	6.41		103.11	100.44	93.97	89.7	
	SEM ±	CD (P =0.05)						SEM ±	CD (P = 0.05)	
Treatments (T)	0.006	0.01				Treatments (T)		0.02	0.06	
Days (D)	0.004	0.01				Days (D)		0.01	0.04	
T × D	0.01	0.03				T × D		0.04	0.13	

Where, **DAP:** Days after planting **FYM:** Farm Yard Manure, **Azo:** *Azospirillum* sp. **VC:** Vermicompost, **PSB:** Phosphate solubilizing bacterium **RDF:** Recommended dose of fertilizers

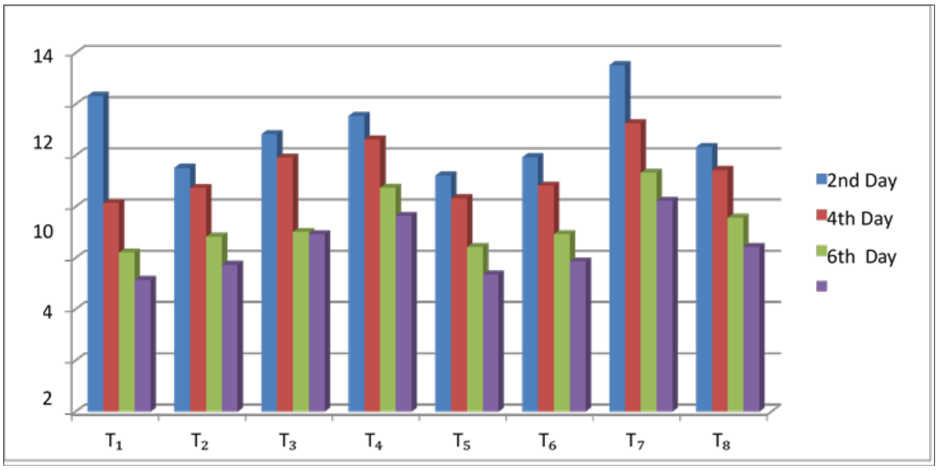

Fig 2: Transpirational loss of water (TLW) (g/spike) during vase life period as influenced by INM on Italian aster (*Aster amellus* L.) cv. Purple Multipetal

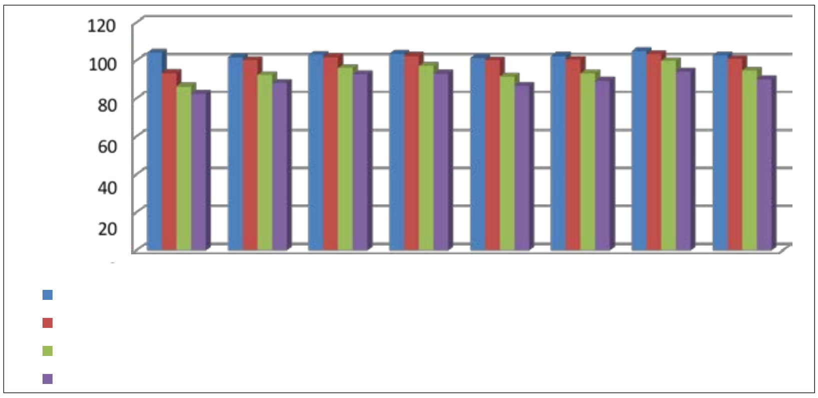

Figure 3: Fresh weight change (% of initial weight) during vase life periods influenced by INM on Italian aster (*Aster amellus* L.) cv. 'Purple Multipetal'.

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