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Research Paper

The Effect of Location, Cultivar, and Sowing Time on the Growth and Productivity of Buckwheat in Egypt

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ABSTRACT

The present study was conducted in Egypt at two different locations Bilbeis City Site (BCS) and Sadat City Site (SCS) during two successive seasons (2018/2019 - 2019/2020) planting cultivars Tartary buckwheat (FT) and common buckwheat (FE) in three planting times (mid-Nov., mid-Jan., and mid-March) to investigating the effect of location, cultivar, and sowing time on the growth and productivity under the Egyptian environmental conditions. The study followed a randomized complete block design (RCBD) and compared two buckwheat cultivars, FT and FE to separate locations and different planting times in Egypt. Our results showed that planting buckwheat in BCS consistently outperformed those in SCS in terms of growth and productivity attributes. Species FT showed superior growth metrics and productivity over FE in both sites and seasons. In terms of sowing times, mid-March demonstrated optimal productivity with yields of 596 kg/hectare and 576 kg/hectare across two seasons. The study underscores the combined influence of location, cultivar, and sowing time on the growth and productivity of buckwheat in Egypt, reiterating the need for tailored agricultural practices specific to each region and cultivar for enhanced yield of this promising undertilized and neglected crop in Egypt.

INTRODUCTION

Egypt faces numerous challenges in achieving food and nutritional security, due largely to its unique geography, water stress, and population growth. However, non-traditional crops and pseudo cereals such as buckwheat, quinoa, sorghum, teff, and millet offer promising avenues for sustainable agricultural development and improved nutrition (Hassona, 2023). The growth of buckwheat can be influenced by numerous factors such as location, cultivar, and sowing time. These factors can affect the plant's physiological processes, yield, and the accumulation of certain compounds in the plant. Location plays a significant role in the growth of buckwheat. Studies have shown that buckwheat cultivars from different elevations may have different responses to environmental factors. For example, common buckwheat originating from high elevations was found to be sensitive to enhanced ultraviolet B (UV-B) radiation, which inhibited plant growth, development, and reproduction (Yao et al., 2008). On the other hand, Tartary buckwheat from different elevations showed different responses to selenium treatment, with the effects on biochemical, physiological, and anatomical traits varying depending on the growing location (Golob et al., 2021).

Cultivar selection is another crucial factor that can affect buckwheat growth. Different cultivars may have various levels of allelopathic activity and accumulation of specific compounds. For example, Polish cultivars of buckwheat were found to contain flavonoids (rutin, quercetin, (+)-catechin, and (-)-epicatechin) and phenolic acids (chlorogenic, caffeic, ferulic, and gallic acids), with rutin being the main compound found in the above-ground organs of buckwheat (Golisz et al., 2007). The allelopathic activity of buckwheat was attributed to the presence of rutin, which was found to be the major allelochemical in Polish buckwheat (Golisz et al., 2007). Additionally, the level of catechin, myricetin, quercetin, and isoquercitrin in buckwheat can vary during vegetation, and these compounds have been shown to affect the growth of selected weeds (Kalinova and Vrchotova, 2009).

Sowing time is a critical factor that can influence buckwheat growth and yield. The optimal timing for sowing buckwheat may vary depending on the geographical region. For example, in central New York, the optimal timing for sowing buckwheat was found to be late June to early August, with a minimum accumulation of 700 growing degree days necessary to reach the appropriate growth stage for incorporation (Björkman and Shail, 2013). Sowing time can also affect the accumulation of specific compounds in buckwheat. Late spring sowing was found to result in the highest rutin concentration and yield in the grain of common buckwheat (Mariotti et al., 2020). Additionally, sowing time can affect the synthesis of flavonoids, such as rutin, and their partitioning within the plant, thus affecting the nutraceutical value of buckwheat products (Mariotti et al., 2020).

The effect of location, cultivar, and sowing time on buckwheat grain yield has been extensively studied in various research articles (Morishita et al., 2006; Mariotti et al., 2016; Liang et al. 2016; Вільчинська Л. and Ночвіна, 2020; Wu et al., 2020). Location plays a significant role in buckwheat grain yield as various locations can have different environmental conditions, such as temperature, rainfall, and soil fertility, which can affect the growth and yield of buckwheat. For example, a study conducted in the Kyushu and Kanto areas of Japan found that Tartary buckwheat's morphological and yield characteristics varied between the two regions. Similarly, a study conducted in Mediterranean conditions found that sowing time and irrigation influenced the forage and grain yield of common buckwheat (Mariotti et al., 2016).

Cultivar selection is another critical factor that can affect buckwheat grain yield. Different cultivars may have different genetic traits and characteristics that can influence their yield potential (Liang et al., 2016). For instance, a study comparing the high-yield common buckwheat cultivar 'Fengtian 1' and the Tartary buckwheat cultivar 'Jingqiao' (Liang et al., 2016) found that both cultivars showed higher values of initial growth power, final grain weight, and longer linear increase phase, which contributed to increased buckwheat yield (Liang et al., 2016). Another study compared different buckwheat varieties and found that the variety 'Kalyna' had economic and biological advantages, making it suitable for cultivation in specific regions (Вільчинська Л. and Ночвіна, 2020).

Sowing time is a critical factor that can affect buckwheat grain yield. The optimal sowing time may vary depending on the geographical region and climate conditions (Mariotti et al., 2016). Studies have shown that early spring sowing is generally recommended for grain production, while late spring sowing is more suitable for forage production (Mariotti et al., 2016). Additionally, the response of buckwheat grain yield to sowing time can vary depending on the cultivar. For example, a study found that late summer sowings produced acceptable grain yield in Tartary buckwheat, whereas short days and low temperatures limited forage production (Mariotti et al., 2016). Other factors that can influence buckwheat grain yield include tillage methods and the use of microbial inoculants (Wu et al., 2020; Singh et al., 2015). Deep tillage has been found to promote grain filling and increase final yield in Tartary buckwheat. Similarly, microbial inoculants have been shown to increase plant growth, yield, and quality of common buckwheat (Singh et al., 2015).

Buckwheat is known for its nutritional value and functional properties, making it a potential candidate for the development of new products (Ahmed et al., 2013). It is rich in flavonoids, phytosterols, fagopyrins, phenolic compounds, resistant starch, dietary fiber, lignans, vitamins, minerals, and antioxidants (Ahmed et al., 2013). These compounds contribute to the health benefits associated with buckwheat consumption, such as cholesterol-lowering effects and potential anti-inflammatory and antioxidant properties (Ahmed et al., 2013). In terms of cultivation, buckwheat has been grown in various regions around the world, including Europe, Asia, and America (Аверчев et al., 2021). It is adaptable to different growing conditions and can tolerate a range of climates. However, specific information on its suitability for cultivation in Egypt does not exist, as the crop was never planted before this study (Hassona et al., 2023). However, this study aims to investigate the effect of location, cultivar, and sowing time on buckwheat grain yield under Egyptian environmental conditions as a unique attempt for the first time in Egypt (Hassona et al., 2013).

