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The impact of various soilless substrates and chitosan application on flowering characteristics of *Lilium* cv. break out grown under shade net condition

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Abstract
The current study, titled "The impact of various soilless substrates and chitosan application on flowering characteristics of *Lilium* cv. Break Out grown under shade net conditions," was conducted at the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, during the years 2022-23 and 2023-24. Throughout both years, as well as in the aggregated data, significant differences were noted in the interaction effects of various soilless substrates and the foliar application of different concentrations of chitosan on flowering and bulb yield. The findings revealed that the earliest flowering times, specifically the days required for bud initiation (44.63), the days from bud initiation to bud color appearance (19.17), and the days until flower opening (67.71), were significantly reduced in the treatment T_{11} (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_2: 250 ppm Chitosan). In contrast, the treatment T_{11} exhibited significantly higher values for flower characteristics, including the average number of buds per plant (3.25) and the flower diameter (14.53 cm).

Keywords: Soilless substrates, chitosan, flowering, bulb and *Lilium*

Introduction
Lilium stands out as one of the most captivating ornamental plants, renowned for its aesthetic appeal, diverse forms, and a wide spectrum of colors. It is characterized as a low-volume, high-value crop and is often regarded as a symbol of purity and nobility. Its versatility in the floral industry is evident, as it is utilized both as cut flowers and potted plants. Native to the Northern Hemisphere, *Lilium* is extensively found in regions such as China, Japan, southern Canada, Siberia, and even extends into Florida in the United States. It ranks among the six principal genera of flower bulbs cultivated globally. The economic significance of *Lilium* is notable, particularly in the production and commercialization of cut flowers in the international market (Jimenez *et al.*, 2012) [4]. Its high market value and popularity stem from its rich variety of colors and the abundance of blooms it produces (Chaudhari *et al.*, 2024) [2]. *Lilium* is one of the most prevalent bulbous ornamental plants. Horticulturists highly value the cultivars of the *Lilium* genus for their exceptional color range, fragrance, and adaptability to various environmental conditions (Bahr and Compton, 2004) [1]. The implementation of shade nets is intended to enhance favorable physiological responses while also providing physical protection, significantly influencing shoot elongation, branching, and flowering in ornamental crops (Oren-Shamir *et al.*, 2001) [7]. The physical and chemical properties of soilless substrates are vital for ensuring adequate support and nutrient supply to plants; these substrates must be lightweight, porous, and well-drained (Noguera *et al.*, 2003) [6]. The choice of potting media is crucial for the quality and production of flowering plants, with natural soil and peat being the most commonly used growing substrates for the container cultivation of both annual and perennial ornamental plants (Tariq *et al.*, 2012) [11]. The use of peat in potting media is commercially costly and cannot be reused; however, the development of affordable alternatives utilizing nutrient-rich organic materials may lead to reduced fertilization and irrigation needs, as well as lower nursery expenses, as noted by Wilson and Stoffella (2002) [13]. Peat remains the predominant substrate for the cultivation of potted plants in nurseries, constituting a substantial portion of the materials

employed in this sector, according to Ribeiro *et al.* (2007) [8]. Consequently, there is an increasing demand for lightweight growing media, which are favored for their ease of transport and presentation at exhibitions and flower shows, as highlighted by Dubey *et al.* (2013) [3]. Various lightweight media, such as perlite and leaf mold, have been shown to modify the physical and chemical properties of growing mixtures, thereby influencing the growth of potted ornamental plants, as reported by Vendrame *et al.* (2005) [12] and Kumar *et al.* (2022) [5]. Chitosan, a significant biopolymer, enhances plant growth characteristics, flowering behavior, and yield traits, as indicated by Sultana *et al.* (2019) [10]. This carbohydrate, derived from a glucose framework, features a linear chain structure and includes free amino groups, resembling cellulose. Chemically, chitosan is a linear polymer made up of two subunits, D-glucosamine and N-acetyl-D-glucosamine, which are connected by 1,4-glycosidic bonds, as described by Rinaudo *et al.* (2003) [9]. Chitosan can be sourced from the exoskeletons of insects or extracted from marine crustaceans, including crabs and prawns.

