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Original Research Paper

Standardisation of agro-techniques for flower quality parameters in ornamental sunflower (*Helianthus annus* L.)

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ABSTRACT

An experiment was carried out on standardisation of agro-techniques for flower quality parameters in ornamental sunflower during 2012-13 at GKVK, campus, College of Horticulture, University of Horticultural Sciences, Bagalkot. In three way interaction effect longest stalk length (36.33) was in the treatment combination of mulching i.e M_1 (with mulch) with a spacing of S_1 (60 cm x 40 cm) at the fertilizer rate F_1 (40:60:40 NPK kg ha^{-1}). Stalk girth was maximum with mulching treatment of M_1 (with mulch) at a spacing of S_1 (60 cm x 40 cm) with the fertilizer rate of F_3 (80:90:80 NPK kg ha^{-1}) and without mulch at the spacing of S_1 (60 cm x 40 cm) with fertilizer rate of F_3 (80:90:80 NPK kg ha^{-1}) recording 0.49 and 0.46 cm respectively. Mulching i.e M_1 (with mulch) at spacing S_1 (60 cm x 40 cm) with fertilizer rate if F_3 (80:90:80 NPK kg ha^{-1}) produced plants with largest flower head diameter (13.24 cm). The treatment combinations of M_1 (with mulch) + S_1 (60 cm x 40 cm) + F_3 (80:90:80 NPK kg ha^{-1}) 4.65 cm recorded broadest flower disc diameter. Considering the results ornamental sunflower can be grown best without mulching, at a spacing of 60 x 30 cm or 60 x 40 cm with optimum to higher fertilizer dose to give best flower quality in ornamental sunflower.

Key words: Ornamental sunflower, mulching, spacing, fertilizers, quality

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is native to North America and belongs to the family *Asteraceae*. The term *Helianthus* comes from the Greek word '*Helios*' meaning sun and '*anthos*' meaning flower. Initially the Americans used sunflower for food and medicinal purposes. In later years, sunflower became a very important oil seed crop around the world due to the industrial value of its oil. In the early ninetees, sunflower regained popularity as a cut flower crop. Historically sunflower was first used as a garden plant, then as a flowering pot plant. This crop is very easy to grow and has wide adaptability. In India the area under cultivation of sunflower as garden crop or cut flower is negligible, as it is often grown for oil extraction purpose in India. In any crop, genotypes, soil, cultural practices and their interactions exert profound influence on productivity and quality of crops. However, it is not possible to manipulate the environment for better crop growth, but one can manipulate the micro climate of the field to certain extent by adopting suitable cultural practices. In the present study an attempt was made to study the impact of agrotechniques on quality parameters in ornamental sunflower. Crop production and the resultant yield is a complex phenomenon interacted by several factors. The yield can be manipulated by taking advantage of their combined actions. Hence three factors *viz*., plastic mulching, spacing and fertilizer levels were used in the present experiment.

MATERIAL AND METHODS

An experiment was carried out on Standardisation of agro-techniques for flower quality parameters in ornamental sunflower during 2012-13 at GKVK, campus, College of Horticulture, University of Horticultural Sciences, Bagalkot. The promising genotype M-17R was used to standardize

agro-techniques for flower yield and post harvest quality. Split Split Plot design was followed by adopting Fisher's method of analysis of variance technique as given by Panse and Sukhatamane (2002) by using SAS package V9-3 available at statistical cell, IIHR, Bengaluru. The experiment consisted of three replications and eighteen treatments. The experiment consisted of main factor, sub factor and sub sub factor.

Main factor: Mulching
1) Plastic mulch 50 (µ) (M_1) 2) Without mulch (M_2)

Sub factor: Spacing (cm)
1) 60 cm x 40 cm (S_1) 2) 60 cm x 30 cm (S_2) 3) 60 cm x 20 cm (S_3)

Sub-Sub factor: Fertilizers (NPK kg/ha)
1) 40:60:40 kg/ha (F_1) 2) 60:75:60 kg/ha (F_2) 3) 80:90:80 kg/ha (F_3)

The experiment was laid out with the above stated factors into plots measuring 6.72 m^2 each with 4 rows in each plot of 2.8 meter length and 2.4 meter width with 37.33 plants in each plot. Minimum distance of 60 cm was maintained between the plots. There were totally 54 plots. Basal dose of 50% nitrogen in the form of urea + full dose of phosphorous (SSP) & potassium (MOP) were applied at the time of sowing and top dressing of 50% Nitrogen was taken up at 30-35 days after sowing. After sowing, plastic mulch (25 µ) was applied to the plots whereever mulching treatment was applicable. Irrigation was provided 2 days before sowing and immediately after sowing and thereafter at 8-10 days interval and 45 days after sowing earthing-up was done.

