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Research Article

Growth, Achene Yield and Oil Content of Sunflower (*Helianthus annuus* L.) as Affected by Row Spacing

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ABSTRACT

Exploring the effects of row spacing is of crucial significance to achieve the economically optimum achene yield and oil content of sunflower. We conducted a field study during Kharif 2023 to study the effect of row spacing on growth and yield of sunflower. The experiment was administered in a randomized complete block design with three replications. Sunflower was grown providing five different row spacings, viz. 25, 30 (recommended), 35 cm, 40, and 45-cm. The crop was raised following standard recommended agronomic practices and balanced fertilization. Our findings suggested that narrow row spacing (25 cm) significantly enhanced the vegetative traits of sunflowers, i.e., plant population and plant height. In contrast, wide row spacing found significantly beneficial in decreasing the days to 50% flowering (at 40-cm) and days to 50% maturity (at 45-cm). Interestingly, wider row spacing (45-cm followed by 35-cm) significantly enhanced stem girth, head diameter, achene per head, achene weight per head, 1000-achene weight, achene yield, and oil content of sunflower. It was evident that the improved yield traits of sunflower, especially achene characteristics, enhanced the achene yield and oil content of sunflower. In contrast, all these traits were found to be lowest where sunflower was planted in rows that were 25-cm apart. We conclude that sowing of sunflower with a wide row spacing of 45-cm, as against comparatively narrow row spacings, significantly improves its yield contributing traits, achene yield, and oil content.

Keywords: Sunflower, Row spacing, Achene yield, Oil content

Introduction

The sunflower (*Helianthus annuus* L.) is an important oil-seed crop. Sunflower meal is one of the major protein sources in livestock feed (Elsheikh & Schultz, 2019). In Pakistan, sunflower is grown on an area of 75536 ha with a total production of 132803 tons. Pakistan produces 18% of its total required edible oil while the leftover has been imported from other countries. The sunflower contributes only 11% of total local oil production of Pakistan (GoP, 2024).

The annual report of Pakistan oil-seed and product report states that the federal and provincial Punjab governments' cash payment subsidy package to boost sunflower seed production resulted in a 17 percent (%) increase in sunflower seed area harvested during 2019–20, a marginal increase in area, and a significant increase in production, up 7 and 10 percent, respectively (Corpuz & Bedford, 2020). Researchers found that sunflower growth and production are positively impacted by row spacing. When compared to the other treatments, the 30 cm row spacing resulted in noticeably greater plant height, green forage production, and dry forage yield of sunflowers, while the 45 cm row spacing resulted in fewer days to 50% blooming. The highest yields were obtained at 75 cm row spacing under favorable growing

conditions and at 50 cm row spacing under less favorable growing conditions (Ion et al., 2015). Row spacing also had varying effects on the yield components of sunflower head depending on the soil and climatic conditions. Higher nitrogen content was recorded at 30 cm row spacing (Dhakar et al., 2022).

Row spacing is an important factor that can significantly impact sunflower yield. The appropriate row spacing for sunflower cultivation depends on various factors, including soil type, climate conditions, and the specific variety of sunflower being grown. In general, the optimal row spacing for sunflower production aims to maximize plant density while allowing sufficient light penetration and airflow to promote healthy growth and high yield. The relationship between row spacing and sunflower yield, providing insights into the most effective spacing techniques (Umar et al., 2016). The combined impact of row spacing and weed control measures on sunflower growth, yield attributes, and economic aspects. The results revealed that narrower row spacing (60 cm) significantly increased sunflower yield compared to wider row spacing (90 cm). The study emphasized the importance of proper weed control and appropriate row spacing to enhance sunflower productivity. The influence of varying row spacing and nitrogen levels on the growth and yield of sunflower. It reported that narrower row spacing resulted in higher sunflower yield compared to wider row spacing. The importance of optimizing row spacing to maximize yield potential (Thakur et al, 2018).

The row spacing and timing can have a substantial impact on sunflower growth and yield. The way sunflower plants are spaced can affect their competition for resources such as water, nutrients, and sunlight. The altering row spacing at specific growth stages had a significant effect on sunflower development and crop production, leading to recommendations for optimizing these practices. The row spacing and timing are critical factors in maximizing the growth and yield of sunflower (Schulz et al., 2020; Yiberkew et al., 2020; Belay & Mengistu, 2023). This study was conducted to evaluate the effect of different row spacings on growth, achene yield, and oil content of sunflower.

Materials and Methods

Experimental design and treatment details: This field study was carried out by sowing sunflower (*cv.* HO-1) seeds 25 cm deep @12 kg ha^{-1} in 15 m^2 (3m x 5m) plots, at the Students Experimental Farm, Department of Agronomy, Sindh Agriculture University, Tandojam, following randomized complete block design with three replications. The treatments included five row spacings (T_1 to T_5), i.e. 25, 30, 35, 40 and 45 cm.

