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Effect of integrated nutrient management on growth characters Italian aster (*Aster amellus* L.) cv. Purple Multipetal

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Abstract
The present investigation was carried out to evaluate the effect of integrated nutrient management on growth parameters of Italian aster (*Aster amellus* L.) cv. 'Purple Multipetal'. Different combinations of inorganic fertilizers, organic manures, and bio-inoculants were tested to assess their influence on plant height and plant spread at various growth stages (30, 60, 90, and 120 days after planting). The results revealed that integrated application of nutrients significantly improved growth attributes compared to partial substitution with organic sources alone. Among the treatments, application of 50% recommended dose of fertilizers (RDF) combined with 50% RDF through vermicompost along with *Azospirillum* and phosphate solubilizing bacteria (PSB) recorded the maximum plant height and plant spread at all growth stages. In contrast, the lowest growth was observed with 50% RDF combined with 50% RDF through farmyard manure without bio-inoculants. The enhanced growth under integrated treatments may be attributed to improved nutrient availability, biological nitrogen fixation, phosphorus solubilization, and secretion of growth-promoting substances by bio-inoculants, leading to increased metabolic and photosynthetic activity. The study highlights the importance of integrating chemical fertilizers with organic manures and bio-fertilizers for sustainable and enhanced growth of Italian aster.

Keywords: Italian aster, integrated nutrient management, vermicompost, *Azospirillum*, phosphate solubilizing bacteria, plant height; plant spread

Introduction
Italian Aster (*Aster amellus* L.), commonly known as Michaelmas daisy, is an ornamental flowering plant valued for its attractive blooms and prolonged flowering period. It contributes significantly to both domestic landscapes and the cut flower industry due to its vibrant colors and flower longevity. Successful cultivation of ornamental crops largely depends on nutrient management, which influences plant growth, flower quality, and aesthetic appeal.

Traditionally, the application of chemical fertilizers has been the primary approach to supply nutrients. However, continuous use of inorganic fertilizers negatively impacts soil health, reduces microbial activity, and leads to nutrient imbalances. Integrated Nutrient Management (INM) a strategy that combines organic, inorganic, and biofertilizer sources is gaining recognition for sustaining soil fertility, enhancing plant growth, and maximizing nutrient use efficiency (Sharma, 2024) [13].

Bio fertilizers or more appropriately called microbial inoculants are the preparations containing live or latent cells of efficient strains of micro organisms. These may be biological nitrogen fixers, P-solubilizing, mineralization of nitrogen and transformation of several elements like sulphur and iron into available forms. These bio-fertilizers benefit agriculture production by supplying nutrients. Common bio-fertilizers used in horticulture crops are Azotobacter, Azospirillum, and PSB and VAM fungi. Azotobacter is a free living N fixing bacteria and it can be applied in many non-leguminous crops. Besides, it is also known to promote the production of certain growth substances like auxins, gibberellins and cytokinins. Azospirillum is a non-symbiotic, N fixing bacterium. Azotobacter and Azospirillum fixes atmospheric nitrogen when inoculated to plants, which help to save the application of N fertilizers to an extent of 20-25 per cent (Krushnaiah, 2018) [2].

Recently, emphasis has been given on the possibility of utilizing indigenously available rock phosphate. By the addition of PSB the unavailable forms of P is converted to the available forms, increasing P uptake and leading to increased yield.

Integrated nutrient management play an important role for improving the soil structure, physico-chemical properties and flower yield. At present, these nutrients are supplied through chemical fertilizers. The indiscriminate and continuous use of chemical fertilizers has led to an imbalance of nutrients in soil which has adversely affected the soil health, affecting the yield and quality of the produce. Therefore, the use of organic manures and bio fertilizers along with the balance use of chemical fertilizers is known to improve physico-chemical and biological properties of soil, besides improving the efficiency of applied fertilizers as well as crop yield and quality.

No attempts have been made so for to study the combinational efficiency of organic as well as inorganic fertilizers on growth and chlorophyll content of daisy. Besides the above facts, to get higher flower yield, the use of bio fertilizers (*viz*., Azospirillum and Phospho-bacteria) along with organic manures with balanced use of inorganic fertilizers is of paramount importance in Horticulture in general and Floriculture in particular. Since the Integrated Nutrient Management (INM) concept is one of the eco-friendly approaches, the INM approaches not only improve the quality of the produce but also help in improving the soil fertility including the biosphere by reducing the cost of production (Krushnaiah, *et al*., 2019) [3].

