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V Priyadarshini
Department of Horticulture, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

VK Rao
Department of Horticulture, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

BD Bhuj
Department of Horticulture, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

DC Dimri
Department of Horticulture, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

SK Guru
Department of Plant Physiology, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

KP Raverkar
Department of Soil Science, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Corresponding Author:
V Priyadarshini
Department of Horticulture, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Effect of fertigation and mulching on growth and flowering of marigold (*Tagetes erecta* L.) cv Pusa Narangi Gainda

V Priyadarshini, VK Rao, BD Bhuj, DC Dimri, SK Guru and KP Raverkar

Abstract
The present work entitled as effect of fertigation and plastic mulching on vegetative and flowering characters of marigold cv. Pusa Narangi Gainda under open conditions. The experiment was laid out in factorial randomized block design with fertigation and mulching as two factors. The experiment was carried out at Model Floriculture Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, during the winter season of 2018-2019 and 2019-2020. Treatment containing 100% of RDF using WSF with mulching gave maximum plant height, number of branches per plant, dry weight of plant, days to first flower bud initiation, days for first flower opening, days for 50% flowering, duration of flowering, flower diameter and flower weight. Followed by application of 75% of WSF + 25% Straight Fertilizer with mulching, 75% of RDF using WSF with mulching and minimum results were found with 100% Straight Fertilizer (Control) + without mulch.

Keywords: Marigold, water soluble fertilizers, fertigation, mulching

Introduction
African marigold (*Tagetes erecta* L.) is becoming popular among flower traders and gardeners due to its ease of cultivation and adaptability to a wide range of soil and climatic conditions. It is main traditional flower crop and one among the five commonly grown flowers in both urban and rural India. Marigold flowers are widely utilized in garlands, beautification, spiritual gifts, public events, and for various purposes such as oil extraction and carotenoids like lutein for medicinal benefits.

Fertigation is a process in which water as well as nutrients are given straight to the root zone using drippers in lesser but regular amounts. Drip fertigation has a potential to improve crop quality and production, resulting in increased output. Fertigation provides nutrients directly into the plant root zone at the required amount during specific times (Singandhupe *et al*., 2003) [10]. The major benefits of fertigation over surface irrigation combined with broadcast fertilizer application are accurate control over the amount of nutrients as required by the plant, minimized fluctuations in nutrient concentration in the root zone, improved fertilizer use efficiency and reduced nutrient leaching, labor and uniformity in application along with restricted weed growth. Fertilizer requirements can be cut down by 15-25 percent with drip fertigation with no loss of yield.

Mulching raises soil temperature, moisture, and weed control while additionally improving the chemical and physical qualities of the soil and increasing crop yield (Barman *et al*., 2005) [1]. It has been stated that covering the soil surrounding the plant provides ideal conditions for improved growth, development, and crop productivity (Nagalakshmi *et al*., 2002) [5]. It has the specific property of lowering the maximum soil temperature while raising the lowest temperature (Solaiman *et al.*, 2008) [11]. Mulches are used to limit water usage and reduce erosion. Mulching minimizes degradation of soil by decreasing runoff and erosion of soil, as well as weed infestation and loss of moisture. As a result, it improves the physical, biological, and chemical qualities of the soil, adds nutrients to the soil, and assists in the regulation of temperature changes, eventually enhancing crop development and productivity.

Materials and Methods
The trial was held during the years, 2018 -19 and 2019 – 20 to study the effect of fertigation and mulching on vegetative and floral characters of marigold grown under open conditions at

Model Floriculture Center, G. B. Pant University of Agriculture and Technology, Pantnagar. The soil of investigational plot is sandy loam with adequate drainage and optimum water holding capacity. The investigation was carried out in Factorial Randomized Block Design (FRBD) involving fertilizer and mulching combinations which are replicated thrice. The treatments consists of T_1- F_1M_0 - 50% of RDF using WSF + without mulch; T_2 - F_1M_1- 50% of RDF using WSF + with mulch; T_3 - F_2M_0 - 75% of RDF using WSF + without mulch; T_4 - F_2M_1- 75% of RDF using WSF + with mulch; T_5 - F_3M_0- 100% of RDF using WSF + without mulch; T_6 - F_3M_1- 100% of RDF using WSF + with mulch; T_7 - F_4M_0 - 75% of WSF + 25% Straight Fertilizer + without mulch; T_8 - F_4M_1 - 75% of WSF + 25% Straight Fertilizer + with mulch; T_9 - F_5M_0 - 50% of WSF + 50% Straight Fertilizer + without mulch; T_{10} - F_5M_1 - 50% of WSF + 50% Straight Fertilizer + with mulch; T_{11} - F_6M_0 -25% of WSF + 75% Straight Fertilizer + without mulch; T_{12} - F_6M_1 - 25% of WSF + 75% Straight Fertilizer + with mulch; T_{13} - F_7M_0 - 100% Straight Fertilizer (Control) + without mulch; T_{14} - F_7M_1 -100% Straight Fertilizer (Control) + with mulch.

