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Effect of Low Cost Fertigation on Flower Yield of Marigold and Tuberose Grown on the Bunds in the Rice based Cropping System

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ABSTRACT: Large area of field bunds remains unused in the areas dominated with rice cultivation. These available spaces in the form of bund can be utilized for additional income besides the main crop by planting flower crops. An investigation was carried out to develop an economically suitable model for utilization of field bunds through flower cultivation. The growth, flowering parameters and yield of African marigold and tuberose cultivated on bunds under low cost drip system were assessed for profitability. A modified low cost drip irrigation system recommended by Precision Farming Development Centre, Raipur was used for drip irrigation and fertigation. The flower crops, African marigold and Tuberose were tested at two different plant spacing (30 × 30cm and 40 × 30cm) on one metre wide bund with different methods of irrigation and fertilizer application in factorial RBD design with three replications. Maximum duration of flowering, flower diameter, number of flowers and flower yield per plant in African marigold was recorded under drip fertigation with WSF @ 100% RDF application at plant spacing of 40 × 30cm. In tuberose, spike length, number of florets per spike and number of spikes per plant was observed with drip fertigation with WSF @ 100% RDF application at plant spacing of 30 × 30cm. However, maximum gross returns, net returns as well as highest B:C ratio in both the crops was obtained from drip fertigation with WSF @ 100% RDF application at plant spacing of 30 × 30cm. Therefore, either African marigold or tuberose may be planted on bunds at a plant spacing of 30 × 30cm along with fertigation (WSF @ 100% RDF) for additional income.

Keywords: Bund, flower, fertigation, low-cost drip, marigold, rice based cropping, tuberose.

INTRODUCTION

Field bunds occupy a sizeable proportion of the paddy cultivated area in the whole world including India where it is one of the principal crops. Many of the Indian states viz., Uttar Pradesh, Bihar, West Bengal, Punjab, Chhattisgarh, Andhra Pradesh, Tamil Nadu, Odisha, Assam, Karnataka are predominantly rice growing states having a large area under rice cultivation. In Chhattisgarh alone, rice area under wide bunds was about 2.5 lakh hectare in 2007 (Anon., 2007). These rice fields having wide bunds which remain unutilized are of concern as it comes out to be a big area gone as wasteland when seen cumulatively. Though bunds play an important role in retaining moisture on sloped ground and acts as demarcation between adjoining fields, but it also serves as source of weed propagules if poorly managed (Rao *et al.*, 2017). Various studies have revealed that bund planting of agroforestry trees is the traditional practice adopted by the farmers on these bunds. Apart from the agroforestry system, introduction of vegetation with high profit is necessary for field bund (Yan *et al.*, 2021). Though, a lot of impetus had been given on growing pulses on these bunds in India but it was mostly to increase the area and production of pulses. In fact, well-managed bunds can provide source of additional income through the production of cash crops. For better and higher economic returns, floricultural crops having high profitability could be an option to be explored as these are low volume high value crops with higher returns per unit area (Sharma and Singh, 2007). Flower planting is already promoted as a pest management strategy in irrigated rice field bunds.

In the past one and a half decade, floriculture has gained momentum and popularity in the Asian countries in general and India in particular. There has been a considerable increase in the area as well as production of flower crops in this state. The area under flower crops got almost tripled from 106000 ha during 2001-02 to 339000 ha during 2018-19 (Anon., 2021). Both marigold and tuberose flower crops are grown in a large scale for commercial cultivation in India. African marigold (*Tagetes erecta* L.) is in demand round the year for its loose flowers used in garlands and decorations (Sahu *et al.*, 2019) and has also been reported to be grown in summer rice fallows (Suvija *et al.*, 2019). Similarly, tuberose (*Polianthes tuberosa* L.) grown for its cut spikes, loose flowers and essential oils are in high demand in the domestic market (Singh *et al.*, 2021). There lies an opportunity of utilizing the bund by planting it with highly profitable flower crops which are popularly called as low volume high value cash crops.

