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Morphological and physiological variations in wild tetraploid wheats collected from the Zagros Mountains[1)]

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The phylogenetic relationships between the Emmer group and the Timopheevi group of the tetraploid wheats have been studied by many workers from various viewpoints.

The distribution area of the wild tetraploid wheats is divided into three geographical regions: the wild tetraploid wheats collected from Palestine and Transcaucasus are exclusively of the Emmer group and the Timopheevi group, respectively; namely, *Triticum dicoccoides* Körn. and *T. araraticum* Jakubz. On the other hand, massive stands of both wild species have been found in the Zagros Mountains (or the eastern part of the Fertile Crescent) in 1970 by the Botanical Expedition of Kyoto University to the Northern Highlands of Mesopotamia (BEM) (Tanaka and Ishii 1973).

Using these samples, morphological and physiological studies on the variations and speciation of the wild tetraploid wheats in this area were carried out. The present report comprises the results obtained from geographical distribution of variations.

Materials and Methods

From 38 localities in Northern Iraq, Southeastern Turkey and Western Iran, the samples of the wild tetraploid wheats were collected and divided into 489 strains based on their morphological characteristics and collection sites. According to the geographical as well as the ecological conditions, the whole area has been divided into 11 regions: namely, Sulaymaniya, Koi-Senjaq, Rowanduz, Amadiya and Sinjar in Iraq, and Savur, Silvan, Ergani and Hozat in Turkey, and Karand and Ravansir in Iran.

Randomly selected twenty-two *dicoccoides* strains from seven localities and 148 *araraticum* strains from 31 localities were grown at the Plant Germ-plasm Institute, Kyoto University in 1972. The following characters of each strains; leaf pubescence, glume pubescence, ear color and heading date, were observed.

T. dicoccoides was found sporadically in a single locality in each of seven different regions, while *T. araraticum* was collected at 31 localities of nine regions and was distributed widely. Both species were found sympatrically at four localities, Sulaymaniya, Rowanduz, Amadiya and Silvan (Tanaka and Ishii 1973).

Results

1. Leaf pubescence: The distribution of this character in the Zagros Mountains is given in Table 1. As shown in Table 1, in all *araraticum* strains, heavy pubescent or pubescent type were

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Table 1. Frequency of heavy pubescent, pubescent and glabrous populations in leaf pubescence of *T. araraticum* and *T. dicoccoides*

Region	Localities	Heavy-pubescent populations	Pubescent populations	Glabrous populations	Mixed populations (h-pub.: pub.)
T. araraticum					
Iraq:					
Sulaymaniya	8	—	4(13)	—	4(12:39)
Koi-Senjaq	3	3(9)	—	—	—
Rowanduz	10	2(6)	2(6)	—	6(10:14)
Amadiya	5	—	3(9)	—	2(3:11)
Turkey:					
Savur	1	—	1(3)	—	—
Silvan	1	—	1(5)	—	—
Hozat	1	—	1(3)	—	—
Iran:					
Karand	2	—	2(5)	—	—
Total	31	5(15)	14(44)	0	12(25:64)
T. dicoccoides					
Iraq:					
Sulaymaniya	1	—	—	1(3)	—
Rowanduz	1	—	—	1(3)	—
Amadiya	1	—	—	1(2)	—
Sinjar	1	—	—	1(7)	—
Turkey:					
Silvan	1	—	—	1(2)	—
Ergani	1	—	—	1(2)	—
Iran:					
Ravansir	1	—	—	1(3)	—
Total	7	0	0	7(22)	0

F. N. Numbers in parentheses indicate strains.

found and completely glabrous strains were not collected. The distribution of heavy pubescent type was limited in Iraq. Also, among 26 localities in Iraq, five were pure heavy pubescent populations, nine were pure pubescent populations and the rest mixed. While, all *dicoccoides* strains were only glabrous type.

Accordingly, it is easy to make a clearcut classification between *T. dicoccoides* and *T. araraticum* based on leaf pubescence. The pubescent type is probably dominant over glabrous type. In the F_1 hybrids between both species, the pubescence of *T. araraticum* was dominant, but the gene analysis of this character was difficult, because these F_1 hybrids show complete seed sterility.

2. Glume pubescence: In all wild tetraploid wheats, both pubescent and glabrous types were found, pubescent being dominant over glabrous. The distribution of this character is given in Table 2.

