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R Krushnaiah
Department of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Mulugu, Siddipet, Telangana, India

P Prashanth
Department of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Mulugu, Siddipet, Telangana, India

D Saidanaik
Department of Crop Physiology, Professor Jayashanker Telangana Agricultural University, Hyderabad, Telangana, Inida

Corresponding Author:
R Krushnaiah
Department of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Mulugu, Siddipet, Telangana, India

Effect of integrated nutrient management on flowering and yield of Italian Aster (*Aster amellus* L.) cv. Purple multipetal

R Krushnaiah, P Prashanth and D Saidanaik

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Abstract
An experiment was conducted to evaluate the effect of integrated nutrient management (INM) on growth, flowering, yield, and postharvest performance of Italian aster (Aster amellus L.) cv. Purple multipetal at the Floricultural Research Station, Agricultural Research Institute, Rajendranagar, Hyderabad, during September 2017 to January 2018. The experiment was laid out in a randomized block design with eight treatments comprising different combinations of inorganic fertilizers, organic manures (farmyard manure and vermicompost), and bio-fertilizers (Azospirillum and phosphate-solubilizing bacteria), replicated thrice. Results revealed that INM treatments significantly influenced flowering and yield attributes of Italian aster. Among the treatments, application of 50% RDF + 50% RDF through vermicompost + Azospirillum + PSB (T_7) resulted in earliest flower bud initiation (69.66 days) and 50% flowering (81.73 days). The same treatment also recorded significantly higher number of flowers per plant (92.80 and 300.33 at 90 and 120 DAP), number of flowers per spike (181.00), number of spikelets per spike (35.20), flower spikes per plant (4.20), spike yield per plot (105.00), and spike yield per hectare (4.66 lakh ha^{-1}). Maximum flower spike length (54.28 cm at 120 DAP) was also observed under T_7, followed by T_8 (50% RDF + 50% RDF through FYM + Azospirillum + PSB). The superior performance under integrated application may be attributed to enhanced nutrient availability, improved soil health, increased microbial activity, and growth-promoting substances produced by bio-fertilizers. The study clearly demonstrates that combined application of organic manures, bio-fertilizers, and reduced levels of chemical fertilizers is an effective, eco-friendly, and sustainable approach for improving productivity and quality of Italian aster under commercial floriculture.

Keywords: Italian aster, Integrated nutrient management, Vermicompost, Azospirillum, Phosphate-solubilizing bacteria, Flowering, Yield attributes, Sustainable floriculture

Introduction
India is a country characterized by immense diversity in culture, traditions, religions, attire, and social customs. Despite this diversity, a common thread of emotions such as faith, respect, belief, and compassion binds the people together. Flowers play a vital role in expressing these shared human emotions and sentiments. Being an integral component of nature, flowers have been closely associated with human life since time immemorial. They are widely used on various occasions such as weddings, birthdays, religious ceremonies, funerals, hospital visits, and festivals, as they enhance emotional bonding, reduce stress, and convey feelings more effectively than words.

Historically, the Aryans were among the earliest communities to introduce the practice of offering flowers to deities, considering them sacred and precious. Since then, flowers have remained indispensable in social, cultural, and religious ceremonies. Whether used for home decoration, welcoming a newborn, expressing congratulations, admiration, love, or mourning, flowers symbolize nature's most perfect form of celebration. Their universal appeal and ability to communicate emotions naturally have established a strong association between flowers and human life from birth to death (Yadav, 2022) [26].

With changing lifestyles, increasing urbanization, and rising purchasing power, the demand for flowers in India has increased substantially. At present, flowers are cultivated over an area of approximately 3.09 lakh hectares with a production of about 22.46 million tonnes of loose flowers (Anonymous, 2017). While the demand for traditional flowers remains stable, the demand for cut flowers is rapidly increasing in both domestic and international markets.

Consumers are increasingly attracted to novel, rare, and unconventional cut flowers for decorative purposes, particularly for floral arrangements and vase displays, where uniqueness and aesthetic appeal are highly valued.

Among the many potential flower crops, daisy (*Aster amellus* L.), commonly known as Italian aster, has emerged as a promising cut flower. Desirable traits such as attractive colours, larger flower size, longer spike length, higher number of flowers per spike, and extended vase life make it an ideal filler flower for bouquets and floral arrangements. Aster amellus L., belonging to the family Asteraceae, is a perennial flowering plant cultivated worldwide for its ornamental value. In India, it is gaining popularity around major urban centres due to its suitability for interior decoration and bouquet preparation (Krushnaiah, *et al*., 2019) [11].

