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Investigation the effect of drought stress on tolerant and resistant rice (Oryza sativa L.) varieties in terms of morphologic and genetic characters

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Abstract

Drought associated with global warming is a major limiting factor for crop production. This abiotic stress affects the quality and yield of rice (Oryza sativa L.) which is a model organism and also one of the major consumed products all over the world. In this study, we aimed to analyse morphologic (root length, shoot length, root wet weight, shoot wet weight, root dry weight and shoot dry weight) of rice varieties (dhan 65, dhan 71, kızıltan and Karacadağ local rice) grown under drought stress during 21 days. For genetic properties, Hopi and Osr30 retrotransposon movements were investigated by using IRAP marker technique. Depending on the decreasing in the amount of water, we observed that all growth parameters showed variable results in four varieties. Moreover, IRAP-PCR indicated different polymorphism ratios among samples. These rates were 0-75% for Hopi and 0-50% for Osr30 . As far as we know, this is the first detailed report on dhan 65, dhan 71, kızıltan and Karacadağ local rice varieties grown under drought stress.

Introduction

Stress can be defined as the factors, changing the metabolic homeostasis in plants and thus causing any change in the growth and development of the plant (Shulaev et al. 2008). Stress factors are classified into two groups: abiotic and biotic stress. Drought, one of the abiotic stress factors, is defined as the lack of necessary and sufficient moisture for a plant to complete its normal growth and life cycle. It is one of the most destructive stress factors, reducing crop productivity in agricultural production compared to other environmental stress (Ault 2020).

Drought is a complex natural phenomenon that includes concepts such as severity, duration and geographical spread. Drought can also occur not only in regions with low precipitation but also in regions with high precipitation (Violita &Azhari 2021). It is predicted that global warming in drought-prone regions and even various tropical and subtropical ecosystems will increase the water deficit by 20% (Ault 2020).

Rice (*Oryza sativa* L.) is one of the most important annual cereal products used as a food source by more than half of the world's population. 21% of World population and about 80% of Far East Asians are met their daily calories from rice. Rice is widely grown in many parts of the world, especially in South and Southeast Asia, and Africa (Tamzil et al. 2021). The predominantly rice-growing areas in Asia are generally under the threat of drought. On the other hand, rice is a drought sensitive crop since it has a weak root system, and even minimal water shortage which causes stomata to close quickly (Ramachandran et al. 2021). According to the water regime in the World, rice farming has been performed in different cultivation ways including 45% irrigation, 30% rain, 11% deep water, 10% rural and 4% floating rice. In Turkey, rice production is also carried out with continuous irrigation and keeping the field under water (Arvas 2017). Since global warming affects the physiological processes related to grain production, rice yield is also directly affected. It was reported that the increase of $1^{o}C$ in the optimum temperature in the dry season causes 10% decrease in rice yield. Moreover, studies show that rice production will decrease by 40% in the coming years due to global warming (Fahad et al. 2019). Despite this decrease, it

is also stated that due to the increasing world population, approximately 25% more rice will be needed in 2030 (Genua-Olmedo et al. 2022).

Retrotransposons are mobile genetic elements, constituting very large parts in plant genomes. Almost all known plant retrotransposons are inactive during normal growth and development but can be activated by different abiotic and biotic stress factors (Araz et al. 2021, Czajka et al. 2021, Fambrini et al. 2020, Ramakrishnan et al. 2021). Thus, their mobility increases the mutation rate and reveals new genetic diversity (Habig et al. 2021). They are used as molecular markers for DNA fingerprinting, phylogeny research and genetic mapping (Gupta et al. 2021, Khan et al. 2021, Naeem et al. 2021, Scott et al. 2020, Shata et al. 2021, Zarei &Erfani-Moghadam 2021). Molecular markers such as IRAP (Inter-Retrotransposons Amplified Polymorphisms) (Lancíková &Žiarovská 2020), REMAP (Retrotransposon-Microsatellite Amplified Polymorphism) (Yigider et al. 2021), RIBP (Retrotansposon Based Insertional Polymorphism) (Wang et al. 2020), and S-SAP (Sequence-Specific Amplified Polymorphism) (Roy et al. 2021) are commonly used to determine the polymorphisms due to retrotransposons movements.