Table 2. Frequency of pubescent and glabrous populations in glume pubescence of *T. araraticum* and *T. dicoccoides*

Region	Localities	Pubescent populations	Glabrous populations	Mixed populations (pubescent: glabrous)
T. araraticum				
Iraq:				
Sulaymaniya	8	—	2(3)	6(40:21)
Koi-Senjaq	3	1(3)	—	2(2: 4)
Rowanduz	10	4(10)	—	6(15:11)
Amadiya	5	3(11)	—	2(10: 2)
Turkey:				
Savur	1	1(3)	—	—
Silvan	1	—	—	1(4: 1)
Hozat	1	1(3)	—	—
Iran:				
Karand	2	2(5)	—	—
Total	31	12(35)	2(3)	17(71:39)
T. dicoccoides				
Iraq:				
Sulaymaniya	1	—	1(3)	—
Rowanduz	1	1(3)	—	—
Amadiya	1	1(2)	—	—
Sinjar	1	—	1(7)	—
Turkey:				
Silvan	1	1(2)	—	—
Ergani	1	—	—	1(1: 1)
Iran:				
Ravansir	1	1(3)	—	—
Total	7	4(10)	2(10)	1(1: 1)

F. N. Nubmers in parentheses indicate strains

1) *T. araraticum*: Both pubescent and glabrous types were collected from all regions in Iraq. Among 26 localities, the strains from eight localities were pubescent and the strains from two localities in Sulaymaniya region were glabrous, while both types were collected from the remaining 16 localities in all region of Iraq. In Turkey, only pubescent strains were collected from two regions, namely Savur and Hozat, but both were collected from Silvan region. Also, all strains collected from Iran were pubescent. It is noteworthy that both types occurred by an overwhelming majority in the Zagros Mountains of Iraq and usually pubescent type was more frequently found.

2) *T. dicoccoides*: Both types were not found together in same locality and even in same region, except Ergani region. The pubescent strains were collected from four regions, namely Rowanduz, Amadiya, Silvan and Ravansir. On the contrary, the glabrous strains were collected from two regions, namely Sulaymaniya and Sinjar.

Table 3. Frequency of populations with various ear colors in *T. araraticum* and *T. dicoccoides*

Region	Localities	Number of populations: yellow	brown	black	mixed (ye.: br.: bl.)
T. araraticum					
Iraq:					
Sulaymaniya	8	1(2)	1(1)	—	6(10:25:26)
Koi-Senjaq	3	—	—	1(3)	2(2: 2: 2)
Rowanduz	10	4(11)	1(3)	—	5(6:10: 6)
Amadiya	5	—	—	—	5(6: 5: 2)
Turkey:					
Savur	1	—	—	—	1(1: 2: 0)
Silvan	1	—	1(5)	—	—
Hozat	1	—	—	—	1(1: 2: 0)
Iran:					
Karand	2	—	1(2)	—	1(1: 0: 2)
Total	31	5(13)	4(11)	1(3)	21(27:56:38)
T. dicoccoides					
Iraq:					
Sulaymaniya	1	1(3)	—	—	—
Rowanduz	1	—	—	1(3)	—
Amadiya	1	—	1(2)	—	—
Sinjar	1	1(7)	—	—	—
Turkey:					
Silvan	1	1(2)	—	—	—
Ergani	1	1(2)	—	—	—
Iran:					
Ravansir	1	1(3)	—	—	—
Total	7	5(17)	1(2)	1(3)	0

F. N. Numbers in parentheses indicate strains.

3. Ear color: Variation in ear color was observed as given in Table 3.

1) *T. araraticum*: Mixed populations, namely yellow-brown-black, yellow-brown or yellow-black, were found in all regions except for Silvan region. Also, ten populations were single ear color, but 21 populations were mixed colors.

2) *T. dicoccoides*: Almost all regions had yellow ear population, but Rowanduz and Amadiya regions had black and brown ear population, respectively. Mixed color populations of *dicoccoides* were not found. It is noteworthy that all *dicoccoides* strains collected showed homogeneous ear color type.

4. Heading date: Heading date of strains observed in Kyoto condition is given in Table 4. They were roughly classified into three types, early, intermediate and late.

