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Effect of integrated nutrient management on plant growth, flower yield of African marigold (*Tagetes erecta* L.)

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Abstract
The experiment was conducted in the experimental area of the department of Horticulture, Udai pratap autonomous college, Varanasi during winter season, 2014-15. The weather data recorded from meteorological observatory were maximum/minimum temperature/humidity were 25.90C and 13.20C / 90% and 51% respectively and 51 mm rainfall during the crop period. The experiment consisting of thirteen treatments with different combinations of inorganic fertilizers (RDF), organic manures (farm yard manure, vermicompost, poultry manure) and bio-fertilizers (azotobactor). The experiment was laid out in a Randomized Block Design with eight treatments replicated thrice. The results revealed that application of the treatment of T2 (75% RDF + 25% vermicompost) observed maximum plant growth and highest flower yield (16.64 t/ha). However the application of 50% RDF + 50% vermicompost (T6) was effective for enhancing shelf life in marigold.

Keywords: Biofertilizer, farmyard manure, flower yield, marigold

Introduction
African marigold c.v "Pusabasanti" is one of the traditional flower crops grown extensively in India. It has gained popularity among the flower growers and gardeners on account of its easy cultivation, long flowering habit and wide adaptability. Marigold is mainly grown in India, Tropical Africa, Sri Lanka and Madagascar. Marigold is broadly divided into two groups, *viz*., African marigold and French marigold (*Tagetes patula* L.). The former generally grows tall and is known as tall marigold and latter is short called as dwarf marigold, their origin to Mexico and South Africa, respectively. There is several other important species *viz*., *Tagetes tenuifolia* L. (striped marigold), *Tagetes lucida* L. (sweet scented marigold) and *Tagetes minuta* L. (perfume marigold).

African marigold is tall, erect-growing plants, up to approximately three feet in height. The flowers are globe-shaped and large, flowers measures up to 5 inches across. These flowers are yellow to orange and do not include red colour marigold. French marigold is dwarf with compact growth (30-40cm) and flowers profusely in singles or doubles. The recent extra dwarf plants (15cm) look just like cushions fully covered with blooms. The colour range is deep scarlet, mahogany rusty red, prim rose, golden yellow orange and combination of these colors. Though the African marigold is one of the important commercial flower crops, its yield levels are quite low and hence there is a need to standardize the optimum dose of nutrients particularly the integrated nutrient management for improving the soil structure, physical chemical properties and flower yield. Marigold is a heavy feeder of nutrients specially nitrogen and phosphorus. At present, these nutrients are supplied through chemical fertilizers. The indiscriminate and continuous use of chemical fertilizers has leads to an imbalance of nutrients in soil which has an adversely effected the soil health, affecting the yield and quality of the product.

Total organic farming may be a desirable proposition for improving the quality of agricultural produce. It may not be possible to maintain the quality of the produce in commercial agriculture, where mostly the stress will be given mainly on yield. It is impossible to meet the nutrient requirement of the crops, exclusively through the organic farming. Under these circumstances, integrated soil fertility management practices involving judicious combination of organic manures, bio-fertilizers and chemical fertilizers seems to be a feasible option for sustained agriculture on a commercial and profitable scale. Bio-fertilizers or more

appropriately called 'microbial inoculants' are the preparations containing live or latent cells of efficient strains of microorganisms. These may be biological nitrogen fixers, mineralization of nitrogen and transformation of several elements like sulphur and iron into available forms. Therefore, the use of organic manures and bio-fertilizers along with the balanced use of chemical fertilizers is known to improve physical, chemical and biological properties of soil, besides improving the efficiency.

Keeping all these points in vision an investigation was carried out to find out the effect of integrated nutrient management on plant growth, flower, yield and economics of cultivation of African marigold.

Material and Methods

An investigation was carried out at horticulture experimental field, department of Horticulture, Udai pratap autonomous college, Varanasi during winter season, 2014-15.