Materials and Methods

The present investigation 'Influence of different soilless substrates and chitosan treatment on flowering and bulb yield of *Lilium* cv. Break Out grown under shade net condition' was conducted at Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, during the year 2022-23 and 2023-24. The experimental material for the research investigation was Asiatic Lillium cv. Break out. For the first and second year research trails, Bulbs were obtained from Holland. For the experiment, evenly sized *Lilium* bulbs (12/14 size) were selected. Bulbs were planted at a depth of 5-7 inches. The pots were maintained in shade net house. Different soilless susbtrates were prepared using peat, perlite, leaf mould and coconut fiber in different proportions. The constituents of growing media were first solar sterilized for a week before planting of the bulbs. Thorough cleaning of the media constituents was done by removing the stones, pebbles and unwanted materials present in it. Different growing media were prepared by mixing peat, perlite, leaf mould and coconut fiber in required ratios volume by volume. The respective media were then filled into earthen pots provided with drainage holes for aeration and drainage of excess water. The experiment comprised of different soilless substrates growing media viz., (Peat, perlite, leaf mould and coconut fiber) and foliar application of different concentration of chitosan viz., (0.00, 100, 250 and 400 ppm) having 16 treatment combinations. The experimental was laid out in Factorial Complete Randomized Design (FCRBD) with three replications and the data were analyzed accordingly. The treatments in each replication were allotted randomly. Sixteen factor combinations having one cultivar were tried in the experimental design. Five plants were randomly chosen from each treatment group and labeled for the purpose of recording observations. Each repetition of the different treatments yielded the necessary data, from which the average values were then computed. The data generated from present investigations were subjected to the statistical analysis in accordance with the procedure outlined by Panse and Sukhatme (1985) [30]. The significance of differences among growing conditions, foliar application treatments and their combinations means were tested by F-test.

