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Conjoint Application of INM Modules on Vegetative, Flowering, and Seed Yield in French marigold

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out at Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu during 2018-19. The experiment was laid out in Randomized Block Design and comprised of twenty-three treatments replicated thrice. Among the various treatments, maximum plant height (90.10 cm) and highest number of laterals (21.89) were recorded with treatment T_7 comprising of 75 % RDF + Spent mushroom compost (1 kg/m^2) + 1% foliar spray of MKP (00:52:34). Lesser number of days taken to 50% flowering (70.22 days), number of flowers/plant (86.78), maximum flower diameter (6.20g), weight of flower (5.78 g), flower yield per plant (500 g), seed yield/plant (105.91 g), 1000 seed weight (11.67g) was recorded with the treatment of 75 % RDF + Spent mushroom compost (1 kg/m^2) + 1% foliar spray of MKP (T_9). Maximum plant spread (68.44 cm) was recorded with treatment comprising of 75 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers (T_6). However, minimum electrical conductivity of seed leachate (0.688 µmhos/cm/g) was recorded with 25 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers (T_{20}). The effects of treatments on flowering duration (days) and shoot: root ratio was found to be non-significant.

Keywords: Water-soluble fertilizers; biofertilizers; spent mushroom compost; flowering and seed production.

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1. INTRODUCTION

Marigold (*Tagetes patula*) is one of the most popular and commercial loose flower crop of Jammu. Popularly known as the city of temples, Jammu region witnesses a huge demand of marigold flowers for garland making, offering in temples and other decorative purposes during various festive occasions. As a result, the production of flowers in Jammu alone cannot meet the ever-increasing demand, and flowers worth lakh need to be procured from neighboring states. Keeping in view the importance of crop and the present demand of quality flower, the investigations were carried out with the view to optimize a suitable Integrated Nutrient Management (INM) schedule for enhancing flower yield parameters in French marigold under Jammu subtropics. To fulfill the demand and rule out this limitation, it is necessary to increase its production through improved production technologies. Excessive use of chemical fertilizers following hit and trial methods by the farmers nowadays results in poor health of the soil, nutrient imbalances and ultimately poor fertilizer use efficiency. Also, small hold farmers do not have access to chemical fertilizer because of high price of fertilizers, poor distribution and other socio-economic factors involved. Therefore, modern nutrient management strategy aims towards the concept of sustainability.

Urgent need of natural, low cost and eco-friendly sources of nutrient elements that not only fulfill the requirements of the crop but also sustain the health of the soil are needed. Under these circumstances, integrated soil fertility management practices involving judicious combination of organic sources and chemical fertilizers seems to be a feasible option on a commercial and profitable scale. Organic sources viz. spent mushroom compost and biofertilizers, hold a great promise as a source of macro as well as micro-nutrients and can improve quality flower production on a sustainable basis. Spent mushroom compost (SMC) could be a suitable substitute for chemical fertilizers as an environmentally friendly material in cultivation of ornamentals [1]. Further, foliar fertilization technique may also be a good alternative to the conventional soil application to avoid the loss of fertilizers. Plant response to foliar applications of water-soluble nutrients is a function of the amount of nutrients absorbed by the leaf tissues, the mobility of the nutrients within the plant and the phytotoxicity of the nutrients solution to the foliage. Thus, an ideal nutritional situation may be achieved through the promotion of plant growth by application of basal soil treatments in combination with foliar-applied nutrients.

2. MATERIALS AND METHODS

The present investigation was carried out at the experimental farm of the Division of Vegetable Science and Floriculture, FoA, SKUAST-Jammu during the year 2018-19. A basic study of the soil of the experimental field was conducted before starting the experiment. The physio-chemical characteristics of soil taken revealed sandy loam textural class with Available N (232.54 kg/ha), Available P_2O_5 (27.71 kg/ha), Available K_2O (225.81 kg/ha), EC (0.35dS/m) and Organic carbon content of 0.38%.

Healthy seedlings were transplanted on 26/10/2018 in the experimental plots at a spacing of 40 cm x 40 cm thereby accommodating 21 seedlings per bed size of 2.80 m × 1.20 m. Transplanting was done during evening hours when the temperature was low to avoid the transplanting shock. Light irrigation was given immediately after transplanting.