The weather data recorded from meteorological observatory were maximum/minimum temperature/humidity were 25.9^{0}C and 13.2 ^{0}C / 90% and 51% respectively and 51 mm rainfall during the crop period (fig 1).

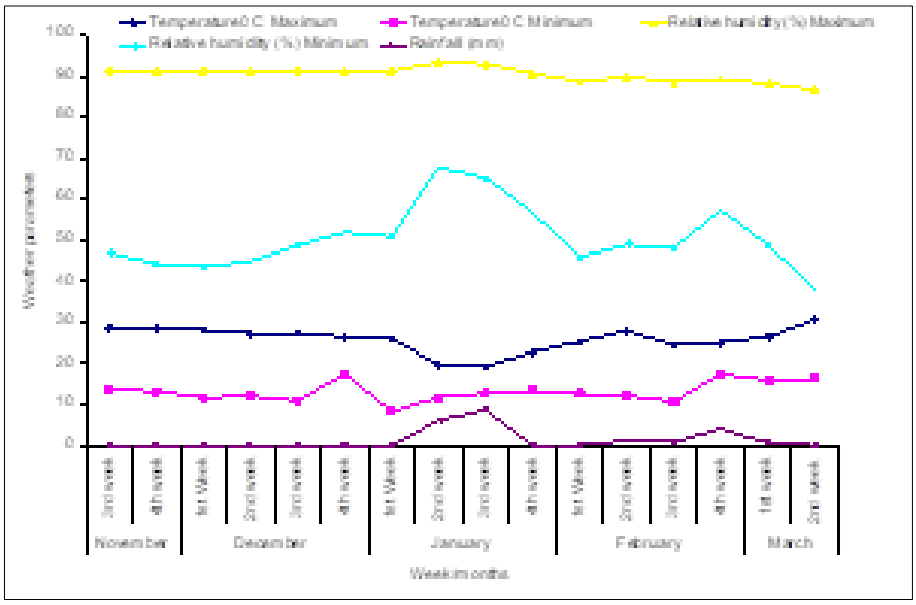

Fig 1: Meteorological data recorded during experimental period

The experimental site is fairly level land with sandy loam soil of uniform fertility status with low clay and high sand percentage. Soil samples were collected at random spots from depth of 0-30 cm for soil analysis. Soil contains 48.15% sand, 21.34% silt and 30.51% clay. Chemical properties of soil comprises 6.87 pH, 0.15 dsm^{-1} electrical conductivity, 0.44% organic carbon, 212.56 kg/ha available nitrogen, 37.32 kg/ha phosphorus and 210.05 kg/ha potash. The seeds of marigold cultivar 'Pusa basanti' were sown on raised nursery beds and after seedlings germination regularly watered and timely plant protection measures were taken up. Regarding preparation of experimental field, the land was brought to a fine tilts by repeated ploughing and harrowing. All the weeds and stubbles of previous crop were completely removed. The entire experimental land was divided into small plots of 2 m x 1.8 m size with 30 cm thick bunds. Irrigation channels of 0.5 m size were provided between the replications. The healthy and uniform seedlings of twenty five days old were transplanted in field at 4 leaf stage during evening hours. Light irrigation was given after transplanting for better establishment of seedlings in the main field. The experimental plot was kept weed free by regular hand weeding and hoeing. Irrigations were given twice in a week during the initial stages and later at an interval of 7-9 days depending upon the soil moisture content during the entire period of crop growth. The apical growing buds of the plants were hand pinched at 30 days after transplanting to produce more number of lateral shoots and good quality uniform flowers. Prophylactic plant protection measures were adopted for controlling common pests and diseases. The flowers with the central whorls of petals fully open were harvested in the early morning hours.