Chlorophyll content is a vital physiological indicator of plant health and directly correlates with photosynthetic capacity, vegetative vigor, and overall productivity. In ornamentals like Italian Aster, higher chlorophyll content often leads to improved leaf color, sturdier plants, and enhanced flowering attributes. Therefore, understanding the effects of INM on growth dynamics and chlorophyll synthesis is essential for optimizing production practices (Manohar, 2019) [7].

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Materials and Methods

Experimental Site and Climate

The experiment was conducted on Agricultural Research Institute) Rajendranagar, Sri Konda Laxman Telangana State Horticultural University, Hyderabad during September 2017 to January 2018. The experimental site falls under subtropical climate zone with an average rainfall of 800 mm located at an altitude of 542.3 m above MSL on 17.90^0 N latitude and 78.23^0 E longitudes.

Plant Material

Certified healthy seedlings of Italian Aster (*Aster amellus L.*) cv. "Purple Multipetal" were procured from a certified nursery. Seedlings of uniform size were selected and transplanted.

Soil Characteristics

Prior to transplanting, soil samples were collected from 0-15 cm depth and analyzed for physical and chemical properties. Soil of the experimental site was sandy clay loamy soil with pH of 7.7 and EC of 0.43 dS/m. It consisted of 165kg/ha of available nitrogen and 36.1kg/ha of phosphorus and 144 kg/ha of potassium with uniform topography.

Experimental Design

The experiment was laid out in randomized block design (RBD) with three replications.

Treatment details

T_1=100% RDF

T_2=RDF 50%+RDF 50% through Vermicompost.

T_3=RDF 50% +RDF 50% through Vermicompost +Azospirillum

T_4=RDF 50%+ RDF 50% through Vermicompost + PSB

T_5=RDF 50% + RDF 50% through Farm yard manure

T_6 =RDF 50% + RDF 50% through Farm yard manure + PSB

T_7= RDF 50% + RDF 50% through Vermicompost + Azospirillum + PSB

T_8 = RDF 50% + RDF 50% through Farm yard manure+Azospirillum+PSB Where,

Azo: Azospirillum sp.

PSB: Phosphate Solubilizing Bacterium FYM: Farm Yard Manure

VC: Vermicompost

RDF: Recommended Dose of Fertilizers.

Method of application

Slurry of 200 g of Azospirillum and PSB was prepared in 1000 ml of jaggery solution (100 g of jaggery in 1000 ml of water) individually and combination of both 100 g Azospirillum and 100 g PSB. (Verma *et al.*, 2011) [14]. The rooted suckers of daisy were dipped in the slurry for about 30 minutes before transplanting.

Transplanting and Cultural Practices

Seedlings were transplanted at a spacing of 30 cm × 30 cm. Standard crop management practices such as irrigation, weeding, staking, and plant protection were uniformly followed across all plots. Data taken best 5 selected plant.

Data Collection

Observations were recorded at 30, 60, and 90 days after transplanting (DAT) for the following parameters:

Growth Parameters

- **Plant Height (cm):** Measured from the base to the apical tip.
- **Plant spread (cm):** The maximum horizontal spread of the plant was measured in centimetres. *i.e.* N-S and E-W directions at each growth stage.
- **Number of Leaves per Plant:** Counted manually.
- **Leaf Length (cm):** The length of the leaves was recorded in centimetres from base to the tip of the leaves**.**
- **Leaf Width (cm):** The width of the leaves was recorded by portable leaf area meter.

- **Leaf Area (cm²):** Using a leaf area meter or by nondestructive measurement formula.
- **Number of suckers per plant (No.):** The number of suckers produced by each tagged plant were counted and their mean was calculated

Statistical Analysis
Data were subjected to analysis of variance (ANOVA) using statistical software [Opstat] and Panse and Sukhatme (1985) [9] at 5% significance level.