The aim of this study was to investigate the drought effects on root length, shoot length, root wet weight, shoot wet weight, root dry weight and shoot dry weight, and the movement of *Hopi* and *Osr30* retrotransposons in dhan 65, dhan 71, kızıltan and Karacadağ local rice varieties. Responses of varieties were examined and the tolerance levels against drought were tried to be determined.

Material And Methods

In this study, seeds belonging to four different rice varieties (dhan 65, dhan 71, kızıltan and Karacadağ local rice) were designed in factorial order with 3 replications according to the Random Plots Trial Design. After surface sterilisation with sodium hypochlorite (%20 v/v), they were planted in pots contaning 1/3 of peat (Klassman) and 2/3 of garden soil.

Seeds were germinated 5 days after planting. During this time, they irrigated with tap water. The pots were placed in a climate room with a temperature of 25°C and a humidity of 65% in a light/dark photoperiod of 16/8 hours. After germination, thinning was performed so that two plants were left in each pot (8 plants were sown in the beginning). Before starting the restricted irrigation applications, 0.5 g/l of NPK compound fertiliser (15% N – 30% P – 15% K) was given to each pot. Restricted irrigation applications were started approximately 20 days after seed germination. Restricted irrigation was performed on four groups as 160 ml for control and 120, 80, 40 ml for experimental groups during 21 days. After, plants were collected and used for morphological and molecular analyses.

Morphological Analyses

The aboveground and underground parts of the plants were separated from each other and measurements were made with the help of a ruler in order to determine the lengths. The wet weights were determined (after the roots were washed with tap water and removed from the soil) using precision

balances. After the wet weights were calculated, the root and stem parts were put on separate drying papers and put into the oven at 72 ^{o}C for 72 hours. After incubation, dry weights were measured. Statistical analyses of the data were performed using the COSTAT (version 6.03) package program and multiple comparison tests were performed according to the Duncan test (Düzgüneş et al. 1987) by using at least two biological and technical replicates (Düzgüneş et al. 1987).

Molecular Analyses

Genomic DNA isolation

The method of Kidwell and Osborn (1992) was used for the isolation of genomic DNA (gDNA) of leaves belonging to control and experimental groups with slight modifications (Kidwell &Osborn 1992). The quality and quantity of gDNAs were analysed by agarose gel electrophoresis and spectrohotometer, respectively. gDNA samples were stored at -20°C until use and used for templates for IRAP-PCR reactions.

IRAP-PCR conditions

IRAP-PCR was established for investigation of *Hopi* and *Osr30* retrotransposons movements. Primer sequences were given in Table 1. IRAP-PCR was performed in 20 µL of the reaction mixture containing 1 µL of nuclease-free dH_2O, 10 µL of buffer (DreamTaq Green PCR Master Mix, Thermo Scientific™), 2.5 µL of 25 µM $MgCl_2$ (2.5 mM), 1.75 µL of 10 µM/µL each primer (0.8 µM/µL) and 3 µL of 20 ng/µL (3.2 ng/µL) template genomic DNA. Values given in parenthesis were final concentrations. PCR conditions were one initial denaturation at 95°C for 3 min followed by 30 cycles of denaturation at 95°C for 30 sec, annealing (49°C for *Osr30* and 54°C for *Hopi*) for 30 sec and extension at 72°C 3 min. The reaction was completed by a final extension step (72°C for 10 min).

Table 1
Hopi and *Osr30* primer sequences

Primer name	Sequences (5'-3')	Reference
Hopi-F	CGCGAACCTTCCACTACAGACTAG	
Hopi-R	GGCCACTGTGGG'CCTGATCG	(Yuzbasioglu et al. 2017)
Osr30-F	GCAGCCGATTCTCGCTCTGTTTCCG	
Osr30-R	GGCACGCTCACACATCCGAAGGCGA	

PCR products were analysed by 1% agarose gel (w/v) in 1X TBE (TrisBoric acid-EDTA) at 90 V for 90 min. After, agarose gel photographed on a UV transilluminator and band profiles of samples were evaluated. Monomorphic and polymorphic bands clearly observed in the gels were counted for calculation of polymorphism ratios by using Jaccard Similarity Coefficient (Jaccard 1908).