During the experiment the organic manures were applied 10 days prior to transplanting, for proper decomposition whereas; inorganic fertilizers were applied 10 days after transplanting according to the treatments. Half the dose of N and entire dose of P and K were applied as basal dose ten days after transplanting and remaining dose of N was applied at 30 days after transplanting. The inorganic fertilizers were applied in the form of urea (N), DAP (N & P) and MOP (K) at the rate of 136 kg/ha, 208 kg/ha, 133 kg/ha respectively.

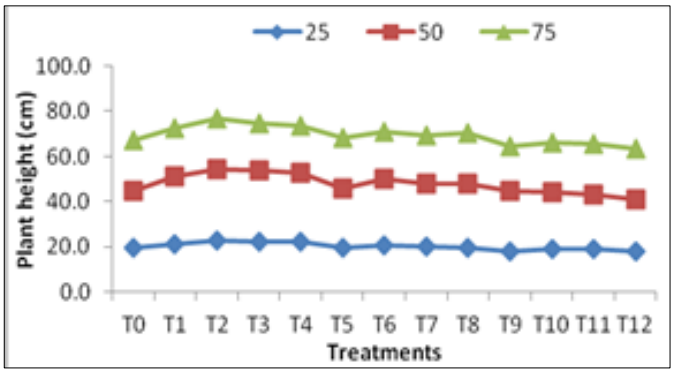

Fig 2: Plant height after 25,50 and 75 days after transplanting

Whereas, the bio-fertilizers like Azotobactor were applied at the time of transplanting through soil application. Soil application of bio-fertilizer @ 1.8 g in 100 g of organic

fertilizer by mixing with field soil at the recommended rate was applied uniformly in the soil and watered well. Treatments comprises T0- Control- RDF (100:100:80 N P K Kg/ha), T1-75% RDF + 25% FYM, T2-75% RDF + 25% Vermicompost, T3-75% RDF + 25% Poultry manure, T4-75% RDF + Azotobactor@5kg/ha, T5-50% RDF + 50% FYM, T6-50% RDF + 50% Vermicompost, T7-50% RDF + 50% Poultry manure, T8-50% RDF +Azotobactor@5 kg/ha, T9-25% RDF + 75% FYM, T10-25% RDF+75% Vermi compost, T11-25% RDF+75% Poultry manure, T12-25% RDF+Azotobactor@5kg/ha. Recommended dose of fertilizer (RDF) for African marigold is 100:100:80 kg of Nitrogen (N), Phosphorus (P) and Potassium (K) per hectare (ha). The details of the observations recorded on 25, 50 and 75 days after transplanting on growth, flower, yield and economics of cultivation.

Results and Discussion

Plant growth

The plant height differed significantly due to application of organic manures, bio-fertilizer and inorganic fertilizers at all the growth stages. At 25, 50 and 75 DAT (days after transplanting) the maximum plant height was observed 22.87 cm, 54.27cm and 76.77cm respectively with treatment T2. The increase in the plant height in the treatment T2 might be due to the beneficial effect of vermicompost with recommended dose of inorganic fertilizers; similar findings were reported by, Sunitha *et al.* (2007) [9] and Pooja *et al.* (2012) [5] in marigold. Regarding number of primary branches per plant, at 25 days after transplanting the maximum number of primary branches was noticed in T2 10.26, at 50 and 75 days after transplanting it were maximum 15.27 and 19.40 respectively in treatment T2 (fig 3).

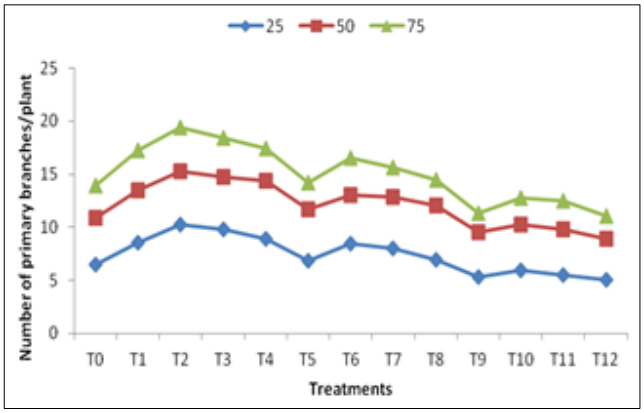

Fig 3: Number of primary branches/plant after 25,50 and 75 days after transplanting.