RESULTS AND DISCUSSION

Individual effect of mulching, spacing and fertilizer levels on quality parameters

Mulching treatment M_1 (with mulch) and M_2 (without mulch) had no significant effect on flower stalk length, flower stalk diameter, number of petals, disc diameter. But M_1 (with mulch) plants produced largest flower head diameter (11.55 cm) while M_2 (without mulch) plants produced smallest flower head diameter (11.17 cm) **(Table 1).**These results are in conformity with Yathindra (2009) in china aster.

Wider spacing S_1 (60 cm x 40 cm) produced highest stalk length (32.77 cm) and stalk girth (0.42 cm). The results are in conformity with Sloan *et al*. (2004) in ornamental sunflower variety 'Sunbright Supreme'. Spacing of the plants at S_1 (60 cm x 40 cm) followed by S_3 (60 cm x 20 cm) increased the flower head diameter 12.09 and 11.18 cm, respectively. While, S_2 (60 cm x 30 cm) spaced plants induced lowest flower head diameter (10.81 cm). Widest flower disc was recorded in plants spaced at wider spacing S_1 (60 cm x 40 cm) recording 4.29 cm. The higher flower diameter in plants grown at wider spacing might be due to the utilization of more nutrients by plants. Similar results were reported by Deepa (2007) and Munikrisnappa (2011) in China aster **(Table 1).**

Fertilizer application with F_3 (80:90:80 NPK kg ha^{-1}) and F_2 (60:75:60 NPK kg ha^{-1}) produced longest flower stalk length (31.4 and 31.09 cm, respectively). Application of F_3 (80:90:80 NPK kg ha^{-1}) followed by F_2 (60:75:60 NPK kg ha^{-1}) increased the flower stalk girth (0.42 and 0.40 cm respectively. It may be due to the utilization of higher amount of nutrients which increases the stalk length and diameter of the flower stalk. Similar results were obtained by Gireesh (2004) and Munikrisnappa (2011) in China aster. The three fertilizer levels registered no significant difference with respect to number of ray florets per flower. Application of plants with higher level of fertilizers F_3 (80:90:80 NPK kg ha^{-1}) followed by optimum level of fertilizers F_2 (60:75:60 NPK kg ha^{-1}) produced maximum flower head diameter (11.62 and 11.32 cm, respectively) while minimum flower head diameter (11.14 cm) was registered with F_1 (40:60:40 NPK kg ha^{-1}) level of fertilizers. Application of higher level of fertilizers F_3 (80:90:80 NPK kg ha^{-1}) and optimum level F_2 (60:75:60 NPK kg ha^{-1}) produced maximum flower disc diameter (4.28 and 4.16 cm, respectively). Similar results were reported by Sowmyamala (2007) in gaillardia and Munikrishnappa (2011) in China aster.

Two way interaction effect of mulching, spacing and fertilizers on quality parameters

Mulching at wider spacing S_1 (60 cm x 40 cm) followed by M_2 (without mulch) plants at S_1 (60 cm x 40 cm), M_2 (without mulch) plants at S_3 (60 cm x 20 cm) and M_2 (without mulch) plants at S_2 (60 cm x 30 cm) induced longest flower stalk length (34.67, 30.87,

Table 1. Individual effect of mulching, spacing and fertilizer levels on flower quality parameters.