Results and Discussion

The data appraisal to various flowering parameters were influenced by different soilless substrates growing media *viz.*, (Peat, perlite, leaf mould and coconut fiber) and foliar application of different concentration of chitosan in pot *Lilium* were presented in tables 1 and graph 2 and 3 during both the year of research investigations. During both the years as well as in the pooled values, Significantly minimum days taken to bud initiation (45.47), days taken to bud initiation to bud color shown (19.95) and days taken to flower opening (67.00) was recorded in the plants growing in M_2: Peat + Perlite + Leaf Mould (1:1:1), which was statistically at par with treatment M_1: Peat + Perlite (1:1) and M_3: Peat + Perlite + Coconut fiber (1:1:1). However, maximum days taken to bud initiation (48.00), days taken to bud initiation to bud color shown (23.99) and days taken to flower opening (69.77) was reported in the plant growing in control M_0: Soil. During the first and second year (2022-23 & 2023-24) research experiment with the pooled data respectively. During both the years as well as in the pooled values, flower attributes was found to be significantly affected by the soilless susbtrates as shown in Table 1 and Fig. 1 & 2. The observed phenomenon may be a result of the plant's vigorous growth within the media, which significantly influences early production through the rapid absorption of nutrients and water. Furthermore, the buildup of photosynthetic substances within this medium may have prompted the onset of early flowering. This phenomenon is probably associated with a heightened synthesis of proteins originating from the carbohydrates accumulated in the vegetative structures, along with improved protoplast development. A comparable outcome was observed by Swarup (1972) [18] in Gerbera, as well as by Jawaharlal *et al.* (2001) [17] in Anthurium and Rose, and by Barreto *et al.* (2006) [23] in Gerbera. Significantly maximum number of buds per plant (2.74) was recorded in the plants growing in M_3: Peat + Perlite + Coconut fiber (1:1:1), which was statistically at par with treatment M_2: Peat + Perlite + Leaf Mould (1:1:1). However, minimum number of buds per plant (2.27) was reported in the plant growing in control M_0: Soil. During the first and second year (2022-23 & 2023-24) research experiment with the pooled data respectively. Significantly maximum flower diameter (cm) (13.99) was recorded in the plants growing in M_3: Peat + Perlite + Leaf Mould (1:1:1), which was statistically at par with treatment M_3: Peat + Perlite + Coconut fiiber (1:1:1). However, minimum flower diameter (12.96 cm) was reported in the plant growing in control M_0: Soil, during the first and second year (2022-23 & 2023-24) research experiment with the pooled data respectively. The observed increase in size may result from the combined effects of various growth parameters. Enhanced yield parameters within the growing medium contributed to the enlargement of the flowers, facilitated by the availability of moisture and nutrients. The observed enlargement of flower size might be correlated with the increased area of leaves, potentially arising from the augmented production and storage of photosynthetic substances that are conveyed from the leaves to the flowers. The application of potting materials such as cocopeat and leaf mold is likely a factor in the elevated potassium concentration, as well as in the advantageous physicochemical traits, which include high porosity, remarkable water retention capacity, and improved moisture conservation. Collectively, these factors play a significant role in enhancing petal length, petal width, the number of petals per flower, and the overall diameter of rose flowers. This assertion is supported by the studies of Ysmeen *et al*. (2012) [24] on carnations, along with the investigations by Barreto and Jagtap (2006) [14] and Barman *et al*. (2006) [15] focusing on both roses and carnations. The plants cultivated in leaf mould demonstrate their potential under optimal conditions of bulk density, electrical conductivity (EC), and pH, resulting in enhanced flower production. As substances resembling humus, leaf mould exhibited similar characteristics that facilitated nutrient absorption and positively influenced protein synthesis and vegetative growth, thereby leading to an increase in flower yield. Similar results were obtained by Ysmeen *et al.* (2012) [24] in rose, Anthurium in Jawaharlal *et al*. (2001) [17], Carnation in Bhatia *et al.* (2004) [21], Gerbera Gupta *et al.* (2004) [22] and Carnation in Ysmeen *et al,* (2012) [24]. Lopez *et al.* (2008) [20] indicated that various growing media had a substantial impact on the growth and flowering of gladiolus (*Gladiolus tristis* subsp. Concolor). They found that plants cultivated individually in peat exhibited greater stem length, spike length, and number of florets compared to those grown in perlite. Furthermore, peat moss-based substrates produced higher yields and superior flower quality when compared to single substrate options, as noted by Ümmü Özgül Karagüzel (2023) [19]. During both the years as well as in the pooled values, flowering and bulb yield was found to be significantly affected by the foliar application of different concentration of chitosan as shown in Table 1 and Fig. 1 & 2. Among the foliar application of various concentration of chitosan, Significantly lowest days taken to bud initiation (45.80), days taken to bud initiation to bud color shown (20.66) and days taken to flower opening (69.294) was recorded in C_2 which includes foliar application of 250 ppm Chitosan which was statistically at par with treatment C_3:400 ppm Chitosan and C_1:100 ppm Chitosan. However, highest days taken to bud initiation (47.04), days taken to bud initiation to bud color shown (23.15) and days taken to flower opening (70.20) was recorded in C_0 (foliar application of water). During both the years as well as in the pooled values, Among the foliar application of various concentration of chitosan, Significantly highest number of buds per plant (2.88) and flower diameter (cm) (13.64) was recorded in C_2 which includes foliar application of 250 ppm Chitosan which was statically at par with treatment C_3:400 ppm Chitosan and C_1:100 ppm Chitosan. However, lowest number of buds per plant 2.32) and flower diameter (cm) (13.26) was recorded in C_0 (foliar application of water). The application of a chitosan solution to *Ornithogalum saundersiae* bulbs prior to planting resulted in taller plants that flowered earlier (Salachna *et al.*, 2015) [26]. Additionally, the use of chitosan improved the inflorescence length and width of pineapple lilies, leading to earlier flowering compared to the control group **(**Byczyńska, 2018) [27]. In addition, research conducted by Ramos-Garcia *et al.* (2009) [31] demonstrated that the application of chitosan as a natural stimulant significantly improved the production of gladiolus corms. Notably, the most pronounced increase in corm weight was recorded in freesia plants subjected to chitosan treatment (Salachna and Zawadzińska, 2014) [25]. Conversely, Rady *et al*. (2018) [32] suggested that soaking garlic bulbs in a seaweed extract at a concentration of 3 ml/l is effective for promoting the growth of larger bulbs. Furthermore, *Dracaena surculosa* plants that received chitosan treatment showed the highest levels of total nitrogen and chlorophyll a in their leaves, with these parameters rising in correlation with increased chitosan concentrations (El-Khateeb *et al*., 2018; Abd-El-Hady, 2020) [28, 29]. Significant differences were noted in the interaction effects of various soilless substrates and the foliar application of different concentrations of chitosan on both flowering and bulb yield, across both years and in the pooled data. The interaction results showed that, minimum days taken to bud initiation, days taken to bud initiation to bud color shown and days taken to flower opening was recorded in treatment T_{11}: (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_2: 250 ppm Chitosan) which was statistically at par with treatment T_{14}: (M_3: Peat + Perlite + Coconut fiber (1:1:1) + C_3: 100 ppm Chitosan), T_{10} (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_1: 100 ppm Chitosan) and T_9: (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_0:Water). Whereas the maximum days taken to bud initiation, days taken to bud initiation to bud color shown and days taken to flower opening was recorded in control T_3: (M_0: Soil + C_0: Water). Where the interaction results showed that, maximum number of buds per plant, bud length (cm), bud diameter (cm), length of floret (cm), width of floret (cm), flower diameter (cm), spike length (cm), vase life (days), number of bulbs per plant, number of bulblets per mother bulb, weight of bulbs (gm) and bulb diameter (cm) was recorded in treatment T_{11}: (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_2: 250 ppm Chitosan) which was statistically at par with treatment T_{14} (M_3: Peat + Perlite + Coconut fiber (1:1:1) + C_1 100 ppm Chitosan), T_{10} (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_1: 100 ppm Chitosan) and T_9 (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_0 Water). Whereas the minimum number of buds per plant and flower diameter (cm) was recorded in control T_1 (M_0 Soil + C_0 Water).

