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GROWTH AND YIELD OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) UNDER DIFFERENT ORGANIC (FARMYARD MANURE) AND INORGANIC PHOSPHORUS DOSES

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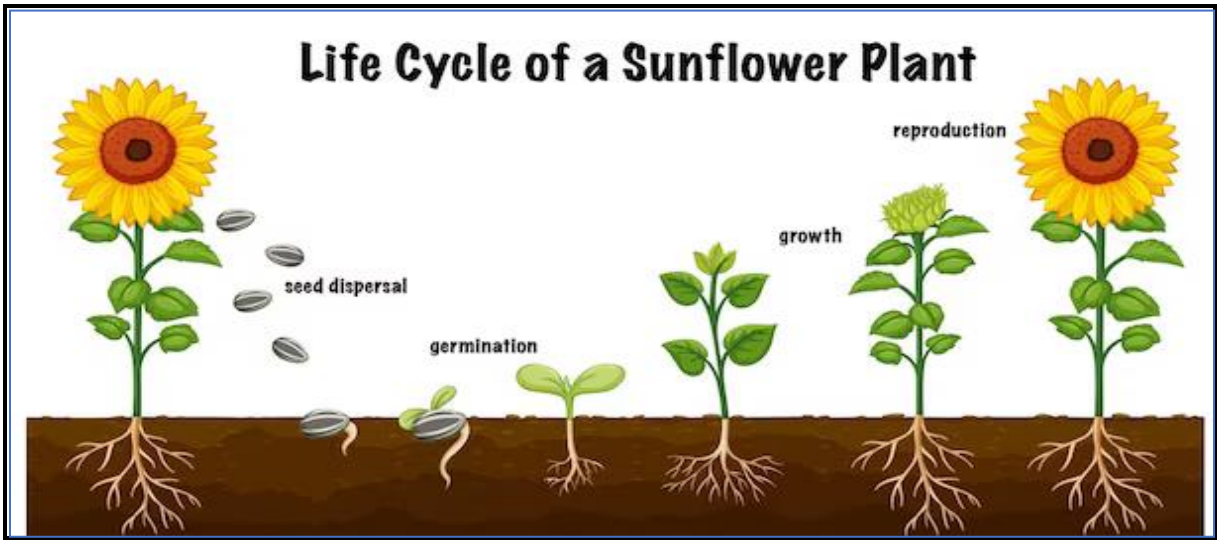
ABSTRACT

In this study, we investigate the impact of different rates of farmyard manure and phosphorus application on the growth and yield of sunflower (Helianthus annuus L.). Our objective is to assess how various levels of organic and inorganic fertilizer influence the development and productivity of this crop. The experiment involved five integrated applications of farmyard manure: T1 = 00 tons of farmyard manure + (P = 00), T2 = 1 ton of farmyard manure + (P = 30 kg ha^{-1}), T3 = 3 tons of farmyard manure + (P = 60 kg ha^{-1}), T4 = 4 tons of farmyard manure + (P =90 kg ha-1), and T5 = 5 tons of farmyard manure + (P = 120 kg ha^{-1}). The results revealed that T_5 = 5 tons of farmyard manure + (P = 120 kg ha^{-1}). Resulted best and produced the maximum plant population (m2) (10.5), plant height (273.7 cm), stem girth (10.9 cm), head diameter (53.8 cm), number of seeds head^{-1} (2696.9), seed weight head^{-1} (60.7 g), seed index (32.7 g), and seed yield (2698.7 kg ha^{-1}). Whereas the T_1=00-ton Farm Yard Manure + (P = 00) treatment produced the least results and recorded plant population (m^{-2}) (6.6), plant height (217.7 cm), stem girth (9.3), head diameter (30.3 cm), number of seeds head^{-1} (1510.7), seed weight head^{-1} (26.6 g), seed index (23.0 g), and seed yield (2100.0 kg ha^{-1}). It is therefore recommended that, for obtaining higher growth and seed yields of sunflower, farmyard manure and phosphorus be applied at 5 tons per hectare, +/- (P = 120 kg ha-1), respectively. The results concluded that the growth and yield of sunflowers were significantly affected by the application of farmyard manure as compared to the control (no farmyard manure). The grain yield increased linearly with increasing farmyard manure levels. However, the plot fertilized with 5 tons of farmyard manure produced the maximum grain yield of sunflower.