The drip irrigation system and mulching have been established according to the experimental design and treatment combinations. One month healthy uniform seedlings of marigold had been transplanted in the main field in a double row planting method with a spacing of 60 cm between the rows and 30 cm between the plants. After transplanting, seedlings were given light watering to help them establish in the field. Water soluble and straight fertilizers are used according to the treatment combinations. Fertigation was applied depending on the stage of plant. Black polyethylene sheets of 25 micron were placed over the soil surface and gap filling was done ten days after transplantation. Observations on growth, flowering, yield and soil properties were taken periodically in various treatment combinations. The acquired results were statistically evaluated according to Panse and Sukhatme (1978) [7].

Results and Discussion

Significant findings were attained for vegetative and floral parameters. Tables 1 and 2 provide information on the vegetative growth and floral attributes of the marigold. The results revealed that fertigation with water soluble fertilizers @100% RDF and mulching recorded the maximum values for characters such as plant height at 30 days after transplanting (38.40 cm), plant height at 60 days after transplanting (66.83 cm), and plant height at 90 days after transplanting (86.60 cm). The maximum plant height might be due to the application of optimal doses of WSF at the important phases of plant growth at regular intervals. This might be attributed to improved IAA synthesis, which has a stimulatory effect on cell elongation, resulting in greater plant height. The findings are consistent with Ganesh *et al*. (2014) [2] in chrysanthemum, Palanisamy *et al*. (2015) [6] in gerbera and Yograj Kushwaha (2020) [13] in gladiolus.

The number of primary branches per plant in marigold was significantly affected by fertigation and mulching. The use of 100% RDF as WSF combined with polyethylene mulching resulted in the highest number of primary branches per plant (7.69). The increased number of primary branches might be due to the availability of nitrogen from WSF during important phases of plant growth. Nitrogen provided to the roots may have increased the production of cytokinin and which helped in cell division. The increased levels of cytokinin in effective root zone resulted in producing maximum secondary branches per plant (16.79). Mulching regulates soil temperature and aids in soil moisture retention by lowering evaporation losses from the soil. It also helps maintain high microbial activity, as well as improved nutrient availability and absorption by the plant. Higher nutrient availability and water absorption improve plant growth and development in terms of vegetative and reproductive growth. The vegetative parameters like plant spread (49.84 cm), stem girth (7.25 cm) and dry weight of plant (81.52 g) was obtained because of the amount of WSF present in the rhizosphere reduced nutrient losses by leaching and caused effective nutrient utilization.

Early flower bud initiation under mulching might be linked to higher soil temperature, This conclusion was consistent with Solaiman *et al.* (2008) [11] in China aster. The higher soil temperature caused by mulching might be linked to the early completion of 50% blooming, which was directly connected to early flower initiation. Early flower bud initiation ceases the vegetative phase of plant development and directing the available nutrients to reproductive phase, leading to earlier flower development with improved qualities and prolonged duration resulting in high productivity Kurakula Divya (2017) [4]. Among the different treatment combinations, treatment containing 100% of RDF with WSF with mulching has significantly limited the number of days required for first flower bud initiation (44.16 days), first flower opening (59.52 days), number of days to 50% flowering (79.11 days) and finally increased duration of flowering (57.52 days). Similarly increased flower weight (9.26 g) and flower diameter (5.92 cm) might be due to enhanced nutritional intake, which resulted in the accumulation of adequate photosynthates (Shashidhar *et al*., 2008) [11]. The findings are similar with Raja Babu (2018) [8] in marigold, Salma *et al.* (2014) [9] in gerbera and Thamara *et al.* (2010) [12] in China aster.