Mulching levels (Main factor)		Flower stalk length (cm)	Flower stalk girth (cm)	Number of ray florets per flower head	Flower head diameter (cm)	Flower disc diameter (cm)
M_1	With mulch	30.19	0.41	33.86	11.55	4.16
M_2	Without mulch	30.24	0.38	34.04	11.17	4.11
CD (P=0.05)		1.61	0.05	1.15	0.36	0.30
F-test		NS	NS	NS	*	NS
Spacing levels (Sub factor)		Flower stalk length (cm)	Flower stalk girth (cm)	Number of ray florets per flower head	Flower head diameter (cm)	Flower disc diameter (cm)
S_1	60 cm x 40 cm	32.77	0.42	34.10	12.09	4.29
S_2	60 cm x 30 cm	29.01	0.39	34.20	10.81	4.03
S_3	60 cm x 20 cm	28.87	0.39	33.54	11.18	4.07
CD (P=0.05)		0.99	0.02	0.70	0.22	0.10
F-test		*	*	NS	*	*
Fertilizer levels (Sub-sub factor)		Flower stalk length (cm)	Flower stalk girth (cm)	Number of ray florets per flower head	Flower head diameter (cm)	Flower disc diameter (cm)
F_1	40:60:40 NPK kg ha^{-1}	28.14	0.37	33.98	11.14	3.96
F_2	60:75:60 NPK kg ha^{-1}	31.09	0.40	33.94	11.32	4.16
F_3	80:90:80 NPK kg ha^{-1}	31.41	0.42	33.92	11.62	4.28
CD (P=0.05)		0.98	0.01	0.77	0.12	0.11
F-test		*	*	NS	*	*

* - Significant at $P = 0.05$ NS - Non significant at $P = 0.05$

30.49 and 29.38 cm respectively). The combination of M_1 (with mulch) at wider spacing S_1 (60 cm x 40 cm) induced maximum stalk girth (0.45 cm). Most of the treatment combinations induced non-significant difference with respect to increased stalk girth. It is due to response of plant density levels to the behaviour of yield and growth characters. Similar results were observed by Venugopal (1991) in everlasting flower and Munikrishnappa (2011) in China aster with different spacing levels **(Table 2).**

Maximum number of ray florets per flower, was registered with M_2 (without mulch) at S_2 (60 cm x 30 cm) and S_1 (60 cm x 40 cm) spacing levels (34.91 and 34.76 ray florets per flower, respectively and M_2 (without mulch) S_3 (60 cm x 20 cm) with (33.87) ray florets per flower, respectively. Spacing without mulch gave maximum number of ray florets per flower which is an important character in ornamental cut flowers. Generally number of petals is a genetic character and mulching or spacing plays a very little role to increase or decrease the character. M_1 (with mulch) plants at all the three spacing levels registered highest flower disc diameter (4.45, 4.24 and 4.20 cm, respectively). This might be because sunflower is basically a drought tolerant crop, and performs better when it is not stressed for water. If all the resources needed for optimum growth and flowering parameters are supplied adequately there is no need of additional treatments in this crop (Marc and Palmer, 1976).

While in mulching with fertilizer levels, M_2 (without mulch) with F_3 (80:90:80 NPK kg ha^{-1}) and F_2 (60:75:60 NPK kg ha^{-1}) increased stalk length of 32.64 and 31.36 cm respectively and M_1 (with mulch) F_2 (60:75:60 NPK kg ha^{-1}) 30.82 cm **(Table 3)**. The increase in stalk length may be due to adequate supply of nutrients and water to the crop. Similar results were also recorded by Gavhane *et al*. (2004) in marigold.

Overall treatment combinations of mulching and fertilizers levels recorded non significant influence on the number of ray florets per flower. Flower head diameter was highest in M_1 (with mulch) plants applied with F_3 (80:90:80 NPK kg ha^{-1}) (12.25 cm). The combination of M_1 (with mulch) F_3 (80:90:80 NPK kg ha^{-1}) and M_2 (without mulch) F_2 (60:75:60 NPK kg ha^{-1}) produced maximum flower disc diameter (4.44 and 4.23 cm, respectively). The results are in conformity with Gavhane *et al*. (2004) in marigold and Yathindra (2009) in China aster **(Table 3).**

Wider spaced plants at S_1 (60 cm x 40 cm) with F_3 (80:90:80 NPK kg ha^{-1}), F_1 (40:60:40 NPK kg ha^{-1}) and F_2 (60:75:60 NPK kg ha^{-1}) levels of fertilizers produced plants with increased flower stalk length (34.93, 31.87 and 31.50 cm, respectively **(Table 4).** Similar results were also reported by Karuppaiah and Krishna (2005) in marigold. Spacing S_1 (60 cm x 40 cm) with F_3 (80:90:80 NPK kg ha^{-1}) produced maximum flower stalk girth 0.48 cm. The treatment combinations of spacing and fertilizers levels showed non significant influence on the number of ray florets per flower. The wider spacing S_1 (60 cm x 40 cm) supplied with F_3 (80:90:80 NPK kg ha^{-1}) increased the flower head diameter (12.52 cm). While S_1 (60 cm x 40 cm) F_3 (80:90:80 NPK kg ha^{-1}) produced flowers with maximum disc diameter (4.60 cm). These results are in conformity with the findings of Rangawala (1987) in tuberose.