Drip irrigation has the potential to save considerable irrigation water, labour and time. Also, surface run-off and soil evaporation is reduced considerably along with lesser weed growth in drip as compared to flood irrigation (Kaur and Brar, 2016). Fertigation has been found to be the most economical fertilizer application technique for most of the flower crops resulting in increased yield and enhanced quality (Divya *et al.*, 2018). It not only enhances the fertilizer use efficiency but also helps in economizing the use of water and fertilizers and thereby reduces the cost of cultivation by reducing the cost of water, fertilizers, labour and energy (Khan *et al.*, 1997). These qualities are very much desired when planting is to be done on hitherto un-utilized bund as the major concentration is for the main field/major crop. Further, keeping in view the meagre resources and considering the secondary importance of bund cultivation, a low cost fertigation system can be feasible from economical point of view. Moreover, the plant spacing has also an important role to play in overall plant growth and yield and has been reported to affect the flower yield in marigold and tuberose as well (Khalaj *et al.*, 2012; Rolaniya *et al.*, 2017). Therefore, besides proper water and nutrient management, there is also a need to work out optimum planting distance for bund cultivation under low cost fertigation system for higher productivity, as the plant spacing has been reported to influence the yield.

Only a few studies have examined the full impact of alternative bund management practices in rice cropping systems. If crops of high economic and marketing values are successfully grown on the field bund, the large area of wasteland bund may be used properly with optimum resource utilization. Keeping these points in view and with the objective of conserving water, enhancing the nutrient utilization, labour efficiency and additional income from unutilized bunds, this experiment was conducted for suggesting a flower based farming model.

MATERIALS AND METHODS

The present investigation was carried out on the bunds of rice field of the All India Coordinated Research Project-Soil test crop response, Indira Gandhi Krishi Vishwavidyala, Raipur, Chhattisgarh. The experiment consisted of treatments comprising of different methods of irrigation alongwith fertilizer application and planting distance in Factorial Randomized Block Design (FRBD) with three replications. The two factors tested comprised of irrigation and fertilizer application methods (drip irrigation, surface flood irrigation, fertigation and soil application of fertilizer) along with plant spacing (30×30cm and 40×30cm) in African marigold and tuberose. African marigold var. Pusa Narangi Gainda and Tuberose var. Prajwal were taken as test varieties planted in three rows. Bulbs of tuberose was planted in June 2018 which continued with intermittent flowering round the year whereas, rooted cuttings of African marigold were planted twice, both in *kharif* (June 2018) and *rabi* season (November 2018) on $50m^2$ bund (50m length and 1m width). At a spacing of 30×30cm, 483 plants were accommodated/$50m^2$ whereas at a spacing of 40×30 cm, 360 plants were accommodated /$50m^2$.

A low cost drip irrigation system recommended by Precision Farming Development Centre (PFDC), Indira Gandhi Agricultural University, Raipur was used for irrigation and fertigation. The low cost drip irrigation system consisted of two buckets of 20 litres which were joined together by 'T'; the buckets were supported on bamboo sticks of 5m height. The 'T' was connected to lateral pipe having inbuilt dripper at spacing of 30 cm with discharge of 2.2 lph, placed between two rows of crops. Water to the buckets was provided through a pipe from the source of water supply used for irrigating the main field. 120 litres of water was utilized every week for irrigating $50m^2$. Soil application of recommended dose of fertilizer (RDF) @ 90:90:75 kg/ha NPK(0.98kg Urea, 2.81kg SSP and 0.62kg MOP/$50m^2$) for marigold and 200:200:200 kg/ha NPK(2.17kg Urea, 6.25kg SSP and 1.67kg MOP/$50m^2$) for tuberose was done. For fertigation, water soluble fertilizer (WSF) 19:19:19 was used. Drip fertigation with WSF @ 100% RDF was applied @ 55g for tuberose and @ 24.5g for marigoldat fortnightly interval through drip irrigation for $50m^2$.Observations were recorded on five randomly selected plants from each treatment. The data were recorded on growth, flowering attributes and yield and were subjected to statistical analysis using SPSS statistical software (SPSS Inc., USA).

