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Effect of spraying with balanced nano fertilizer and boron on yield and chemical characteristics of two hybrids of cabbage *Brassica oleracea* var. *capitata* L.

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ABSTRACT

This study was conducted during agricultural season 2021-2022 at the research station of Department of Horticulture and Landscape/ College of Agriculture/ Tikrit University, to study the effect of foliar application of balanced nano-fertilizer and boron on two hybrids of cabbage *Brassica oleracea* var. capitata L. The experiment included three factors, the first factor is three concentrations of balanced nano-fertilizer viz, 0, 20 and 30 g L^{-1} the second factor is spraying of boron at two concentrations namely, 0 and 5 mg L^{-1}. The third factor is using two hybrids namely, Dlal and Globe Master. The experiment was laid out according to Randomized Completed Block Design (R.C.B.D.) With split plot arrangement with three replications. The results showed that, the spraying with boron at 5 mg L^{-1} concentration led to a significant increase in the total head weight, marketable head weight, head circumference, total plant yield, and nitrate ratio. The hybrid Dlal had highest values in all studied characteristics except the nitrate percentage compared with the hybrid Globe Master.

تأثير الرش بسماد النانو المتوازن والبورون في الحاصل والصفات الكيميائية *Brassica oleracea* var. *capitata* L. لهجينين من الكرنب

حارث برهان الدين عبد الرحمن و أمل الجبوري
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الخلاصة

أجريت هذه الدراسة خلال الموسم الزراعي 2021-2022 في محطة أبحاث قسم البستنة والمناظر الطبيعية/ كلية الزراعة/ جامعة تكريت، لدراسة تأثير الرش الورقي بالسماد النانوي المتوازن والبورون في هجينين من الكرنب Brassica oleracea var . capitata L. تضمنت التجربة ثلاثة عوامل العامل الأول هو ثلاثة تراكيز من السماد النانوي المتوازن أي 0 و 20 و 30 جرام لتر-1 والعامل الثاني هو رش البورون بتركيزين هما 0 و 5 ملجم لتر-1. . العامل الثالث هو استخدام هجينتين هما دلال وجلوب ماستر. صممت التجربة وفق تصميم القطاعات العشوائية الكاملة (R.C.B.D.) وبترتيب الألواح المنشقة بثلاثة

مكررات. أظهرت النتائج أن الرش بالبورون بتركيز 5 ملغم لتر-1 أدى إلى زيادة معنوية في وزن الرأس الكلي ووزن الرأس التسويقي ومحيط الرأس وحاصل النبات الكلي ونسبة النترات. وكان هجين دلال أعلى القيم في جميع الصفات المدروسة ما عدا نسبة النترات مقارنة مع هجين غلوب ماستر.

الكلمات المفتاحية: الأسمدة النانوية، البورون، الهجين.

INTRODUCTION

Cabbage (*Brassica oleracea* var. Capitata L.) is one of the important winter vegetable crops in Iraq, and is grown in most of its regions. It belongs to the Brassicacea family. Its origin is Eastern of Mediterranean and it was grown wild on the coasts of England, Denmark, Northern France and various parts of Europe. It is one of the leafy vegetables which are useful in nutrition, where the head leaves are eaten, which is a group of wrapped leaves that cover the terminal bud and are used in making salads, pickles and cooking (Chatterjee et al., 2014).The production of cabbage in 2019 reached with a total production of 5769 tons (Central Statistics Organization. 2019).

To treat some challenges facing workers in agriculture field, such as low productivity and inefficiency of traditional fertilizers. Therefore, it requires to work by applying leading technologies such as nanotechnology to accurately detect how to provide the right amount of fertilizers that enhance productivity and with high efficiency while ensuring environmental safety so that nanofertilizers can be used Controlling its liberation as an environmental friend towards achieving sustainable and environmentally compatible agriculture (Subramanian and Sharmila, 2009). Boron has an important and effective role in the regulating and producing auxin process in plants through the protection of indol acetic acid which has an important role in inhibiting oxidation processes, thus increasing its concentration in the plant and then performing its functions normally. When it is lacking, this leads to an excess accumulation of auxins and phenols, and this causes death of plant tissues (Gharib and Hegazi, 2010).