The crop exhibits a wide range of colours, including blue, purple, pink, and white, and is also valued as a garden plant for herbaceous borders, bedding, pots, and as a dried flower for interior decoration and export. Italian aster thrives well under sunny conditions, adapts to various garden soils, tolerates heat and drought to a greater extent than many flowering plants, and is relatively free from serious pests and diseases. Its perennial nature and year-round flowering habit make it a suitable substitute for several seasonal cut flowers during the off-season, thereby offering immense potential for commercial floriculture (Krushnaiah, *et al*, 2018) [10].

Despite its commercial importance, the productivity of daisy remains relatively low, primarily due to improper nutrient management practices. Nutrients are largely supplied through chemical fertilizers, and their indiscriminate and continuous use has resulted in nutrient imbalance, deterioration of soil health, and reduced yield and quality of flowers. Therefore, there is an urgent need to standardize appropriate nutrient management strategies, particularly Integrated Nutrient Management (INM), to enhance soil fertility, improve physico-chemical and biological properties of soil, and increase flower yield and quality.

Integrated nutrient management involves the judicious use of organic manures, bio-fertilizers, and inorganic fertilizers to ensure balanced nutrient supply and sustainable crop production. The combined application of organic manures and bio-fertilizers not only improves soil structure and microbial activity but also enhances fertilizer use efficiency and crop performance. Organic manures such as farmyard manure and vermicompost serve as important sources of macro- and micronutrients, humic substances, and beneficial microorganisms. Vermicompost, produced through the activity of earthworms, is increasingly recognized for its ability to improve nutrient availability and soil biological health (Aster, 2020) [2].

Bio-fertilizers, also known as microbial inoculants, consist of beneficial microorganisms such as Azotobacter, Azospirillum, and phosphate-solubilizing bacteria (PSB), which enhance nutrient availability through biological nitrogen fixation and phosphorus solubilization. Azotobacter and Azospirillum fix atmospheric nitrogen and also produce plant growth-promoting substances like auxins, gibberellins, and cytokinins, thereby improving plant growth and reducing the requirement of chemical nitrogen fertilizers by 20-25 per cent. Similarly, PSB convert insoluble forms of phosphorus into available forms, increasing phosphorus uptake and improving crop yield.

Exclusive organic farming may not always meet the nutrient requirements of high-yielding commercial crops. Under such circumstances, integrated nutrient management practices, combining organic manures, bio-fertilizers, and chemical fertilizers in balanced proportions, offer a feasible, eco-friendly, cost-effective, and sustainable approach for commercial floriculture. However, limited research has been conducted on the combined effect of organic, inorganic, and bio-fertilizers on the growth and flower yield of Italian aster. Hence, the present study was undertaken to evaluate the efficiency of integrated nutrient management practices in improving growth, yield, and soil health in Aster amellus L., thereby promoting sustainable and profitable floriculture.

Materials and Methods

Experimental site and plant material

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 located in a subtropical climatic zone at an altitude of 542.3 m above mean sea level (17.90° N latitude, 78.23° E longitude), with an average annual rainfall of approximately 800 mm. Healthy and uniform suckers of Italian aster (Aster amellus L.) cv. 'Purple multipetal' were used as planting material.

Soil and climatic conditions

The soil of the experimental field was sandy clay loam, with a pH of 7.7 and electrical conductivity of 0.43 dS m^{-1}. The soil contained 165 kg ha^{-1} available nitrogen, 36.1 kg ha^{-1} available phosphorus, and 144 kg ha^{-1} available potassium, with uniform topography. Mean monthly meteorological data on rainfall, temperature, and relative humidity during the crop period were recorded at the station.

Experimental design and treatments

The experiment was laid out in a Randomized Block Design (RBD) 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 dose of fertilizers (RDF) for Italian aster was 150:100:60 kg $N:P_2O_5:K_2O$ ha^{-1}. The treatments comprised different combinations of inorganic fertilizers, organic manures, and bio-fertilizers as follows:

T_1: 100% RDF

T_2: 50% RDF + 50% RDF through vermicompost

T_3: 50% RDF + 50% RDF through vermicompost + Azospirillum

T_4: 50% RDF + 50% RDF through vermicompost + phosphate-solubilizing bacteria (PSB)

T_5: 50% RDF + 50% RDF through farmyard manure (FYM)

T_6: 50% RDF + 50% RDF through FYM + PSB

T_7: 50% RDF + 50% RDF through vermicompost + Azospirillum + PSB

T_8: 50% RDF + 50% RDF through FYM + Azospirillum + PSB

Application of fertilizers and bio-fertilizers

Nitrogen, phosphorus, and potassium were applied through urea, diammonium phosphate (DAP), and muriate of potash (MOP), respectively. Half of the nitrogen and the full dose of phosphorus and potassium were applied as basal at planting, while the remaining nitrogen was applied later as urea. Organic manures (FYM and vermicompost) were incorporated into the soil 15 days before planting as per treatment.