The higher number of primary branches per plant was reported in treatment T2 applied with vermicompost and recommended dose of fertilizers. Vermicompost application which might have supplied plant nutrients directly to the plants also had solubilizing effect on fixed form of nutrients favoring plant growth and stimulation and production of auxiliary buds resulting in formation of more number of branches. Similar findings were reported by Pooja *et al.* (2012) [5] in marigold. The number of secondary branches per plant differed significantly due to the application of organic manures, inorganic and biofertilizer at all stages of plant growth. At 25 days after transplanting the maximum 17.70 number of secondary branches were noticed in T2 whereas it was 24.8 at 50 days after transplanting and similar results were also noticed at 75 DAT (33.47) (fig 4).

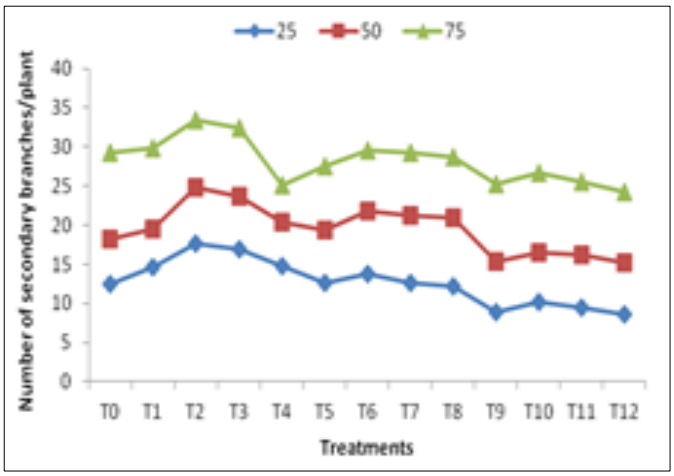

Fig 4: Number of primary branches/plant after 25,50 and 75 days after transplanting.

The higher number of secondary branches per plant with vermicompost and recommended dose of fertilizers might have favoured for stimulation and production of auxiliary buds resulting in formation of more number of branches. Pooja *et al.* 2012 [5] also noticed similar result in marigold.

At 25, 50 and 75 DAT, more number of leaves was observed in the treatment T2 55.40, 94.47 and 209.6 respectively (fig 5).

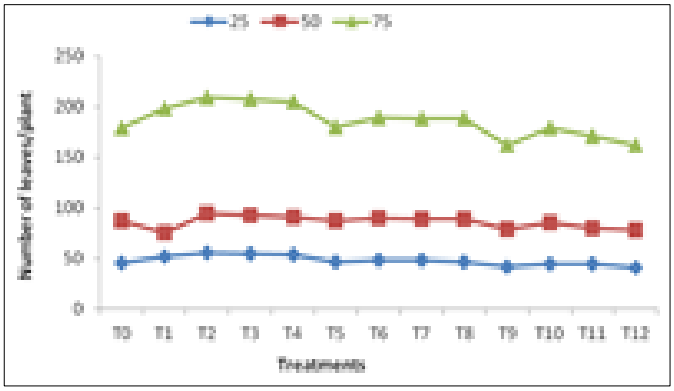

Fig 5: Number of leaves/plant 25,50 and 75 days after transplanting

The increase in number of leaves per plant might be due to beneficial effect of vermicompost with RDF. Since, optimum nutrient supply provided to plant is sufficient for giving balanced nutrition to it, thereby accelerating number of leaves per plant to promote the rate of photosynthesis in turn enhancing vegetative growth and development of plant. Similar findings were reported by Chaitra *et al.* (2007) [3] in China aster and Parya *et al.* (2010) [4] in golden rod.