Genotype is one of the factors that effect on productivity. Ahmed et al. (2019), noted that hybrid of Cabbage Red recorded highest values in the plant height, number of leaves, head diameter, head weight and total yield. Where as, Asha hybrid had highest values in stem diameter and early yield.Therefore, The aim of this study is Knowing the effect of balanced nano-fertilizer and spraying with boron on the chemical properties and yield and determining the appropriate concentration and variety for the conditions of Salah al-Din Governorate.Determining of the interaction treatments that giving the best quantitative, qualitative and yield characteristics

MATERIALS AND METHODS

The field experiment was carried out at Research Station of the Horticulture and Landscape Department/ College of Agriculturel/ Tikrit University from 21/9/2021 to 17/1/2022. The experiment consisted of three factors. First factor is a balanced nano-fertilization viz 0, 2 and 3 g L-1), The spraying process had been twice, starting from 11/10/2021, that is, twenty days after planting and two weeks between one spray and another. Second factor is the spraying by boron at a concentration of 5 mg L^{-1} and addition to control treatment (spraying by distilled water), The spraying process had been twice, starting from 12/10/2021, that is, twenty days after planting, and 15 days between one spray and another.

Third factor is two hybrids namely, Globe Master (American origin, produced by the Turkish company Takii) and Dalal (SeedDutch origin, produced by Mirro Seeds Company). The experiment

was laid out according to Randomize Complete Block Design(RCBD) with split plot arrangement with three replicates. Each replicate included 12 experimental units. The experimental unit included two ridges with a length of 3 meters and a width of 1.5 meters, so that the area of each experimental unit is 4.5 m2. Each experimental unit consisted of 12 plants and the distance between one plant and another is 50 cm. The seeds of the hybrids were planted on 03/08/2021 at the private nurseries in the Dujail district, using seedling trays, after that the seedlings were transferred to the field on 21/9/2021. random samples were taken from the soil of the field at a depth of 0-30 cm before planting, then have been analysis some chemical and physical characteristics of the soil (Table 1). The studied characteristics were total head weight, marketable head weight, total plant yield, percentages of N, P, K and protein and ratio nitrate.

Table 1 Some physical and chemical properties of field soil/before planting

Trait	Value	Unit	Trait	Value	Unit
sand	540	$g.kg^{-1}$	pH	7.8	
slit	338	$g.kg^{-1}$	EC	1.21	$Ds.m^{-1}$
clay	122	$g.kg^{-1}$	nitrogen	0.215	$Mg.Kg^{-1}$
texture	Sandy loam		Phosphorous	9.8	$Mg.Kg^{-1}$
gypsum	13.8	$g.kg^{-1}$	potassium	155	$Mg.Kg^{-1}$
lime	21.2	$g.kg^{-1}$			

Replace it with the experiment included three factors:

The first factor is spraying with balanced nano-fertilizer:

The experiment included three concentrations of foliar spraying: the comparison treatment, symbolized in the study by the symbol N0, the spray with a concentration of 20 gL^{-1}, symbolized in the study by the symbol N1, and the spray with a concentration of 30gL^{-1} symbolized in the study by the symbol N2. The spraying process was carried out twice until full wetness during the growing season, starting from 11/10/2021, that is, twenty days after planting and two weeks between one spray and another, a backspray with a capacity of 20 liters was used for spraying.

The second factor is spraying with boron in a concentration 0,5 mg L^{-1} its symbols are B0 and B1, respectively. Boric acid was used as a source of boron by spraying. The spraying process was carried out twice until complete wetness. During the growing season, starting from 12/10/2021, that is, twenty days after planting, and 15 days between one spray and another, a backspray with a capacity of 20 liters was used for spraying.

Statistical analysis:

The data were analyzed using the statistical program SAS (2001). The means were compared according to Duncan multiple range test at a probability level of 5% (Al-Khafaji and Al-Khamisi, 2012).

RESULTS and DISCUSSION

Total head weight

The results in Table 2 indicates that, significant differences between the treatments. N2 treatment had highest value of total weight of head 4.63 kg compared to the control treatment (N0) 3.70 kg. A the same time, the treatment of spraying by boron (B1) increased significantly 4.41 kg compared to the control treatment (B0) 3.68 kg. On the other hand, hybrid (H1) recorded highest value in this characteristics 4.57 kg.