Biofertilizers viz. *Azotobacter chroococcum* and phosphorous solubilizing micro-organisms (*Bacillus polymyxa* +*Pseudomonas striata*) were applied by dipping the roots of marigold seedlings into a slurry of 200 g of the inoculum dissolved in one liter of 10 % sugar solution at the time of planting. Foliar spray of 1% MKP (Mono potassium phosphate; 00:52:34 water soluble fertilizer) was given twice during the experiment. First application was given at 30 days after transplanting (DAT) and second application at 60 days after transplanting.

One year old spent mushroom compost from which the crop of button mushroom has been harvested was procured from Mushroom Research and Training Centre, Division of Plant Pathology, SKUAST-Jammu. Spent mushroom compost before incorporation into the field was treated with 4% formalin and kept covered with polythene for 48 hours. After 48 hours the cover was removed, and the spent mushroom compost was turned upside down frequently to release the fumes of formalin. Once the spent mushroom compost becomes free of formalin fumes, it was incorporated into the plots. Irrigations were given when required during crop growth. Pinching was done after 35 days of transplanting. The experimental plots were kept clean by regular hand weeding. No insect pest and disease

incidence were observed during the experiment. Data on various growth and flowering parameters were recorded and statistically analyzed by applying the technique of analysis of variance using Randomized Block Design [2]. The level of significance for t-test was kept at 5% (P=0.05).

2.1 Experimental Treatment Details and Notations

T_1 = Farmer's practice (no fertilizer)
T_2 = Control [a] (100% RDF)
T_3 = 75 % RDF + Spent mushroom compost (1 kg/m^2)
T_4 = 75 % RDF + Biofertilizers [b]
T_5 = 75 % RDF + 1% foliar spray of MKP [c] (00:52:34)
T_6 = 75 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers
T_7 = 75 % RDF + Spent mushroom compost (1 kg/m^2) + 1% foliar spray of MKP (00:52:34)
T_8 = 75 % RDF + Biofertilizers + 1% foliar spray of MKP (00:52:34)
T_9 = 75 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers + 1% foliar spray of MKP (00:52:34)
T_{10}= 50 % RDF + Spent mushroom compost (1 kg/m^2)
T_{11}= 50 % RDF + Biofertilizers
T_{12}= 50 % RDF + 1% foliar spray of MKP (00:52:34)
T_{13}= 50 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers
T_{14}= 50 % RDF + Spent mushroom compost (1 kg/m^2) + 1% foliar spray of MKP (00:52:34)
T_{15}= 50 % RDF + Biofertilizers + 1% foliar spray of MKP (00:52:34)
T_{16}= 50 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers + 1% foliar spray of MKP (00:52:34)
T_{17}= 25 % RDF + Spent mushroom compost (1 kg/m^2)
T_{18}= 25 % RDF + Biofertilizers
T_{19}= 25 % RDF + 1% foliar spray of MKP (00:52:34)
T_{20}= 25 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers
T_{21}= 25 % RDF + Spent mushroom compost (1 kg/m^2) + 1% foliar spray of MKP (00:52:34)
T_{22}= 25 % RDF + Biofertilizers + 1% foliar spray of MKP (00:52:34)
T_{23}= 25 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers + 1% foliar spray of MKP (00:52:34)

[a] Recommended dose of fertilizer (RDF)of marigold by Punjab Agriculture University (200 kg N, 100 kg P_2O_5 and 100 kg K_2O/ha), Biofertilizers; [b] *Azotobacter chroococcum* + phosphorous solubilizing micro-organisms root dip; MKP; [c] MKP (Mono potassium phosphate, 00:52:34 water soluble fertilizer)

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The effect of conjoint use of chemical fertilizers, biofertilizers, spent mushroom compost on various growth parameters of French marigold such as plant height, plant spread, and numbers of lateral shoots were studied. The findings revealed maximum plant height (90.10 cm) and number of laterals (21.89) with 75 % RDF + spent mushroom compost (1 kg/m^2) + 1% foliar spray of MKP (T_7). The maximum plant spread (68.44 cm) was recorded with the application of 75 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers (T_6) which was found to be at par with the treatment T_7. These results suggest that the combined application of inorganics, compost and foliar spray was superior over the individual application for better plant growth. The increased plant height could also be due to better nutrient uptake, photosynthesis and source-sink relationship, besides excellent physiological and biochemical activities. Application of Spent mushroom compost also improves soil texture which might have augmented the plant growth. Singh *et al* also reported significant increase in vegetative growth parameters with conjoint application of inorganic fertilizers supplemented with foliar application of water soluble fertilizer Sujala (19:19:19 NPK) in carnation cv.Master [3]. Kumawat et al. also reported significantly higher plant height with the application of 75% RDF+FYM along with inoculation of seedlings of marigold with *Azotobacter* and PSB [4]. Goutham et al. also reported the maximum number of branches and plant spread with the application of *Azotobacter*+ PSB + RDF in African marigold cv. Pusa Narangi Gainda [5]. Similar results of a significant increase in vegetative growth parameters by integrated nutrient management have also been reported by other works in china aster [6] and marigold [7-13].