MATERIALS AND METHODS

Locations of cultivation: Bilbeis City Site (BCS) = 30.4196° N, 31.5619° E, Sadat City Site (SCS) = 30.3594° N, 30.5327° E. However, the soil's physical and chemical properties and irrigation water of the experiment area have been analyzed and described as follows:

- Soil: The Bilbeis City Site soil is slightly alkaline with a pH of 7.83 and higher salinity than the Sadat City Site, which has a more alkaline pH of 8.57. Bilbeis have distinct levels of bicarbonate reflecting their pH, while Sadat boasts higher iron content. Nutrient availability varies, but both sites seem adequate for many crops. Mechanically, both soils are sandy; however, Bilbeis have more silt, classifying it as "Clay sandy", whereas Sadat, with more clay, is "Sandy loamy". Bilbeis have a higher limestone presence, indicated by their $CaCO_3$ content. Organic matter, beneficial for soil health, is slightly higher in Sadat.
- Water: Both sites have alkaline irrigation water, with the Sadat City Site (pH 7.98) being more alkaline than the Bilbeis City Site (pH 7.41). The electrical conductivity (EC), which indicates salinity, is almost double at Sadat City (1.26 dS/m) compared to Bilbeis (0.64 dS/m). This suggests that Sadat's water has more dissolved salts. Sadat's water also contains higher Fe, Zn, Mn, and Cu concentrations. While both sites have calcium (Ca++) at negligible levels, the magnesium (Mg++), sodium (Na+), and bicarbonate (HCO3) concentrations are notably higher in Sadat's water. Interestingly, while Bilbeis has a significant potassium (K+) concentration, Sadat's water has a considerably lower value. Total dissolved solids (TDS), represented in ppm, are also much higher in Sadat, indicating a higher mineral content. Concisely, Sadat's irrigation water is more saline and mineral-rich, which may require more strategic management for optimal agricultural use to prevent potential soil salinity issues.

The cultivars: Two cultivars are selected from the two major species of buckwheat; *Fagopyrum esculentum*, the trade name is "Japanese", and *Fagopyrum tataricum*, the trade name of the cultivar is "Madawaska" imported from Sustainable Seeds Company, based in California, USA, accessed through www.trueleafmarket.com

The sowing times: The sowing time for season 1 was the second week of November 2018, the second week of January 2019, and the second week of March. The weather data including temperate, humidity, dew point, precipitation, snow depth, and wind are collected as per table 3. In the second season, the sowing times were the second week of November 2019, the second week of January 2020, and the second week of March 2020 respectively, the weather data including temperate, humidity, dew point, precipitation, snow depth, and wind are collected as below.

Weather: The Sadat City Site over two seasons shows temperatures ranging from 7.97°C to an average of around 23.28°C, peaking at 35.86°C. Precipitation varies from 0mm to an average of about 0.19mm, with a max of 1.12mm. Relative humidity fluctuates between

21.26% and an average of 57.81%, with highs of 89.44%. Wind gusts swing between 9.79 km/h, averaging 24.26 km/h, to a max of 41.82 km/h. Sunshine duration spans from 367.36 to an average of 597.99 minutes, peaking at 788.43 minutes.

Experimental sites preparation: The study, following ARC, Egypt protocols, involved two sites with thorough land preparation, including plowing, composting, and leveling. Plots of 3m x 1.5m had controlled irrigation canals. Seeds, mixed with sand for even distribution, were hand-sown on afeer land. Regular irrigation ensured optimal germination, with watering ceasing two weeks before harvest.

Growth and productivity factors measured: Plant height per plant in centimeters, Number of branches per plant, number of internodes, number of leaves and the fresh weight per plant (grams) were manually measured and weighed using tape and digital scale during various growth stages. However, the Productivity metrics included seed count per plant and weight from dried seeds of plants in square meter. Calculating the productivity rate per hectare involved weighing seeds from a 1-square-meter frame, scaled to the hectare, and then dividing by 1,000. The entirely manual harvest, common in Egypt, employed a consistent group for technique uniformity.

Experimental Design: The study utilized a randomized complete block design (RCBD) to ensure that diverse cultivation conditions were considered and potential biases were minimized.

Statistical Analysis: The data was analyzed using a randomized complete block design, accounting for three factors. Each parameter was replicated three times. The mean values from treatments were compared using the least significant difference (LSD) test, as defined by Snedecor and Cochran (1994). The Assistat software program facilitated the data analysis process.