The application of different sources of nutrients showed significant effect on days taken to flower bud initiation. Treatment T9 took maximum number of days to flower bud initiation (54.50) followed by T11 (54.13) and T12 (53.40). Treatment T2 was found to be early flower bud initiation, which took least number of days (50.07) (fig 6).

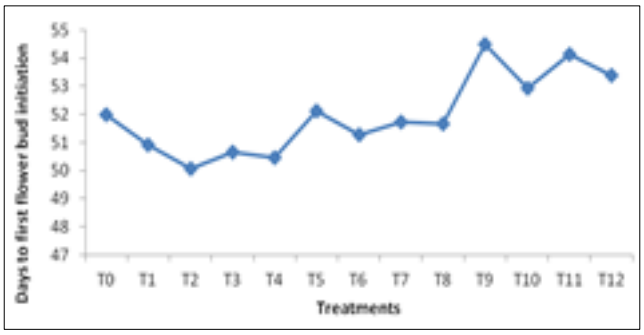

Fig 6: Days to first flower bud initiation after 25,50 and 75 days after transplanting

The earliness in bud initiation by the application of vermicompost in combination of inorganic fertilizer is due to optimum availability of nutrients to the plant due to which plant completed their vegetative growth soon resulting in early flower bud initiation. Similar observation was recorded by Rahul *et al.* (2013) [7] in gladiolus and Anita *et al.* (2013) [1] in marigold. Days taken for first flowering followed a similar trend as that of days taken for flower bud initiation. Treatment T2 (75% RDF + 25% vermicompost) took minimum number of days (58.07) to first flowering (fig 7).

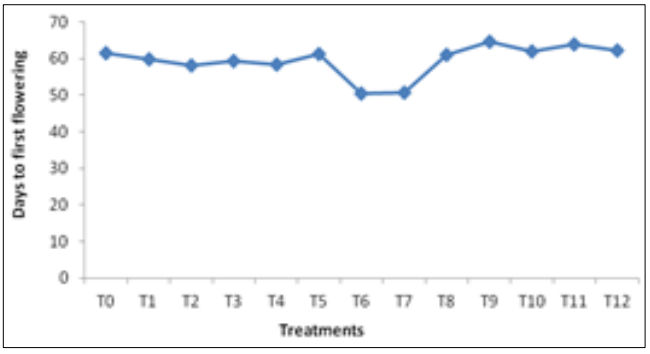

Fig 7: Days to first flowering after 25,50 and 75 days after transplanting

The time taken to flowering is an important character which decides their early flower yield of the crop. Treatments varied significantly with respect to 50 per cent flowering. Treatment T2 took minimum number of days (62.87) to 50 per cent flowering, whereas, treatment T9 (25% RDF + 75% FYM) took maximum number of days (70.40) for 50 per cent flowering (fig 8).

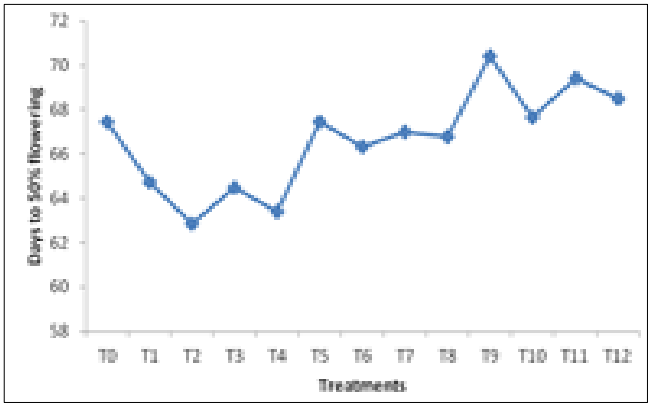

Fig 8: Days to 50% flowering after 25,50 and 75 days after transplanting

The availability of organic and inorganic nitrogen and other essential nutrients for longer period at optimum level resulting in early flowering. Treatment T2 showed its superiority by yielding 44.07 flowers per plant which is significantly superior over the rest of the treatments (fig 9).