Table 2 Effect of spraying with balanced nano-fertilizer and boron for two hybrids of cabbage on total weight of the head (kg).

Treatment / hybrid	spraying with boron	The effect of spraying with nano-fertilizer			Interaction between hybrids and boron	Hybrid effect
		No	N1	N2		
H1	B0	3.53 h	4.72 e	4.46 d	4.09 b	4.57 a
	B1	4.46 c	4.98 b	5.56 a	5.06 a	
H2	B0	3.18 k	3.27 jk	3.37 ji	3.27 d	3.51 b
	B1	3.43 i	3.78 g	4.07 f	3.76 c	
H1		4.09 c	4.62 b	5.00 a		
H2		3.31 f	3.52 e	3.72 d	The effect of spraying with boron	
B0		3.36 f	3.77 e	3.91 d	3.68 b	
B1		4.04 c	4.37 b	4.81 a	4.41 a	
The effect of nano fertilizer		3.70 c	4.07 b	4.63 a		

*Numbers with the same alphabet are not significantly different according to Duncan's multiple range test at 5% probability level

Same table refers that, the interaction treatment between hybrids and boron (H1B1) gave significant increment 5.06 kg compared to the lowest value of 3.27 kg for the (H2B0) treatment. Where as, the interaction treatment between hybrids and spraying with nano-fertilizer(H1N2) had highest value 5.00 kg, in contrast H2B0 gave the lost value 3.31 kg. While the interaction between nano-fertilization and spraying with boron(B1N2) showed significant increment 4.81 kg, compared to the lowest value given by the treatment (B0N0) which was 3.36 kg. But, the interaction between nano-fertilization and spraying with boron (H1B1N2) gave significant superiority reaches 5.56 kg compared to minimum value 3.18 kg at H2B0N0 treatment.

Marketable head weight (kg)

From Table No. 3, it is noticeable that there were significant differences in the single treatments, where is the value of spraying with nano-fertilizer was 3.31 kg compared to the lowest value given by comparison treatment N0, which was 2.61 kg .As for the treatment of spraying with boron, spraying B1 differed over non-spray B0, where they reached, respectively, 3.29 kg and 2.57 kg. As for the treatment of effect of hybrids, the marketable head weight of hybrid H1 increased significantly compared with hybrid H2 and their weights reached 3.30 kg and 2.56 kg, respectively. From the same table it is noted that there were significant differences in the dual interaction treatments between hybrids and spraying with boron and the value of marketable head weight was 3.79 kg in H1B1 treatment, compared to the lowest value 2.33 kg in H2B0 treatment. In the dual interaction treatment between hybrids and spraying with nano-fertilizer, the H1N2 treatment increased significantly and reached 3.84 kg compared to the lowest value for the H2N0 treatment was 2.36 kg, As for the interaction treatment between spraying with boron and spraying with nano fertilizer, it differed significantly

from B1N2 treatment and its value was 3.79 kg compared to the lowest value was 2.29 kg for B0N0 treatment, regarding the triple interaction between nano fertilization, spraying with boron and the effect of hybrids, H1B1N2 treatment excelled and its value was 4.48 kg compared to the lowest value given by H2B0NO treatment which was 2.22 kg.

Table 3 Effect of spraying with balanced nano-fertilizer and boron for two hybrids of cabbage on marketable head weight (kg)

Treatment / hybrid	spraying with boron	The effect of spraying with nano-fertilizer			Interaction between hybrids and boron	Hybrid effect
		No	N1	N2		
H1	B0	2.83 gf	2.85 e	3.20 dc	2.81 b	3.30 a
	B1	3.32 c	3.58 b	4.48 a	3.79 a	
H2	B0	2.22 g	2.32 gf	2.45 f	2.33 c	2.56 b
	B1	2.50 f	2.73 e	3.10 d	2.78 b	
H1		2.85 c	3.21 b	3.84 a		
H2		2.36 e	2.53 d	2.78 c	The effect of spraying with boron	
B0		2.29 e	2.58 d	2.83 c	2.57 b	
B1		2.91 c	3.15 b	3.79 a	3.29 a	
The effect of nano fertilizer		2.61 c	2.87 b	3.31 a		

***Numbers with the same alphabet are not significantly different according to Duncan's multiple range test at 5% probability level**