Keywords: Farmyard manure, Phosphorus Sunflower, Growth, Yield.

Introduction

Sunflower (*Helianthus annuus* L.) is extensively grown as a crucial oilseed crop and belongs to the Compositae family (Vangelisti *et al*., 2014). Reports indicate that edible oil holds a prominent position among essential daily commodities. In the fiscal year 2018–19, the import expenditure on edible oil amounted to Rs 192.203 billion (GoP, 2019). Around the globe, it ranks as the fourth-largest source of vegetable oil, after palm and rapeseed. In Pakistan, it ranks second behind cotton seeds (Siddiqui *et al*., 2015). Pakistan ranks third in the world and is the country that imports the most edible oil. (Soomro *et al*., 2015). Stimulating the germination of pollen tubes in sunflowers led to improved fertilization and increased seed production. The sunflower (Arif *et al*., 2017) stands out as a crop with remarkable phenotypic plasticity, adaptable to cultivation on every continent. Ranked second only to soybean, sunflower holds a pivotal position as one of the world's crucial oil crops. It finds applications in both edible oil production and animal feed. With an oil content ranging from 30% to 42% and a protein content of 20–21%, sunflower is of significant importance (Awais *et al*., 2018). Identified for its remarkable phenotypic plasticity, the sunflower (Arif *et al*., 2017) exhibits the ability to thrive on every continent. It holds the second position, following soybean, among the world's most crucial oil crops. Sunflower is utilized in the production of edible oil and animal feed, boasting an oil content ranging from 30% to 42% and a protein content of 20–21% (Awais *et al*., 2018). Farmyard manure has been shown to be a highly beneficial and valuable source of nutrients for plants (Rabia *et al*., 2023). It provides crucial macronutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S), along with essential micronutrients necessary for the growth and development of plants. It delivers an immediately accessible portion of nitrogen for plant uptake, with the remaining nutrients released gradually during decomposition. Furthermore, it improves nutrient availability for plants, enhances soil structure, increases water retention, and promotes a favorable environment for soil microorganisms (Nouraein *et al*., 2019). Phosphorus is a pivotal element that holds the key to enhancing the yield of field crops (Singh *et al*., 2017). Phosphate assumes a critical role in facilitating energy transfer within plants, making it indispensable during phases of rapid growth. During early growth stages, it also promotes the development of roots, which is vital for efficient absorption of other essential nutrients (Naresh *et al*., 2016). Sunflowers flourish in diverse soil and climatic conditions (Nasim *et al*., 2018). The beneficial influence of FYM on soil fertility and production surpasses that of alternative nutrient sources. Additionally, FYM introduces plant growth-promoting substances, humus-forming microbes, and nitrogen-fixing microbes into the soil, essential for preserving soil health and optimizing yield potential. With a composition of 0.5% nitrogen (N), 0.2% phosphorus (P), and 0.5% potassium (K), FYM plays a crucial role in maintaining soil health and striving for self-sufficiency in sunflower production (Dambale *et al*., 2018). Organic manures enhance the organic carbon content in the soil, making primary and secondary nutrients more readily available, thus ensuring an adequate supply of essential micronutrients. To better understand the significance of FYM in crop production and its solubility enhancement through biological methods, studies were conducted to investigate the impact of farmyard manure (FYM) application. Additionally, the residual effects of these treatments on the subsequent sunflower crop were examined (Mukherjee *et al*., 2019) and (Kaleri *et al*., 2019).