RESULTS AND DISCUSSION

Effect of different methods of irrigation and fertilizer application in marigold: Drip fertigation with WSF @ 100% RDF had significantly superior effect as compared to other treatments for plant height (71.60cm) as evident from the data of *kharif* and *rabi* season in the Table 1. Maximum plant spread (46.43cm) was recorded under drip fertigation with WSF @ 100% RDF but was statistically similar to the treatment drip irrigation with soil application of RDF (44.36cm). In case of flowering parameters, maximum duration of flowering (65.33 days) was found under drip fertigation with WSF @ 100% RDF which was significantly superior over all the other methods. Maximum flower diameter (4.82cm) was also recorded with drip fertigation with WSF @ 100% RDF which however, was *at par* with the treatment drip irrigation + soil application of RDF (4.67cm). Highest number of flowers/plant (48.96) and maximum flower yield/plant (288.58g) was recorded under drip fertigation with WSF @ 100% RDF application which was significantly superior over all the other treatments (Table 1). Due to application of 100% RDF through fertigation directly around the root system there may have been no leaching losses and availability of optimum soil moisture also contributed in better utilization of applied nutrients (Shedeed *et al.*, 2007). Highest yield and yield attributes with 100% RDF through water soluble fertilizers has also been observed in marigold. These results are in conformity with the findings of other researchers who also reported highest nutrient use efficiency in 100% recommended fertigation dose though drip irrigation in marigold (Srinivas *et al.*, 2018).

Effect of plant spacing in marigold: Plant spacing significantly affected the vegetative and flowering parameters except for plant spread. Significantly maximum plant height (67.88cm) was recorded at a plant spacing of 30×30cm (Table 1). Tall plant height with closer spacing has also been observed in other flower crops with one of the reason that plant has lesser area for lateral growth (Ahmad *et al.*, 2019). However, maximum flowering duration (59.40 days), flower diameter (4.77cm), number of flowers/plant (41.33) and flower yield/plant (203.84g) was recorded at plant spacing of 40×30cm. Higher individual plant yield at wider spacing may be due to for nutrients, light and moisture thereby increases the flowering attributes. The increase in floral characters might be due to the availability of more space resulting in less competition among the plants which provided better penetration of light, more aeration and ultimately increased photosynthetic activity resulting into higher yield. Similar results have been obtained in marigold which also indicated that the wider spacing of 40x30 cm resulted in highest flower yield per plant whereas, the closer spacing resulted in maximum plant height (Jat, 2006; Naik *et al.*, 2019). Optimum plant spacing enhances better utilization of spaces, high yield, and quality production (Ara *et al.*, 2007).

Interaction effect of different methods of irrigation and fertilizer application with plant spacing in marigold: The interaction effect of methods of irrigation and fertilizer application with plant spacing was found to be significantly different for all the parameters under investigation except for plant spread. In case of plant height, maximum plant height (73.06cm) was recorded under drip fertigation with WSF @ 100% RDF at plant spacing of 30×30cm followed by drip irrigation + soil application of RDF at plant spacing of 30x30cm (72.26cm) and drip fertigation with WSF @ 100% RDF at 40×30cm (70.93cm), however all being statistically equal (Table 1). Longest flowering duration (67 days) was noted in the treatment drip fertigation with WSF @ 100% RDF at 40 × 30cm plant spacing, which was *at par* with drip fertigation with WSF @ 100% RDF at plant spacing of 30×30cm (60 days) and also drip irrigation + soil application of RDF at 40×30cm (59 days). Maximum flower diameter (5.32cm) was recorded in the treatment drip fertigation with WSF @ 100% RDF with 40×30cm plant spacing, followed by drip irrigation + soil application of RDF at 40×30cm spacing (5.28cm) and drip fertigation with WSF @ 100% RDF at 30×30cm (4.96cm), all having *at par* effect (Table 1). Significantly highest number of flowers/plant (54.60) and flower yield/plant (299.73g) was recorded in the treatment drip fertigation with WSF @ 100% RDF at 40×30cm plant spacing which was superior over all other treatments.