RESULTS AND DISCUSSIONS

1. The Evaluation of Buckwheat Growth by Location, Cultivar type and Planting time:

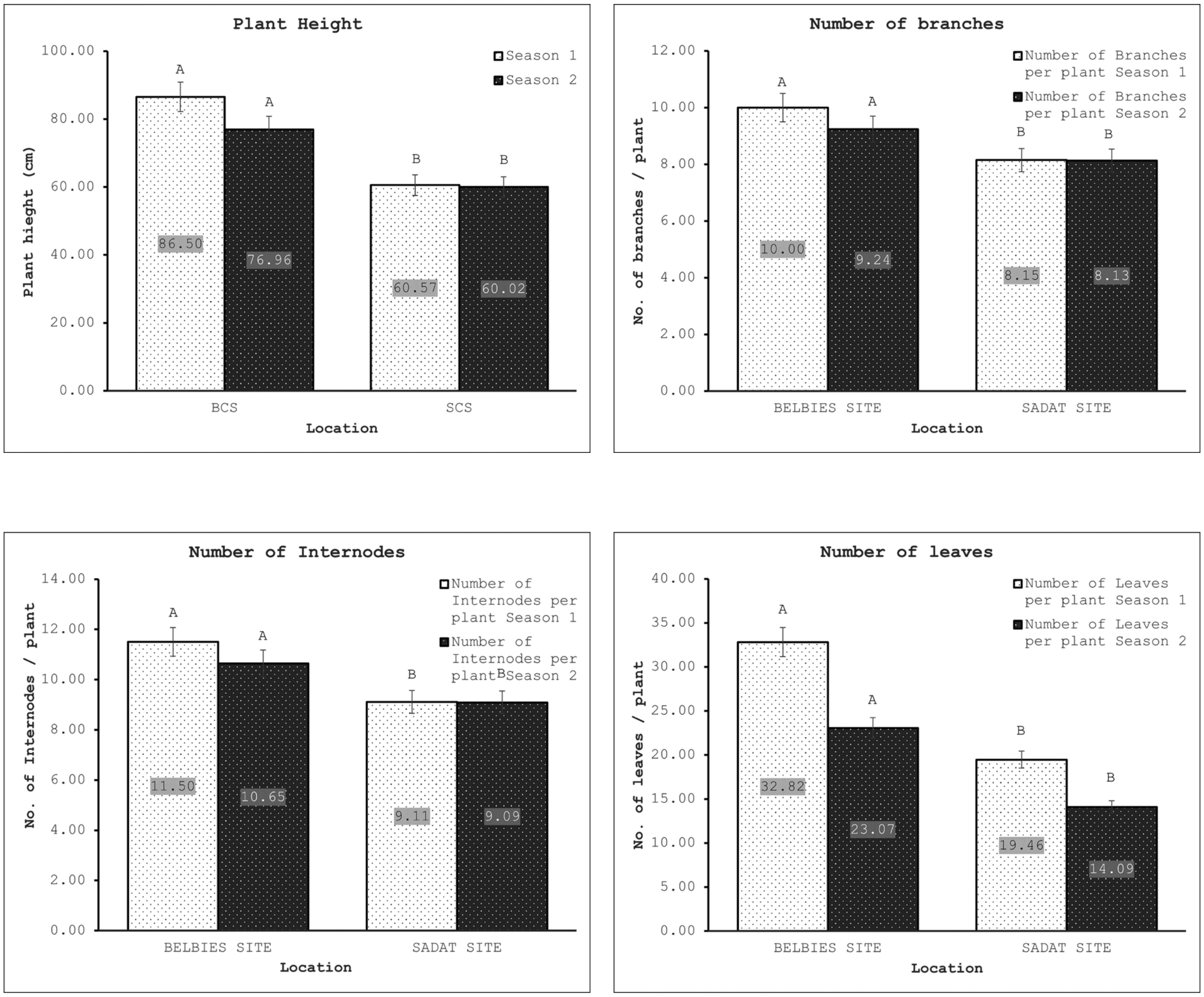
1.1. Effect Of Location On Buckwheat Growth:

The growth and development of buckwheat, as substantiated by data in Table (1), are intrinsically linked to the conditions of their cultivation location. The plants at the Bilbies City Site (BCS) consistently exhibited superior growth attributes compared to those at the Sadat City Site (SCS) as Figure (1). This trend is supported by scientific literature. Yao et al. (2008) highlighted how buckwheat from different elevations, akin to the differential

Table (1): *Evaluation of the Effect of Location on the Growth of Buckwheat Cultivars Under Egyptian Environmental Conditions during 2018/2019 and 2019/2020 seasons*

Parameters	Treatments	*Bilbeis City Site*	*Sadat City Site*	**LSD 0.05**
Plant Height cm per plant	***1st Season***	86.50a	60.57b	**4.680**
	2nd Season	76.96a	60.02b	**2.601**
Number of Branches per plant	***1st Season***	9.10a	8.15b	**0.336**
	2nd Season	9.24a	8.13b	**0.236**
Number of Internodes per plant	***1st Season***	11.50a	9.11b	**0.422**
	2nd Season	10.65a	9.09b	**0.249**
Number of Leaves per plant	***1st Season***	32.82a	19.46b	**1.868**
	2nd Season	23.08a	14.09b	**2.031**
Fresh Weight per plant (gm)	***1st Season***	25.26a	16.18b	**1.141**
	2nd Season	27.68	18.04	**1.330**

Different letters within the same row indicate significant differences ($P \leq 0.05$).



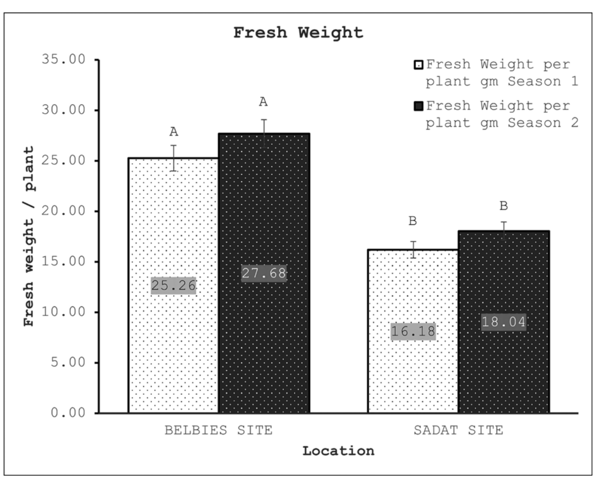


Figure (1): *The charts highlight a significant difference between Bilbeis city (BCS) and Sadat City (SCS). However, Buckwheat growth in Bilbeis site showed a higher values in the measured parameters including the average plant height, the number of branches, the number of internodes, the number of leaves, and the fresh weight of each plant, in both growing seasons. Different letters indicate statistically significant differences (P≤0.05).*

environments of BCS and SCS, responded distinctly to external stimuli like UV-B radiation. For instance, common buckwheat from high elevations displayed heightened sensitivity to UV-B, experiencing hindered growth and development. Similarly, the distinct responses of Tartary buckwheat from different elevations to selenium treatment, as indicated by Golob et al. (2021), mirror the varied growth metrics observed between BCS and SCS. These disparities in height, branch count, internode number, leaf number, and fresh weight emphasize the profound influence of location on buckwheat's physiological performance. In essence, as shown in our data and the aforementioned studies, location-specific conditions play a pivotal role in dictating the growth attributes of buckwheat cultivars.

1.2. The Effect Of Cultivar On Buckwheat Growth:

The choice of cultivar undeniably influences the growth dynamics of buckwheat. Our study, as evidenced by the data in Table (2), substantiates this observation. We compared two distinct species: *Fagopyrum tataricum* (FT) and *Fagopyrum esculentum* (FE). Notably, FT consistently outperformed FE across all evaluated parameters for both seasons as in Figure (2). This trend is in line with the allelopathic attributes attributed to buckwheat cultivars, as reported by Golisz et al. (2007). Specifically, they identified rutin as the major allelochemical present in Polish buckwheat cultivars, contributing to its allelopathic activity. This aligns with our observations where FT, possibly boasting a higher rutin concentration, showcased superior growth characteristics compared to FE. Furthermore, the variability in the accumulation of compounds like catechin, myricetin, quercetin, and isoquercitrin throughout vegetation, as noted by Vrchotova (2009), may further elucidate the growth disparities between the two cultivars. Their findings suggested that these compounds influence the growth of selected weeds, potentially hinting at the enhanced resilience or competitive advantage of one cultivar over the other. In essence, our findings reiterate the vital role of cultivar selection in dictating buckwheat's growth and highlight the intricate biochemical interplay underlying these observed differences when juxtaposed with prior research.

