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Growth and Yield of Triticale (× *Triticosecale Wittmack*) as Influenced by Different Sowing Dates

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A B S T R A C T

Pot experiment involving three sowing dates was conducted for studying the response of triticale (× *Triticosecale Wittmack*) to sowing dates. Triticale grains were sown at three different times October 15, November 15, and December 15. The current outcomes revealed that there is a significant difference between sowing dates on plant growth and yield attributes. The most effective in this regard was 15th October followed by 15th November and then 15th December. The greatest values of plant height (95.5 cm), flag leaf area (37.5 cm^2), tiller number plant^{-1} (9.5 tillers), spike length (18.5 cm), grain number spike^{-1} and spike weight (3.8 g), were recorded within the 1st sowing date (15th October). Additionly, the lowest values of grains and biological yield was recorded under the 3rd sowing date (Dec 15). It is concluded from this study that the best date for triticale sowing falls within the period between late October and the middle of November.

1 Introduction

Triticale (×*Triticosecale Wittmack*) is an anthropogenic cereal designed to incorporate the functionality and high yield of wheat (*Triticum* spp. L.) and the durability of rye (*Secale cereale* L.) (McGoverin et al., 2011; Abdelaal et al., 2019). Triticale is a new promising grain crops worldwide due to its ability to grow well in low-fertility soil and high resistance to biotic and abiotic stresses (Randhawa et al., 2015; Khoshkharam and Shahrajabian, 2021, Ehtaiwesh, 2022). The importance of triticale comes from its high protein content and their constituents, i.e., it contains the most important amino acids in the nutrition of living organisms (Neuweiler et al.., 2021). So far triticale is grown generally as a feed grain, green forge, cover crop, as well as for biogas production (Wójcik-Gront and Studnicki, 2021; Coblentz et al., 2022). Nevertheless, with the integration of new breeding tools and enabling technologies such as doubled haploid, marker-assisted selection, genomics selection, transgenic, and targeted genome editing, with conventional plant breeding approaches, triticale has the prospective to be a successful future crop (Randhawa et al., 2015). The world area cultivated with triticale was about 3.830.794 hectares and worldwide yield production reached 38755 hectogram per hectare (FAO, 2022). However, cereal production for both forage and grain is strongly influenced by environmental conditions and farming practices such as, spacing, fertilization, seeding rate, and sowing date (Khoshkharam and Shahrajabian, 2021)

Global warming drastically reduced cereal crop yield by hampering germination capacity and seedling establishment associated with reduced crop productivity, therefore sowing dates adjustment is a critical measure to alleviate and adapt to global warming (Xiao et al., 2017; Ali et al., 2021). Sowing time is the key to successful wintering and ensures efficient use of resources (Salmon et al., 2004; Santiveri et al., 2004; Bielski et al., 2020). Many studies have indicated that inappropriate planting dates affected wheat grain yield, plant height, number of grains per spike, and the weight of wheat grains (Ali et al., 2010; Ahhmed, 2015; Tahir et al 2019). Earlier sowing time contributed to intensive tillering, and strong growth, which may cause plant death and lower yields

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(Pomortsev et al., 2019). Sowing date significantly affected the grain yield of triticale plants as reported in some studies. For example, sowing triticale seed on November 1 was significantly superior and gave the highest values of plant height, spike length, and number of spikes^{m2}, number of grains per spike, grain yield, and the biological yield, while sowing triticale seed in the middle of November gave the highest average of 1000 grains (Noaema et al., 2020). The use of triticale is still limited now in Libya, and there are few studies on the seeding rates, the appropriate varieties, the date of planting and the environmental conditions that may have an impact on triticale growth and yield. Therefore, the aim of this study was to highlight the effect of sowing times on the growth and yield component of triticale plant.