Table 1: Effect of soilless substrates and chitosan treatment on flowering bulb yield parameters of *Lilium* cv. Break Out grown under shade net condition

Effect of Growing Media (v/v)	Days taken to bud initiation			Days taken to bud initiation to bud color shown			Days taken to flower opening		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
M_0: Soil	48.25	47.75	48.00	20.77	27.21	23.99	67.88	71.65	69.77
M_1: Peat + Perlite (1:1)	46.25	47.48	46.87	20.15	22.73	21.44	67.71	71.64	69.68
M_2: Peat + Perlite + Leaf Mould (1:1:1)	45.35	45.58	45.47	18.81	21.08	19.95	63.56	70.44	67.00
M_3: Peat + Perlite + Coconut fiber (1:1:1)	46.25	46.25	46.25	19.73	21.67	20.70	67.25	71.17	69.21
F-Test	S	S	S	S	S	S	S	S	S
S.Ed. (±)	0.447	0.427	0.2704	0.193	0.214	0.1385	0.469	0.689	0.4193
CD (5%)	0.910	0.869	0.5508	0.393	0.435	0.2821	0.956	1.404	0.8541
Effect of Chitosan									
C_0-Water	47.23	46.85	47.04	20.25	26.04	23.15	68.604	71.791	70.20
C_1:100 ppm Chitosan	47.21	46.83	47.02	20.23	22.27	21.25	68.25	71.042	69.65
C_2:250 ppm Chitosan	45.6	46.00	45.80	19.25	22.06	20.66	67.771	70.813	69.29
C_3:400 ppm Chitosan	46.06	47.38	46.72	19.73	22.31	21.02	67.791	71.249	69.52
F-Test	S	S	S	S	S	S	S	S	S
S.Ed. (±)	0.447	0.427	0.2704	0.193	0.214	0.1385	0.469	0.689	0.4193
CD (5%)	0.910	0.869	0.5508	0.393	0.435	0.2821	0.956	1.404	0.8541
Treatment combinations									
T_1 (M_0: Soil + C_0:Water)	49.58	48.92	49.25	22.75	24.27	23.51	71.333	72.80	72.83
T_2 (M_0: Soil + C_1:100 ppm Chitosan)	49.33	48.17	48.75	20.42	23.33	21.875	69.83	71.33	70.58
T_3 (M_0: Soil + C_2:250 ppm Chitosan)	48.34	46.5	47.42	20.58	23.83	22.205	69.000	71.333	70.17
T_4 (M_0: Soil + C_3:400 ppm Chitosan	45.75	46.59	46.17	19.33	21.67	20.50	68.083	71.667	69.88
T_5 (M_1: Peat + Perlite (1:1) + C_0:Water)	47.83	47.92	47.88	19.50	23.50	21.50	69.167	70.667	69.92
T_6 (M_1: Peat + Perlite (1:1) + C_1:100 ppm Chitosan)	45.67	47.58	46.63	21.25	22.08	21.665	67.75	70.587	69.17
T_7 (M_1: Peat + Perlite (1:1) + C_2:250 ppm Chitosan)	44.92	46.59	45.76	20.83	22.66	21.745	66.583	71.000	68.79
T_8 (M_1: Peat + Perlite (1:1) + C_3:400 ppm Chitosan)	46.58	48.67	47.63	19.00	24.00	21.50	68.083	72.247	70.17
T_9 (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_0:Water)	44.92	44.92	44.92	19.00	20.75	19.875	69.000	71.747	70.37
T_{10} (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_1:100 ppm Chitosan)	46.17	47.09	46.63	18.83	21.92	20.375	68.42	70.667	69.54
T_{11} (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_2:250 ppm Chitosan)	44.83	44.42	44.63	18.17	20.17	19.17	66.167	69.253	67.71
T_{12} (M_2: Peat + Perlite + Leaf Mould (1:1:1) + C_3:400 ppm Chitosan)	45.17	45.92	45.55	19.25	21.50	20.375	67.247	70.08	68.66
T_{13} (M_3: Peat + Perlite + Coconut fiber (1:1:1) + C_0:Water)	46.67	45.92	46.30	19.67	22.75	21.21	67.75	70.917	69.33
T_{14} (M_3: Peat + Perlite + Coconut fiber (1:1:1) + C_1:100 ppm Chitosan)	47.67	44.5	46.09	21.17	20.25	20.71	67.00	70.583	68.79
T_{15} (M_3: Peat + Perlite + Coconut fiber (1:1:1) + C_2:250 ppm Chitosan)	45.5	46.5	46.00	18.67	22.58	20.625	66.5	71.667	69.08
T_{16} (M_3: Peat + Perlite + Coconut fiber (1:1:1) + C_3:400 ppm Chitosan	45.5	48.09	46.80	19.42	21.09	20.255	67.75	70.503	69.13
F-Test	S	S	S	S	S	S	S	S	S
S.Ed. (±)	0.893	0.853	0.5408	0.386	0.427	0.277	0.939	1.378	0.8386
CD (5%)	1.819	1.738	1.1017	0.787	0.870	0.5643	1.912	2.808	1.7082