Results

In this study, seedlings belonging to dhan 65, dhan 71, kızıltan and Karacadağ local were exposed to drought stress with different amounts of limited water during 21 day. After, root and stem length, root and stem fresh weight, and root and stem dry weight) were measured to determine the stess effects. It was observed the direct relationship between decreasing water availability and a statistical decrease in the morphological parameters ($p < 0.01$) (Table 2).

Table 2
The effects of different restricted irrigations on rice

Factor		Root length (cm)	Shoot length (cm)	Root wet weight (g)	Shoot wet weight (g)	Root dry weight (g)	Shoot dry weight (g)
Drought stress	Rice varieties						
DS (40 ml)	1	**14.15 cd**	**23.70 de**	**0.015**	**0.114**	**0.003**	**0.025**
	2	**13.80 cd**	**20.85 fg**	**0.008**	**0.082**	**0.003**	**0.02**
	3	**8.80 f**	**19.20 g**	**0.002**	**0.029**	**0.001**	**0.004**
	4	**9.60 f**	**23.70 de**	**0.004**	**0.101**	**0.002**	**0.02**
		11.58 C	**21.86 D**	**0.007 D**	**0.081 C**	**0.002 D**	**0.017 C**
DS (80 ml)	1	11.95 de	25.65 cd	0.031	0.141	0.005	0.029
	2	14.55 cd	20.85 fg	0.02	0.088	0.004	0.022
	3	9.30 f	19.70 g	0.004	0.053	0.002	0.011
	4	9.65 f	28.10 b	0.016	0.147	0.003	0.033
		11.36 C	**23.57 C**	**0.017 B**	**0.107 B**	**0.003 C**	**0.023 B**
DS (120 ml)	1	12.20 de	27.45 bc	0.02	0.145	0.005	0.029
	2	15.80 bc	20.75 fg	0.009	0.102	0.003	0.024
	3	11.50 e	20.30 g	0.007	0.091	0.004	0.02
	4	14.90 bc	29.50 b	0.018	0.146	0.005	0.032
		13.6 B	**24.50 B**	**0.013 C**	**0.121 B**	**0.004 B**	**0.026 B**
DS (160 ml)	1	14.65 bcd	29.70 b	0.046	0.264	0.012	0.05
	2	17.05 ab	22.80 ef	0.049	0.106	0.003	0.026
	3	18.45 a	20.85 fg	0.053	0.097	0.004	0.023
	4	15.75 bc	33.65 a	0.019	0.248	0.006	0.04
		16.47 A	**26.75 A**	**0.042 A**	**0.178 A**	**0.006 A**	**0.034 A**
Rice varieties	1	*12.23 B*	*26.62 B*	*0.028 A*	*0.166 A*	*0.006 A*	*0.033 A*
	2	*15.30 A*	*21.31 C*	*0.021 B*	*0.094 B*	*0.003 C*	*0.023 B*

1, Karacadağ local rice; 2, dhan71; 3, dhan65; 4, Kızıltan. ** *p <0.01* level significances: ns: not significance

Factor		Root length (cm)	Shoot length (cm)	Root wet weight (g)	Shoot wet weight (g)	Root dry weight (g)	Shoot dry weight (g)
Drought stress	Rice varieties						
DS (40 ml)	1	14.15 cd	23.70 de	0.015	0.114	0.003	0.025
	2	13.80 cd	20.85 fg	0.008	0.082	0.003	0.02
	3	8.80 f	19.20 g	0.002	0.029	0.001	0.004
	4	9.60 f	23.70 de	0.004	0.101	0.002	0.02
	3	*12.01 C*	*20.01 D*	*0.016 C*	*0.067 C*	*0.002 C*	*0.014 C*
	4	*12.47 BC*	*28.73 A*	*0.014 D*	*0.160 A*	*0.004 B*	*0.031 A*
Drought Stress (DS)		**	**	**	**	**	**
Rice varieties (RV)		**	**	**	**	**	**
DS×RV		**	**	ns	ns	ns	ns
Variation coefficient		7.44	4.26	19.84	19.27	19.49	18.87