For bio-fertilizer application, a slurry was prepared using 200 g of Azospirillum or PSB separately in 1000 ml jaggery solution (100 g jaggery L^{-1} of water). For combined application, 100 g each of Azospirillum and PSB were used. The rooted suckers were dipped in the slurry for 30 minutes prior to transplanting, following the method described by Verma *et al*..

Crop management

Planting was done on 9 September 2017 during the Rabi season. Irrigation was provided at 4-6 day intervals depending on soil moisture and weather conditions. Hand weeding was carried out as and when required to maintain weed-free plots. Recommended plant protection measures were adopted uniformly across treatments to control pests and diseases.

Harvesting

Harvesting commenced at 90 days after planting (DAP) and continued up to 120 DAP. Three harvests were taken at weekly intervals. Flower spikes were harvested when approximately 25% of the florets on the spike were open.

Data recording

Five plants were randomly selected and tagged in each plot for recording observations. Flowering and yield parameters recorded were days to flower initiation, days to 50% flowering, number of flowers per plant, number of flowers per spike, number of flower spikes per plant, number of spikelets per spike, spike length, flower diameter, weight of ten fresh flowers, weight of ten dry flowers, spike yield per plot, spike yield per hectare, and flower longevity on the plant.

Statistical analysis

The experimental data were subjected to analysis of variance (ANOVA) appropriate to the Randomized Block Design. Treatment means were compared using the critical difference (CD) test at 5% probability level, Panse and Sukhatme (1985) [20].

Results and discussion

Number of days taken to flower bud initiation (days)

The data presented in table-1 and graphically depicted reveals that number of days taken to flower bud initiation (days) is significantly affected by integrated nutrient management on Italian aster. Application of different sources of nutrients showed significant effect on days taken to flower bud initiation. Among the treatment where the plants were supplied with RDF 50% + RDF 50% through VC + Azo + PSB (T7) were first to show its visible flower bud (69.66 days) this was significantly followed by T8 RDF 50% + RDF 50% through FYM + Azo + PSB (72.73 days). Whereas, in the treatment where the plants supplied with RDF 50% + RDF 50% through FYM (T5) was late to initiate flower bud (82.86 days). Remaining other treatments showed intermediate results (Indhumathi, *et al*., 2023) and Yadav, 2017) [9, 27].

Number of days taken to 50% flowering (days)

The data indicated in the table-2 and graphically depicted reveals that number of days taken to 50 per cent flowering (days) is significantly affected by integrated nutrient management on Italian aster. Variation in days taken for 50 per cent flowering was significant due to different sources of nutrients. Treatment T7 (RDF 50% + RDF 50% through VC + Azo + PSB) took significantly lesser number of days (81.73 days) for 50 per cent flowering when compared to rest of the treatments. This was significantly followed by T8 (RDF 50% + RDF 50% through FYM + Azo + PSB). Whereas, the treatment T5 (RDF 50% + RDF 50% through FYM) has taken more number of days (94.90 days) for 50 per cent flowering and it was on par with T2 (RDF 50%+RDF 50% through VC). The earliness of flowering might be attributed to the presence of bio fertilizers especially inoculation with *Azospirillum* and PSB which consequently lead to flower initiation. This may be ascribed to easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinins to the auxiliary buds resulting in breakage of apical dominance. Vermicompost inclusion in INM might have an indirect role for early flowering through better uptake of nutrients ultimately, resulted in better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase. These results are in the line with the findings in Gurung *et al. (*2018) [7] in tulip, Yadav *et al. (*2017) [27] in marigold, Abhinav Kumar *et al*., 2009) [12] in marigold, Chopde, *et al.* (2017) in jasmine, Dalawai, and Naik *(*2014) [4] in carnation.