Three way interaction effect of mulching, spacing and fertilizers on quality parameters

Longest stalk length (36.33) was recorded in the treatment combination M_1 (with mulch) plants at wider spacing S_1 (60 cm x 40 cm) with lower level of fertilizer F_1 (40:60:40 NPK kg ha^{-1}). Stalk girth was maximum with M_1 (with mulch) + S_1 (60 cm x 40 cm) + F_3 (80:90:80 NPK kg ha^{-1}) and M_2 (without mulch) + S_1 (60 cm x 40 cm) + F_3 (80:90:80 NPK kg ha^{-1}) recording 0.49 and 0.46 cm, respectively **(Table 5)** Sloan *et al.* (2004 reported that spacing in ornamental sunflower depends on the desired plant population, length and thickness of the stem and the size of the inflorescence. The most popular spacing range is 15-30 cm in between the plants and 45-91 cm between rows. Similar results were also reported by Hemalatha (2010) in *Gomphrena globosa*. The number of ray florets per flower was not significantly influenced by the treatment combination of mulching, spacing and fertilizer levels. The treatment combination M_1 (with mulch) S_1 (60 cm x 40 cm) with F_3 (80:90:80 NPK kg ha^{-1}) produced plants with largest flower head diameter (13.24 cm). The treatment combinations of M_1 (with mulch) + S_1 (60 cm x 40 cm) + F_3 (80:90:80 NPK kg ha^{-1}) 4.65 cm recorded broadest flower disc diameter which was at par with M_2 (without mulch) + S_1 (60 cm x 40 cm) + F_3 (80:90:80 NPK kg ha^{-1}), M_1 (with mulch) + S_3 (60 cm x 20

Table 2. Effect of different levels of mulching with spacing levels on flower quality parameters.

Mulching levels (Main factor)		Flower stalk length (cm)	Flower stalk girth (cm)	Number of ray florets per flower head	Flower head diameter (cm)	Flower disc diameter (cm)
M_1	With mulch	30.19	0.41	33.86	11.55	4.16
M_2	Without mulch	30.24	0.38	34.04	11.17	4.11
CD (P=0.05)		1.61	0.05	1.15	0.36	0.30
F-test		NS	NS	NS	*	NS
Spacing levels (Sub factor)		Flower stalk length (cm)	Flower stalk girth (cm)	Number of ray florets per flower head	Flower head diameter (cm)	Flower disc diameter (cm)
S_1	60 cm x 40 cm	32.77	0.42	34.10	12.09	4.29
S_2	60 cm x 30 cm	29.01	0.39	34.20	10.81	4.03
S_3	60 cm x 20 cm	28.87	0.39	33.54	11.18	4.07
CD (P=0.05)		0.99	0.02	0.70	0.22	0.10
F-test		*	*	NS	*	*
Fertilizer levels (Sub-sub factor)		Flower stalk length (cm)	Flower stalk girth (cm)	Number of ray florets per flower head	Flower head diameter (cm)	Flower disc diameter (cm)
F_1	40:60:40 NPK kg ha^{-1}	28.14	0.37	33.98	11.14	3.96
F_2	60:75:60 NPK kg ha^{-1}	31.09	0.40	33.94	11.32	4.16
F_3	80:90:80 NPK kg ha^{-1}	31.41	0.42	33.92	11.62	4.28
CD (P=0.05)		0.98	0.01	0.77	0.12	0.11
F-test		*	*	NS	*	*

* - Significant at $P = 0.05$ NS - Non significant at $P = 0.05$

Table 3. Effect of different levels of mulching with fertilizer levels on flower quality parameters.