Table 1: Effect of irrigation, fertigation and plant spacing on growth and flowering parameters in African marigold *Mean values Kharif and Rabi (2018-19).*

Treatments	Plant height (cm)	Plant spread (cm)	Duration of flowering (days)	Flower diameter (cm)	No. of flowers/ plant	Yield/ plant (g)
I_1	59.03	39.86	44.50	3.62	33.50	150.11
I_2	66.20	44.36	53.33	4.67	40.80	208.50
I_3	71.60	46.43	65.33	4.82	48.96	288.58
I_4	63.53	41.73	55.50	4.30	39.26	188.99
I_5	57.30	38.36	42.00	3.56	28.83	138.03
SEm (+)	2.50	1.38	2.16	0.16	1.11	4.44
LSD (P=0.05)	7.49	4.13	6.48	0.50	3.32	13.29
S_1	67.88	41.85	52.86	3.94	35.21	194.85
S_2	60.78	42.45	59.40	4.77	41.33	203.84
SEm (+)	1.58	0.87	1.36	0.10	0.70	2.78
LSD (P=0.05)	4.73	NA	4.09	0.31	2.11	8.34
$I_1 S_1$	63.00	40.73	48.00	3.61	31.00	158.81
$I_2 S_1$	72.26	40.20	56.66	3.75	38.00	242.21
$I_3 S_1$	73.06	39.93	60.00	4.96	43.86	276.59
$I_4 S_1$	66.73	47.20	55.66	4.03	35.53	218.68
$I_5 S_1$	64.33	44.20	51.00	2.96	27.66	122.89
$I_1 S_2$	41.53	42.73	55.66	4.28	36.00	153.18
$I_2 S_2$	68.06	39.53	59.00	5.28	46.06	219.16
$I_3 S_2$	70.93	36.80	67.00	5.32	54.60	299.90
$I_4 S_2$	64.06	45.66	56.00	4.92	40.53	174.80
$I_5 S_2$	59.33	44.53	54.33	4.37	30.00	141.54
SEm (+)	3.53	1.95	3.06	0.23	1.57	6.28
LSD (P=0.05)	10.59	NA	9.16	0.70	4.72	18.80

I_1: Drip irrigation, I_2: Drip irrigation + Soil application of RDF, I_3: Drip fertigation with WSF @ 100% RDF, I_4: Surface flood irrigation + Soil application of RDF, I_5: Surface flood irrigation (Control); S_1: 30×30cm, S_2: 40×30cm

Significantly higher flower yield in marigold associated with wider spacing and water soluble fertilizers at 100% RDF supplied through fertigation have also been reported earlier by Chaitra and Gopinath (2018). It has been opined that higher yield under fertigation may be due to increased nutrient uptake due to frequent and direct application of water soluble fertilizers in the root zone which led to minimum leaching losses (Sumangala *et al.*, 2018). Further, the increase in nutrient uptake due to conducive environment of the growing media created by maintaining high moisture level at root zone, might have increased the solubility of these nutrients and their uptake thereby enhancing the yield parameters.

Effect of different methods of irrigation and fertilizer application in tuberose: Effect of irrigation and fertilizer application method significantly affected the plant spread in tuberose. Significantly maximum plant spread (29.36 cm) was recorded due to the effect of drip fertigation with WSF @ 100% RDF over all the other methods (Table 2). Similarly, the effect of drip fertigation with WSF @ 100% RDF was found to be significantly superior over other methods for spike length (85.11cm) and number of florets/spike (53.50). Maximum number of spikes per plant (8.00) was also recorded with drip fertigation with WSF @ 100% RDF which however, was found to be *at par* with the application drip irrigation + soil application of RDF. The results are in line with the of findings of other researchers who in tuberose observed that 100% water soluble fertilizers applied through drip fertigation system significantly increased the plant growth (Kabariel and Kannan, 2015). Fertigation at frequent interval of time in small quantities might have increased the fertilizer use efficiency and nutrient uptake preventing the loss of nutrients by leaching, erosion as well as by weeds. Effective and efficient utilization of water and nutrients by the plants may have resulted in better plant growth (Kabariel and Kannan,2015). Similarly, it has been reported that fertigation with water soluble fertilizers at 125% of recommended dose of fertilizers recorded higher vegetative growth whereas, 75% of RDF using WSF showed better yield characters and 100% RDF using WSF resulted in maximum vase life in tuberose (Kumari *et al.*, 2020).