Number of flowers per plant

Number of flowers per plant was significantly affected by integrated nutrient management on Italian aster. (Table 2). Significantly higher number of flowers per plant (92.8, 300.33) was noticed in the treatment T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) at 90, 120 DAP respectively, it was significantly followed by T_8 RDF 50% + RDF 50% through FYM + Azo + PSB (80.13 and 284.33). The minimum number of flowers per plant (29.53, 185.86) was recorded in T_5 (RDF 50% + RDF 50% through FYM) at 90, 120 DAP respectively. Similar as reported by Pansuriya *et al*. (2015) [19] in gladiolus.

Number of flowers per spike

The data presented in table 2 shows that number of flowers per spike is significantly affected by integrated nutrient management on Italian aster. The maximum number of flowers per spike (181.00) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) at 120 DAP and it was significantly followed by T_8 (RDF 50% + RDF 50% through FYM + Azo + PSB). The minimum number of flowers per spike (104.33) was recorded in T_5 (RDF 50% + RDF 50% through FYM) at 120 DAP, which was on par with T_2 RDF 50%+RDF 50% through VC (114.66) and T3 RDF 50%

+RDF 50% through VC + Azo (117.00) similar reported as Verma, *et al*., 2012) [25].

Number of spikelets per spike

It is vivid from the table 1 that the number of spikelets per spike was significantly affected by integrated nutrient management on Italian aster.

Maximum number of spikelets per spike (35.20) was found on application RDF 50% + RDF 50% through VC + Azo + PSB (T7) at 120 DAP and it was significantly followed by T8 (RDF 50% + RDF 50% through FYM + Azo + PSB) (32.90) whereas minimum number of spikelets per spike (24.06) was registered in T5 (RDF 50% + RDF 50% through FYM) at 120 DAP and which was on par with T2 RDF 50%+RDF 50% through VC (25.26). Remaining all other treatments showed intermediate results. The increased number of flowers per plant and per spike might be due to the capability of inoculants in providing phosphorous useful in increasing the number of flowers per plant (Laishram *et al*., 2013) [15]. Availability of ample quantity of macro and micro nutrients in vermicompost might have also added to the production of more number of flowers per plant and per spike, besides this, vermicompost enhances photosynthesis which may have enhanced food accumulation resulting in better plant growth and subsequently higher number of flowers per plant. These results are in the line with the findings in Harish *et al*. (2018) [8] in chrysanthemum, Pandey *et al*. (2018) [18] in Dahlia, Palagani *et al*. (2013) [16] in chrysanthemum.

Number of flower spikes per plant

Number of flower spikes per plant is significantly affected by integrated nutrient management on Italian aster as presented in table 1. Maximum number of flower spikes per plant (4.20) was recorded with application of RDF 50 per cent + RDF 50 per cent through VC + Azo + PSB (T7) and was significantly followed by T8 RDF 50% + RDF 50% through FYM + Azo + PSB (4.06). Significantly minimum number of flower spikes per plant (2.06) was noticed in T_5 (RDF 50% + RDF 50% through FYM). Remaining all other treatments showed intermediate results. Similar as reported as by Pandey *et al*., 2017) [17] and Geeta *et al*. (2016) [5] in china aster and Rahul Singh, 2017) [22].

Number of flower spikes per plot

The data indicated in table 1 revealed that number of flower spikes per plot was significantly affected by integrated nutrient management on Italian aster.

Maximum number of flower spikes per plot (105.00) was registered in RDF 50% + RDF 50% through VC + Azo + PSB (T7), which was significantly followed by T8 RDF 50% + RDF 50% through FYM + Azo + PSB (101.66). Significantly minimum number of flower spikes per plot was recorded in T5 RDF 50% + RDF 50% through FYM (51.66). similar as finding reported as Krushnaiah, *et al*., (2018) [10] and Rao, *et al*., 2025) [23].

Number of flower spikes per hectare (lakh/ha)

The data presented in table 4.2.3 reveals that number of flower spikes per hectare is significantly affected by integrated nutrient management on Italian aster.