Same table refers that, the interaction treatment between hybrids and boron (H1B1) gave significant increment 5.06 kg compared to the lowest value of 3.27 kg for the (H2B0) treatment. Where as, the interaction treatment between hybrids and spraying with nano-fertilizer(H1N2) had highest value 5.00 kg, in contrast H2B0 gave the lost value 3.31 kg. While the interaction between nano-fertilization and spraying with boron(B1N2) showed significant increment 4.81 kg, compared to the lowest value given by the treatment (B0N0) which was 3.36 kg. But, the interaction between nano-fertilization and spraying with boron (H1B1N2) gave significant superiority reaches 5.56 kg compared to minimum value 3.18 kg at H2B0N0 treatment.

Total yield (ton ha^{-1})

The data in the table below indicates that there were significant differences between the single treatments, as nano-fertilizer N2 treatment was superior by recording the highest value, which was 88.24 tons ha^{-1}, compared with the lowest value recorded by comparison treatment N0, which amounted to 69.38 tons ha^{-1}, as for the boron spray treatment, it differed significantly, the spraying treatment B1 recorded the highest value 87.61 tons ha^{-1} Compared with non-spray treatment B0, it gave the lowest value of 68.46 tons ha^{-1}, and with regard to the effect of hybrids, the hybrid H1 outperformed hybrid H2, and their value was 87.95 tons ha^{-1}, 68.13 tons ha^{-1}, respectively. The results of the same table indicate significant differences between the binary interaction treatments of hybrids and boron H1B1 whose value was 101.13 tons ha^{-1} compared with the lowest

value given by treatment H2B0 which was 62.16 tons ha^{-1}, as for the interactions treatment between hybrids and spraying with nano-fertilizer, H1N2 outperformed with a value of 102.44 tons ha^{-1} compared with the lowest value given by H2N0 was 62.98 tons ha^{-1}. As for the binary interaction treatment between spraying with boron and with nano fertilizer, B1N2 treatment was superior, with a value 101.06 tons ha^{-1} compared to the lowest value 61.02 tons ha^{-1} given by the interaction treatment B0N0. For the triple interaction treatments, significant differences were observed between the effect of hybrids, nano fertilization and spraying with boron, where the interaction treatment H1B1N2 excelled with a value 119.46 tons ha^{-1} compared to the lowest value given by the interaction treatment H2B0N0 was 59.20 tons ha^{-1}.

Boron contributes to increasing the proportions of nutrients and activating enzymes and increases protein synthesis and thus increases the total plant yield (Saha et al., 2010). The superiority of hybrid H1 is due to vegetative differences caused by genotype variation lead to dissimilarity in quality and quantity of the yield, the responsible genes on absorption of nutrients differs from one hybrid to another. Therefore, the superior hybrid may have a greater ability to absorb nutrients in a higher way than the other hybrid, and this led to an increase in its vegetative growth, which was reflected in the yield increasing , (Mohammed and Menea, 2018).

Table 4 Effect of spraying with balanced nano-fertilizer and boron of two hybrids of cabbage on the Total yield, ton ha^{-1}

Treatment / hybrids	Spraying with boron	Effect of spraying with nano fertilizer			Interaction between hybrid and boron	The effect of hybrids
		NO	N1	N2		
H1	B0	62.84 gf	76.00 e	85.42 dc	74.76 b	87.95 a
	B1	88.71 c	95.20 b	119.46 a	101.13 a	
H2	B0	59.20 g	61.87 gf	65.42 f	62.16 c	68.13 b
	B1	66.76 f	72.89 e	82.67 d	74.10 b	
H1		75.78 c	85.60 b	102.44 a		
H2		62.98 e	67.38 d	74.04 c	Effect of spraying with boron	
B0		61.02 e	68.93 d	75.42 c	68.46 b	
B1		77.73 c	84.04 b	101.06 a	87.61 a	
Effect of nano fertilizer		69.38 c	76.49 b	88.24 a		

***Numbers with the same alphabet are not significantly different according to Duncan's multiple range test at 5% probability level**

Same table refers that, the interaction treatment between hybrids and boron (H1B1) gave significant increment 5.06 kg compared to the lowest value of 3.27 kg for the (H2B0) treatment. Where as, the interaction treatment between hybrids and spraying with nano-fertilizer(H1N2) had highest value 5.00 kg, in contrast H2B0 gave the lost value 3.31 kg. While the interaction between nano-fertilization and spraying with boron(B1N2) showed significant increment 4.81 kg, compared to the lowest value given by the treatment (B0N0) which was 3.36 kg. But, the interaction between nano-fertilization and spraying with boron (H1B1N2) gave significant superiority reaches 5.56 kg compared to minimum value 3.18 kg at H2B0N0 treatment.