Table 2. Effect of irrigation, fertigation and plant spacing on growth and flowering parameters in Tuberose.

Treatments	Plant spread (cm)	Spike length (cm)	No. of florets/spike	No. of spikes
I_1	22.93	72.95	45.83	5.66
I_2	24.35	82.11	52.00	7.50
I_3	29.36	85.11	53.50	8.16
I_4	27.46	79.46	49.66	6.83
I_5	21.01	70.65	46.33	5.66
SEm (+)	0.38	1.89	1.09	0.27
LSD (P=0.05)	1.13	5.68	3.27	0.81
S_1	24.98	79.30	49.13	6.73
S_2	25.06	77.61	49.20	6.80
SEm (+)	0.24	1.20	0.69	0.17
LSD (P=0.05)	NA	NA	NA	NA
I_1 S_1	21.20	73.56	47.00	5.66
I_2 S_1	25.40	85.36	48.00	8.00
I_3 S_1	29.53	88.53	54.33	9.00
I_4 S_1	28.20	77.66	51.33	6.00
I_5 S_1	20.03	72.03	45.00	5.33
I_1 S_2	22.00	73.86	46.66	6.00
I_2 S_2	24.66	84.73	52.33	7.66
I_3 S_2	30.10	85.50	53.66	8.66
I_4 S_2	28.63	75.70	49.66	6.33
I_5 S_2	20.50	67.63	43.66	5.00
SEm (+)	0.53	2.68	1.54	0.38
LSD (P=0.05)	1.60	8.03	4.62	1.15

Interaction effect of different methods of irrigation and fertilizer application and plant spacing in tuberose: The interaction effect of methods of irrigation and fertilizer application with plant spacing significantly influenced the vegetative and flowering parameters in tuberose (Table 2), though the effect of spacing on tuberose yield was found to be non-significant. Significant interaction effect was found in plant spread, with maximum plant spread (30.10cm) recorded with drip fertigation with WSF @ 100% RDF at 40×30cm plant spacing which was *at par* with drip fertigation with WSF @ 100% RDF at 30×30cm (29.53cm) and treatment surface flood irrigation + soil application of RDF at 40×30cm (28.63cm). The interaction effect was found to be significantly different for flowering parameters as well. Maximum spike length (88.53cm) was recorded with drip fertigation with WSF @ 100% RDF at 30×30cm which was statistically equal with drip fertigation with WSF @ 100% RDF at 40×30cm (85.50cm) and drip irrigation + soil application of RDF at 30×30cm (85.36cm). As evident from Table 2, similar trend was observed for number of florets/spike with maximum number (54.33) recorded with drip fertigation with WSF @ 100% RDF at 30×30 cm followed by drip fertigation with WSF @ 100% RDF at 40×30cm (53.66) and drip irrigation +

soil application of RDF at 30×30cm (52.33),all being *at par* with each other. In case of number of spikes/plant, maximum number (8.33) was noted under drip fertigation with WSF @ 100% RDF at 30×30cm which was found to be *at par* with drip fertigation with WSF @ 100% RDF at 40×30cm (8.00) and drip irrigation + soil application of RDF at 30×30cm (8.00). The higher yield as compared to normal fertilizer may be due to proper distribution and availability of nutrients in the in soil with fertigation whereas soil application generally tends to cause uneven distribution of fertilizers in the root zone (Shedeed *et al.*, 2007). The results are in conformity with the findings reported earlier in tuberose (Shashidhar *et al.*, 2008; Desai and Thirumala, 2015).