1, Karacadağ local rice; 2, dhan71; 3, dhan65; 4, Kızıltan. ** $p < 0.01$ level significances: ns: not significance

The effect of restricted irrigation, cultivar and restricted irrigation × cultivar interaction on root length was found to be statistically significant ($p < 0.01$). According to limited irrigation practices, the highest root length value was obtained from 160 ml of water applied application with 16.47 cm, and the lowest value was obtained from 80 ml of water applied application application with 11.36 cm. However, it was determined that there was no statistically significant difference with the 40 ml of water applied application and it was in the same Duncan group. According to the cultivars, the highest root length value was obtained from dhan 71 with 15.30 cm, and the lowest value was obtained from dhan 65 with 12.01 cm (Table 2).

The effect of restricted irrigation, cultivar and restricted irrigation × cultivar interaction on seedling length was found to be significant at the 1% level. According to the restricted irrigation practices, the highest seedling length value was obtained from 160 ml of water applied application with 26.75 cm, and the lowest value was obtained from 40 ml of water applied application with 21.86 cm. According to the cultivars, the highest seedling length value was obtained from Kızıltan with 28.73 cm, and the lowest value was obtained from dhan 65 with 20.01 cm (Table 2).

The effect of restricted irrigation and cultivars on root fresh weight was found to be statistically significant at the 1% level. According to the restricted irrigation applications, the highest value was obtained from 160 ml of water applied application with 0.042 g, and the lowest value from 40 ml of water

applied application with 0.007. Among the cultivars, the highest root wet weight was obtained from Karacadağ local rice with 0.028 g, and the lowest value from Kızıltan with 0.014 g (Table 2).

The effect of limited irrigation and cultivars on root wet weight was found to be statistically significant at the 1% level. According to limited irrigation practices; While the highest seedling fresh weight was obtained from 160 ml of water applied application (0.0178 g), the lowest value was obtained from 40 ml of water applied application (0.081 g). Considering the varieties, the highest value was obtained from Karacadağ local rice (0.166 g), which did not differ statistically from Kızıltan and was in the same Duncan group, and the lowest value was obtained from dhan 65 (0.067 g) (Table 2).

The effect of restricted irrigation on root dry weight of cultivars was found to be significant at the 1% level. According to the restricted irrigation applications, the highest value was obtained from 160 ml of water applied application with 0.006 g, and the lowest value was obtained from 40 ml of water applied application with 0.002 g. According to the varieties, the highest value was reached from Karacadağ local rice (0,006 g), while the lowest value was reached from dhan 65 (0,002 g), which did not make a statistically significant difference with dhan 71 (0,002 g) and was in the same Duncan group (Table 2).

The effect of limited irrigation and cultivars on seedling dry weight was statistically significant at the rate of 1%. According to restricted water applications, the highest value in seedling dry weight was determined from 160 ml of water applied application (0.034 g) and the lowest value from 40 ml of water applied application (0.017 g). Considering the varieties; While the highest seedling dry weight value was obtained from Karacadağ local rice (0.033 g), which did not differ statistically from Kızıltan and was in the same Duncan group, the lowest value was obtained from dhan 65 (0.014 g) (Table 2). In this presented study, *Hopi* and *Osr30* movements were also analysed. IRAP-PCR results for *Hopi* indicated 352 bands between 300 bp and 1500 bp (Fig. 1). Band profiles showed that 213 are monomorphic and 139 are polymorphic.

According to the polymorphism results calculated with the Jaccard Similarity Coefficient, 0–80% polymorphism rates were found in rice leaves. Moreover, polymorphism ratios were 0–75% for DS (160 ml), 0–70% for DS (120 ml), 0–64% for DS (80 ml) and 0–56% for DS (40 ml). Among the irrigation groups, the highest polymorphism was observed in rice varieties treated with 160 ml of water, while the Hopi retrotransposon movements decreased as the amount of water applied decreased, and the lowest polymorphism was observed in the rice varieties treated with 40 ml of water (0–56%) (Table 3). There were 288 bands were counted between 300 bp and 1500 bp as a result of *Osr30* IRAP-PCR results (Fig. 2). 216 are monomorphic and 72 are polymorphic bands were counted in agarose gel.