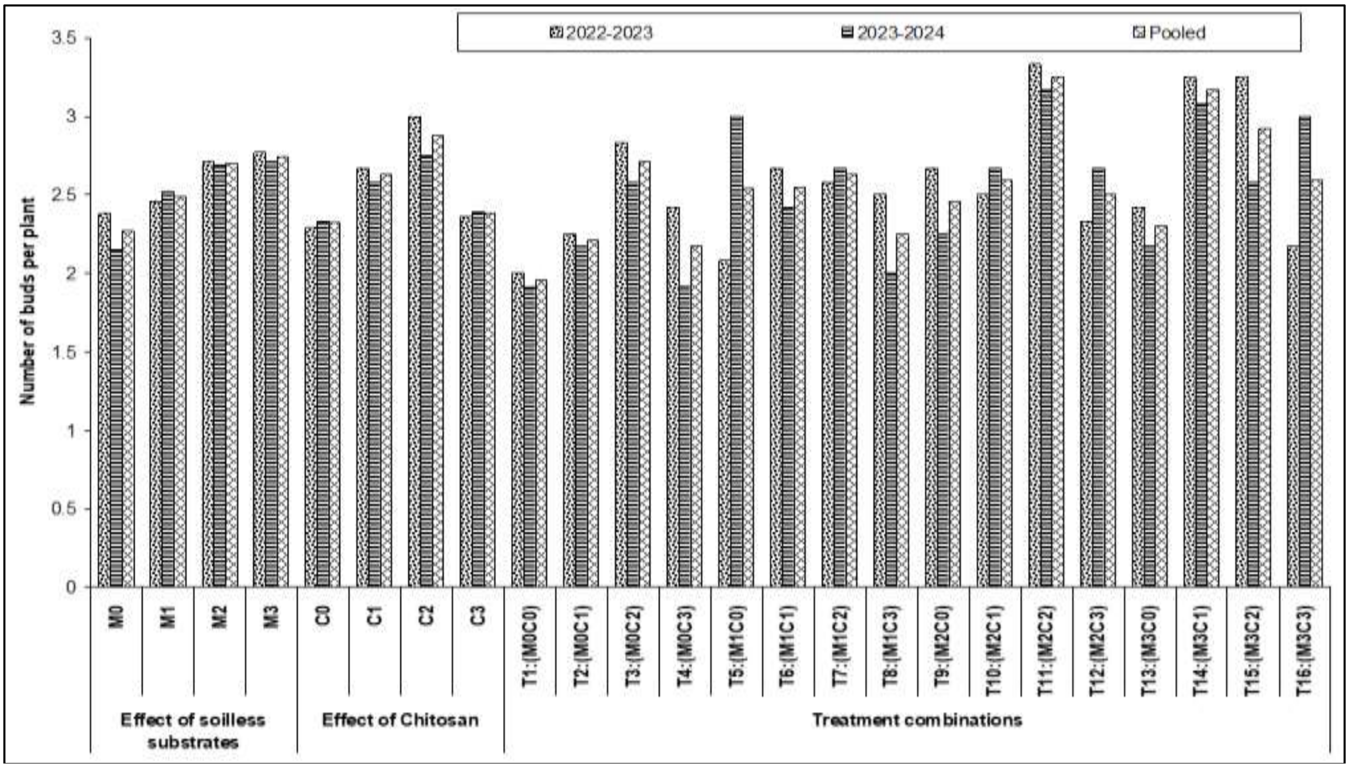

Fig 1: Effect of soilless substrates and chitosan treatment on number of buds per plant of *Lilium* cv. Break Out