3.2 Flowering and Yield Parameters

In the present investigation, time is taken for 50 % flowering (70.22 days) was recorded earliest when the plants were supplied with 75 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers + 1% foliar spray of MKP (T_9).

However, different integrated nutrient management treatments did not significantly influence the flowering duration. The earliness of flowering due to the presence of biofertilizers especially inoculation with *Azotobacter* and PSB may be ascribed to easy uptake of nutrients and simultaneous transport of growth-promoting substances like cytokinins to the axiallary buds resulting in breakage of apical dominance. Ultimately, they resulted in a better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase. Dubey et al. reported that *Azospirillum* and PSB induce early flowering and increase flower diameter in gladiolus [14]. Nammidevi also reported early flower bud initiation and the minimum number of days taken for 50 % flowering in annual chrysanthemum when applied with *Azotobacter* + PSB + *Azospirillum* along with 80 % NPK [15]. They also reported lesser number of days to first flower opening in marigold with 60% RDF + vermicompost + *Azotobacter+Azospirilium* + PSB. These results are also in consonance with the findings of Chandrikapure et al. [16] in marigold, Narashima Raju and Haripriya [17] in crossandra, Gyathri et al. [18] in limonium and Kumar and Kumar [19] in marigold.

Application of 75% RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers + 1% foliar spray of MKP (T_9) recorded the highest number of flowers per plant (86.78; Fig1), maximum flower diameter (6.20 cm), flower weight (5.78 g) and highest flower yield per plant (500 g; Fig 2).The maximum increase in flower yield parameters with the scheduled application of T_9 (75% RDF+ Spent mushroom compost + Biofertilizers + 1% foliar spray of MKP) might be ascribed to the fact that this treatment might have supplied requisite amounts of nutrients viz a viz. improved fertilizer use efficiency through timely applications of N, P and K that had led to increased photosynthetic rate and in turn resulted in production of more flowering in comparison to other treatments. In addition foliar application through MKP also promoted better uptake of nutrients and hence resulted in higher utilization and translocation. The efficacy of foliar fertilization is higher than that of soil fertilization because of the supply of required nutrient directly to the location of demand in the leaves and its relatively quick absorption. The effect is manifested in the production of significantly higher number of flowering shoots which in turn results in an increase in the flowering and yield parameters of commercial importance.

Enhancement in flowering attributes might also be evident from excellent physiological and biochemical activities due to conjoint application of chemical fertilizers, mushroom compost, biofertilizers and foliar fertilization. An increase in weight might be attributed to stimulation of growth and photosynthesis and subsequent translocation of assimilates to sustain the growth of developing shoots.

Kumar and Kumar reported a significant increase in flower yields of Purnima and Ajay cultivars of chrysanthemum with conjoint application of inorganic fertilizers, vermicompost and Biofertilizers [19]. Singh *et al* [3] and Singh et al. [20] also reported improved flowering parameters with conjoint application of inorganic fertilizers supplemented with foliar application of water-soluble fertilizer Sujala (19:19:19 NPK) in carnation cv. Master. Kumawat et al. reported a significantly higher number of flowers/plant, weight of flower viz. a viz. yield per plant by conjoint application of 75 % RDF+ FYM+ *Azotobacter*+ PSB in African marigold [4]. Goutham *et al* also reported the maximum fresh weight of flower and highest number of flowers/plant with the application of RDF+ *Azotobacter*+ PSB in African marigold cv. Pusa Narangi Gainda [5]. These findings also get support from the previous work of various workers in tuberose [21]; in statice [18], and in African marigold [6], [22], [23] in chrysanthemum and incarnation [24].