Table 3
Polymophism ratios for *Hopi* retrotransposon

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	**0**															
2	**44**	**0**														
3	**33**	**13**	**0**													
4	**71**	**71**	**75**	**0**												
5	25	60	50	71	**0**											
6	56	14	25	67	**70**	**0**										
7	56	14	25	67	**70**	**0**	**0**									
8	30	45	36	80	**30**	**55**	**55**	**0**								
9	33	64	55	75	13	73	73	20	**0**							
10	33	13	0	75	50	25	25	36	**55**	**0**						
11	44	25	13	71	60	14	14	45	**64**	**13**	**0**					
12	67	50	56	60	50	43	43	64	**56**	**56**	**50**	**0**				
13	38	56	44	67	14	67	67	40	25	44	56	**43**	**0**			
14	44	25	13	71	60	14	14	45	64	13	0	**50**	**56**	**0**		
15	44	25	13	71	60	14	14	45	64	13	0	**50**	**56**	**0**	**0**	
16	38	56	44	67	14	67	67	40	25	44	56	**43**	**0**	**56**	**56**	**0**

1, Karacadağ local rice grown under DS (160 ml); 2, dhan71 in DS (160 ml); 3, dhan 65 in DS (160 ml); 4, Kızıltan in DS (160 ml); 5, Karacadağ local rice in DS (120 ml); 6, dhan 71 in DS (120 ml); 7, dhan 65 in DS (120 ml); 8, Kızıltan in DS (120 ml); 9, Karacadağ local rice in DS (80 ml); 10, dhan 71 in DS (80 ml); 11, dhan 65 in DS (80 ml); 12, Kızıltan in DS (80 ml); 13, Karacadağ local rice in DS (40 ml); 14, dhan 71 in DS (40 ml); 15, dhan 65 in DS (40 ml); 16, Kızıltan in DS (40 ml)

There are 0–50% polymorphism ratios among all samples (Table 3). Polymorphism ratios showed varying results as 0–25% for DS (160 ml), 0–57% for DS (120 ml), 0–38% for DS (80 ml) and 0–25% for for DS (40 ml). Polymorphism is observed at different rates among irrigation groups. In contrast to the Hopi retrotransposon, the highest polymorphism in the Osr30 retrotransposon was observed with 0–57% in rice treated with 120 ml of water. Lowest polymorphism in Osr30 retrotransposon was seen in 40 ml water application (Table 4).

Table 4
Polymophism ratios for *Osr30* retrotransposon

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	**0**															
2	**25**	**0**														
3	**25**	**0**	**0**													
4	**0**	**25**	**25**	**0**												
5	38	43	43	38	**0**											
6	25	0	0	25	**43**	**0**										
7	13	38	38	13	**29**	**38**	**0**									
8	38	17	17	38	**57**	**17**	**50**	**0**								
9	25	50	50	25	17	50	14	63	**0**							
10	0	25	25	0	38	25	13	38	**25**	**0**						
11	13	38	38	13	29	38	0	50	**14**	**13**	**0**					
12	13	14	14	13	50	14	25	29	**38**	**13**	**25**	**0**				
13	25	29	29	25	43	29	14	43	29	25	14	14	**0**			
14	0	25	25	0	38	25	13	38	25	0	13	13	**25**	**0**		
15	13	38	38	13	29	38	0	50	14	13	0	25	**14**	**13**	**0**	
16	13	14	14	13	50	14	25	29	38	13	25	0	**14**	**13**	**25**	**0**

1, Karacadağ local rice grown under DS (160 ml); 2, dhan71 in DS (160 ml); 3, dhan 65 in DS (160 ml); 4, Kızıltan in DS (160 ml); 5, Karacadağ local rice in DS (120 ml); 6, dhan 71 in DS (120 ml); 7, dhan 65 in DS (120 ml); 8, Kızıltan in DS (120 ml); 9, Karacadağ local rice in DS (80 ml); 10, dhan 71 in DS (80 ml); 11, dhan 65 in DS (80 ml); 12, Kızıltan in DS (80 ml); 13, Karacadağ local rice in DS (40 ml); 14, dhan 71 in DS (40 ml); 15, dhan 65 in DS (40 ml); 16, Kızıltan in DS (40 ml)