Results and Discussion
Plant height (cm)
The mean data pertaining to plant height of Italian aster (*Aster amellus* L.) cv. „Purple multipetal" as influenced by integrated nutrient management is presented in table 1 and fig.-1.
The plant height differed significantly due to imposition of integrated nutrient management at all the growth stages. The maximum plant height (18.36 cm) at 30 days after planting (DAP) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) it was on par with T_8 RDF 50% + RDF 50% through FYM + Azo + PSB (17.43 cm). Significantly minimum plant height (13.43 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM). At 60 DAP, significantly the maximum plant height (32.20 cm) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) followed by T_8 RDF 50% + RDF 50% through FYM + Azo + PSB (29.72 cm). The minimum plant height (17.46 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM). The significantly highest plant height (52.16 and 64.25 cm) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) at 90 and 120 DAP respectively. While, the lowest plant height (28.25 and 37.33 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM), at 90 and 120 DAP respectively. The increase in plant height on the combined application of bio inoculant like *Azospirillum* and PSB might be due to fixing the atmospheric nitrogen and solubilizing fixed phosphorous in soil and make it available to plant. Similar findings have been reported by Harish, *et al.*, 2018) [1].

Plant spread (E-W) (cm)
It was evident for on the data presented in table 1 that plant spread varied significantly on application of integrated nutrient management. There was significant effect of integrated nutrient management on Plant spread (E-W). The maximum plant spread (17.23, 28.36, 30.52 and 34.30 cm) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) at 30, 60, 90 and 120 DAP respectively. This was significantly followed with T_8 (RDF 50% + RDF 50% through FYM + Azo + PSB). The minimum plant spread (E-W) (9.33 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM) at 30 DAP, it was on par with T_2 (RDF 50% +RDF 50% through VC) and T_3 (RDF 50% +RDF 50% through VC + Azo). At 60 DAP the minimum plant spread (E-W) (18.60 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM) and it was on par with T_2 (RDF 50%+RDF 50% through VC) At 90 DAP, significantly minimum plant spread (E-W) (19.43 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM) and 120 DAP the minimum plant spread (E-W) (24.13 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM) and it was on par with T_2 (RDF 50%+RDF 50% through VC). Remaining other treatments showed intermediate results. Similar as reported as Kumawat, *et al.*, 2017) [5].

Plant spread (N-S) (cm)
The data presented in table 1, reveals that plant spread (N-S) is significantly affected by integrated nutrient management. The maximum plant spread (16.23, 29.20, 31.33 and 36.43 cm) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) at 30, 60, 90 and 120 DAP respectively. This was significantly followed by T_8 (RDF 50% + RDF 50% through FYM + Azo + PSB). The minimum plant spread (N-S) (8.5 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM) at 30DAP, it was on par with T_2 (RDF 50%+RDF 50% through VC) and T_3 (RDF 50% +RDF 50% through VC + Azo). At 60 DAP the minimum plant spread (N-S) (19.40 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM) it was on par with T_2 (RDF 50%+RDF 50% through VC). At 90 and 120 DAP, significantly minimum plant spread (N-S) (22.53 & 27.50 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM). Remaining other treatments showed intermediate results. The increase in plant spread on the combined application of *Azospirillum*, PSB and vermicompost might be due to their beneficial effect in combination with the inorganic fertilizers. Inorganic fertilizers might have supplied the optimum macronutrients, whereas, bio fertilizers might have provided growth promoting substances (Krushnaiah, *et al*. 2018) [2].

Number of leaves per plant
Number of leaves are significantly influenced by integrated nutrient management. (Table 1) The maximum number of leaves per plant (15.20) at 30 DAP was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) which was on par with T_8 (14.26) (RDF 50% + RDF 50% through FYM + Azo + PSB). Significantly minimum number of leaves per plant (10.53) was recorded in T_5 (RDF 50% + RDF 50% through FYM). At 60, 90 and 120 DAP, the maximum number of leaves per plant (45.06, 81.20 and 198.06) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) which was significantly followed by T_8 (RDF 50% + RDF 50% through FYM + Azo + PSB). The minimum number of leaves per plant (30.80, 58.93 and 151.60) was recorded in T_5 (RDF 50% + RDF 50% through FYM) at 60, 90 and 120 DAP respectively. Remaining other treatments showed intermediate results. The increasing number of leaves per plant might be due to balanced availability of nutrients and growth promoting hormones produced by different bio-fertilizers applied in different treatment combinations (Pandey, *et al.* 2018) [8]. Similar findings were also reported by Sathyanarayana *et al.* (2017) [12] in gladiolus.