Nitrogen percentage %

The results of the table below show no significant differences appeared between the individual treatments of nano-fertilizer, spraying with boron and hybrids. From same table, it is noted there are no significant differences between the two interactions hybrids and spraying with boron, hybrids and spraying with nano fertilizer, as for the binary interaction treatment between spraying with boron and spraying with nano fertilizer, B1N0 treatment outperformed, with a value of 2.92%, compared to the lowest value given by B0N0 treatment was 2.23%. Regarding the triple interactions, there are significant differences between the effects of hybrids, nano fertilization and spraying with boron, the value of H1B1N0 was 3.05%, compared to the lowest value given by H1B0N0 was 2.13%. The reason for the differences in some of the triple interactions is mainly due to the role of the study factors in activating the photosynthesis process, which leads to a high percentage of carbohydrates and an increase in the percentage of dry matter, which had a positive impact in increasing the vegetative growth indicators, quantity and quality.

Table 5: Effect of spraying with balanced nano-fertilizer and boron of two hybrids of cabbage on the nitrogen percentage %

Treatment / hybrids	Spraying with boron	Effect of spraying with nano fertilizer			Interaction between hybrid and boron	The effect of hybrids
		NO	N1	N2		
H1	B0	2.13 e	2.40 edc	2.40 edc	2.31 a	2.54 a
	B1	3.05 a	2.90 ba	2.35 ed	2.77 a	
H2	B0	2.31 ed	2.51 bedc	2.57 bdc	2.71 a	2.59 a
	B1	2.80 bac	2.77 bac	2.58 bdc	4.10 b	
H1		2.60 a	2.65 a	3.82 a		
H2		2.56 a	2.64 a	2.57 a	Effect of spraying with boron	
B0		2.23 b	2.45 b	2.48 b	2.39 a	
B1		2.92 a	2.83 a	2.47 b	2.74 a	
Effect of nano fertilizer		2.58 a	2.65 a	2.47 a		

***Numbers with the same alphabet are not significantly different according to Duncan's multiple range test at 5% probability level**

Potassium percentage%

By noting Table 7, there are no significant differences between the single treatments and the binary treatments. As for the triple interaction treatments, there are significant differences between the effect of hybrids, nano fertilization and spraying with boron, where t H2B1N1 treatment excelled, as it scored 3.76% compared to the lowest value recorded by H2B0N1 treatment was 2.31%.

Table 6: Effect of spraying with balanced nano-fertilizer and boron of two hybrids of cabbage on phosphorou percentage s%

Treatment / hybrids	Spraying with boron	Effect of spraying with nano fertilizer			Interaction between hybrid and boron	The effect of hybrids
		NO	N1	N2		
H1	B0	0.24 a	0.14 bc	0.15 bac	0.18 a	0.17 a
	B1	0.14 bc	0.16 bac	0.16 bac	0.15 a	
H2	B0	0.15 bac	0.22 ba	0.11 c	0.16 a	0.15
	B1	0.16 bac	0.11 c	0.17 bac	0.15 a	
H1		0.19 a	0.15 a	0.15 a		
H2		0.15 a	0.17 a	0.14 a	Effect of spraying with boron	
B0		0.19 a	0.18 a	0.13 a	0.16 a	
B1		0.15 a	0.14 a	0.17 a	0.15 a	
Effect of nano fertilizer		0.17 a	0.16 a	0.15 a		

***Numbers with the same alphabet are not significantly different according to Duncan's multiple range test at 5%**

Table 7: Effect of spraying with balanced nano-fertilizer and boron for two hybrids of cabbage on potassium percentage %