MATERIAL AND METHOD

The field trial was conducted at the Student's Experimental Farm in Tandojam, affiliated with the Department of Agronomy at SAU Tandojam. This experiment, carried out in the autumn of 2022, aimed to evaluate the growth and yield of sunflower (Helianthus annuus L.) with varying amounts of farmyard manure and phosphorus. To establish an optimal seedbed for sunflower, ground preparation adhering to recommended practices was meticulously performed using mechanical tools. Employing a randomized complete block design, the trial featured net plots measuring 6m x 5m (30 m^2) each. The experimental setup comprised five rounds, incorporating the application of different doses of phosphorus, with farmyard manure (FYM) serving as the treatment. The examined treatments included Farm Yard Manure = 5, T1 = Control (No Farm Yard Manure + P = 00), T2 = Farm Yard Manure 01 ton + (P = 30 kg ha^{-1}), T3 = Farm Yard Manure 03 tons + (P = 60 kg ha^{-1}), T4 = Farm Yard Manure 05 tons + (P = 90 kg ha^{-1}), and T5 = Farm Yard Manure 07 tons + (P = 120 kg ha^{-1}). At the point of maturity, five plants were selectively chosen from each experimental plot for detailed analysis. The recorded measurements encompassed plant population (m^2), plant height (cm), stem girth (cm), head diameter (cm), number of seeds per head, seed weight per head (g), seed index (1000-seed weight, g), and seed yield per hectare (kg ha-1).

Statistical analysis: 8.1 computer software, an ANOVA was used to perform statistical analysis on the gathered data (Statistix, 2006). The LSD test was used to examine the effectiveness of various therapies in situations where it was still considered necessary

Characteristics	**Units**	**Value (2020)**
Soil depth	(cm)	0–15
		15–30
Texture	(Class)	Sandy clay loam
pH		7.5
		7.7
EC	(dS m−1)	2.31
		2.36
Organic matter	(%)	0.60
		0.67
Total nitrogen	(%)	0.041
		0.039
Available P	(mg kg−1)	0.6
		1.4

Table: 1 Sunflower under Different Farmyard Manure + Phosphorus Doses

Treatments	(Plant population m^{-2})	(Plant height cm)	(Stem girth cm)
T_1 = 00 ton FYM + 00 P kg ha^{-1}	5.99 d	215.1 d	8.1 d
T_2 = 1 tons FYM + 30 P kg ha^{-1}	6.85 c	225.8c	9.8 c
T_3 = 3 tons FYM + 60 P kg ha^{-1}	8.1 b	235.1b	10.5 b
T_4 = 4 tons FYM + 90 P kg ha^{-1}	8.90 a	260.0 a	10.8a
T_5 = 5 tons FYM + 120 P kg ha^{-1}	9.6 a	274.5a	10.10a
S.E. ±	0.4670	4.7720	3.7840
P value	0.0000	0.0000	0.0000
LSD 0.05%	0.3180	1.0811	0.2590

Plant Population cm2: The application of farmyard manure and phosphorus onto the leaves of sunflower plants had a significant and positive impact on various physiological yields and yield component traits (Table 1). The plant population per cm2 of sunflower is affected by different levels of farmyard manure and phosphorus. The treatments T5 = 5 tons of farmyard manure + (P = 120 kg ha^{-1}). Produced a maximum plant population of 9.6 cm2. While the crops receiving T4 = 4 tons of farmyard manure + (P =90 kg ha^{-1}), T3 = 3 tons FYM + 60 P kg ha^{-1}, and T2 = 1 tons FYM + 30 P kg ha^{-1} resulted in mean plant population cm2 of 8.90, 8.1, and 6.85, respectively. Further, the lowest mean plant population (5.99 m2) was noted with T1 = control, no fertilizer, 00 kg ha^{-1}.

Plant height (cm): The application of farmyard manure and phosphorus onto the leaves of sunflower plants had a significant and positive impact on various physiological yields and yield component traits (Table 1). The plant height (cm) of sunflowers is affected by different levels of farmyard manure and phosphorus. The treatments T5 = 5 tons of farmyard manure + (P = 120 kg ha^{-1}). Produced a maximum plant height (cm) of 274.5 While the crops receiving T4 = 4 tons of farmyard manure + (P =90 kg ha^{-1}), T3 = 3 tons FYM + 60 P kg ha^{-1}, and T2 = 1 tons FYM + 30 P kg ha^{-1} resulted in mean plant heights (cm) of 260.0, 235.1, and 225.8, respectively. Further, the lowest mean plant height (cm) (215.1 m2) was noted with T1 = control, no fertilizer, 00 kg ha^{-1}.