3.3 Seed Yield Parameters

The maximum seed yield/plant (105.91 g; Fig 3) and 1000 seed weight (11.67 g; Fig 3) was recorded with the application of 75 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers + 1% foliar spray of MKP (T_9). This increase in seed yield might be due to better flower quality parameters with the same treatment. Seed production is directly influenced by proper plant growth and nutrient supply to the plants. Positive increment in seed yield by integrated use of nutrients may be due to the availability of micro and macro nutrients to the plants via. a viz., increase in hormonal activation within the plants. The combined and positive effect of recommended dose of fertilizers supplemented with various organic amendments on seed yield parameters in various ornamentals has been advocated by numerous workers. Bappitodu *et al* reported higher seed yield/plant and higher test weight with the application of 75% NPK+ *Azotobacter* + PSB + KMB + 3% HA in

Calendula officinalis [25]. Jadhav et al. [26] reported the maximum number of seeds/peduncle, weight of seeds/peduncle and 100 seed weight with the application of 75 % NPK + PSB+ *Azotobacter* and 75 % NPK + PSB+ *Azotobacter*+ recommended dose of FYM in marigold [8]. Koli et al. also reported the highest 1000 seed weight and seed yield/plot with the application of RDF+ FYM+ Arka microbial consortium+ VAM+ micronutrient foliar spray in marigold cv. Pusa Basanti Gainda [19].

3.4 Electrical Conductivity of Seed Leachate and shoot: Root Ratio

Lowest electrical conductivity of seed leachate (0.688 µmhos/cm/g) was recorded with 25 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers(T_{20}) whereas highest electrical conductivity of seed leachate (0.911 µmhos/cm/g) was recorded with the treatment of 75 % RDF + Spent mushroom compost + Biofertilizers + 1% foliar spray of MKP (T_9). Bappitodu *et al* also reported lowest EC of seed leachate with the application of 75% NPK + *Azotobacter* + PSB + KMB + 3% HA in *Calendula officinalis* [25].

It is apparent from the data (Table 1) that different integrated nutrient management treatments do not significantly influence the shoot: root ratio on fresh weight basis [27]. However, the highest shoot: root ratio on fresh weight basis (0.28) was recorded with farmers practice (T_1) and the lowest shoot: root ratio on fresh weight basis was recorded with 50 % RDF + Spent mushroom compost + biofertilizers + 1% foliar spray of MKP (T_{16}). The root/shoot ratio on fresh weight basis was derived to denote the ratio of water absorbing area (root) and the transpiration area (shoot) of a plant. Change in root: shoot ratio during a plant's life cycle is part of an intrinsic ontogeny, but growth rates of roots and shoots continually adjust to resource availability with photo assimilate. These results are in close conformity with the findings of Sujatha et al. [28] in gerbera.

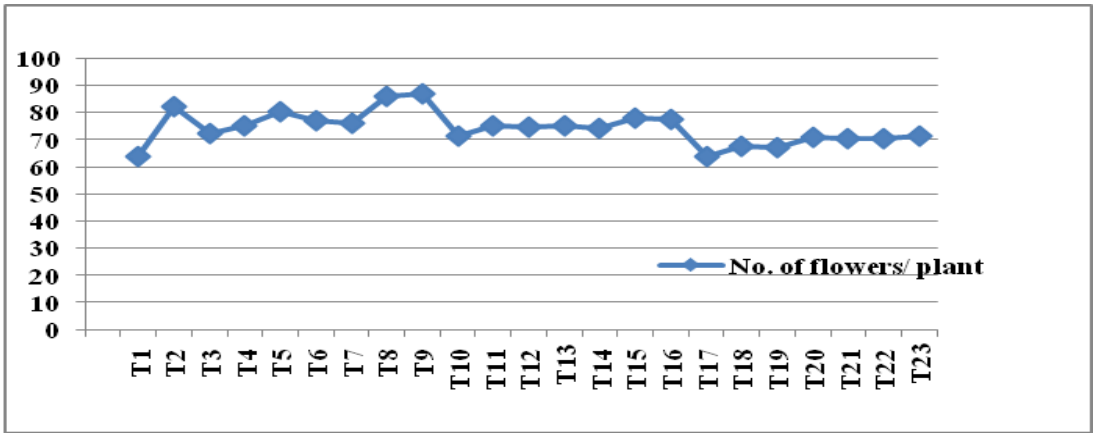

Fig. 1. Effect of spent mushroom compost, biofertilizers and MKP on flower number