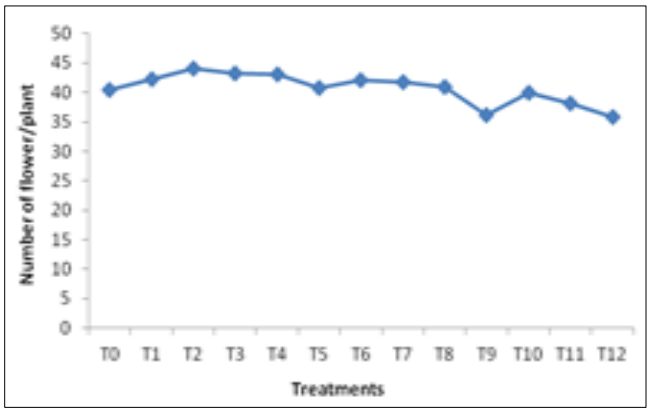

Fig 9: Number of flower/plant after 25,50 and 75 days after transplanting

The increase in flower yield might be due to increased amount of RDF and vermicompost level in leaves helped the plant to produce maximum number of flowers per plant involving in photosynthesis for better development of bud and flower. Also the availability of organic and inorganic nitrogen and other essential nutrients for longer period at optimum level resulting in more number of flowers per plant. Similar findings were reported Pooja *et al.* (2012) [5] in marigold. The maximum flower diameter (6.96cm) was recorded in treatment T2, this treatment was found to be superior over the rest of the treatments (fig 10).

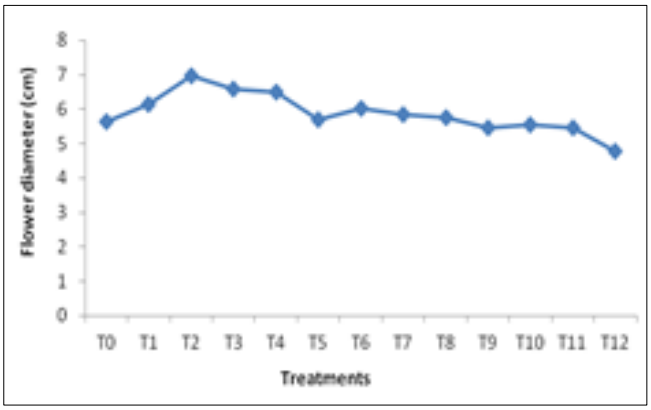

Fig 10: Flower diameter (cm) after 25,50 and 75 days after transplanting

The increase in flower characters like flower diameter in treatment application RDF with vermicompost might be due to better nutrient availability, translocation of higher amount of photosynthesis and maintenance of proper physiological activities of the plant, result in more food which is turn might have been utilized for better development of bud and flower size. Our result is in accordance with the result of Pooja *et al.* (2012) [5] and Anita *et al.* (2013) [1] in marigold. In the treatments 75% RDF + 25% vermicompost recorded significantly maximum flowering duration 54.0 days followed by 52.0 daya, 75% RDF + 25% Poultry manure and 50.2 days, 75% RDF + Azotobactor @ 5 kg/ha (fig 11).

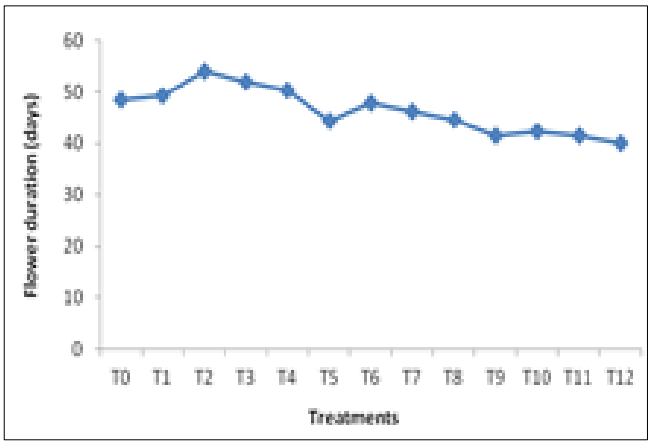

Fig 11: Flower duration (days) after 25,50 and 75 days after transplanting.