The maximum number of spike per hectare (4.66 lakhs) was recorded in T7 (RDF 50% + RDF 50% through VC + Azo + PSB) and it was significantly followed by T8 RDF 50% + RDF 50% through FYM + Azo + PSB (4.51lakhs). Whereas, the minimum number of spike per hectare (2.29 lakhs) was observed in T5 (RDF 50% + RDF 50% through FYM). The increase in number of flower spikes might be due to possible role of Azospirillum through atmospheric nitrogen fixation, better root proliferation, uptake of nutrients and water. More photosynthesis enhanced food accumulation which might have resulted in better growth and subsequently higher number of flower spikes per plant and hence, more number of flower yield per hectare. Besides this, increase in flower spike yield may be attributed to increased availability of phosphorus and its greater uptake by PSB (Kundu and Gaur, 1980). Further vermicompost, as the source of macro and micro nutrients like Fe and Zn, enzymes, growth hormones and beneficial effects of micro flora might have played a secondary role in increasing the flower spike yield. These results are in line with the findings Akter *et al*. (2017) [1] in gladiolus, Kumari and Prasad (2017) [17] in petunia, Parmar *et al*. (2017) [21] in golden rod and Ghisewad *et al*. (2016) [6] in gladiolus.

Length of flower spike (cm)

It is apparent from the table 2 and fig.-2 that length of flower spike (cm) was significantly affected by integrated nutrient management on Italian aster.

Significantly maximum length of flower spike (42.03 and 54.28 cm) was noticed in the treatment T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) at 90, 120 DAP respectively, and it was significantly followed by T_8 RDF 50% + RDF 50% through FYM + Azo + PSB (39.99 and 48.36 cm). The minimum length of flower spike (26.73 and 31.33 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM) at 90 and 120 DAP respectively; which was on par with T_2 (RDF 50%+RDF 50% through VC). The significant increase in spike length is combined application of bio- organic nutrient sources along with 50 per cent inorganic nutrient sources proved to be beneficial for robust growth of plants as compared to other treatments. Bio inoculants like Azo and PSB might have been beneficial in fixing atmospheric nitrogen and solubilizing fixed phosphorous in the soil making it available to plants and also by secretion of growth substances like auxin which might have stimulated cell division, plant metabolic activity and photosynthetic efficacy leading to better growth and development leading to the increase in of spike length. These findings corroborate with that of Parmar *et al.* (2017) [21], Neelima Palagani, *et al*., (2013) [16] and Satapathy *et al.* (2016) [24] in Gladiolus.

Table 1: Effect of integrated nutrient management on flowering and yield of Italian Aster

Treatments	Days taken to flower bud initiation	Days taken to 50 percent flowering	Numbe r of flowers per spike	Numbe r of spikelet s per spike	Number of flower spikes per plant	Number of flower spikes per plot	Spike no. per ha. (in lakhs)
T1=100% RDF	74.8	86.83	153.33	30.33	3.9	97.5	4.33
T2=RDF 50%+RDF 50% through VC	81.66	93.66	114.66	25.26	2.26	56.66	2.69
T3=RDF 50% +RDF 50%	79.73	91.9	117	28.23	2.43	60.83	2.73

through VC + Azo							
T4=RDF 50%+ RDF 50% through VC + PSB	75.73	87.73	130.01	28.2	3.2	80	3.55
T5=RDF 50% + RDF 50% through FYM	82.86	94.9	104.33	24.06	2.06	51.66	2.29
T6 =RDF 50% + RDF 50% through FYM + PSB	76.93	88.86	121.66	28.16	3.03	75.83	3.36
T7= RDF 50% + RDF 50% through VC + Azo + PSB	69.66	81.73	181	35.2	4.2	105	4.66
T8 = RDF 50% + RDF 50% through FYM + Azo + PSB	72.73	84.83	164	32.9	4.06	101.66	4.51
Mean	76.76	88.8	135.75	29.04	3.14	78.64	3.51
S.Em ±	0.5	0.48	5.3	0.52	0.02	0.69	0.08
CD at 5%	1.51	1.46	16	1.57	0.08	2.09	0.25