T_1- F_1M_0 - 50% of RDF using WSF + without mulch; T_2 - F_1M_1- 50% of RDF using WSF + with mulch; T_3 - F_2M_0 - 75% of RDF using WSF + without mulch; T_4 - F_2M_1- 75% of RDF using WSF + with mulch; T_5 - F_3M_0- 100% of RDF using WSF + without mulch; T_6 - F_3M_1- 100% of RDF using WSF + with mulch; T_7 - F_4M_0 - 75% of WSF + 25% Straight Fertilizer + without mulch; T_8 - F_4M_1 - 75% of WSF + 25% Straight Fertilizer + with mulch; T_9 - F_5M_0 - 50% of WSF + 50% Straight Fertilizer + without mulch; T_{10} - F_5M_1 - 50% of WSF + 50% Straight Fertilizer + with mulch; T_{11} - F_6M_0 -25% of WSF + 75% Straight Fertilizer + without mulch; T_{12} - F_6M_1 - 25% of WSF + 75% Straight Fertilizer + with mulch; T_{13} - F_7M_0 - 100% Straight Fertilizer (Control) + without mulch; T_{14} - F_7M_1 -100% Straight Fertilizer (Control) + with mulchT_1- F_1M_0 - 50% of RDF using WSF + without mulch; T_2 - F_1M_1- 50% of RDF using WSF + with mulch; T_3 - F_2M_0 - 75% of RDF using WSF + without mulch; T_4 - F_2M_1- 75% of RDF using WSF + with mulch; T_5 - F_3M_0- 100% of RDF using WSF + without mulch; T_6 - F_3M_1- 100% of RDF using WSF + with mulch; T_7 - F_4M_0 - 75% of WSF + 25% Straight Fertilizer + without mulch; T_8 - F_4M_1 - 75% of WSF + 25% Straight Fertilizer + with mulch; T_9 - F_5M_0 - 50% of WSF + 50% Straight Fertilizer + without mulch; T_{10} - F_5M_1 - 50% of WSF + 50% Straight Fertilizer + with mulch; T_{11} - F_6M_0 -25% of WSF + 75% Straight Fertilizer + without mulch; T_{12} - F_6M_1 - 25% of WSF + 75% Straight Fertilizer + with mulch; T_{13} - F_7M_0 - 100% Straight Fertilizer (Control) + without mulch;

T_{14} - F_7M_1 -100% Straight Fertilizer (Control) + with mulch

According to the findings of the study, fertigation with WSF at 100% RDF with mulching had shown greater results in terms of vegetative, flowering and yield characteristics in marigold. Fertigation combined with mulching can increase quality and productivity in various crops. It reduces cost of cultivation by limiting usage of labour component for fertilizer application, weeding and increased fertilizer use efficiency which causes reduction of fertilizer used.

Table 1: Effect of fertigation and mulching on growth and flowering in African marigold cv Pusa Narangi Gainda

	Plant height			Number of branches		Plant spread	Stem girth	Dry weight of plant
Treatments	30 days	60 days	90 days	Primary branches	Secondary branches			
T_1	31.08	59.22	78.97	6.32	15.27	41.44	5.60	78.58
T_2	31.72	59.95	79.57	6.58	15.39	42.07	5.49	78.86
T_3	34.66	63.28	82.82	7.09	16.10	45.24	6.30	80.18
T_4	37.14	65.76	85.33	7.48	16.53	48.08	7.00	81.09
T_5	36.52	65.20	84.71	7.39	16.42	47.18	6.82	80.92
T_6	38.40	66.83	86.60	7.69	16.79	49.84	7.25	81.52
T_7	35.87	64.56	84.06	7.29	16.32	46.46	6.58	80.69
T_8	37.72	66.27	85.99	7.58	16.65	49.02	7.10	81.28
T_9	34.05	62.54	82.14	7.00	15.99	44.67	6.17	79.92
T_{10}	35.24	63.90	83.48	7.19	16.21	45.86	6.40	80.44
T_{11}	32.89	61.24	80.84	6.72	15.59	43.37	5.89	79.39
T_{12}	33.44	61.90	81.46	6.88	15.81	44.03	6.00	79.66
T_{13}	30.41	58.86	78.28	6.37	14.74	40.62	5.48	78.30
T_{14}	32.26	60.58	80.20	6.67	15.49	42.74	5.66	79.12
CD at 5%	0.31	0.20	0.33	0.10	0.25	0.35	0.11	0.10

Table 2: Effect of fertigation and mulching on growth and flowering in African marigold cv Pusa Narangi Gainda

	Days taken for			Duration of flowering (days)	Flower diameter (cm)	Flower weight (g)
Treatments	first bud initiation (days)	first flower opening (days)	50 per cent flowering (days)			
T_1	57.81	71.55	93.74	46.12	4.97	8.16
T_2	56.74	70.58	92.46	46.85	5.04	8.26
T_3	50.66	65.67	86.56	51.25	5.44	8.71
T_4	46.39	61.38	81.53	54.53	5.76	9.06
T_5	47.29	62.60	82.67	53.68	5.68	8.98
T_6	44.16	59.52	79.11	57.52	5.92	9.26
T_7	48.38	63.76	84.06	52.74	5.60	8.90
T_8	45.39	60.30	80.35	56.49	5.83	9.14
T_9	51.72	66.57	87.79	50.28	5.36	8.62
T_{10}	49.60	64.79	85.41	52.05	5.52	8.81
T_{11}	54.18	68.70	90.00	48.45	5.21	8.44
T_{12}	52.78	67.71	89.00	49.33	5.29	8.52
T_{13}	59.23	72.40	94.85	45.21	4.89	8.04
T_{14}	55.46	69.46	91.30	47.17	5.12	8.35
CD at 5%	0.99	0.36	0.31	0.66	0.055	0.031

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