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Effect of Integrated Nutrient Management on Flowering, Flower Quality and Flower Yield of Gaillardia (*Gaillardia pulchella* Foug.) under Hill Zone of Karnataka

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ABSTRACT: **The integrated nutrient management (INM) focuses at efficient and judicious use of the major sources of plant nutrients. It is done in an integrated manner so as to get maximum economic yield without any deleterious effect which is affecting the physio-chemical and biological properties of the soil. Only few experimental study has been done in gaillardia for integrated nutrient management. With this background an experiment was conducted at the Experimental block located at the department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere during 2021-22. The experiment was laid out in Randomized Block Design (RBD) having twelve treatments *viz.*, T_1-75% Recommended Dose of Fertilizers + vermicompost @ 1.25 t/ha T_2-50% RDF + vermicompost @ 2.5 t/ha, T_3 -75% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha, T_4 -50% RDF+ vermicompost@ 2.5 t/ha + *Azospirillum* @ 2 kg/ha, T_5-75% RDF + *Azospirillum* @ 2 kg/ha + VAM@2 kg/ha, T_6 - 50% RDF + *Azospirillum* @ 2 kg/ha + VAM @2 kg/ha, T_7-75% RDF+ vermicompost @ 1.25 t/ha + VAM @2 kg/ha, T_8-50% RDF+ vermicompost @ 2.5 t /ha + VAM @2 kg/ha, T_9-75% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @2 kg/ha, T_{10}-50% RDF + vermicompost @ 2.5 t/ha +*Azospirillum* @ 2 kg/ha + VAM @2 kg/ha, T_{11}-100% RDF + vermicompost @1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha and T_{12}-100% RDF (Control) replicated thrice. The treatment T_9-75% RDF+ vermicompost@ 1.25 t/ha + *Azospirillum*@ 2 kg/ha + VAM @2 kg/ha recorded the minimum days for 50 per cent flowering (78.30), maximum flowering duration (141.67 days), flower head diameter (6.58 cm), flower petiole length (39.20 cm), corolla length (3.09 cm), shelf life (3.13 days), vase life (5.67 days), average flower weight (3.48 g), number of flowers per plant (104.30), flower yield per hectare (22.09 tonnes)and it was statistically on par with the treatment comprising of T_{11}-100% RDF + vermicompost@ 1.25 t/ha + *Azospirillum*@ 2 kg/ha + VAM@ 2 kg/ha. Hence, this treatment proved to be promising for the enhancement the flower quality and yield of gaillardia under hill zone of Karnataka.**

Keywords: Gaillardia, integrated nutrient management, flowering, flower quality and yield.

INTRODUCTION

Gaillardia (*Gaillardia pulchella*), a member of the family Asteraceae, is native of Central and Western United States. The generic name Gaillardia stands in honour of M. Gaillard, a French patron of botany (Bailey, 1929). It is popularly known as blanket flower. Because of its wide array of colours and patterns including Mexican blankets, gold tipped with russet - red centers but recent introductions have expanded the colour range further. *Gaillardia pulchella* is diploid (2n=36) as reported by Moringa *et al*. (1929). The cultivars of *G. pulchella* have single or double flowers with different colours red, orange yellow, yellow-tipped red, red tipped yellow, bronzed - scarlet and others. Despite its utility for landscape, gaillardia is also useful in reduction of soil erosion in coastal areas (Carig, 1977). Gaillardia flourishes well in all kind of garden soils and it can also tolerate high level of light intensities, drought as well as high temperature in a better way as compared to most of the flowering plants. Up to a certain extent it can also tolerant to soil salinity (Tija and Rose 1988).

This is a flower crop which can be utilized as a substitute for chrysanthemum, China aster and marigold etc. of other Asteraceae family crops (Bose *et al*., 2003). Panchaude (1990) reported that gaillardia also has some nematicidal property, it is grown as a catch crop as well as a crop for green manure. The plant has anti-tumour activity owing to the presence of methyl caffeate distributed throughout the plant (Srivastava and Kandpal 2006).