1.3. The Effect Of Sowing time On Buckwheat Growth:

The timing of sowing greatly influences buckwheat's development, yield, and compositional quality. Drawing from the insights in Table (3), it is evident that varying sowing times yield different growth results for buckwheat cultivated under Egyptian environmental conditions as per Figure (3). However, a closer look reveals that plants sown in mid-January demonstrated marginally superior growth metrics in plant height, number of branches, and fresh weight during the first season, compared to those

Table (2): *Evaluation of the Effect of Cultivar on the Growth of Buckwheat Cultivars Under Egyptian Environmental Conditions during 2018/2019 and 2019/2020 seasons*

Parameters	Treatments	*Fagopyrum tataricum*	*Fagopyrum esculentum*	**LSD 0.05**
Plant Height cm per plant	***1st Season***	91.69a	55.38b	**4.68**
	2nd Season	84.54a	52.44b	**2.601**
Number of Branches per plant	***1st Season***	11.06a	7.09b	**0.337**
	2nd Season	10.07a	7.29b	**0.236**
Number of Internodes per plant	***1st Season***	12.57a	08.03b	**0.422**
	2nd Season	11.57a	8.17b	**0.249**
Number of Leaves per plant	***1st Season***	37.37a	14.90b	**1.869**
	2nd Season	25.70a	11.46b	**2.031**
Fresh Weight per plant (gm)	***1st Season***	29.19a	12.25b	**1.141**
	2nd Season	32.06a	13.66b	**1.33**

Different letters within the same row indicate significant differences (P ≤ 0.05).

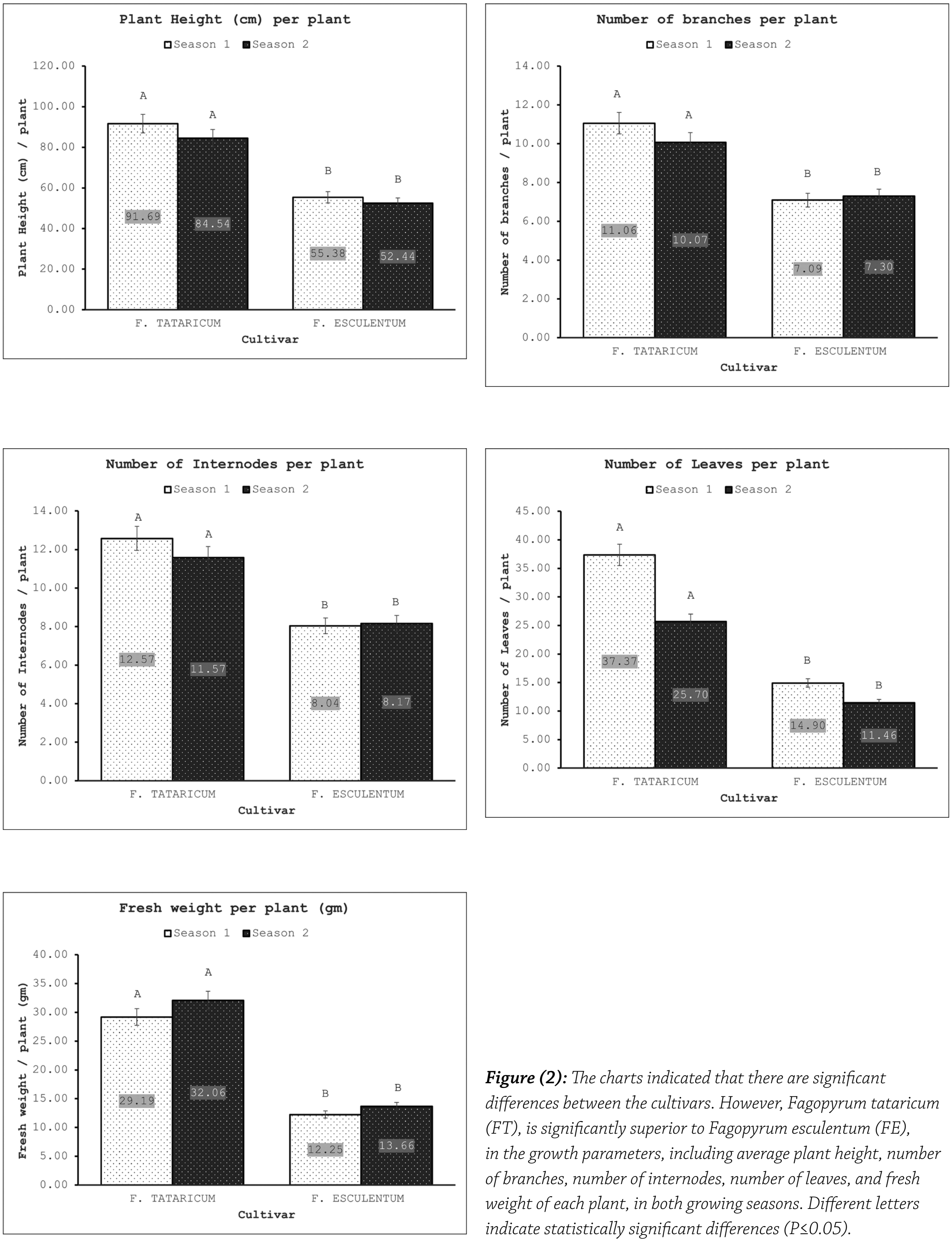


Figure (2): *The charts indicated that there are significant differences between the cultivars. However, Fagopyrum tataricum (FT), is significantly superior to Fagopyrum esculentum (FE), in the growth parameters, including average plant height, number of branches, number of internodes, number of leaves, and fresh weight of each plant, in both growing seasons. Different letters indicate statistically significant differences (P≤0.05).*

sown in mid-November and mid-March. This resonates with the findings from Björkman and Shail (2013), who pinpointed a specific window of growing degree days necessary for optimal buckwheat growth in central New York.