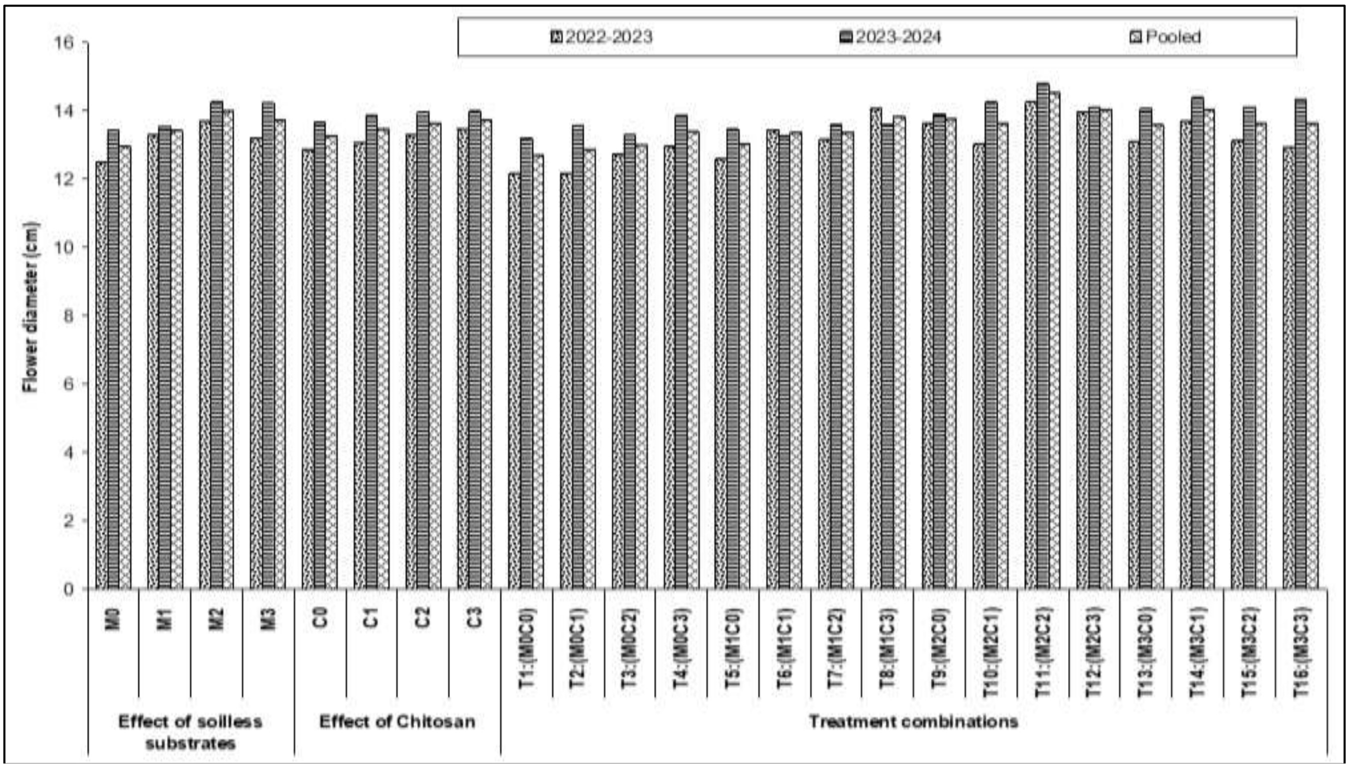

Fig 2: Effect of soilless substrates and chitosan treatment on flower diameter (cm) of *Lilium* cv. Break Out

Conclusion

The findings from the current study indicate that the treatment T_{11}, which consists of a mixture of Peat, Perlite, and Leaf Mould in a 1:1:1 ratio combined with 250 ppm Chitosan, resulted in the shortest duration for bud initiation (44.63 days), the time from bud initiation to bud color appearance (19.17 days), and the time until flower opening (67.71 days). Additionally, this treatment also yielded the highest number of buds per plant (3.25) and the largest flower diameter (14.53 cm).

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