2 Materials and Methods

Plant Material

Grains of triticale plants were obtained from the Libyan National Gen-Bank in Tripoli, Libya

2.1 Experimental and treatment conditions

The pot experiment with a completely randomized design (RCD) was done within the 2021/2022 winter season to highlight the effect of sowing date (15th October, 15th November, and 15th December) on growth and yield trials of triticale. The plastic pots (20 x 25 cm) were filled with 10 kg of homogeneous sandy soil, and then 10 grains were cultivated in each pot.

After seedling establishment, seedlings were thinned to four seedlings per pot, which was kept until harvesting. From the sowing date until harvesting, the triticale plants were irrigated with fresh water as needed to ensure germination, growth and yield processes naturally. Fertilizer (N. P. K 20, 20, 20) was added at different plant growth stages at a rate of 5g pot^{-1} was added, at tillering, booting, and flowering stages, Diammonium phosphate (DAP) $(NH_4)_2HPO_4$ NP 18:46 was also added around emergence.

Data collection

At maturity, four plants from each replicate were hand-harvested by cutting them at the soil level. Data on plant height (cm), number of tillers plant^{-1}, and number of spike plant^{-1} was recorded on the day of harvesting. Plant height was determined as the distance between the bases of the plant to the tip of the main stem spike including awns. Tiller number plant^{-1} contained both fertile (with spikes) and non-fertile tillers (without spikes). Flag leaf area (cm^2) was measured according to the equation of Aldesuquy et al., (2014) as indicated leaf area =Length * Breadth * 0:75. After drying for 7 days in the air oven at 40°C, the main spike of each replicate was weighted (g), and spikelet numbers spike^{-1} were counted. Then the main spikes were hand threshed to separate grains, and grain number spike^{-1} was counted manually. Grain yield for the main spike, per plant, and 1000-grain weight were calculated. The harvest index was calculated as the ratio of grain yield plant^{-1} to the total vegetative dry weight for each replicate.

2.2 Experiment design and data analysis

Data were analyzed using GLM procedure in statistical software SAS 9.4 (SAS Institute Inc., Cary, NC, USA) for mean and standard error estimation. Separation of means was carried out using the least significant differences (LSD; $P < 0.05$).

3 Results

The data presented in table 1 show the effect of different sowing dates on the growth and yield traits of triticale. The results showed that the effect of sowing dates was highly significant ($P< 0.01$) on tiller number plant^{-1}, spike number plant^{-1}, spike length, and grain yield plant^{-1}. In addition, the result indicated that the effect of sowing dates was significant ($P< 0.05$) on other traits included in this study Table 1.

Table: (1). Probability values of the effects of sowing date on various growth and yield traits of triticale plant.

Traits	Treatment
Plant height (cm)	0.0491
Leaf area (cm^2)	0.0497
Dry weight plant^{-1} (g)	0.0419
Tiller number plant^{-1}	0.0098
Spike number plant^{-1}	0.0088
Spikelet number spike^{-1}	0.0475
Spike length (cm)	0.0179
Spike weight (g)	0.0485
Grain number spike^{-1}	0.0485
1000 grain weight (g)	0.0496
Grain yield plant^{-1} (g)	0.0096
Harvest index (%)	0.0442

The results indicate that there was a significant increase in growth and yield traits in triticale plants when triticale sowed in the period between October 15th and November 15th compared to late sowing (December 15).

The results shown in Figure 1a pointed out that planting dates significantly affected plant height (cm). The first sowing date provided the highest average of plant height, where triticale plant height reached to 95.5 cm, while the third sowing time recorded the lowest plant height, which was 75 cm (Figure 1a). In addition, the result showed the advantage of the first sowing date of triticale as it averaged in the highest of flag leaf area of triticale with almost 37.5 and 37 cm^2 in the first and second date of sowing. However, this result varied significantly with the third sowing date, which recorded the lowest in flag leaf area (30.5 cm^2) as observed in Figure 1b. As for total plant dry weight, the result indicated that both early first and second sowing dates resulted in higher accumulations of above*ground biomass which account for total plant dry weight. However, plant dry weight did not vary significantly between the first and second date of sowing, which gave about 34 and 35 g of plant dry weight, while the third sowing date recorded the lowest value of plant dry weight 25g) as observed in Figure 1c.