Discussion

Drought is one of the main abiotic stresses, especially during the global warming. Therefore, it is important to characterise the effect of this stress in terms of morphological, physiological and molecular analyses to improve quality and quantity of plant species. For this purpose, Kato et al. (2007) investigated the root-soil relationship in six different rice cultivars (Akihikari, IRAT109, Yumeno-hatamochi, Otomemochi, Lemont, and Nipponbare) exposed to drought stress Factor (Kato et al. 2007). Concordant with our results, they reported that root development increased and shoot biomass decreased due to stress in all rice varieties. Werner et al. (2010) also reported that root length increased in cases of

water deficiency in transgenic tobacco plants (Werner et al. 2010). Another study was carried out by Ferreira et al. (2020). Drought stress during 14 days was applied on Catetão and Mira unpland rice varieties which exhibit opposite behavior towards drought tolerance. A higher root biomass was obtained in Catetão variety when compared to Mira. Moreover, a higher deep rooting rate (RDR) was observed for Catetão while Mira remained stable in response to drought stress in this study (Ferreira et al. 2020). It was noted that as the severity of the drought factor increased, dry matter weight and relative water content was decreased and decrease ratio was higher in the sensitive variety (Ghotbi-Ravandi et al. 2014).

We used dhan 65 and dhan 71 rice varieties to examine the effects. Similar to this, Islam et al. (2021) stated that they conducted a study with 22, 24, 27 and 30-day-old seedlings to determine the effect of sowing date on growth and yield performance of dhan83 and dhan65 rice cultivars. They concluded that dhan83 was better than dhan65 in terms of all of 22 days old seedlings plant height, grain yield and harvest index (Md. Khairul Islam et al. 2021). BRRI dhan65 variety showed the lowest yield as compared to Binadhan-14, Binadhan-19, BRRIdhan43, BRRI dhan48, BRRI dhan55 and BRRI dhan65 varieties (Chowhan et al. 2021). PEG-applied (5%, w/v) 38-day-old Binadhan-11, BRRI dhan 52, Binadhan-7, BRRI dhan 71 plants during 17 days were analysed in terms of root morphology. They reported that the root length of dhan71 was shorter than the control under 5% PEG 6000 application (Hannan et al. 2020). On the other hand, the root length of dhan 71 was increased with the severity of drought in our study.

The IRAP analysis results obtained from this study indicated that *Hopi* and *Osr30* retrotransposons are still active, causing genomic polymorphism among rice grown under drought stress. Retrotransposon movements have been investiogated in different plant species grown under salt and drought conditions (Aydin et al. 2021, Badirdast et al. 2021, Ruang-Areerate et al. 2021, Turhan et al. 2021). One of these studies was carried out by Turhan et al., (2021). They determined the polymorphism of *Nikita-E2647, Nikita-57 (N57), Sukkula, BARE 1(0), WLTR2105* retrotransposons in wheat exposed to drought stress. They reported that drought stress induced by polyethylene glycol (-4, -6 and − 8 bar PEG 8000) led to an increase in retrotransposon polymorphism and also a decrease in genomic template stability (GTS) (Turhan et al. 2021)

Noormohammadi et al. (2020). They investigated salicylic acid and NaCl effetcts on cotton plants by IRAP (*Nikita, LTR6149, LTR615*0,5´LTR1, 5´LTR2, and 3´LTR) and REMAP (10 different combinations of six IRAP primers and four cotton SSR primers) movements in cotton plants (GT40 and NNC). They obtained distinctive profiles from the retrotransposon movement in salt stress and salicylic acid applications (Noormohammadi et al. 2020). Heavy metal stress also induced the retrotransposon (*Nikita-57 N (57), Sukkula, Stowaway, Nikita E2647, and WLTR2105*) in maize. As a result of IRAP and REMAP analyses Zn (from 37.4 to 48.2%) and Fe (from 22.9 to 36.4%), for Zn from 74.3 to 58.0% and for Fe from 87.6 to 65.4% polymorphism ratios were observed via IRAP and REMAP analyses, respectively (Yigider et al. 2021).