1) *T. araraticum*: There was a marked tendency of early heading in the strains from Sulaymaniya region, while late types were found more in the strains from Rowanduz and Amadiya

Table 4. Frequency of strains with various heading dates in *T. araraticum* and *T. dicoccoides*

Region	Strains	Heading date observed in Kyoto 1972					
		−30/IV	−5/V	−10/V	−15/V	−20/V	−25/V
T. araraticum							
Iraq:							
Sulaymaniya	64	4	37	15	8		
Koi-Senjaq	9		5	1	3		
Rowanduz	36			10	18	8	
Amadiya	23		1	3	9	9	1
Turkey:							
Savur	3					3	
Silvan	5		1	3	1		
Hozat	3					1	2
Iran:							
Karand	5			4	1		
Total	148	4	44	36	40	21	3
T. dicoccoides							
Iraq:							
Sulaymaniya	3				3		
Rowanduz	3				3		
Amadiya	2				2		
Sinjar	7		3	4			
Turkey:							
Silvan	2				2		
Ergani	2					2	
Iran:							
Ravansir	3		3				
Total	22		6	4	10	2	

regions.

2) *T. dicoccoides*: Early types were found in the strains from Sinjar and Ravansir regions, while late types were found in the strains from the remaining regions of Iraq and Turkey.

There was a marked tendency of early heading in the materials of the wild tetraploid wheats from the highly dry and higher temperature regions or in the southern regions, namely Sulaymaniya, Sinjar and Ravansir. While, the late types were found among plants growing in moderately dry and lower temperature or in the northern regions, namely Rowanduz, Amadiya, Savur, Ergani and Hozat. However, *T. dicoccoides* strains collected from Sulaymaniya region showed the late type, while *T. araraticum* strains collected from the same region showed the early type.

Discussion and Conclusion

Morphological differences in the shape of upper margin of empty glume and ear size between

Table 5. Comparison between *T. araraticum* and *T. dicoccoides* strains collected from four mixed stands with regard to frequency of some characters

Region and localities	Species[1]	Strains	Leaf[2]		Glume[2]		Ear color[3]		
			pu	gl	pu	gl	ye	br	bl
Sulaymaniya:	ara	6	6	0	5	1	1	4	1
13.2 km S from Sulaymaniya to Qara Dagh	dic	3	0	3	0	3	3	0	0
Rowanduz:	ara	1	1	0	1	0	1	0	0
Suburbs of Rowanduz	dic	3	0	3	3	0	0	0	3
Amadiya:	ara	5	5	0	5	0	2	3	0
15.3 km ENE from Dohuk to Amadiya	dic	2	0	2	2	0	0	2	0
Silvan:	ara	5	5	0	4	1	0	5	0
17.3 km E from Silvan to Bitlis	dic	2	0	2	2	0	2	0	0

1) ara=*T. araraticum*, dic=*T. dicoccoides*.
2) pu=pubescent, gl=glabrous.
3) ye=yellow, br=braown, bl=black.

Palestinian *dicoccoides* and Transcaucasian ***araraticum*** are clear. On the contrary, these differences between both species in the Zagros Mountains were always not clear showing wide and continuous variations of those characters. However, as shown in Table 1, the leaf surface of the *dicoccoides* strains was exclusively glabrous, while that of the *araraticum* strains was pubescent. All *dicoccoides* strains collected from Palestine were glabrous, but all *araraticum* strains from Transcaucasus were pubescent. Accordingly, it is used as a key character to distinguish *T. dicoccoides* from *T. araraticum*.

The comparison of frequency in three morphological characters between both species from four mixed stands is given in Table 5. As shown in this table, in four mixed populations, variation pattern of the morphological characters of each species showed almostly independent with each other. Therefore, it can be said that there is no possible introgressive hybridization between both species in the modern time.

Also, almost all of the morphological and physiological vatiations of the wild tetraploid wheats, especially of *T. araraticum*, have concentrated in the Sulaymaniya, Rowanduz and Amadiya regions. It is concluded that the Zagros Mountains, especially districts covering the Sulaymaniya, Rowanduz and Amadiya regions, are diversity center of the wild tetraploid wheats.

Literature Cited

Tanaka, M. and H. Ishii, 1973 Cytogenetical evidence on the speciation of wild tetraploid wheats collected in Iraq, Turkey and Iran. Proc. 4th Int. Wheat Genet. Symp. 115–121.