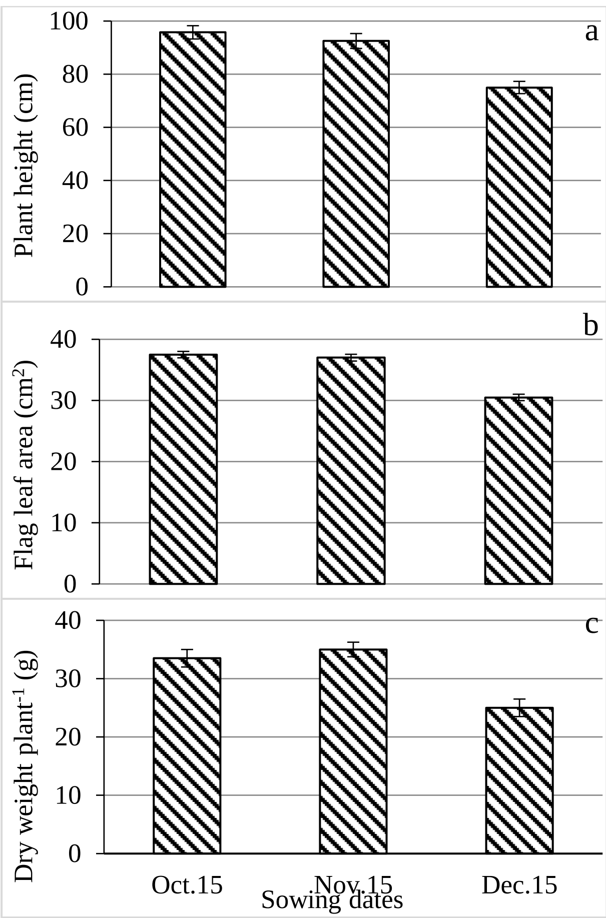

Figure: (1). The effect of sowing dates on (a) plant height (cm), (b) leaf area (cm^2) and (c) dry weight (g) $plant^{-1}$ of the triticale plant. Each datum indicates the mean value and vertical lines on top of the bars indicate the standard error of means (n = 4).

The same trend was found with the number of tillers $plant^{-1}$ of triticale plants, which is considered as one of the important indicators in plant growth and it has a great impact and prompting yield. Either first and second sowing dates gave the highest tillers number of 9.5 and 9 tillers $plant^{-1}$ respectively as compared with the third sowing date that recorded 6 tillers $plant^{-1}$ (Figure 2a). The results also indicated that there was a significant effect of sowing dates on the number of spikes $plant^{-1}$. Figure 2b showed that the second date of sowing gave the highest average number of spikes $plant^{-1}$ (8.7 spikes $plant^{-1}$) followed by the first sowing date (8.5 spikes $plant^{-1}$), which significantly altered in the third sowing date that gave the lowest average of spikes $plant^{-1}$ (5.5 spikes $plant^{-1}$) as seen in Figure 2b. Triticale yield is also effected by the sowing date in terms of the number of spikelet $spike^{-1}$. The result herein indicated that the second sowing date averaged with 27.5 spikelet number $spike^{-1}$, which was close to the average of the first sowing time that gave 27 spikelet number $spike^{-1}$. Conversely, the spikelet number $spike^{-1}$ was significantly reduced by the third sowing date, which averaged with 21 spikelet number $spike^{-1}$ as observed in Figure 2c.