There are many studies to investigate the movements of retrotransposons in response to several abiotic and biotic stress in different plant species. However, drought stress effects on dhan 65, dhan 71, kızıltan and Karacadağ local rice in terms of *Hopi* and *Osr30* retrotransposon were analysed for the first time in this study. There were 0–80% polymorphism ratios for the *Hopi* and 0–57% for *Osr30* retrotransposons. Moreover, severity of drought stress indicated varying polymorphism rates. Differences in polymorphism ratios could be related to both severity of drought and also rice varieties. In our study, the movements of *Osr30* and *Hopi* rice-specific retrotransposons in dhan 65 and dhan 71 rice varieties developed as drought-tolerant and untreated Kızıltan and Karacadağ local rice varieties were investigated using IRAP molecular marker technique. Polymorphism rates among cultivars showed that restricted irrigation practices could increase retrotransposon movements. It is thought that the data obtained in this study can provide an important reference for the functions of retrotransposons in these rice varieties.

Declarations

Conflict of interest

The authors declare no conflict of interest.

Ethical standards

The study is proper with ethical standards

Authors' contributions

All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by Yunus Emre Arvas, Muhammed Said Yolci and Sevgi Marakli. The first draft of the manuscript was written by Yunus Emre Arvas and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Consent to participate

Informed consent was obtained from all individual participants included in the study.

Consent to publish

The study does not include human and animal experiments.