Leaf length (cm)
It is clear from the data presented in table 1 pertaining to leaf length (cm) is significantly influenced by integrated nutrient management. The maximum leaf length (14.66, 17.50 and 19.50 cm) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) at 30, 60 and 90 DAP respectively, which was significantly followed by T_8 (RDF 50% + RDF 50% through FYM + Azo + PSB). The minimum leaf length (9.33 and 12.20 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM) at 30 and 60 DAP respectively and was on par with T_2 (RDF 50%+RDF 50% through VC). At 90 DAP the minimum leaf length (13.70 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM). Remaining other treatments showed intermediate results. Azospirillum and PSB increased the availability of nitrogen and phosphorus to the plants and might have produced several growth hormones *viz.* auxins, cytokinins and gibberellins etc., which may have the influence on leaf length. The reduction in leaf length in T_5 might be due to the lack of nutrition to the plants which received half dose of RDF through inorganic and other half dose through FYM, hence, in the absence of bio fertilizers they could not assimilate required food materials to support the vegetative growth similar as reported as (Krushnaiah, *et al*., 2018) [2].

Leaf width (cm)

The leaf width is significantly affected by integrated nutrient management. (Table 2 and fig. 2). The maximum leaf width (1.66, 2.72 and 2.85 cm) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) at 30, 60 and 90 DAP respectively, which was significantly followed by T_8 (RDF 50% + RDF 50% through FYM + Azo + PSB). At 30 DAP the minimum leaf width (0.93 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM). At 60 and 90 DAP the minimum leaf width (1.60 and 1.76 cm) was recorded in T_5 (RDF 50% + RDF 50% through FYM) respectively and was on par with T_2 (RDF 50%+RDF 50% through VC). Closed as result reported as Kumari, *et al*., 2014) [4].

Leaf area (cm^2)

The data in the table 2 and fig.2 clearly indicated that leaf area is significantly affected by integrated nutrient management. The maximum leaf area (14.61, 15.70 and 16.68 cm2) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) at 30, 60 and 90 DAP respectively, which was significantly followed by T_8 (RDF 50% + RDF 50% through FYM + Azo + PSB). Significantly the minimum leaf area (9.13, 10.13 and 11.02 cm2) was recorded in T_5 (RDF 50% + RDF 50% through FYM) at 30, 60 and 90 DAP respectively. Remaining other treatments showed intermediate results. Similar findings have been reported by Mamta, *et al*., 2017) [6].

Number of Suckers per plant

Number of suckers per plant was significantly affected by integrated nutrient management in Italian aster. (Table 2 and fig.2). The maximum number of suckers per plant (6.33, 10.16 and 15.46) was recorded in T_7 (RDF 50% + RDF 50% through VC + Azo + PSB) at 60, 90 and 120 DAP respectively, and it was significantly followed by T_8 (RDF 50% + RDF 50% through FYM + Azo + PSB). At 60 and 90 DAP the minimum number of suckers per plant (1.16 and 6.50) was recorded in T_5 (RDF 50% + RDF 50% through FYM), which was on par with T_2 (RDF 50%+RDF 50% through VC). At 120 DAP the minimum number of suckers per plant (10.06) was recorded in T_5 (RDF 50% + RDF 50% through FYM). Combined application of inorganic, organic and biofertilizers enhances the number suckers per plant. *Azospirillum* fixes the atmospheric nitrogen and PSB mobilize phosphorous making these elements available for plant growth and development. *Azospirillum* secretes certain growth promoting substances like auxin, gibberellins, vitamins and organic acids which improve the growth. Whereas, PSB has ability to fix higher dose of phosphorous which stimulate root growth and enhances the absorption of nutrients and continuous supply and uptake of nutrients with higher moisture content thus resulting vigorous growth and enhances the number suckers per plant (Parmar, *et al.* 2017) [10].