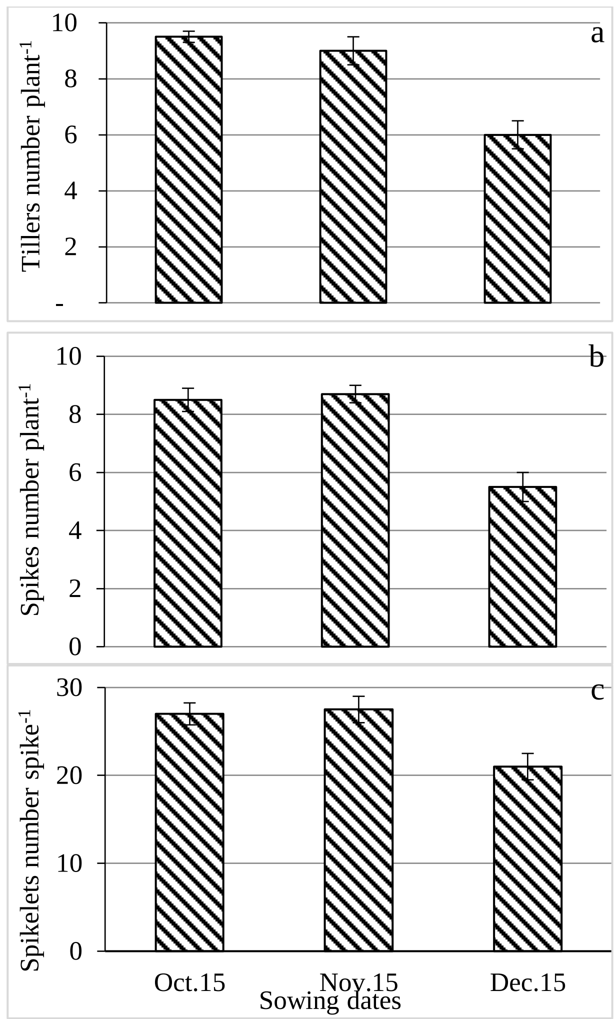

Figure: (2). The effect of sowing dates on (a) the number of tillers $plant^{-1}$, (b) the number of spikes $plant^{-1}$, and (c) the number of spikelet $spike^{-1}$ of the triticale plant. Each datum indicates the mean value and vertical lines on top of the bars indicate the standard error of means (n = 4).

Moreover, spike length (cm) and spike weight (g) of triticale significantly altered with the sowing date. Yet the third sowing date negatively affected both parameters. In the first and second sowing dates, the average length of the spikes was 18.5 and 18 cm respectively and was 13 cm in the third sowing date (Figure 3a). The same trend was found in spikes weight (g). The result revealed that in the first, the second and the third sowing dates the average weight of the spikes were 3.8, 3.7, and 3 g respectively as observed in Figure 3b. The number of grains spike^{-1} was significantly affected by the sowing date. As the results showed that the first and second sowing dates gave the highest average number of grains spike^{-1} with 62 and 61 grains spike^{-1}, whereas the third sowing date significantly differ from the first and second sowing dates and gave 49 grains spike^{-1} as observed in Figure 3c.