Treatment / hybrids	Spraying with boron	Effect of spraying with nano fertilizer			Interaction between hybrid and boron	The effect of hybrids
		NO	N1	N2		
H1	B0	2.55 bc	3.22 bac	2.59 bc	2.79 a	2.82 a
	B1	2.73 bac	2.58 bc	3.26 bac	2.86 a	
H2	B0	3.50 ba	2.31 c	2.97 bac	2.93 a	3.06 a
	B1	3.01 bac	3.76 a	2.77 bac	3.18 a	
H1		2.90 a	2.90 a	2.92 a		
H2		3.04 a	3.04 a	2.87 a	Effect of spraying with boron	
B0		2.77 a	2.77 a	2.78 a	2.86 a	
B1		3.17 a	3.17 a	3.01 a	3.02 a	
Effect of nano fertilizer		2.97 a	2.97 a	2.90 a		

***Numbers with the same alphabet are not significantly different according to Duncan's polynomial test at 5% probability level**

Nitrate ratio mg L-

Through Table 8, significant differences were observed between the individual treatments, as the nano-fertilizer N1 treatment recorded a value of 0.86 mg L^{-1} compared to the control N0 treatment, which was 0.46 mg L^{-1}. As for the boron spray treatment, there are no significant differences between the two treatments, spray B1 or No spraying B0 for their recording of similar values, and with regard to the treatment of effect of hybrids, no significant differences are also seen between the two hybrids H1, H2 for this trait.

From same table, significant differences were found between most of the two-interaction treatments. There are no significant differences between the two-interaction treatments of hybrids and spraying with boron to give them close values. As for hybrids and spraying with nano-fertilizer, H2N1 treatment excelled and its value was 0.90 mg L^{-1} compared to H1N0 treatment which was 0.44 mg L^{-1}, as for the binary interaction treatment between spraying with boron and spraying with nano fertilizer, the interaction B1N1 treatment was superior, with a value of 1.09 mg L^{-1}, compared to B0N0 the value was 0.42 mg L^{-1}. For triple interaction treatments, it was noted that there were significant differences between the effect of hybrids, nano fertilization and spraying with boron, where the treatment H2B1N1 excelled with a value of 1.21 mg L^{-1}, compared with the lowest value given by the interaction H1B0N0 treatment was 0.40 mg L^{-1}.

Table 8: Effect of spraying with balanced nano-fertilizer and boron for two hybrids of cabbage on nitrate percentage(mg L^{-1})

Treatment / hybrids	Spraying with boron	Effect of spraying with nano fertilizer			Interaction between hybrid and boron	The effect of hybrids
		NO	N1	N2		
H1	B0	0.40 b	0.66 ba	0.52 b	0.52 a	0.61 a
	B1	0.47 b	0.96 ba	0.59 b	0.70 a	
H2	B0	0.44 b	0.59 b	0.71 ba	0.58 a	0.74 a
	B1	0.57 b	1.21 a	0.89 ba	0.89 a	
H1		0.44 b	0.82 ba	0.59 ba		
H2		0.51 ba	0.90 a	8.0 ba	Effect of spraying with boron	
B0		0.42 b	0.63 b	0.61 b	0.56 a	
B1		0.52 b	1.09 a	0.78 ba	0.79 a	
Effect of nano fertilizer		0.47 b	0.86 a	0.70 ba		

***Numbers with the same alphabet are not significantly different according to Duncan's multiple range test at 5% probability level**

The superiority of the triple interaction treatments between spraying with nano-fertilizer, boron and hybrids in the proportion of nitrates because nano-fertilizer contains the major nutrients necessary for plant growth, which are of great importance in the plant biological construction , which increased the efficiency of the photosynthesis process and increased the absorbed elements amount and thus increased the amount of nutrients transferred to the heads, which increased nitrates percentage , (Alshami and Al-Juthery, 2019).

The superiority of the Globe Master hybrid over the Dlal hybrid in most of the quantitative and qualitative yield traits is due to the variation in the genetic structure of these hybrids and the different genetic characteristics of each hybrid (Hope et al, 2016).

CONCLUSION

The results of this study showed that addition of balanced NPK nano-fertilizer by spraying at a concentration of 30 g l^{-1} gave a significant difference in most of the studied indicators represented by yield and chemical indicators. Spraying with boron element at a concentration of 5 mg L^{-1} had a significant effect in increasing most of the studied traits, whether chemical indicators or yield indicators. The Dalal hybrid was significantly superior in most of the studied traits.

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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