In Karnataka, cultivation of this crop is concentrated in districts such as Belgaum, Dharwad and Bijapur. The growing popularity of this crop has led to expand its cultivation to other parts of the state. The farmers in southern Karnataka are lured by the flower and are braced to take up cultivation of the same on a large scale. In North Karnataka, flowers are used for making *veni* and garlands (Arulmani *et al.,* 2016).

In modern agriculture, the use of chemical fertilizers is an essential. To keep the sustainability of yield it is important, but it poses problems to soil health in long span of time. Therefore, there is a need to restrict the use of chemical fertilizers to certain limit (Gotmare *et al*., 2007). The integrated nutrient management (INM) focuses at efficient and judicious use of all the major sources of plant nutrients. Nutrients applied in an integrated manner to get maximum economic yield without any deleterious effect which is affecting the physio-chemical and biological properties of the soil.

The nutritional management of gaillardia crop can manifest the performance of the crop. There is an incessant demand for integrated nutrient management. The integrated nutrient management focuses at getting higher yield, quality, and safeguards the interests of farmers and environmental concerns. Hence, the present experimental study was conducted to evaluate the effect of integrated nutrient management on flowering, flower quality and yield of gaillardia.

The multifarious effects of vermicompost influence the growth and yield of crops. *Azospirillum* is a bacterial associative symbiotic biofertilizer contributes in fixation of nitrogen. The vesicular arbuscular mycorrhiza (VAM) is a beneficial fungus that plays an important role in soil nutrient dynamics improving soil physical, chemical and biological properties. VAM is able to alter mobilization of soil phosphorous dynamics in the rhizosphere and mycorrhizal mechanisms (Sharma, 2006).

MATERIALS AND METHODS

Studies were carried out at the experimental block, Department of Floriculture and Landscape Architecture located at College of Horticulture, Mudigere, Keladi Shivappa Nayaka University of Agriculture and Horticultural Sciences, Shivamogga during 2021 - 22. The soil was prepared to fine tilth.The plot size of 2 m × 1.5 m were prepared under open field condition. Gaillardia seedlings were transplanted at a spacing of 45 cm × 30 cm. The experiment was laid out in randomized block design (RBD) with twelve treatment combinations consisting of inorganic fertilizers (150:80:60 kg NPK), FYM, Vermicompost and bio-fertilizers like VAM, *Azospirillum* with three replications. The different organic manures like FYM, vermicompost and biofertilizers like VAM, *Azospirillum* were supplemented as basal dose according to the treatment to respective plots before transplanting gaillardia seedlings. The recommended dose of chemical fertilizers for gaillardia at 150:80:60 kg NPK per hectare has been applied according to the treatments. 50 per cent dose of nitrogen and full dose of phosphorus and potash were applied as basal dose before transplanting of gaillardia. The balance of 50 per cent dose of nitrogen was applied as top dressing at 30 days after transplanting of the seedlings. Treatments included T_1 - 75 % Recommended Dose of Fertilizers + vermicompost @ 2.5 t/ha, T_2 - 50 % RDF + vermicompost @ 1.25 t/ha, T_3 - 75 % RDF + vermicompost @ 2.5 t/ha + *Azospirillum* @ 2 kg/ha, T_4 - 50 % RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha, T_5 - 75 % RDF+ *Azospirillum* @ 2 kg/ha + VAM @2 kg/ha, T_6 - 50 % RDF + *Azospirillum* @ 2 kg/ha + VAM @2 kg/ha, T_7 - 75 % RDF + vermicompost @ 2.5 t /ha + VAM @2 kg/ha, T_8 - 50 % RDF + vermicompost @ 1.25 t/ha + VAM @2 kg/ha, T_9 - 75 % RDF + vermicompost @ 1.25 t/ha + *Azospirillum*@ 2 kg/ha + VAM @2 kg/ha, T_{10} - 50 % RDF + vermicompost@ 2.5 t/ha + *Azospirillum* @ 2 kg/ha + VAM @2 kg/ha, T_{11} - 100 % RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha and T_{12} - 100 % RDF (Control). The observations were recorded at 30, 60 and 90 DAT and were statistically analysed.