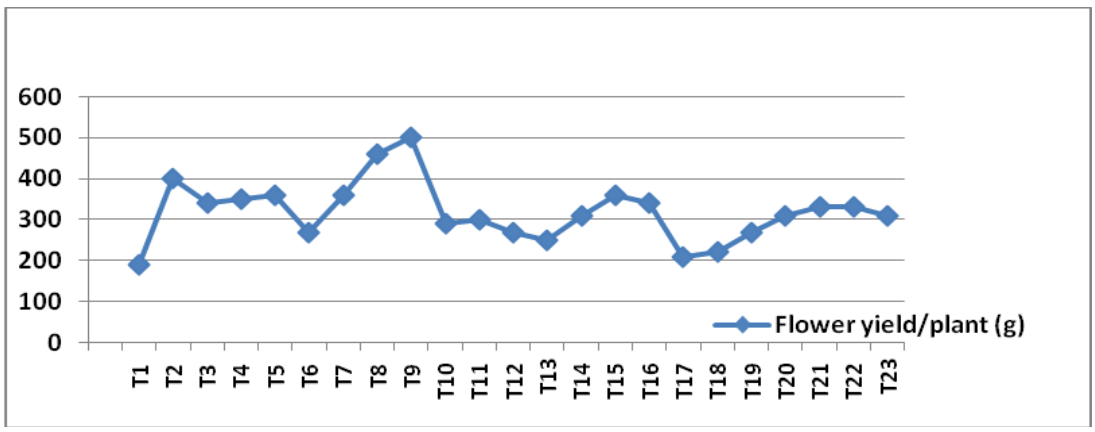

Fig. 2. Effect of spent mushroom compost, biofertilizers and MKP on Flower yield/plant (g)

Table 1. Effect of various modules on vegetative flowering and yield traits of French marigold

Treatments	Plant height (cm)	Plant spread (cm)	No. of laterals	Days taken to 50% flowering	Flowering duration (days)	Flower diameter (cm)	Weight of flower (g)	EC of seed leachate (µmhos/cm/g)	Shoot:root ratio
T_1	78.01	55.33	14.44	76.39	53.56	4.69	3.00	0.944	0.28
T_2	88.10	63.33	19.77	71.00	54.78	6.17	4.89	0.868	0.25
T_3	83.46	62.00	19.22	73.37	55.11	5.17	4.67	0.804	0.27
T_4	87.89	63.67	19.66	73.22	54.22	5.15	4.67	0.812	0.26
T_5	85.68	68.00	18.22	73.00	54.11	5.04	4.44	0.741	0.26
T_6	86.66	68.44	19.66	72.89	55.56	5.42	3.56	0.699	0.27
T_7	90.10	68.22	21.89	72.51	57.89	5.63	4.69	0.819	0.25
T_8	88.32	64.45	20.00	72.05	54.67	6.03	5.41	0.735	0.26
T_9	88.22	63.22	19.89	70.22	53.44	6.20	5.78	0.911	0.25
T_{10}	88.00	65.78	19.77	73.66	55.44	6.06	4.11	0.838	0.26
T_{11}	87.10	60.33	19.22	74.00	54.00	5.02	4.00	0.813	0.25
T_{12}	87.22	66.55	20.00	74.11	56.56	5.22	3.56	0.73	0.27
T_{13} 75.00	86.79	62.78	19.78	74.16	55.56	4.93	3.33	0.746	0.25
T_{14}	85.57	62.45	18.33	74.44	54.11	4.97	4.11	0.776	0.26
T_{15}	87.79	68.00	19.44	72.89	56.00	4.97	4.67	0.724	0.25
T_{16}	87.45	61.66	19.11	72.80	55.56	4.92	4.44	0.775	0.22
T_{17}	87.57	51.67	15.78	76.81	52.78	4.94	3.33	0.812	0.24
T_{18}	78.68	51.78	15.89	75.41	55.67	4.96	3.33	0.754	0.27
T_{19}	85.21	53.67	16.89	75.66	55.56	5.95	4.00	0.774	0.24
T_{20}	86.79	55.78	17.00	75.78	54.33	5.98	4.33	0.688	0.25
T_{21}	83.68	55.66	18.00	76.23	57.33	5.98	4.67	0.757	0.24
T_{22}	86.21	55.56	18.33	74.44	54.56	5.74	4.66	0.789	0.26
T_{23}	87.01	58.55	18.78	74.91	54.78	5.81	4.33	0.762	0.25
SE ± (m)	1.71	0.97	1.20	1.04	1.27	0.28	3.67	0.023	0.009
CV	3.42	2.73	11.17	2.45	3.99	9.23	30.38	5.023	6.341
$CD_{0.05}$	4.89	2.76	3.44	2.98	N.S	0.81	9.23	0.065	N.S