Mulching x Fertilizer (Main factor x Sub-sub factor)	Flower stalk length (cm)			Flower stalk girth (cm)			Number of ray florets per flower head			Flower head diameter (cm)			Flower disc diameter (cm)		
	(M_1) With mulch	(M_2) Without mulch	Mean	(M_1) With mulch	(M_2) Without mulch	Mean	(M_1) With mulch	(M_2) Without mulch	Mean	(M_1) With mulch	(M_2) Without mulch	Mean	(M_1) With mulch	(M_2) Without mulch	Mean
(F_1) 40:60:40	29.56	26.73	28.14	0.40	0.34	0.37	34.29	33.67	33.98	11.35	10.93	11.14	3.94	3.98	3.96
(F_2) 60:75:60	30.82	31.36	31.09	0.40	0.39	0.40	33.31	34.58	33.94	11.57	11.06	11.32	4.09	4.23	4.16
(F_3) 80:90:80	30.18	32.64	31.41	0.43	0.41	0.42	33.98	33.87	33.92	12.25	11.00	11.62	4.44	4.11	4.28
Mean	30.19	30.24	30.21	0.41	0.38	0.40	33.86	34.04	33.95	11.72	11.17	11.44	4.16	4.11	4.13
CD (P=0.05) to compare Mulching treatments at same level of fertilizers	1.39			0.02			1.09			0.16			0.16		
F-test	*			*			*			*			*		
CD (P=0.05) to compare Mulching treatments at same or different levels of fertilizers	2.07			0.05			1.55			0.37			0.33		
F-test	*			*			NS			*			*		

* - Significant at $P = 0.05$ NS - Non significant at $P = 0$

Table 4. Effect of different levels of spacing with fertilizer levels on flower quality parameters.

Spacing x Fertilizer Sub factor x Sub-sub factor)	Flower stalk length (cm)				Flower stalk girth (cm)				Number of ray florets per flower head				Flower head diameter (cm)				Flower disc diameter (cm)			
	(S_1) 60x40	(S_2) 60x30	(S_3) 60x20	Mean	(S_1) 60x40	(S_2) 60x30	(S_3) 60x20	Mean	(S_1) 60x40	(S_2) 60x30	(S_3) 60x20	Mean	(S_1) 60x40	(S_2) 60x30	(S_3) 60x20	Mean	(S_1) 60x40	(S_2) 60x30	(S_3) 60x20	Mean
(F_1) 40:60:40	31.87	27.23	25.33	32.77	0.38	0.38	0.36	0.37	34.53	34.07	33.33	33.98	11.87	10.93	10.63	11.14	4.06	3.94	3.88	3.96
(F_2) 60:75:60	31.50	30.47	31.30	29.01	0.40	0.38	0.41	0.40	33.83	34.50	33.50	33.94	11.89	10.85	11.21	11.32	4.23	4.09	4.17	4.16
(F_3) 80:90:80	34.93	29.33	29.97	28.87	0.48	0.39	0.39	0.42	33.93	34.03	33.80	33.92	12.52	10.65	11.69	11.62	4.60	4.07	4.16	4.28
Mean	28.14	31.09	31.41	30.21	0.42	0.39	0.39	0.40	34.10	34.20	33.54	33.95	12.09	10.81	11.18	11.36	4.29	4.03	4.07	4.13
CD (P=0.05) to compare spacing treatments at same level of fertilizers	1.70				0.02				1.33				0.20				0.20			
F-test	*				*				NS				*				*			
CD (P=0.05) to compare spacing treatments at same or different levels of fertilizers	1.57				0.02				1.21				0.23				0.18			
F-test	*				*				NS				*				*			

* - Significant at $P = 0.05$ NS - Non significant at $P = 0.05$

Table 5. Interaction effect of different levels of mulching x spacing x fertilizer levels on flower quality parameters.