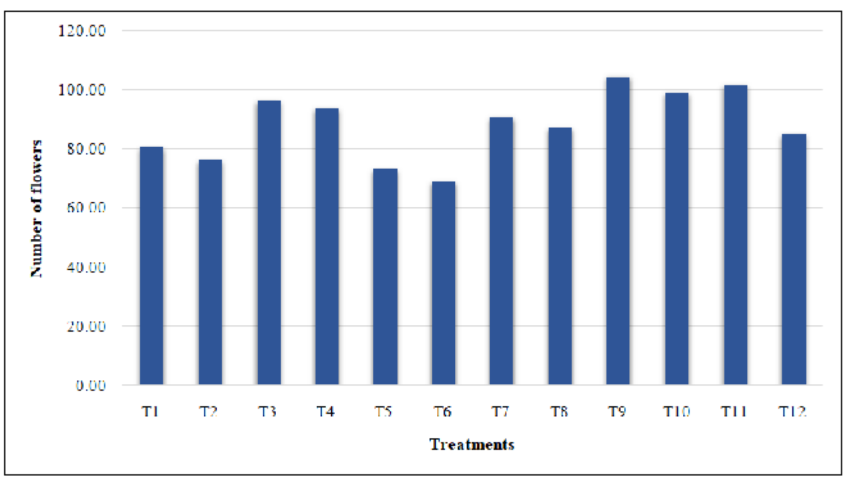

Fig 1. Effect of integrated nutrient management on number of flowers per plant of gaillardia.

Table 1: Effect of integrated nutrient management on flowering parameters of gaillardia.

Tr. No.	Treatment details	Days taken for visible flower bud formation	Days taken for flower stalk emergence	Days taken for blooming	Days taken for 50% flowering	Flowering duration (days)
T_1	75 % RDF + VC @ 1.25 t/ha	66.77	68.63	74.63	99.30	123.33
T_2	50 % RDF + VC @ 2.5 t/ha	67.90	70.77	76.77	102.10	120.67
T_3	75% RDF + VC @ 1.25 t/ha + Azo @ 2 kg/ha	56.50	59.50	66.20	87.17	135.00
T_4	50% RDF + VC @ 2.5 t/ha + Azo @ 2 kg/ha	58.43	61.97	68.43	90.43	133.33
T_5	75% RDF + Azo @ 2 kg/ha + VAM @ 2 kg/ha	69.30	72.23	78.57	103.57	118.67
T_6	50% RDF + Azo @ 2 kg/ha + VAM @ 2 kg/ha	70.20	74.97	79.97	105.30	116.00
T_7	75% RDF + VC @ 1.25 t/ha + VAM @ 2 kg/ha	60.80	63.23	71.03	92.90	131.33
T_8	50% RDF + VC @ 2.5 t/ha + VAM @ 2 kg/ha	62.80	64.47	72.80	94.80	127.67
T_9	75% RDF + VC @ 1.25 t/ha+ Azo @ 2 kg/ha + VAM @ 2 kg/ha	49.37	53.03	59.03	78.30	141.67
T_{10}	50% RDF + VC @ 2.5 t/ha + Azo @ 2 kg/ha + VAM @ 2 kg/ha	53.87	57.53	64.20	85.20	136.67
T_{11}	100% RDF + VC @ 1.25 t/ha +Azo @ 2 kg/ha + VAM @ 2 kg/ha	50.57	55.07	61.13	80.67	138.33
T_{12}	100% RDF (Control)	64.30	66.47	62.80	97.80	124.67
S. Em±		**0.76**	**0.78**	**0.80**	**0.83**	**1.17**
C.D @ 5%		**2.24**	**2.28**	**2.35**	**2.44**	**3.42**

RDF = Recommended Dose of Fertilizers VC = Vermicompost Azo = *Azospirillum* VAM= Vesicular Arbuscular Mycorrhiza

Table 2: Effect of integrated nutrient management on flower quality and yield parameters of gaillardia.