Stem girth cm: The application of farmyard manure and phosphorus onto the leaves of sunflower plants had a significant and positive impact on various physiological yields and yield component traits (Table 1). The stem girth cm of sunflower is affected by different levels of farmyard manure and phosphorus. The treatments T5 = 5 tons of farmyard manure + (P = 120 kg ha^{-1}). Produced a maximum stem girth cm (10.10), while the crops receiving T4 = 4 tons of farmyard manure + (P =90 kg ha^{-1}), T3 = 3 tons FYM + 60 P kg ha^{-1}, and T2 = 1 tons FYM + 30 P kg ha^{-1}resulted in mean stem girth cm of (10.8), (10.5), and 9.8 respectively. Further, the lowest mean stem girth cm 8.1 was noted with T1 = control, no fertilizer, 00 kg ha^{-1}

Table:2 Sunflower under Different Farmyard Manure + Phosphorus Doses

Treatments	(Head diameter cm)	(Number of seeds $head^{-2}$)	(Seeds weight$head^{-1}$ g)
T_1 = 00 ton FYM + 00 P kg ha^{-1}	29.4d	1411.0 d	25.9 d
T_2 = 1 tons FYM + 30 P kg ha^{-1}	35.9 c	1715.5 c	32.2 c
T_3 = 3 tons FYM + 60 P kg ha^{-1}	41.5 b	2246.8 b	41.0 b
T_4 = 4 tons FYM + 90 P kg ha^{-1}	45.1 a	2485.1 a	52.1 a
T_5 = 5 tons FYM + 120 P kg ha^{-1}	52.9 a	2600.6 a	59.9 a
S.E. ±	2.8271	5.8850	0.3426
P value	0.0000	0.0000	0.0000
LSD 0.05%	3.0539	140.51	1.8912

Head diameter: cm: The application of farmyard manure and phosphorus onto the leaves of sunflower plants had a significant and positive impact on various physiological yields and yield component traits (Table 2). The head diameter cm of sunflowers is affected by different levels of farmyard manure and phosphorus. The treatments T5 = 5 tons of farmyard manure + (P = 120 kg ha^{-1}). Produced a maximum head diameter cm (52.9), while the crops receiving T4 = 4 tons of farmyard manure + (P =90 kg ha^{-1}), T3 = 3 tons FYM + 60 P kg ha^{-1}, and T_2 = 1 tons FYM + 30 P kg ha^{-1} resulted in mean head diameter cm of 45.1, 41.5, and 35.9, respectively. Further, the lowest mean head diameter cm (29.4) was noted with T_1 = control, no fertilizer, 00 kg ha^{-1}.

Number of seeds: head^{-2}: The application of farmyard manure and phosphorus onto the leaves of sunflower plants had a significant and positive impact on various physiological yields and yield component traits (Table 2). The number of seeds in head^{-2} of sunflowers is affected by different levels of farmyard manure and phosphorus. The treatments T5 = 5 tons of farmyard manure + (P = 120 kg ha^{-1}). Produced a maximum number of seeds head^{-2} (2600.6), while the crops receiving T4 = 4 tons of farmyard manure + (P =90 kg ha^{-1}), T3 = 3 tons FYM + 60 P kg ha^{-1}, and T_2 = 1 tons FYM + 30 P kg ha^{-1} resulted in mean head diameter cm of 2485.1, 2246.8, and 1715.5, respectively. Further, the lowest mean number of seeds head^{-2} (1411.0) was noted with T_1 = control, no fertilizer, 00 kg ha^{-1}.

Seed weight: head^{-1} g: The application of farmyard manure and phosphorus onto the leaves of sunflower plants had a significant and positive impact on various physiological yields and yield component traits (Table 2). Seed weight head^{-1} head of sunflower is affected by different levels of farmyard manure and phosphorus. The treatments T5 = 5 tons of farmyard manure + (P = 120 kg ha^{-1}). Produced a maximum seed weight head^{-1} g (2600.6), while the crops receiving T4 = 4 tons of farmyard manure + (P =90 kg ha^{-1}), T3 = 3 tons FYM + 60 P kg ha^{-1}, and T_2 = 1 tons FYM + 30 P kg ha^{-1} resulted in mean seed weights of 2485.1, 2246.8, and 1715.5, respectively. Further, the lowest mean seed weight head^{-1} g (1411.0) was noted with T_1 = control, no fertilizer, 00 kg ha^{-1}.