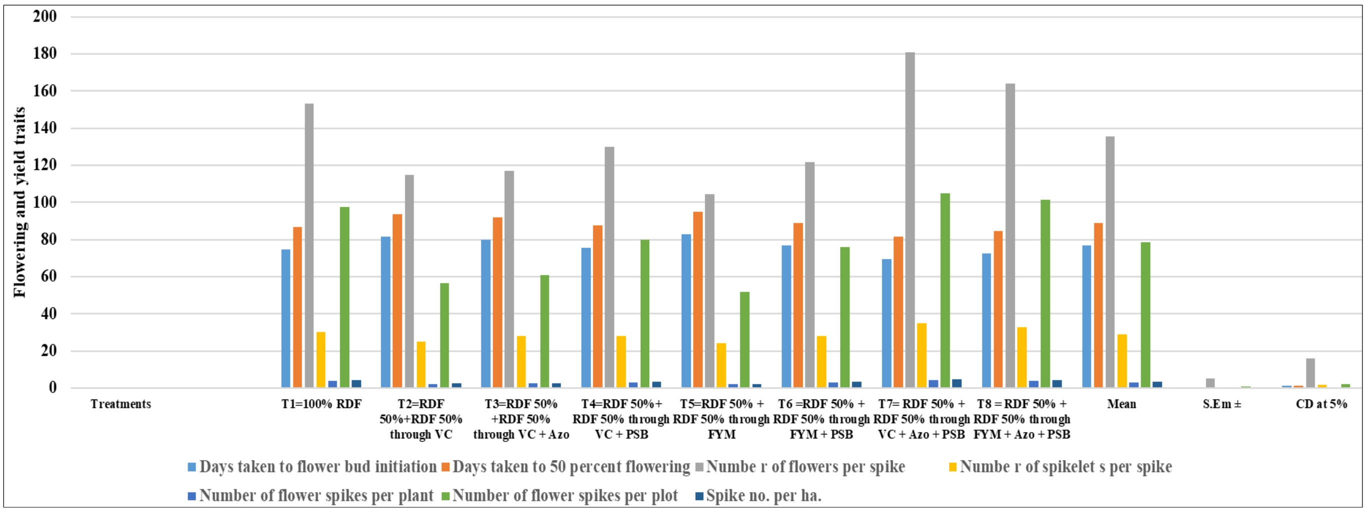

Fig 1: Effect of integrated nutrient management on flowering and yield of Italian Aster

Table 2: Effect of integrated nutrient management on flowering and yield of Italian Aster

Treatment	Number of flowers per plant		Spike length (cm)	
	90 DAP	120 DAP	90 DAP	120 DAP
T1=100% RDF	65.73	267.86	37.55	46.58
T2=RDF 50%+RDF 50% through VC	40.13	194.86	28.54	33.75
T3=RDF 50% +RDF 50% through VC + Azo	44.93	241.46	30.95	38.16
T4=RDF 50%+ RDF 50% through VC + PSB	60.8	252.2	35.76	44.33
T5=RDF 50% + RDF 50% through FYM	29.53	185.86	26.73	31.33
T6 =RDF 50% + RDF 50% through FYM + PSB	51.2	251.8	33.52	40.50
T7= RDF 50% + RDF 50% through VC + Azo + PSB	92.8	300.33	42.03	54.28
T8 = RDF 50% + RDF 50% through FYM + Azo + PSB	80.13	284.33	39.99	48.36
Mean	58.15	247.34	34.38	42.16
S.Em ±	0.6	1.63	0.66	1.40
CD at 5%	1.81	4.93	2.017	4.23

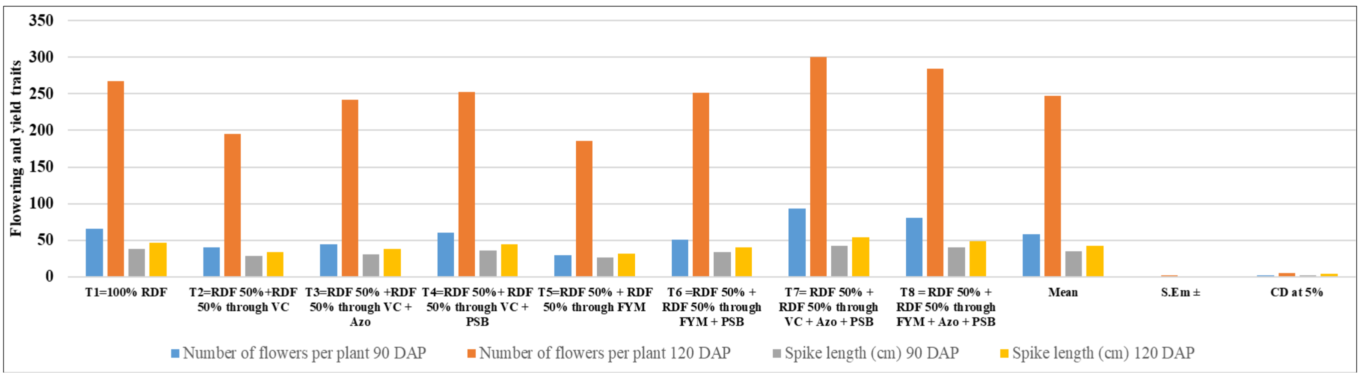

Fig 2: Effect of integrated nutrient management on flowering and yield of Italian Aster

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