Furthermore, the correlation between sowing time and compound accumulation is accentuated by Mariotti et al. (2020). They observed that late spring sowing culminates in higher rutin concentration in the grain of common buckwheat. This phenological connection is significant as the synthesis and distribution of flavonoids like rutin within the buckwheat plant have implications for its nutraceutical value. In the Egyptian context, sowing in mid-March produced the highest number of leaves in both seasons, which could be a focal point for studies targeting flavonoid distribution and accumulation. To sum up, our results, when analyzed alongside prior research, underline the significance of sowing time in modulating buckwheat cultivation's growth and biochemical outcomes.

2. The Evaluation of Buckwheat Productivity by Location, Cultivar type and Planting time:

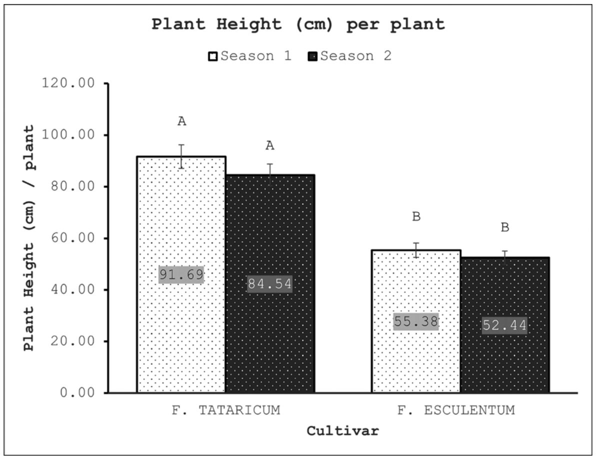
2.1. The Location Effect On Buckwheat Productivity

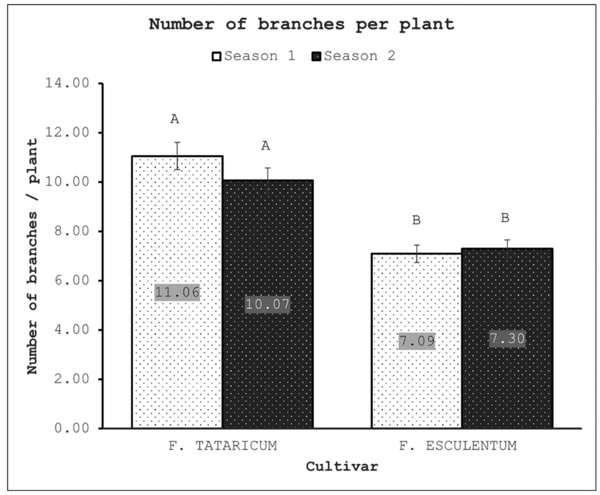
The impact of location on buckwheat productivity is a recurrent theme in our study as in Table (4) and literature. Our research distinctly underscores the superior productivity of buckwheat at the Bilbeis City Site (BCS) over the Sadat City Site (SCS) under Egyptian environmental conditions as highlighted in the taken parameters in Figure (4). Specifically, metrics like the number of seeds per plant, weight of seeds per meter, and overall productivity rates were markedly higher at BCS across two observation seasons. However, This pronounced influence of location on buckwheat yields aligns well with the literature. As highlighted by Morishita et al. (2006), Mariotti et al. (2016), Liang et al. (2016), Вільчинська Л. and Ночвіна (2020), and Wu et al. (2020), location emerges as a critical factor due to varying environmental conditions. Each location, with its unique mix of temperature, rainfall, and soil fertility, shapes the buckwheat's growth and yield. Such a phenomenon was observed in Japan, where the Tartary buckwheat showcased differing morphological and yield attributes between the Kyushu and Kanto regions. further emphasize this by noting how sowing time and irrigation, dictated by location-specific Mediterranean conditions, influenced buckwheat yields. However, drawing parallels, it is plausible that a combination of soil quality, climatic conditions, and other location-specific environmental factors shapes the difference in productivity between BCS and SCS. Just as Japan's Kyushu and Kanto regions displayed variances, so too do BCS and SCS, reflecting the overarching significance

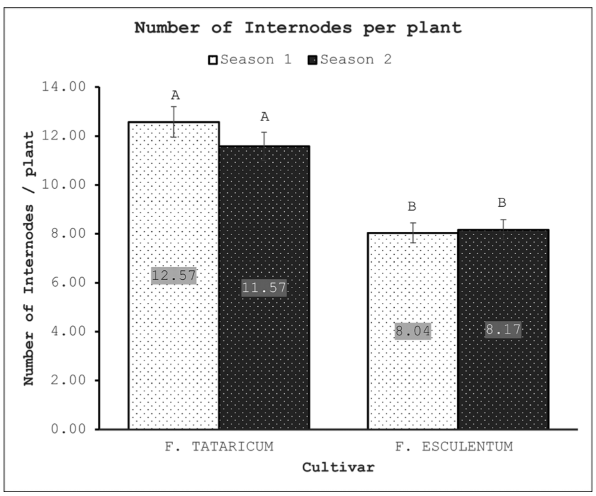
Table (3): *Evaluation of the Effect of Sowing time on the Growth of Buckwheat Cultivars Under Egyptian Environmental Conditions during 2018/2019 and 2019/2020 seasons*

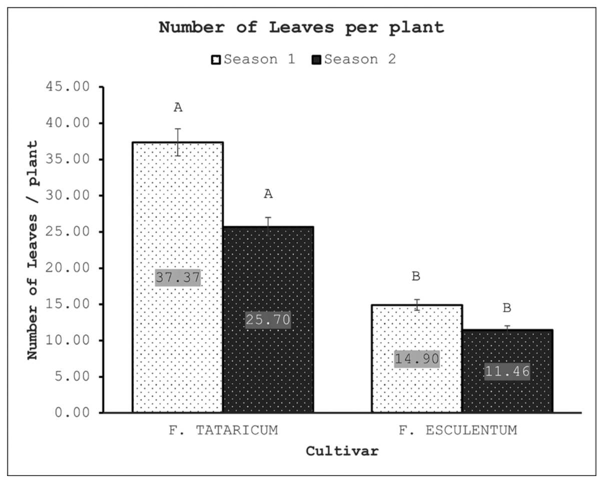
Parameters	Treatments	Mid-Jan	Mid-Nov	Mid-Mar	LSD 0.05
Plant Height cm per plant	***1st Season***	75.51a	73.89a	71.20a	**5.732**
	2nd Season	69.06ab	69.86a	66.56ab	**3.185**
Number of Branches per plant	***1st Season***	9.14a	9.03a	9.06a	**0.412**
	2nd Season	8.67a	8.67a	8.72a	**0.289**
Number of Internodes per plant	***1st Season***	10.31a	10.25a	10.36a	**0.517**
	2nd Season	10.00a	10.00a	9.61b	**0.304**
Number of Leaves per plant	***1st Season***	25.11b	24.81b	28.50a	**2.289**
	2nd Season	17.86a	18.19a	19.69a	**2.487**
Fresh Weight per plant (gm)	***1st Season***	20.13b	19.81b	22.22a	**1.398**
	2nd Season	21.41b	22.29b	24.89a	**1.629**

Different letters within the same row indicate significant differences (P ≤ 0.05).