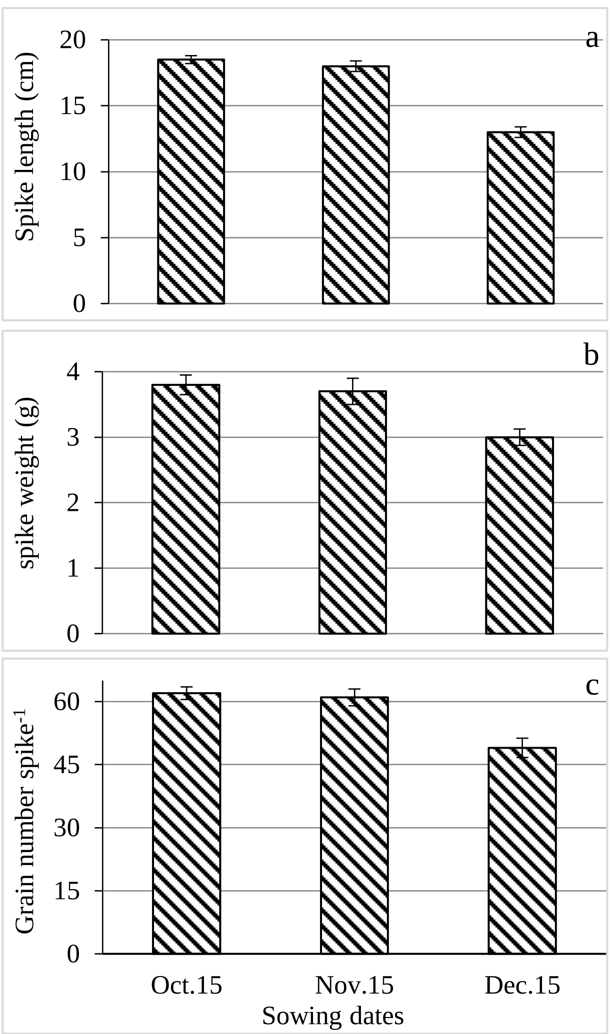

Figure: (3). The effect of sowing dates on (a) spike length (cm), (b) spike weight (g) and (c) the number of grains spike^{-1} of the triticale plant. Each datum indicates the mean value and vertical lines on top of the bars indicate the standard error of means (n = 4).

Furthermore, the results revealed a significant effect of sowing dates on 1000 grains weight of triticale. Figure 4a showed that the 1000-grain weight of the first and second sowing date surpassed third sowing dates by giving the highest average weight of 1000 grains amounting to 51.5 and 53g respectively, whereas the third sowing date gave an average of 44g for 1000 gains weight as seen in Figure 4a. With the regard to the grain yield plant^{-1}, which is considered the final outcome of yield components that include the number of spikes plant^{-1}, grains yield spike^{-1} and the weight of 1000 grains, the results showed a significant effect of sowing dates. The first and second sowing dates gave the highest average of grains yield of 27.5 and 28.05 g plant^{-1} respectively while the third sowing date recorded the lowest average of grain yield of about 17g plant^{-1} (Figure 4b). Moreover, the result illustrated that there was no difference between the first and second sowing dates in terms of harvest index parameters both sowing dates recorded the highest harvest index of 0.80 %. However third sowing date significantly affected the harvest index which recorded the lowest harvest index of 0.69% as seen in Figure 4c.

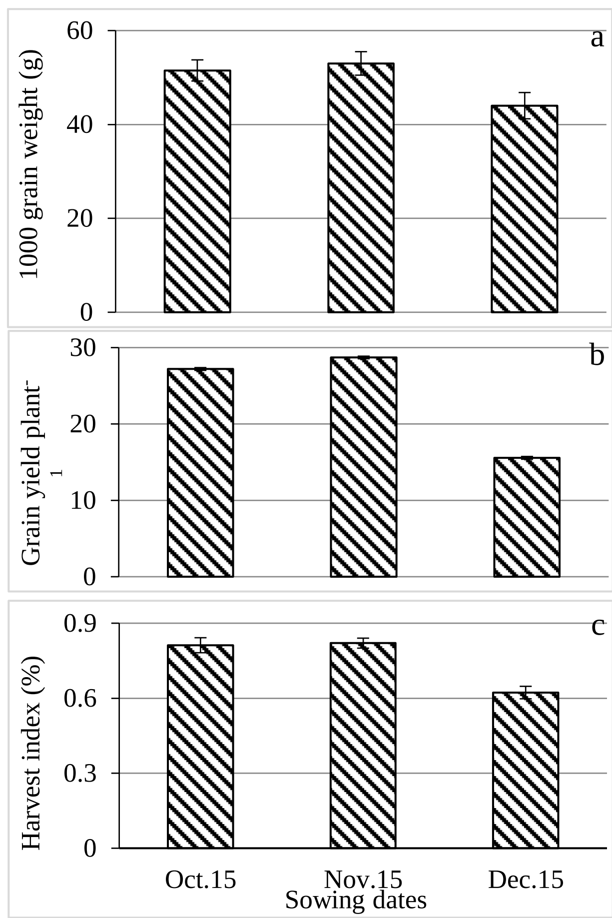

Figure: (4). The effect of sowing dates on (a) 1000 grain weight (g), (b) grain yield plant^{-1}, and (c) harvest index of the triticale plant. Each datum indicates the mean value and vertical lines on top of the bars indicate the standard error of means (n = 4).