Flower duration was more in the treatment T2 may be due to the influence of nutrients availability for longer period compared to application inorganic fertility and control. Similar findings were reported by Renukaradya (2011) [8] in carnation and Pooja *et al.* (2012) [5] in marigold.

Yield parameters

Fresh weight of flowers differed significantly among the different treatments. The treatment T2 recorded the maximum fresh weight (8.52 g), whereas, minimum flower weight (5.51 g) was recorded with T12 (fig 12).

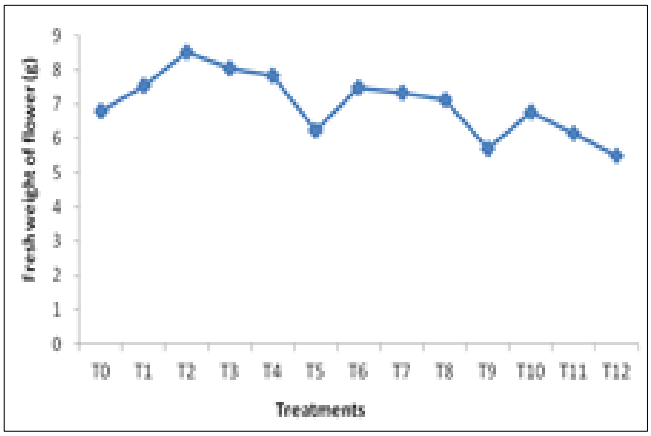

Fig 12: Fresh weight of flower (g) after 25,50 and 75 days after transplanting

RDF and vermicompost, cause nutrient availability in a better way to plant at all crop growth stages. The organic compound released by vermicompost for translocation of photosynthesis from vegetative parts of flower stalk help in better accumulation of dry matter might be the other reason for enhancing fresh weight. Similar findings are reported by Radhika *et al*. (2010) [6] in marigold.

The treatment T2 recorded highest flower yield per plant (375.42 g) followed by T3 and minimum observed in T12 (197.27g) (fig 13).

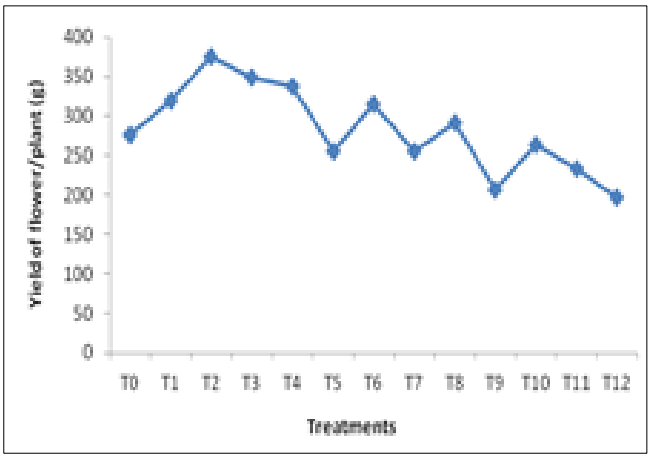

Fig 13: Yield of flower/plant (g) after 25,50 and 75 days after transplanting

The increased yield resulted due to integrated approach of vermicompost with inorganic fertilizers, might be due to easy balanced availability of nutrients to plant by vermicompost for better root proliferation enhanced microbial activity excellent uptake of NPK due to improved biological characteristics, enhancement of photosynthetic activity. This leads to better assimilation of carbohydrate and protein resulting in better vegetative growth of plant. This probably helped in increase their weight and size of flower. This result is in accordance with the result of Chaitra *et al.* (2007) [3] in China aster, Pooja *et al.* (2012) [5] in marigold and Anita *et al.* (2013) [1] in marigold. The treatment combination 75% RDF + 25% vermicompost recorded highest flower yield per plot (3.51 kg), whereas, minimum was recorded in T12 (1.77 kg) (fig 14).