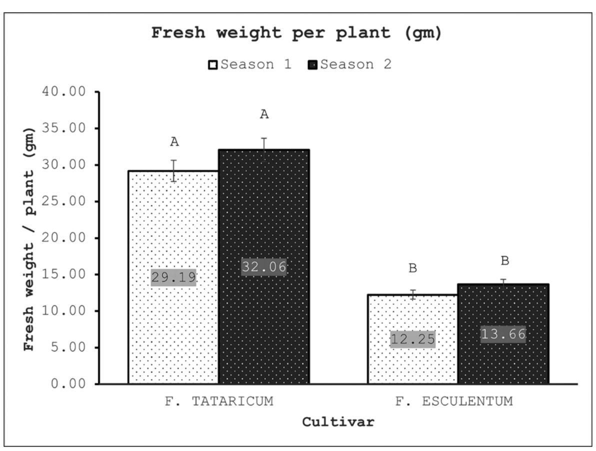


Figure (3): *The charts indicated non-significant differences between the planting times pduring the two planting seasons. While buckwheat cultivars planted in mid-January in both locations recorded the highest plant height and number of branches and leaves, while the mid-March planting time recorded the highest fresh weight, with no significant differences between the three times. Different letters indicate statistically significant differences (P≤0.05).*

of location in determining buckwheat productivity. Thus, our results mirror the broader scientific consensus, reiterating the crucial role of location in modulating buckwheat yields.

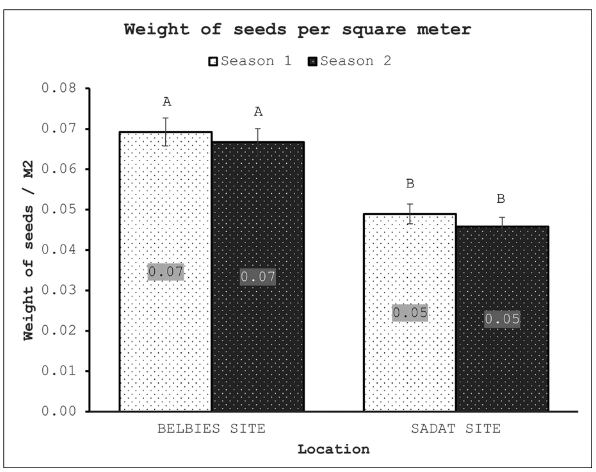
2.2. The Cultivar Effect On Buckwheat Productivity

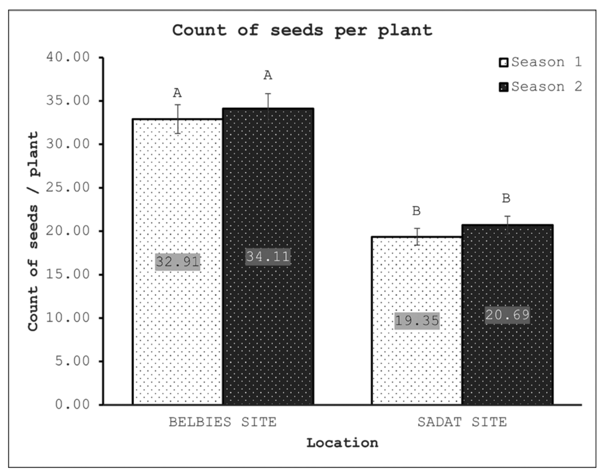
The critical role of cultivar selection in determining buckwheat grain yield is evident in our study and existing literature as showed in Table (5). Our results consist-

Table (4): *Evaluation of the Effect of Location on the productivity of Buckwheat Under Egyptian Environmental Conditions during 2018/2019 and 2019/2020 seasons*

Parameters / Treatment	Number of seeds per plant		Weight of seeds in plants of 1 meter^2		Productivity rate kg/hectare	
	1st Season	***2nd Season***	***1st Season***	***2nd Season***	***1st Season***	***2nd Season***
Bilbeis City Site	32.91a	34.11a	0.0692a	0.0667aa	678.70a	650.00 a
Sadat City Site	19.35b	20.69b	0.0489b	0.0458b	488.87b	456.78b
LSD 0.05	**2.4091**	**2.1965**	**2.72E-03**	**4.12E-03**	**28.082**	**42.529**

Different letters in same column are indicate statistically significant differences (P≤0.05).





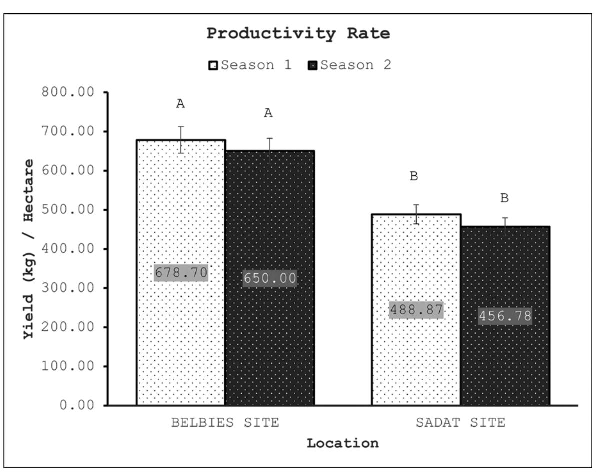


Figure (4): *The charts indicating a significant difference in the Location. However, planting buckwheat in Bilbeis city site resulted the highest number of seeds per plant, the highest seed weight per plant, and the total productivity rate per hectare compared to Sadat City, in both growing seasons (2018/2019 - 2019/2020). Different letters indicate statistically significant differences (P≤0.05).*

ently indicated that the species *Fagopyrum tataricum* (FT) outperformed *Fagopyrum esculentum* (FE) in all aspects of productivity over two consecutive seasons as in Figure (5). Specifically, FT showed higher seed counts, greater seed weight per meter, and overall higher yields. This finding aligns well with the literature, which emphasizes the inherent genetic differences among cultivars and their influence on yield. Liang et al. (2016) compared the

Table (5): *Evaluation of the Effect of Cultivar on the Growth of Buckwheat Under Egyptian Environmental Conditions during 2018/2019 and 2019/2020 seasons*

Parameters / Treatment	Number of seeds per plant		Weight of seeds in plants of 1 meter		Productivity rate kg/hectare	
	1st Season	***2nd Season***	***1st Season***	***2nd Season***	***1st Season***	***2nd Season***
Fagopyrum tataricum	36.56a	38.19a	0.0774a	0.0731a	760.40a	713.35a
Fagopyrum esculentum	15.70b	16.61b	0.0407b	0.0393b	407.17b	393.42b
LSD 0.05	**2.4091**	**2.1965**	**2.72E-03**	**4.12E-03**	**28.082**	**42.529**

Different letters in same column are indicate statistically significant differences (P≤0.05).