Economic analysis: All combinations of drip irrigation and fertigation recorded higher net returns and B:C ratio than control in both crops (Table 3 and 4). In marigold, interaction of drip fertigation with WSF @ 100% RDF at 30×30 cm plant spacing recorded highest gross returns of INR (Indian Rupee) 13070/50m^2 bund and net returns of INR 7270/50m^2 bund as well as highest B:C ratio of 1.25 (Table 3) which was closely followed by combination of drip fertigation with WSF @ 100% RDF at 40×30 cm plant spacing which registered gross returns (INR11903/50m^2) bund and net returns (INR6343/50m^2) bund and B:C ratio of 1.14. Though, highest yield/plant was recorded in the treatment drip fertigation with WSF @ 100% RDF at 40×30 cm plant spacing, but may be due to more number of plants accommodated in lesser spacing of 30x30 cm, the treatment drip fertigation with WSF @ 100% RDF at 30×30 cm plant spacing, was found to have the highest B:C ratio. Similarly, in case of tuberose (Table 4), interaction of drip fertigation with WSF @ 100% RDF at 30×30 cm plant spacing recorded highest gross returns of INR13041/50m^2 bund, net returns of INR 7316/50m^2 bund and highest B:C ratio of 1.28. Comparable results were also obtained in vegetable crops wherein, it was opined that the magnitude of yield is influenced by plant population and its distribution pattern, which are important for getting maximum economic yield from a given field area (Singh and Saimbhi, 1998).

Table 3: Economics of marigold cultivation for 50m^2 bund.

Treatments	Total cost of cultivation* (Rs)	Gross return in (Rs)	Net return in (Rs)	BC Ratio
I_1 S_1	5500	8463	2963	0.54
I_2 S_1	5900	11825	5925	1.00
I_3 S_1	5800	13070	7270	1.25
I_4 S_1	4400	9359	4959	1.13
I_5 S_1	4000	6535	2535	0.63
I_1 S_2	5260	6141	881	0.17
I_2 S_2	5660	11037	5377	0.95
I_3 S_2	5560	11903	6343	1.14
I_4 S_2	4160	8694	4534	1.09
I_5 S_2	3760	5605	1845	0.49

* Cost of cultivation includes low cost drip system, planting material, fertilizers, pesticide cost; Average selling rate of marigold of *Kharif* season: INR60/kg; Average selling rate of marigold of *rabi* season: INR50/kg; No. of plants/50m^2 in S_1 : 483; No. of plants/50m^2 in S_2: 360

Table 4: Economics of tuberose cultivation (one year) for 50m^2 bund.

Treatments	Total cost of cultivation* (Rs)	Gross return in (Rs)	Net return in (Rs)	BC Ratio
I_1 S_1	5500	8211	2711	0.49
I_2 S_1	5800	11592	5792	1.00
I_3 S_1	5725	13041	7316	1.28
I_4 S_1	4290	8694	4404	1.03
I_5 S_1	4000	7728	3728	0.93
I_1 S_2	4900	6480	1580	0.32
I_2 S_2	5190	8280	3090	0.60
I_3 S_2	5125	9360	4235	0.83
I_4 S_2	3690	6840	3150	0.85
I_5 S_2	3400	5400	2000	0.59

* Cost of cultivation includes low cost drip system, planting material, fertilizers, pesticide; Average selling rate: INR3/cut spike; No. of plants/50m^2 in S_1 :483;No. of plants/50m^2 in S_2: 360

CONCLUSION

On the basis of investigation, interaction effect of drip fertigation with WSF @ 100% RDF at 40×30 cm plant spacing was found to be superior for growth, flowering parameters and yield in case of marigold. However, higher B:C ratio was obtained at lesser plant spacing of 30×30 cm due to more number of plants accommodated at lesser plant spacing. In tuberose, application of drip fertigation with WSF @ 100% RDF at plant spacing of 30×30 cm resulted in higher growth, yield parameters and B:C ratio. Therefore, it may be inferred that for additional income, either marigold or tuberose can be taken on bund planting at the spacing of 30×30 cm under low cost fertigation with WSF @ 100% RDF.

FUTURE SCOPE

Planting on bunds not only results in utilization of the waste land but also leads to alternative income. By proper water and nutrient management, higher yield with optimum resource utilization can be obtained. In the future course of time, with shrinking cultivable land, bunds may be utilized more often for cultivation. Other flower crops can also be tested for commercial bund planting. Besides monetary income, scope of these flower crops for biological control can be explored.

Conflict of interest. None.

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