Table 1: Effect of Integrated Nutrient Management on Plant height (cm), Plant Spread (cm) E-W, Plant Spread (cm) N-S, and No. of leaves per plant Italian Aster (*Aster amellus* L.) cv. "Purple Multipetal"

Treatments	Plant height (cm)				Plant spread (cm) E-W				Plant spread (cm) N-S				No. of leaves per plant			
	30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP
T_1=100% RDF	16.63	27.31	44.79	56.58	14.16	25.23	26.76	31.03	13.23	26.06	27.7	32.66	13.4	38.4	70.66	175.8
T_2=RDF 50%+RDF 50% through VC	14.83	20.33	29.47	42.08	10.33	20.3	22.1	25.06	9.5	21.13	24.36	28.36	11.86	33.6	60.8	160.26
T_3=RDF 50% +RDF 50% through VC + Azo	15.46	23.43	34.73	48	11.01	21.4	23.23	26.4	10.16	22.4	25.1	29.5	12.46	35.13	65.06	168.06
T_4=RDF 50%+ RDF 50% through VC + PSB	16.33	25.76	40.3	54.33	12.16	24.1	26.3	29.2	11.13	24.93	27.16	31.3	13.13	36.46	68.26	170.53
T_5=RDF 50% + RDF 50% through FYM	13.43	17.46	28.25	37.33	9.33	18.6	19.43	24.13	8.5	19.4	22.53	27.5	10.53	30.8	58.93	151.6
T_6 =RDF 50% + RDF 50% through FYM + PSB	16.2	23	38.16	50.33	12.01	23.16	25.45	27.8	11.01	24.03	26.3	30.86	12.76	34.26	63.93	165.26
T_7= RDF 50% + RDF 50% through VC + Azo + PSB	18.36	32.2	52.16	64.25	17.23	28.36	30.52	34.3	16.23	29.2	31.33	36.43	15.2	45.06	81.2	198.06
T_8 = RDF 50% + RDF 50% through FYM + Azo + PSB	17.43	29.72	47.16	58.36	15.16	26.13	28.37	32.45	14.33	26.63	29.46	33.4	14.26	40.8	75.33	180.2
Mean	16.08	24.9	39.38	51.41	12.67	23.41	25.27	28.79	11.76	24.22	26.74	31.25	12.95	36.81	68.02	171.22
S.Em ±	0.34	0.75	0.4	1.5	0.57	0.68	0.53	0.47	0.55	0.65	0.57	0.63	0.34	0.48	0.58	0.58
CD at 5%	1.02	2.27	1.2	4.54	1.72	2.07	1.6	1.43	1.69	1.97	1.73	1.92	1.04	1.47	1.77	1.76

Where,

DAP: Days after planting

Azo: Azospirillum sp.

PSB: Phosphate solubilizing bacterium

FYM: Farm Yard Manure

VC: Vermicompost

RDF: Recommended dose of fertilizers

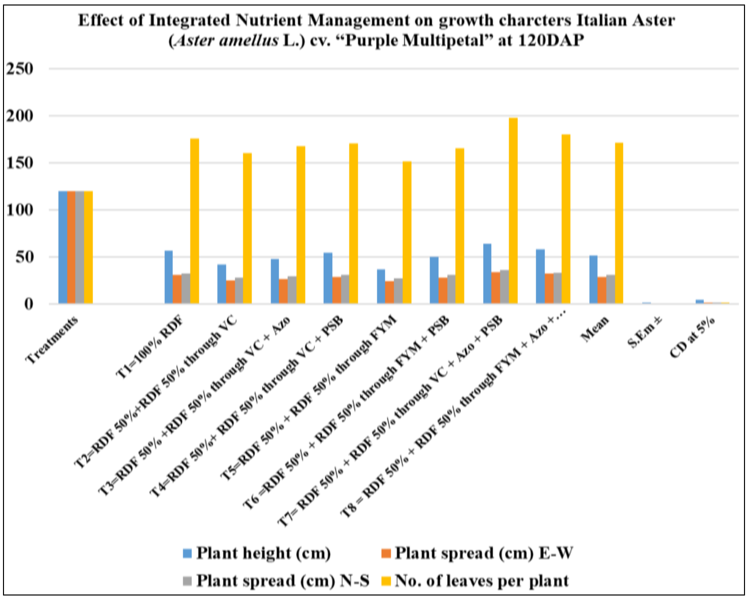


Table 2: Effect of Integrated Nutrient Management on Leaf length (cm), Leaf width (cm), Leaf area(cm^2), and No. of suckers per plant Italian Aster (*Aster amellus* L.) cv. "Purple Multipetal"