Tr. No.	Treatment details	Flower head diameter (cm)	Average flower weight (g)	Shelf life (days)	Flower yield per plant (g)	Flower yield per plot (kg)	Flower yield per hectare (t)
T_1	75 % RDF + VC @ 1.25 t/ha	4.91	2.95	2.03	237.21	3.32	16.56
T_2	50 % RDF + VC @ 2.5 t/ha	4.57	2.88	1.90	219.07	3.07	16.12
T_3	75% RDF + VC @ 1.25 t/ha + Azo @ 2 kg/ha	5.97	3.24	2.80	311.29	4.36	19.89
T_4	50% RDF + VC @ 2.5 t/ha + Azo @ 2 kg/ha	5.81	3.17	2.65	296.38	4.15	19.20
T_5	75% RDF + Azo @ 2 kg/ha + VAM @ 2 kg/ha	4.21	2.81	1.77	205.09	2.87	15.89
T_6	50% RDF + Azo @ 2 kg/ha + VAM @ 2 kg/ha	3.92	2.72	1.56	187.18	2.62	15.46
T_7	75% RDF + VC @ 1.25 t/ha + VAM @ 2 kg/ha	5.50	3.13	2.44	283.32	3.97	18.49
T_8	50% RDF + VC @ 2.5 t/ha + VAM @ 2 kg/ha	5.34	3.07	2.31	267.05	3.74	17.85
T_9	75% RDF + VC @ 1.25 t/ha+ Azo @ 2 kg/ha + VAM @ 2 kg/ha	6.58	3.48	3.13	363.51	5.09	22.09
T_{10}	50% RDF + VC @ 2.5 t/ha + Azo @ 2 kg/ha + VAM @ 2 kg/ha	6.08	3.32	2.95	328.19	4.59	20.38
T_{11}	100% RDF + VC @ 1.25 t/ha +Azo @ 2 kg/ha + VAM @ 2 kg/ha	6.40	3.41	3.04	346.12	4.85	21.01
T_{12}	100% RDF (Control)	5.17	3.03	2.14	256.77	3.59	17.07
S. Em±		**0.07**	**0.04**	**0.03**	**6.79**	**0.10**	**0.51**
C.D @ 5%		**0.21**	**0.13**	**0.09**	**19.91**	**0.28**	**1.51**

RESULTS AND DISCUSSION

The findings of the study were interpreted and listed in Table 1, 2 and Fig. 1 based on the observations recorded.

Effect of integrated nutrient management on flowering parameters

Days taken for visible flower bud initiation and flower stalk emergence. Treatment T_9 (75% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) recorded significantly minimum days after transplanting for first visible flower bud formation (49.37) and flower stalk emergence (53.03 days) which was on par with the treatment T_{11} (100% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) 50.57 days for visible flower bud emergence and flower stalk emergence (55.07 days). The treatment T_6 (50% RDF + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) recorded maximum number of days after transplanting (70.20) for visible flower bud initiation and flower stalk emergence (74.97 days). This might be due to the increased C:N ratio. Which resulted in increased the assimilation of photosynthates. This enhanced the source sink relationship and induced early transformation from vegetative to reproductive phase.

Translocated nutrients from shoots to buds reduced the days taken for flowering in gaillardia. The breakdown of apical dominance influenced by enhanced nutrient availability also impacted the faster bud initiation. Phosphorus is the essential nutrient for flowering in plants. The similar findings were reported in experiments done by Parmar *et al*. (2006) in gaillardia, Patel *et al.* (2015) in gaillardia.

Days taken for blooming and 50 per cent flowering. The plants treated with the treatment T_9 (75% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) recorded significantly minimum days for blooming (59.03) and 50 per cent flowering (78.30 days)which was on par with the treatment T_{11} (100% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) for blooming (61.13 days) and 50 per cent flowering (80.67 days). Whereas, the treatment T_6 (50% RDF + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) took maximum days for blooming (79.97) and 50 per cent flowering (105.30 days). Application of VAM might have mobilized the phosphorus to rhizosphere, thus increased the P uptake of roots. This might have reduced the days taken for flowering. Gibberellin produced in vermicompost also resulted in early flowering of gailardia. The results are in line with the research findingsof Patil *et al.* (2020) in chrysanthemum, Prasad *et al.* (2018) in dahlia and Bose *et al*. (2018) in china aster.

Duration of flowering. The plant applied with the treatment T_9 (75% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) increased the flowering duration (141.67 days) of gailardia when compared to control and other treatments. The optimum dose of NPK is needed for induction of early flowering and maximum duration of flowering. Continuous supply of nutrients due to the increased accumulation of them in plant parts encouraged the long duration of flowering. The similar experimental results also reported by Thumar *et al*. (2013) in marigold, Garge *et al*. (2019) in french marigold.