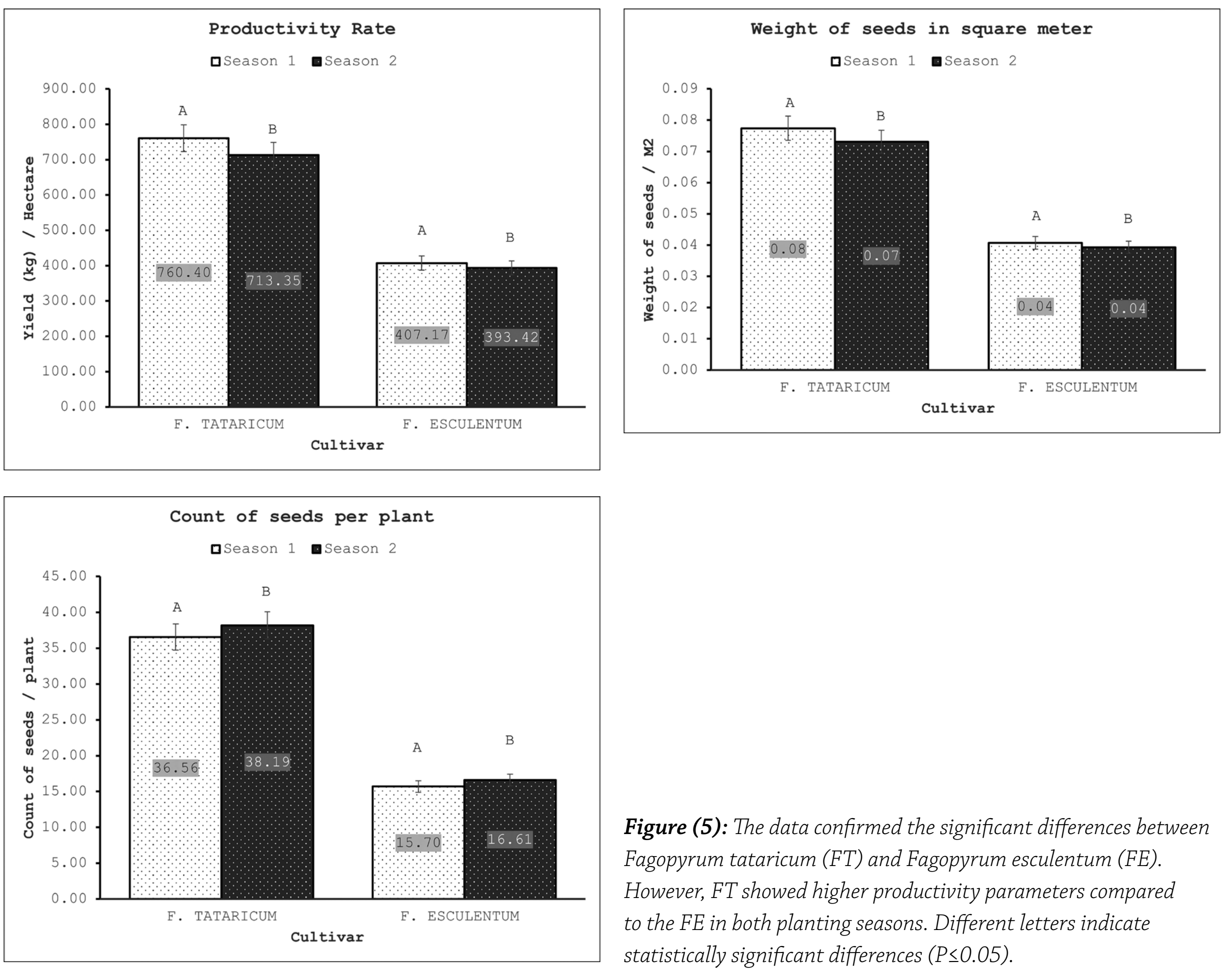


Figure (5): *The data confirmed the significant differences between Fagopyrum tataricum (FT) and Fagopyrum esculentum (FE). However, FT showed higher productivity parameters compared to the FE in both planting seasons. Different letters indicate statistically significant differences (P≤0.05).*

high-yield common buckwheat cultivar 'Fengtian 1' and the Tartary buckwheat cultivar 'Jingqiao' and found both cultivars to have favorable growth attributes contributing to enhanced yield. Similarly, another study underscored the suitability of the 'Kalyna' variety due to its biological and economic advantages in certain regions (Вільчинська and Ночвіна, 2020). Thus, our results and literature underline the paramount importance of careful cultivar selection to optimize buckwheat grain yield.

2.3. The Sowing Time Effect On Buckwheat Productivity

Our results in Table (6) indicated that the effect of sowing time on buckwheat productivity was apparent across two seasons. However, Mid-March emerged as the optimal sowing time, producing the highest yields of 596.77 kg/hectare and 576.38 kg/hectare, followed by mid-November and Mid-January (Figure 6). These findings align with existing research, emphasizing that the optimal sowing time varies depending on geographical region and climate (Mariotti et al., 2016). Early spring sowing is generally recommended for grain production, whereas late spring sowing suits forage production. The response of buckwheat to sowing time also depends on the cultivar. For instance, late summer sowings can yield satisfactory grain output in Tartary buckwheat, while short days and cold temperatures limit forage yield (Mariotti et al., 2016). Other influential factors on buckwheat yield include tillage methods and microbial inoculants. Deep tillage promotes grain filling, enhancing final yield in Tartary buckwheat (Wu et al., 2020), while microbial inoculants can boost common buckwheat growth, yield, and quality (Singh et al., 2015).

CONCLUSION

In this research, we addressed the critical problem of optimizing buckwheat growth and productivity in Egypt. Our comprehensive study examined the effects of location, cultivar, and sowing time on buckwheat cultivation, revealing significant insights. We found that the growth and productivity of buckwheat are highly influenced by these factors. Specifically, buckwheat plants at the Bilbeis City Site consistently outperformed those at the Sadat City Site in both growth and yield. Among the cultivars, Fagopyrum tataricum showed superior performance compared to Fagopyrum esculentum. In terms of sowing time, mid-March emerged as the most favorable for optimal yield.