Table:3 Sunflower under Different Farmyard Manure + Phosphorus Doses

Treatments	(Seed index 1000-seeds wt.,g)	Seed Yield kg ha^{-1}
T_1 = 00 ton FYM + 00 P kg ha^{-1}	22.0 d	2000.0 d
T_2 = 1 tons FYM + 30 P kg ha^{-1}	24.7 c	2295.7 c
T_3 = 3 tons FYM + 60 P kg ha^{-1}	26.0 b	2599.7 b
T_4 = 4 tons FYM + 90 P kg ha^{-1}	30.7 a	2610.3 a
T_5 = 5 tons FYM + 120 P kg ha^{-1}	32.8 a	2690.7 a
S.E. ±	0.4572	3.4572
P value	0.0000	0.0000
LSD 0.05%	1.6224	58.163

Seed index: 1000 seeds wt. g: The application of farmyard manure and phosphorus onto the leaves of sunflower plants had a significant and positive impact on various physiological yields and yield component traits (Table 2). Seed index 1000-seeds wt.g. of sunflower is affected by different levels of farmyard manure and phosphorus. The treatments T5 = 5 tons of farmyard manure + (P = 120 kg ha^{-1}). Produced a maximum seed index of 1000 seeds wt.,g (32.8), while the crops receiving T4 = 4 tons of farmyard manure + (P =90 kg ha^{-1}), T3 = 3 tons FYM + 60 P kg ha^{-1}, and T_2 = 1 tons FYM + 30 P kg ha^{-1} resulted in mean seed index of 1000 seeds wt.,g of (30.7), (26.0), and (24.7), respectively. Further, the lowest mean seed index of 1000 seeds wt.,g (22.0) was noted with T_1 = control, no fertilizer, 00 kg ha^{-1}.

Seed Yield kg ha^{-1}: The application of farmyard manure and phosphorus onto the leaves of sunflower plants had a significant and positive impact on various physiological yields and yield component traits (Table 2). Seed yield kg ha^{-1} of sunflower is affected by different levels of farmyard manure and phosphorus. The treatments T5 = 5 tons of farmyard manure + (P = 120 kg ha^{-1}). Produced a maximum seed yield kg ha^{-1} (2690.7), while the crops receiving T4 = 4 tons of farmyard manure + (P =90 kg ha^{-1}), T3 = 3 tons FYM + 60 P kg ha^{-1}, and T_2 = 1 tons FYM + 30 P kg ha^{-1} resulted in mean seed yield kg ha^{-1} of 2610.3, 2599.7, and 2295.7, respectively. Further, the lowest mean seed yield kg ha^{-1} (2000.0) was noted with T_1 = control, no fertilizer, 00 kg ha^{-1}.