Land preparation & fertilizer application: The land was prepared by giving deep ploughing. The soil around the seed was kept moist during germination. Sunflower crop received a blanket dose of 100 kg nitrogen (as urea) and 50 kg phosphorus (as SSP) ha^{-1} for all the treatments. Entire quantity of phosphorus and $^1/_3$ of nitrogen were applied at sowing time. The leftover nitrogen was applied in two equal splits at first irrigation and grain formation stages.

Crop Husbandry: The sunflower crop received recommended irrigation and other necessary cultural practices as per its requirement. The crop was harvested at maturity.

Observations recorded: Following the standard methods described to note various parameters of sunflower, we collected data for plant population (m^{-2}), plant height (cm), days to 50% flowering and 50% maturity, stem girth (cm), head diameter (cm), achene per head, achene weight per head (g), 1000-achene weight (g), achene yield (kg ha^{-1}) and oil content (%).

Statistical analysis: Collected data were subjected to analysis of variance using Statistix ver. 8.1. Mean separation was done using least significant difference (LSD) test at alpha 0.05.

Results

Plant population (m^{-2}): Plant population was maximum (12.3 m^{-2}) for 25-cm spaced rows, followed 40-cm and 35-cm row spacing (11.50 m^{-2} and 10.33 m^{-2}, respectively). The plant population decreased at maturity (to 9.27 m^{-2}) for the recommended row spacing of 30-cm. Minimum plant population (8.29 m^{-2}) was recorded for 45-cm spaced rows (Table 1).

Plant height (cm): Plant height was maximum (209.3 cm) for 25-cm row spacing, followed by 35-cm and 40-cm row spacing (200.3 cm and 191.4 cm, respectively). For the recommended row spacing of 30-cm, it was further decreased (182.3 cm). Minimum plant height (173.2 cm) was observed with the row spacing of 45-cm (Table 1).

Days to 50% flowering: Maximum days to 50% flowering (45.5) were noted for 30-cm row spacing, followed by 35-cm and 40-cm row spacing (44.2 and 42.9, respectively). It was followed by those noted for 45-cm spaced rows (41.6). Minimum days to 50% flowering (40.3) was recorded for the row spacing of 25-cm (Table 1).

Days to 50% maturity: The days to 50% maturity followed the same pattern as was noted in case of days to 50% flowering. Maximum days to maturity (82.9) were noted for 30-cm row spacing, followed by 35-cm and 40-cm row spacing (80.66 and 78.13, respectively). It was followed by those noted for 45-cm spaced rows (75.6). Minimum days to 50% flowering (73.1) was recorded for the row spacing of 25-cm (Table 1).

Stem girth (cm): Maximum stem girth (6.12 cm) was noted for 45-cm row spacing, followed by the stem girth obtained at 40-cm and 35-cm row spacing (5.9 cm and 5.6 cm, respectively). It was followed by the stem girth achieved at 30-cm recommended row spacing (5.33 cm).

Minimum stem girth (5.07 cm) was recorded for the row spacing of 25-cm (Table 1).

Head diameter (cm): The head diameter followed a similar pattern as was noted in case of stem girth. Maximum head diameter (24.3 cm) was noted for 45-cm row spacing, followed by the head diameter obtained at 40-cm and 35-cm row spacing (23.8 cm and 23.2 cm, respectively). It was followed by the head diameter noted for 30-cm recommended row spacing (22.7 cm). The minimum head diameter (22.2 cm) was recorded for the row spacing of 25-cm (Table 1).

Achene per head: Achene per head also followed the pattern which was not different from stem girth and head diameter. Maximum achene per head (1857) were noted for 45-cm row spacing, followed by the achene per head obtained at 40-cm and 35-cm row spacing (1826 and 1787, respectively). It was followed by the achene per head noted for 30-cm recommended row spacing (1748). The minimum achene per head (1707) was recorded for the row spacing of 25-cm (Table 2).

Seed weight per head (g): Like the previous three traits, seed weight per head also exhibited a similar trend. Maximum seed weight per head (93.4 g) was noted for 45-cm row spacing, followed by the seed weight obtained at 40-cm and 35-cm row spacing (91.2 g and 88.8 g, respectively). It was followed by the seed weight noted for 30-cm recommended row spacing (86.5 g). The minimum seed weight (84.2 g) was recorded for the row spacing of 25-cm (Table 2).

1000-achene weight (g): Similar trend was exhibited by the achene weight, as was noted in case of stem girth, head diameter, seeds per head and achene weight per head. Maximum achene weight (66.2 g) was noted for 45-cm row spacing, followed by the achene weight obtained at 40-cm and 35-cm row spacing (64.2 g and 62.5 g, respectively). It was followed by the achene weight noted for 30-cm recommended row spacing (60.4 g). The minimum achene weight (58.2 g) was recorded for the row spacing of 25-cm (Table 3).