Effect of integrated nutrient management on flower quality parameters of gaillardia

Flower head diameter. The data enumerated in table 2 on flower head diameter in gaillardia as influenced by different nutritional treatments revealed that the treatment T_9 (75% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) recorded significantly maximum flower head diameter (6.58 cm) which was on par with the treatment T_{11} (100% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) (6.40 cm). Whereas, the treatment T_6 (50% RDF + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) recorded minimum flower head diameter (3.92 cm).Colonization by mycorrhizal fungi also increases root surface area, thus triggers higher nutrient acquisition. Induced source sink relationship also might have promoted the flower quality parameters in gaillardia. The experimental results are in accordance with the studies of Gadagi *et al.* (2004) in marigold, Patel *et al.* (2015) in gaillardia, Koli and Jayanthi (2018) in marigold.

Shelf life. The treatment T_9 recorded significantly maximum shelf life (3.13 days) which was on par with the treatment T_{11} (3.04 days). Whereas, the treatment T_6 recorded minimum shelf life (1.56 days). Degeneration of water conducting tissues might have reduced by phytohormonal activities of vermicopost, *Azospirillum* and VAM. Shelf life of gaillardia flowers might have extended by biofertilizers. Higher water retention capacity and lesser desiccation of cells exhibited due to the integration of organic manure and biofertilizers might have enhanced the shelf life and vase life of gaillardia flowers. Similar results observed by Kumar *et al*. (2016) in marigold, Ravindra *et al*. (2013) in china aster and Pandey *et al.* (2018) in chrysanthemum.

Effect of integrated nutrient management on yield parameters of gaillardia

Average flower weight. The treatment T_9 (75% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) recorded significantly maximum average flower weight (3.48 g) which was on par with the treatment T_{11} (100% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) (3.41 g). Whereas, the treatment T_6 (50% RDF + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) recorded minimum average flower weight (2.72 g). It might be due to the activities of vermicompost and biofertilizers. Increased flower diameter and corolla length resulted in maximum individual flower weight. The experimental results are in accordance with the findings of Mittal *et al.* (2010) in marigold, Koli and Jayanthi (2018) in marigold, Kaushik and Singh (2020) in marigold.

Number of flowers per plant. The treatment T_9 (75% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) produced significantly more number of flowers (104.30). This might be due to the increased vegetative growth, as they have produced more number of branches and thus more number of flower buds are initiated compared to control. The increased plant growth accelerated the production of more number of flowers. The results are in accordance with the findings of Gadagi *et al*. (2004) in gaillardia, and Krushnaiah *et al*. (2018) in aster, Abdul *et al.* (2021) in dahlia and Zeighami *et al.* (2015) in Petunia.

Flower yield. The yield parameters *i.e.,* flower yield per plant (363.51 g), per plot (5.09 kg), per hectare (22.09 tonnes) recorded significantly maximum in the treatment T_9 (75% RDF + vermicompost @ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @ 2 kg/ha) as compared to control and other treatments. It might be due to the increased plant growth because of the application of vermicompost, *Azospirillum* and VAM. Growth promoting substances secreted by biofertilizers resulted in increase in yield. Increase in flower yield per plant resulted in maximum flower yield per plot and per hectare. The similar results were also reported by Rathod *et al*. (2002) in gaillardia, Parmar (2006) in gaillardia, Patel *et al.* (2015) in gaillardia, Thumar *et al.* (2013) in marigold and Prasad *et al.* (2018) in dahlia.

CONCLUSION

From the findings of present investigation, it could be concluded that the integrated application of nutrients by different sources *i.e.*, inorganic fertilizers, vermicopost, *Azospirillum* and VAM influence the plant growth, flowering, quality and yield of gaillardia. Hence, the treatment 75% RDF + vermicompost@ 1.25 t/ha + *Azospirillum* @ 2 kg/ha + VAM @2 kg/ha may be recommended for the commercial cultivation of gaillardia under hill zone of Karnataka.

FUTURE SCOPE

Future studies can be carried out to study the influence of organic mulches and bio-inoculants in gaillardia and to study the effect of integrated nutrient management with pinching in gaillardia.

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Conflict of Interest. None.

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