DISCUSSION

The findings indicated that treatment T5, which involved the application of 5 tons of farmyard manure, resulted in the most favorable outcomes. This specific treatment exhibited the highest plant population (9.6) per square meter, tallest plant height (274.5 cm), largest plant girth (10.10 cm), widest head diameter (52.9 cm), highest number of seeds per head (2600.6), heaviest seed weight per head (59.9 g), greatest seed index (32.8 g), and maximum seed yield (2690.7 kg ha-1). The current study's findings demonstrate that both farmyard waste and inorganic fertilizers significantly enhanced the vegetative growth characteristics. The results of this investigation are in line with those of Piracha *et al.* (2023). The discovery that farmyard manure significantly contributes to the provision of essential plant nutrients was attributed to a specific individual or group of researchers. In semi-arid regions, the crop yield is primarily determined by the interplay between water and nutrient availability, which influences the source-sink relationship. One of the critical factors governing plant growth and development at the plant level is the balance between the demand for organic assimilates and their supply (White *et al*., 2016). Phosphorus (P) fertilizer increased plant growth and production (Zamanian *et al*., 2021) and that phosphorus plays a vital role in the development of plants, and its application increases at the early, active phase of development, when increasing the above physiological parameters. However, according to Hammad *et al*. (2021). In this latest research, nutrient management had a discernible impact on farmyard manure. As a result, organic fertilizers had noticeable effects on the number of leaves and their respective surface areas. Leaves, being the primary photosynthetic organs, serve as crucial contributors to light capture and Evapotranspiration and exhibit substantial responsiveness to fertilizers and irrigation (Mahapatra *et al*., 2021). Expanding leaf area not only serves to provide a protective cover that reduces soil surface evaporation but also has a direct impact on the rate of photosynthetic assimilate production. In arid cropping systems facing water constraints, the reduction of water vapor evaporation from the soil surface can enhance water conservation during crucial growth stages and improve overall water utilization efficiency (Singh *et al*., 2017). Our earlier findings align with this observation, demonstrating that appropriate nutrient management significantly increased the source size of safflower (Janmohammadi *et al*., 2016). The application rate of farmyard manure should be determined based on the crop's nutrient requirements, soil type, and other relevant factors. Typically, soils lacking essential nutrients and having poor structure can experience substantial improvements with an increased application of farmyard manure. Nevertheless, it is essential to be cautious, as excessive use of farmyard manure may lead to nutrient imbalances and give rise to various related issues. (Kalaiyarasan *et al*., 2019). Additionally, the concentration of chlorophyll displayed a notable response to nutrient management, with the highest levels achieved through the application of farmyard manure. There exists a close correlation between the capacity for photosynthetic carbon dioxide fixation and chlorophyll concentration. Thus, an increase in chlorophyll content can be regarded as an augmentation of the source's strength. Consequently, a comprehensive definition of source strength should encompass the rate of export of photosynthesis from the source tissue (Kousar *et al*., 2020). Plant growth, resource allocation, and sink size can all be impacted by nutrient management. Applying as much phosphorus as possible to sunflowers recorded the highest plant height at harvest (273.7 cm) and seed yield (2698.7 kg ha^{-1}). This might be because AM fungus formed an outer layer of mycelium surrounding the roots, which may have improved the availability of nutrients at the root surface, leading to an increase in the plant's intake and growth. A related discovery was previously published by Hammad *et al*. (2021). Among the various phosphorus levels, the application of 5 tons FYM significantly recorded the highest plant population (9.6 cm), stem girth (10.10 cm), and head diameter (52.9 cm). In the therapy, the growth attribute values were the lowest at 00-ton FYM. This might be explained by the fact that FYM accelerates crop growth by having a stimulating influence on root development and expansion. Similar results were previously published by Alzamel *et al*. (2022). There was no discernible interaction between the FYMs. Since FYM is a biofertilizer that might improve plant absorption, it is possible that the highest values under these treatments are the result of FYM. The treatment showed the lowest growth features of 00-ton FYM. This can be the result of insufficient nutritional availability. This outcome is consistent with the findings of Balogun *et al*. (2023). Features and yield of yield Plants injected with mycorrhizal had a notable impact on yield characteristics and yield. The yield characteristics and yield were greatly impacted by the amounts of FYM. Among the different levels, 5 tons FYM produced maximum head diameter (52.9 cm), number of seeds $head^{-1}$ (2600.6), 1000 seed weight (32.8 g), and seed yield (2690.7 kg ha^{-1}). A similar finding was earlier reported by Chernova (2021). The application of phosphorus might also have affected increases in factors of seed yield and parameters of seed yield. Sunflower growth and seed yield were significantly impacted by phosphorus level application as compared to the control (no fertilizer). According to the previous results, Shahid *et al*. (2015) also examined that the application of phosphorus significantly improved growth and seed yield if applied at the right time and quantity. Therefore, farmers should apply minerals in the right proportion of at least 75 to 100 kg ha1to their plants for improved yield and growth. Like this, increasing the phosphorus dosages led to an increase in grain production (Jahil *et al*., 2021). Plant growth and seed yield in sunflowers have strongly responded to the increasing availability of phosphorus (Ghaffari *et al*., 2019).

CONCLUSIONS

It is determined that sunflower growth and seed yield were severely impacted ($p<0.05$) by different farmyard manure and (120 P kg ha^{-1}) levels as associated with management (without farmyard manure organic fertilizer and phosphorus inorganic fertilizer). As the levels of farmyard manure and phosphorus increased, there was a corresponding linear increase in the seed yield. However, the plot receiving fertilizer application of 5 tons of farmyard manure produced the largest (2690.7 kg ha1) sunflower seed yield, followed by 4 tons of farmyard manure with 2610.3 kg ha1. Hence, the difference between treatments was very small.

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