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Figures

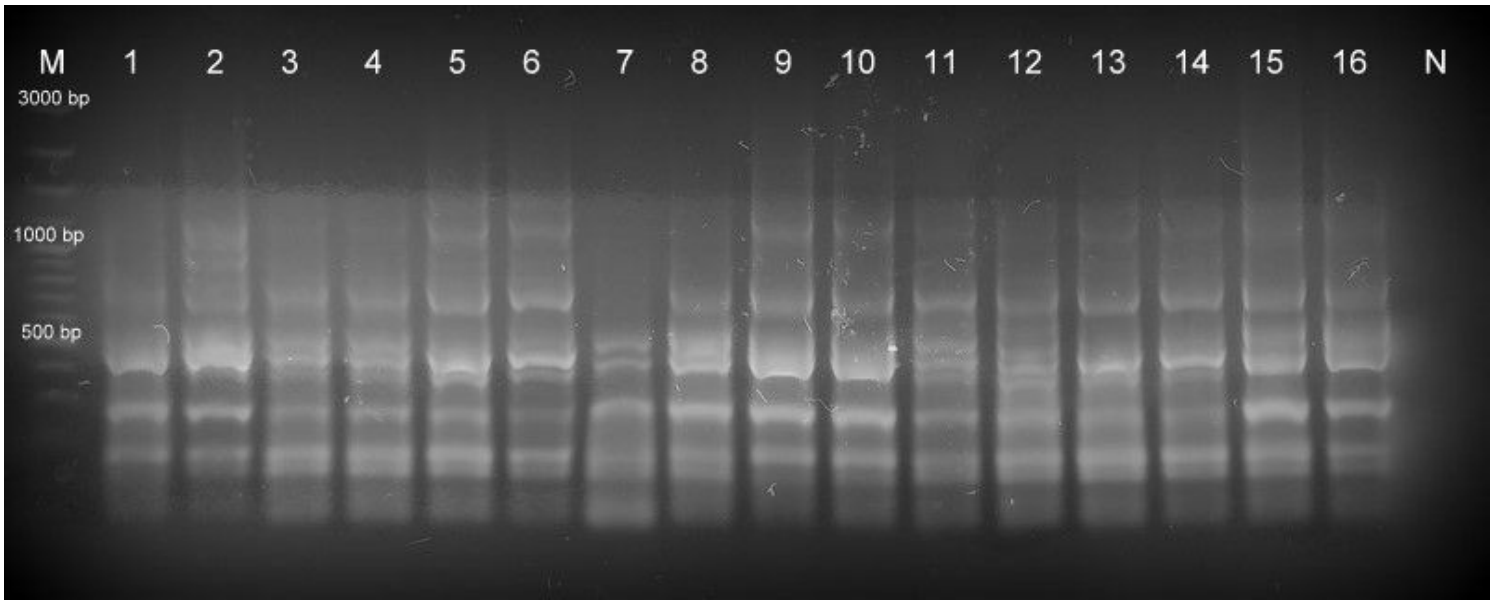

Figure 1

IRAP results for Hopi retrotransposon

1, Karacadağ local rice grown under DS (160 ml); 2, dhan71 in DS (160 ml); 3, dhan 65 in DS (160 ml); 4, Kızıltan in DS (160 ml); 5, Karacadağ local rice in DS (120 ml); 6, dhan 71 in DS (120 ml); 7, dhan 65 in DS (120 ml); 8, Kızıltan in DS (120 ml); 9, Karacadağ local rice in DS (80 ml); 10, dhan 71 in DS (80 ml); 11, dhan 65 in DS (80 ml); 12, Kızıltan in DS (80 ml); 13, Karacadağ local rice in DS (40 ml); 14, dhan 71 in DS (40 ml); 15, dhan 65 in DS (40 ml); 16, Kızıltan in DS (40 ml)

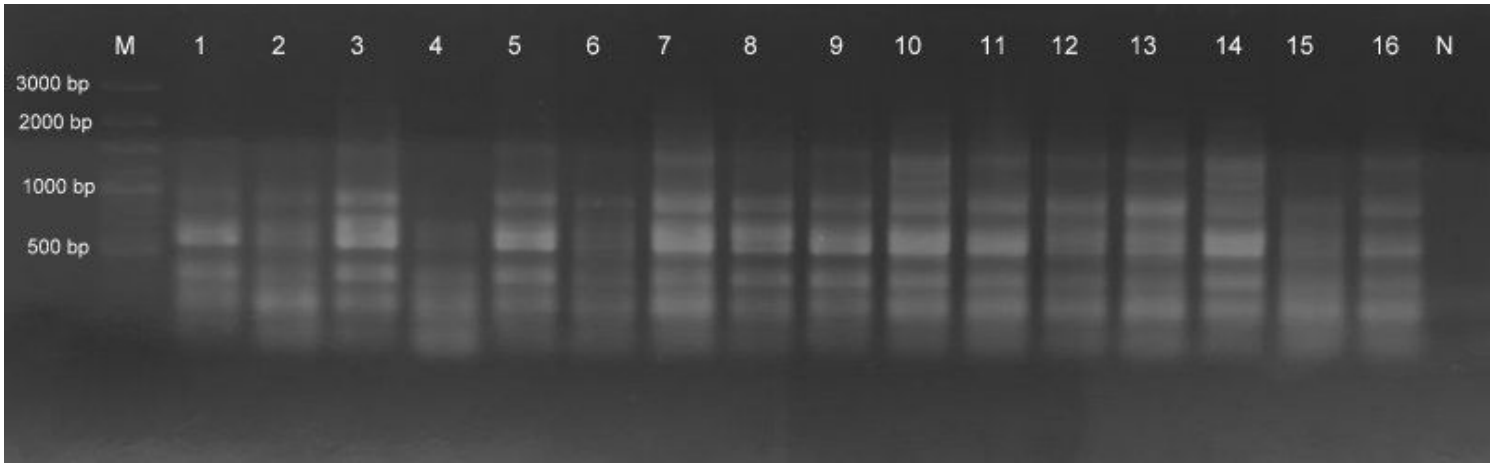

Figure 2

IRAP results for Osr30 retrotransposon

1, Karacadağ local rice grown under DS (160 ml); 2, dhan71 in DS (160 ml); 3, dhan 65 in DS (160 ml); 4, Kızıltan in DS (160 ml); 5, Karacadağ local rice in DS (120 ml); 6, dhan 71 in DS (120 ml); 7, dhan 65 in DS (120 ml); 8, Kızıltan in DS (120 ml); 9, Karacadağ local rice in DS (80 ml); 10, dhan 71 in DS (80 ml); 11, dhan 65 in DS (80 ml); 12, Kızıltan in DS (80 ml); 13, Karacadağ local rice in DS (40 ml); 14, dhan 71 in DS (40 ml); 15, dhan 65 in DS (40 ml); 16, Kızıltan in DS (40 ml)