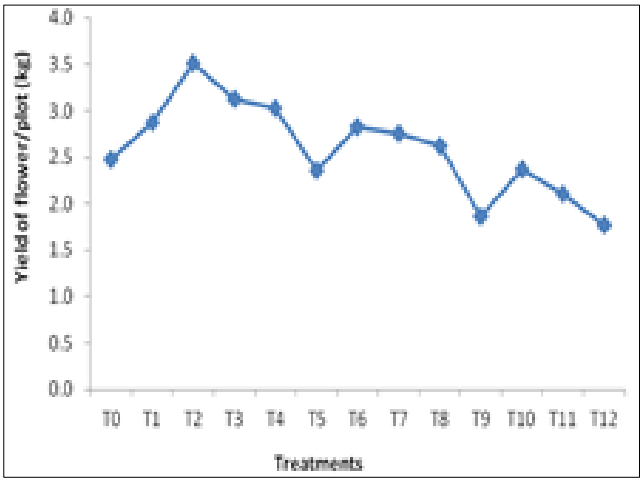

Fig 14: Yield of flower/plot (kg) after 25,50 and 75 days after transplanting

The greater diameter and weight of flower in those treatments might be due to an optimum combination of fertilizers and manures. The similar increase in flower yield due to increase in diameter and weight of flowers. Similar findings are

reported by Bhat *et al*. (2010) [2] in marigold, Pooja *et al.* (2012) [5] in marigold Anita *et al.* (2013) [1] in marigold. Different sources of nutrients showed significant effect on flower yield per hectare. The flower yield per hectare ranged from 8.74 tons per hectare in the treatment T12 to highest 16.65 tons per hectare in the treatment T2 (fig 15).

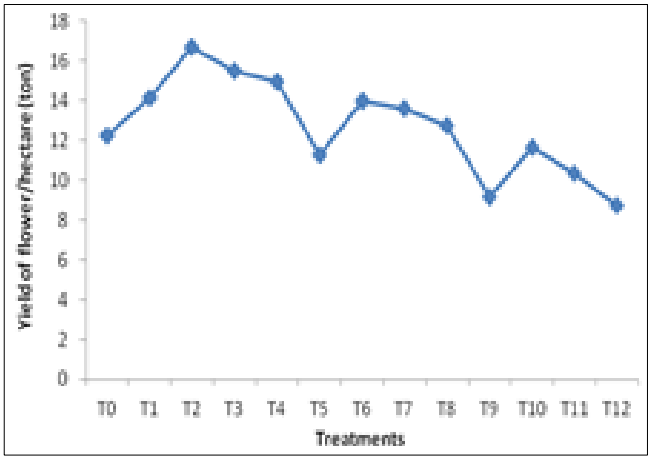

Fig 15: Yield of flower/hectare (ton) after 25,50 and 75 days after transplanting

The greater flower yield in the treatments T2 might be due to the maximum vegetative parameters like plant height, more number of primary and secondary branches per plant along with higher flower parameters *viz*., number of flowers per plant, flowering duration, flower diameter and fresh flower weight. Likewise it is also affected by the beneficial effects of vermicompost in combination with RDF. Treatment with 75% RDF + 25% Vermi compost showed best result on growth, flower, yield and economics of cultivation and can be better integrated nutriment management for effective cultivation of marigold.

Conclusion

It is concluded that based on findings of this experiment, that African marigold var. “Pusa basanti” responded well in terms of plant growth and flower yield to the application containing organic sources. Plant growth characters of marigold flower yield and flower attributes were found promising with 75% RDF + 25% vermi compost.

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