Mulching x Spacing x Fertilizer interaction (Main factor x Sub factor x Sub sub factor)			Flower stalk length (cm)	Flower stalk girth (cm)	Number of ray florets per flower head	Flower head diameter (cm)	Flower disc diameter (cm)
Mulching levels	Spacing levels	Fertilizer levels					
(M_1) With mulch	(S_1) 60 cm x 40 cm	(F_1) 40:60:40 NPK kg ha^{-1}	36.33	0.45	26.33	12.64	4.43
		(F_2) 60:75:60 NPK kg ha^{-1}	32.33	0.41	32.33	11.39	4.25
		(F_3) 80:90:80 NPK kg ha^{-1}	35.33	0.49	35.33	13.24	4.65
	(S_2) 60 cm x 30 cm	(F_1) 40:60:40 NPK kg ha^{-1}	26.47	0.39	26.47	10.73	3.45
		(F_2) 60:75:60 NPK kg ha^{-1}	29.33	0.39	29.33	10.75	3.89
		(F_3) 80:90:80 NPK kg ha^{-1}	30.13	0.40	30.13	11.17	4.14
	(S_3) 60 cm x 20 cm	(F_1) 40:60:40 NPK kg ha^{-1}	25.87	0.37	25.87	10.68	3.94
		(F_2) 60:75:60 NPK kg ha^{-1}	30.80	0.41	30.80	11.04	4.13
		(F_3) 80:90:80 NPK kg ha^{-1}	25.07	0.38	25.07	12.33	4.53
(M_2) Without mulch	(S_1) 60 cm x 40 cm	(F_1) 40:60:40 NPK kg ha^{-1}	27.40	0.31	27.40	11.10	3.68
		(F_2) 60:75:60 NPK kg ha^{-1}	30.67	0.38	30.67	12.38	4.20
		(F_3) 80:90:80 NPK kg ha^{-1}	34.53	0.46	34.53	11.81	4.54
	(S_2) 60 cm x 30 cm	(F_1) 40:60:40 NPK kg ha^{-1}	28.00	0.38	28.00	11.12	4.43
		(F_2) 60:75:60 NPK kg ha^{-1}	31.60	0.38	31.60	10.95	4.29
		(F_3) 80:90:80 NPK kg ha^{-1}	28.53	0.38	28.53	10.13	3.99
	(S_3) 60 cm x 20 cm	(F_1) 40:60:40 NPK kg ha^{-1}	24.80	0.35	24.80	10.57	3.82
		(F_2) 60:75:60 NPK kg ha^{-1}	31.80	0.41	31.80	11.39	4.20
		(F_3) 80:90:80 NPK kg ha^{-1}	34.87	0.39	34.87	11.05	3.79
Mean			30.21	0.40	33.95	11.36	4.13
CD (P=0.05) to compare mulching x spacing x fertilizer levels			3.02	0.06	2.29	0.48	0.41
F-test			*	*	NS	*	*

* - Significant at $P = 0.05$ NS - Non significant at $P = 0.05$

cm) + F_3 (80:90:80 NPK kg ha^{-1}), M_1 (with mulch) + S_1 (60 cm x 40 cm) + F_1 (40:60:40 NPK kg ha^{-1}) and M_2 (without mulch) + S_2 (60 cm x 30 cm) + F_1 (40:60:40 NPK kg ha^{-1}) registering 4.54, 4.53, 4.43 and 4.43 cm, respectively. This may be attributed to the wider spacing with or without mulching which may have provided with optimum space for growth and development of the flowers. The results are in conformity with Shekhawat *et al*. (2008) in sunflower.

CONCLUSION

Mulching at wider spacing S_1 (60 cm x 40 cm) produced longest flower stalk length. M_1(with mulch) at wider spacing S_1 (60 cm x 40 cm) induced maximum stalk girth. Maximum number of ray florets per flower, was with M_2 (without mulch) at S_2 (60 cm x 30 cm) and S_1 (60 cm x 40 cm) spacing levels. Mulching with fertilizer levels, M_2 (without mulch) with F_3 (80:90:80 NPK kg ha^{-1}) and F_2 (60:75:60 NPK kg ha^{-1}) increased stalk length. Flower head diameter was highest in M_1 (with mulch) plants applied with F_3 (80:90:80 NPK kg ha^{-1}) (12.25 cm). The combination of M_1 (with mulch) F_3 (80:90:80 NPK kg ha^{-1}) and M_2 (without mulch) F_2 (60:75:60 NPK kg ha^{-1}) produced maximum flower disc diameter.

While the three way interaction effect of mulching, spacing and fertilizers on quality parameters revealed longest stalk length with treatment combination M_1 (with mulch) plants at wider spacing S_1 (60 cm x 40 cm) with lower level of fertilizer F_1 (40:60:40 NPK kg ha^{-1}). Stalk girth was maximum with mulch) at S_1 (60 cm x 40 cm) + F_3 (80:90:80 NPK kg ha^{-1}) and M_2 (without mulch) + S_1 (60 cm x 40 cm) + F_3 (80:90:80 NPK kg ha^{-1}). The treatment combination M_1 (with mulch) S_1 (60 cm x 40 cm) with F_3 (80:90:80 NPK kg ha^{-1}) produced plants with largest flower head diameter (13.24 cm). The treatment combinations of M_1 (with mulch) + S_1 (60 cm x 40 cm) + F_3 (80:90:80 NPK kg ha^{-1}) 4.65 cm recorded broadest flower disc diameter.

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