T_1 = Farmers practice (no fertilizer); T_2 = Control (Recommended dose of marigold by PAU (200 kg N, 100 kg P_2O_5 and 100 kg K_2O/ha);T_3 = 75 % RDF + Spent mushroom compost (1 kg/m^2);T_4 = 75 % RDF + Biofertilizers;T_5 = 75 % RDF + 1% foliar spray of MKP (00:52:34);T_6 = 75 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers; T_7 = 75 % RDF + Spent mushroom compost (1 kg/m^2) + 1% foliar spray of MKP (00:52:34);T_8 = 75 % RDF + Biofertilizers + 1% foliar spray of MKP (00:52:34); T_9 = 75 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers + 1% foliar spray of MKP (00:52:34); T_{10}= 50 % RDF + Spent mushroom compost (1 kg/m^2); T_{11}= 50 % RDF + Biofertilizers;T_{12}= 50 % RDF + 1% foliar spray of MKP (00:52:34);T_{13}= 50 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers; T_{14}= 50 % RDF + Spent mushroom compost (1 kg/m^2) + 1% foliar spray of MKP (00:52:34); T_{15}= 50 % RDF + Biofertilizers + 1% foliar spray of MKP (00:52:34); T_{16}= 50 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers + 1% foliar spray of MKP (00:52:34); T_{17}= 25 % RDF + Spent mushroom compost (1 kg/m^2);T_{18}= 25 % RDF + Biofertilizers; T_{19}= 25 % RDF + 1% foliar spray of MKP (00:52:34); T_{20}= 25 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers; T_{21}= 25 % RDF + Spent mushroom compost (1 kg/m^2) + 1% foliar spray of MKP (00:52:34); T_{22}= 25 % RDF + Biofertilizers + 1% foliar spray of MKP (00:52:34); T_{23}= 25 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers + 1% foliar spray of MKP (00:52:34)

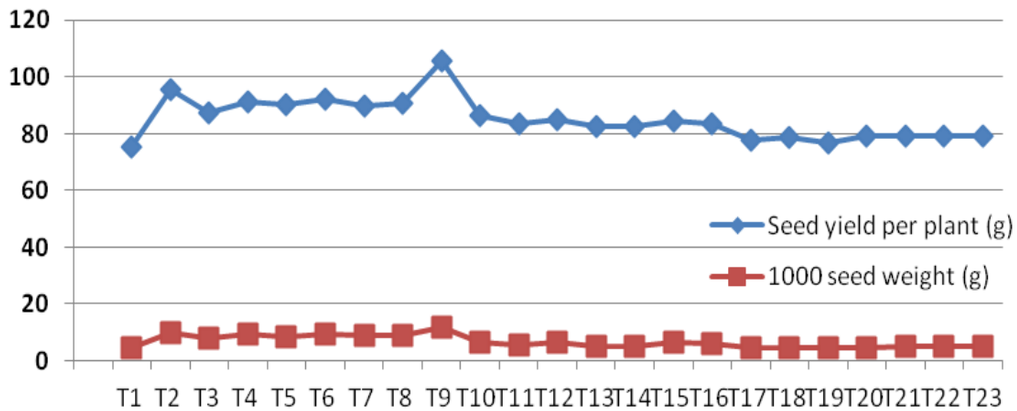

Fig. 3. Effect of spent mushroom compost, biofertilizers and MKP on seed yield per plant (g) and 1000 seed weight (g)

4. CONCLUSION

It is concluded that the best integrated nutrient management schedule for growth and flower production of French marigold is 75 % RDF + Spent mushroom compost (1 kg/m^2) + Biofertilizers + 1% foliar spray of MKP (00:52:34) as it resulted in improvement for most of the parameters of economic importance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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