Achene yield (kg ha^{-1}): Based on the performance of various yield contributing traits, the achene yield of sunflower followed a similar pattern. Maximum achene yield (2402 kg ha^{-1}) was noted for 45-cm row spacing, followed by the achene yield obtained at 40-cm and 35-cm row spacing (2355.2 kg ha^{-1} and 2291.8 kg ha^{-1}, respectively). It was followed by the achene yield noted for 30-cm recommended row spacing (2230.8 kg ha^{-1}). The minimum seed index (2170.7 kg ha^{-1}) was recorded for the row spacing of 25-cm (Table 2).

Achene Oil content (%): The oil content of sunflower also followed a similar trend as was noted in case of important yield contributing traits, especially seed traits. Maximum oil content (41.9%) was noted for 45-cm row spacing, followed by the oil content obtained at 40-cm and 35-cm row spacing (41.8% and 41.6%, respectively). It was followed by the oil content noted for 30-cm recommended row spacing (41.5%). The minimum oil content (40.2%) was recorded for the row spacing of 25-cm (Table 2).

Discussion

Understanding the intricate relationship between row spacing and sunflower growth is essential for tailoring cultivation practices to enhance productivity, economic viability, and sustainability in agricultural systems.

Table 1. Sunflower growth traits as affected by row spacing

Treatment	Row spacing (cm)	Plant population (m^2)	Plant height (cm)	Days to 50% flowering	Days to 50% maturity	Stem girth (cm)	Head diameter (cm)
T1	25	12.3A	209.3A	40.3E	73.2E	5.07E	22.2E
T2	30*	9.3D	182.3D	45.5A	82.9A	5.33D	22.7D
T3	35	10.3C	200.3B	44.2B	80.7B	5.60C	23.2C
T4	40	11.5B	191.4C	42.9C	78.1C	5.86B	23.8B
T5	45	8.3E	173.2E	41.6D	75.6D	6.12A	24.3A
	LSD0.05	0.1307	0.2002	0.1304	0.3977	0.0142	0.1013

** Recommended row spacing*

Table 2. Sunflower achene parameters and oil content as affected by row spacing

Treatment	Row spacing (cm)	Achene per head	Seed weight per head (g)	1000-achene weight (g)	Achene yield (kg ha^{-1})	Achene oil content (%)
T1	25	1707E	84.2E	58.2E	2170.7E	40.2E
T2	30*	1748D	86.5D	60.4D	2230.8D	41.5D
T3	35	1787C	88.8C	62.5C	2291.8C	41.6C
T4	40	1826B	91.2B	64.2B	2355.2B	41.8B
T5	45	1857A	93.4A	66.2A	2402.7A	41.9A
	LSD0.05	11.263	0.2304	0.1935	14.97	0.0386

** Recommended row spacing*

This study was undertaken to investigate the effects of varying row spacing on the growth and yield of sunflower, providing valuable insights into optimizing agronomic strategies for this economically significant crop.

The agronomic practices employed in sunflower cultivation play a crucial role in determining overall plant performance and yield. One such pivotal factor is row spacing, which directly influences the plant's access to sunlight, nutrient availability, and interplant competition.

Compared to many other row plants, sunflowers often have lower planting density and varying row spacing. This increases the susceptibility of crop to weed competition, especially in the initial weeks of development (Bruniard & Miller, 2021).

The optimal row spacing is paramount for maximizing photosynthetic efficiency and promoting robust growth, ultimately impacting the yield potential of sunflower crops. The effects of plant spacing are particularly noticeable in sunflowers as there is no way for branches or tillers to fill up the spaces between plants.

In the present study, sunflower crop grown with wide row spacing (45-cm) offered positively significant results in terms of rate of flowering, growth parameters, achene yield and oil content, as has been reported Yousif & Zain (2023).

In another study, the inter-row spacing significantly affected yield of sunflower (Sandhya et al., 2023). Significant effects of the plant spacing ranging from 15-30 cm were recorded in terms of gradual increase yield and yield contributing traits of sunflower (Maklad, 2023).

The findings of Ibrahim et al. (2023) also endorse our results who highlighted that wider row spacing found to be most significant in enhancing growth and overall quality of the produce of sunflower.

Demir (2020) also unfolded the benefits of proper row spacing to improve the seed yield and oil content of sunflower. Marin & Ion (2022) reported that the highest achene yield of sunflower was recorded at a wider row spacing (70-cm) as compared to narrow ones (50 cm or 60 cm), under favorable climatic conditions. However, the reverse was true under less favorable conditions.

These results clearly demonstrate the importance of proper row spacing to grow sunflower in order to enhance its growth, development, achene yield, and oil content.

Conclusion

We conclude that sowing of sunflower with a wide row spacing of 45-cm, as against comparatively narrow row spacings, significantly improves its yield contributing traits, achene yield, and oil content.

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Conflict of Interest

No competing interests are disclosed by the authors.

Author Contribution

WAO: Conducted field experiment, collected and processed data, literature review, wrote initial draft of MS; AAS: Planned and executed the research, analyzed data, edited all drafts of MS; MNK: helped in data presentation and results interpretation; PAS: format and style, revision of final manuscript drafts; HKP & JAA: Chemical analyses, revision of final draft. All authors approve and assume responsibility of the content of MS.

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