These findings underscore the importance of selecting appropriate cultivars and sowing times and recognizing the unique environmental conditions of each location for successful buckwheat cultivation in Egypt. The key takeaway is the potential for enhanced buckwheat production through tailored agricultural practices, a significant step towards agricultural sustainability and food security in the region. This study narrows down to the broader relevance of local environmental adaptability in crop cultivation, highlighting its critical role in optimizing agricultural outputs.

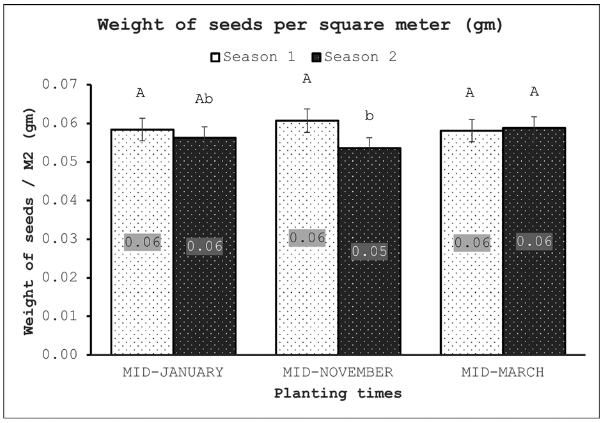
RECOMMENDATION

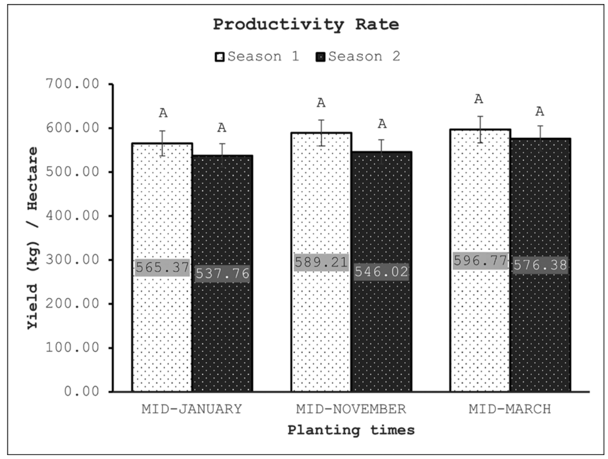
The study conclusively shows that buckwheat growth and productivity in Egypt are significantly influenced by location, cultivar, and sowing time. Optimal yields are achieved when combining the right cultivar, such as *Fa-*

Table (6): *Evaluation of the Effect of Sowing time on the Growth of Buckwheat Under Egyptian Environmental Conditions during 2018/2019 and 2019/2020 seasons*

Parameters / Treatment	Number of seeds per plant		Weight of seeds in plants of 1 meter		Productivity rate kg/hectare	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Mid-Jan	23.69b	26.19b	0.0584a	0.0563ab	565.37a	537.76a
Mid-Nov	24.97b	25.47b	0.0607a	0.0536b	589.21a	546.02a
Mid-Mar	29.72a	30.53a	0.0581a	0.0588a	596.77a	576.38a
LSD 0.05	**2.9505**	**2.6902**	**3.33E-03**	**5.04E-03**	**34.393**	**52.087**

Different letters in same column are indicating significant differences (P≤0.05).





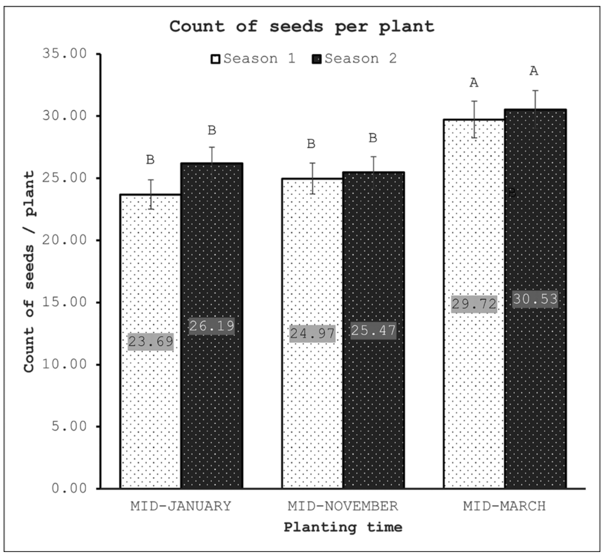


Figure (6): *The charts indicate significant differences in some productivity parameters, as the number of seeds per plant and the weight of seeds per plant per plant. While the results did not indicate significant differences in the productivity rate between the planting dates in both planting seasons. Different letters indicate statistically significant differences (P≤0.05).*

gopyrum tataricum, with suitable sowing periods and locations, highlighting the importance of tailored agricultural practices for maximum efficiency.

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IZVLEČEK

Vpliv lokacije, kultivarja in časa setve na rast in produktivnost ajde v Egiptu

Raziskava je bila izvedena v Egiptu na dveh različnih lokacijah Bilbeis City Site (BCS) in Sadat City Site (SCS) v dveh zaporednih sezonah (2018/2019 - 2019/2020), s setvijo kultivarja tatarske ajde (FT) in navadne ajde (FE) v treh rokih setve (sredi novembra, sredi januarja in sredi marca), da bi raziskali učinek lokacije, kultivarja in časa setve na rast ter produktivnost ajde v egiptovskih okoljskih razmerah. Študija je bila izvedena v randomizirani zasnovi celotnega bloka (RCBD), primerjana sta bila dva vzorca ajde, FT in FE, z ločenima lokacijama in različnimi časi setve. Rezultati so pokazali, da je setev ajde na BCS dosledno presegla setev v SCS glede na lastnosti rasti in produktivnosti. Vrsta FT je pokazala vrhunske lastnosti rasti in produktivnost v primerjavi z FE tako na lokacijah kot v letnih časih. Kar zadeva čas setve, je posevek s setvijo v sredini marca pokazal optimalno produktivnost z donosom 596 kg/hektar in 576 kg/hektar v povprečju dveh sezon. Rezultati raziskave poudarjajo skupni vpliv lokacije, kultivarja in časa setve na rast in produktivnost ajde v Egiptu, pri čemer je poudarjena potreba po prilagojenih kmetijskih praksah, značilnih za vsako regijo in kultivar za dosego večjega pridelka.