Treatments	Leaf length (cm)			Leaf width (cm)			Leaf area(cm^2)			No. of suckers per plant		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	60 DAP	90 DAP	120 DAP
T_1=100% RDF	12.01	15.16	16.9	1.41	2.28	2.41	12.21	13.2	14.32	3.86	8.5	13.23
T_2=RDF 50%+RDF 50% through VC	10.06	13.03	14.7	1.13	1.75	1.81	10.06	11.06	12.1	1.1	7.13	10.7
T_3=RDF 50% +RDF 50% through VC + Azo	10.5	13.53	15.06	1.25	1.93	2.01	10.83	11.33	12.35	1.36	7.6	11.8
T_4=RDF 50%+ RDF 50% through VC + PSB	11.66	14.53	16.73	1.39	2.16	2.3	11.53	12.53	13.75	3.26	8.66	12.8
T_5=RDF 50% + RDF 50% through FYM	9.33	12.2	13.7	0.93	1.6	1.76	9.13	10.13	11.02	1.16	6.5	10.06
T_6 =RDF 50% + RDF 50% through FYM + PSB	11.01	14.06	16.07	1.32	2.06	2.2	10.54	12.23	13.27	2.2	8.4	12.56
T_7= RDF 50% + RDF 50% through VC + Azo + PSB	14.66	17.5	19.5	1.66	2.72	2.85	14.61	15.7	16.68	6.33	10.16	15.46
T_8 = RDF 50% + RDF 50% through FYM + Azo + PSB	13.03	15.7	17.66	1.49	2.4	2.51	13.1	14.03	15.16	4.53	9.6	14.36
Mean	11.53	14.46	16.29	1.32	2.11	2.23	11.5	12.53	13.58	2.97	8.32	12.62
S.Em ±	0.4	0.55	0.23	0.04	0.08	0.09	0.27	0.19	0.16	0.36	0.35	0.33
CD at 5%	1.2	1.66	0.71	0.13	0.24	0.29	0.82	0.59	0.49	1.09	1.08	1.02

Where,

DAP: Days after planting

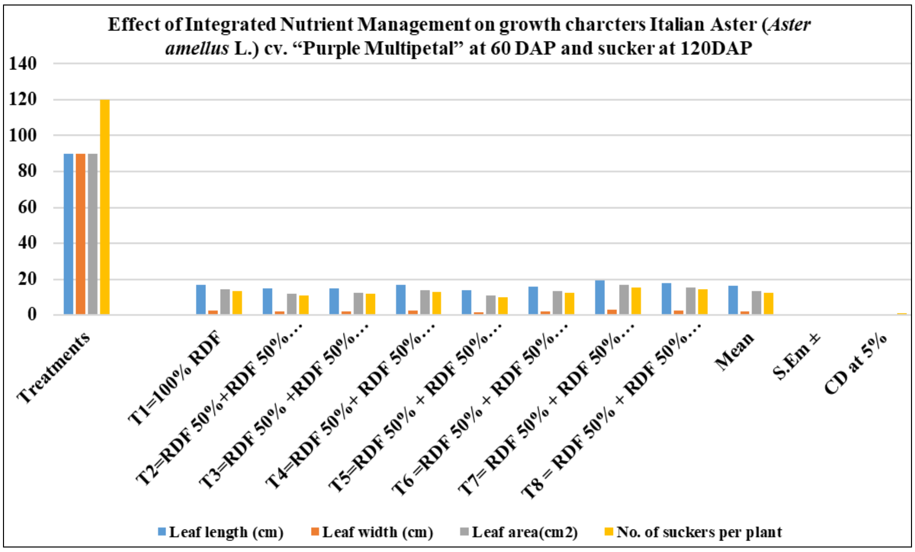
Azo: Azospirillum sp.

PSB: Phosphate solubilizing bacterium

FYM: Farm Yard Manure

VC: Vermicompost

RDF: Recommended dose of fertilizers



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