4 Discussion

The aim of this study was to evaluate growth and yield traits of triticale x *Trititcosecal Wittmack* as affected by sowing dates. The results pointed out that sowing dates significantly affected the growth and yield traits of triticale, which agreed with many previous studies (Alam et al., 2020; Ding et al., 2020). The result showed that grain yield and plant biomass production of triticale plants sowed at the first and second sowing date gave the highest average of grain yield traits, while the third sowing date gave the lowest average of the same traits. The reason for this disparity in plant height is due to the reduction in plants growth at elongation stage, which could be due to the restriction of needed days for plant growth. Ramos et al. (1993) reported a reduction in forage yield by 22 to 44%, grain yield by 12 to 60%, and total useable biomass (i.e., forage + grain) by to 52%. In addition, the result showed that the third sowing date recorded the shortest spike length as compared with the first and second dates of sowing. The reason for the reduction in spike length because of the increased of temperature which resulted in the hastening of plant growth and shortening of time needed for spike growth at the period in which enough time is important in determining the length of the spike. This result was similar to previous findings (Tomple and Jo, 2019; Prasun et al., 2021). This study conclude that depending on the sowing dates, tiller number was between 9.5 and 6 tillers plant^{-1}, spikes number between 8.7 and 5.5 spikes plant^{-1}, dry weight was between 35 and 25 g plant^{-1}, and grain yield was between 28.7 and 15.6 g plant^{-1}. This result was comparable to other studies that reported the impact of delayed sowing date was significant in triticale as it diminished grain-filling duration by 13%, final grain weight by 16%, grain volume by 15%, and embryo area by 8% (Royo et al., 2000, Ganvit et al., 2019). Moreover, the results pointed out that there was a significant effect of sowing dates on the number of spikes plant^{-1}. Both first and third sowing dates gave the lowest mean of spikes plant^{-1}. The reason for this decrease may be due to the short time required for the growth and formation of sprouts, which was reflected negatively in the number of spike plant^{-1}. Similar results were obtained in an earlier study (Tahir et al., 2009). The study indicated a decrease in the number of grains spike-^{1} at the third sowing date. This could be due to the effect of high temperature during grain formation, which caused a reduction in grain numbers spike^{-1}. An early study indicated a similar result (Noaema et al., 2020). Likewise, the result of this study reported a decrease in 1000-grain weight at the third sowing date, which could be because of the adverse effect of high temperatures that accelerate the growing of plant and reduce the length of a period of grain filling to the extent that negatively affected the weight of grains. This result is consistent with what was reported by another study (Shah et al., 2006). In fact, temperature and light are considered among the factors that affect most of the physiological processes of the plant that may influence plant growth and yield traits. The study indicated that grain yield traits are significantly affected by sowing dates. These conclusions were also seen in early studies of different plant species including triticale (Koppensteiner et al., 2021), corn (Van Roekel and Coulter, 2011, Maresma et al., 2019), wheat (Kabir et al., 2019; Tahir et al., 2019), rice (Patel et al., 2019) and barley (Amarjeet et al., 2020; Moustafa et al., 2021).

5 Conclusions

In Libya there has not been sufficient enough work conducted on evaluating the response of triticale plants to different agricultural practices such as sowing dates. This study designated that November 15 sowing date exceeded other sowing dates in spike number plant^{-1}, spikelet number spike^{-1}, the weight of 1000 grains, total dry weight plant^{-1}, grain yield plant^{-1} and harvest index. Therefore, the study concludes that the best balance for forage and grain production in this environment was achieved by sowing during the last week of October or the first week of November. Sowing after this period may reduce growth and yield traits. However, this important crop still needs further research to understand the factors that affect its productivity characteristics under the environmental conditions of Libya.

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Conflict of interest: The authors declare that there are no conflicts of interest.

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