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ON ACCESSORY CHROMOSOMES IN SECALE CEREALE

I. Frequency and geographical distribution of plants with accessory chromosomes in Korea.

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韓國產 호밀의 附屬染色體의 出現頻度와 地理的分布

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ABSTRACT

Cytological observations were carried out to investigate the frequencies and geographical distribution of accessory chromosomes in rye in Korea.

(1) All the 41 strains of rye investigated were found to have accessory chromosomes and the frequencies of accessories are ranged from 2 to 73.3%.

(2) The frequency ranging from 30 to 40% was predominant and it included 13 different strains.

(3) The edaphic factor seemed to play more marked role than the climatic factor in determining geographical distribution of accessories in rye in Korea.

(4) Breakages of A-chromosomes into two fragments were observed in 11 plants. This phenomenon may throw some light on possible origin of accessory chromosomes in rye.

INTRODUCTION

An increasing number of plant species are found to have accessory or B-chromosomes in addition to normal complement of A-chromosomes.

They appear to be, for given population, in equilibrium between plants with and without accessory chromosomes: For example, the frequency of accessory chromosomes in population of rye from Europe is very low while in Transbaikal 28.2%, in Korea 91.5% of the plants in some strain contain accessory chromosomes (Müntzing 1954, 1957).

Furthermore, Oinuma(1952) reported that some strain of rye from Korea contained almost 100% of accessory chromosomes.

This report deals with the frequency and geographical distribution of plants with accessory chromosomes in Korean varieties.

MATERIALS AND METHODS

Seeds of rye belonging to 39 strains were collected from various regions in Korea in 1962 and 1963. Parts of these seeds randomly sampled were sown in the experimental garden in the autumn of 1962 and in the April of 1964 after cold treatment in 3°C for 5 weeks.

Spikes in the garden were fixed in acetic alcohol(1 : 3) with a trace of ferric chloride for a week and then stored in 70% alcohol before staining by the acetocarmine method for P.M.C. In addition, spikes belonging two strains of rye were fixed directly from rye fields.

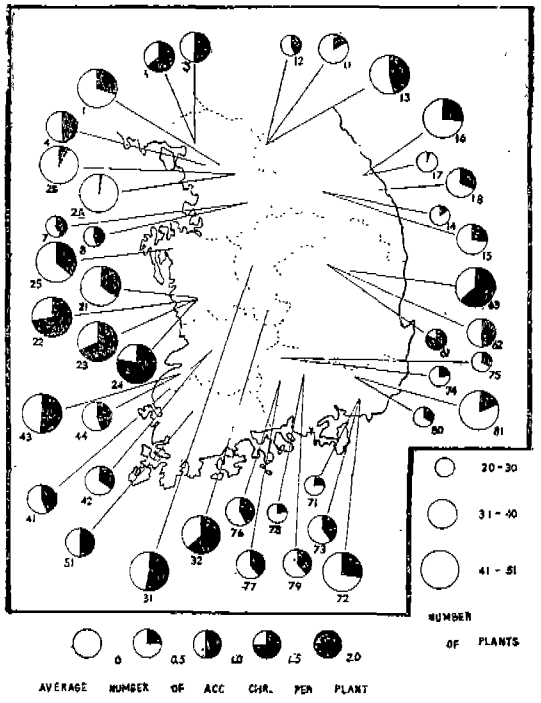
RESULTS

Number of chromosomes were identified in the stage of diplotene, diakinesis and metaphase I in P.M.C.(fig. 1-6). Majority of accessory chromosomes observed were standard type except larger accessories found in two plants.

As can be seen in Table 1, all 42 samples derived from 41 strains contain accessory chromosomes and the frequencies ranged from 2 to 73.3%.

Map 1 shows the geographical distribution of plants of rye with accessory chromosomes in Korea.

Since the province can be considered as fairly good natural unit attempt has been made to find difference in distribution of accessories in each province. Although a number of strains investigated were not adequate and dissimilar in each province, there seemed to exist the difference in frequency of accessories in each province. In the provinces of Kangwon-do and Kyungsang Nam-do the frequencies of accessories were found to be lower than those found in the provinces of Chungchong Nam-do, Chungchong Puk-do and Kyungsang Puk-do.



Map 1 Geographical distribution of plants of rye with accessory chromosomes in Korea.

As may be seen in Table 2, it is evident that the frequency ranging from 30 to 40% is predominant and this is manifested in 13 different strains.

Table 3 shows a number of plants with and without accessories in total 1526 individuals so far investigated. Out of 578 plants with accessories 504 plants (85.5%) were found to have two accessories.

In 11 plants, 6 without accessory, 3 with 2 accessories and 2 with 4 accessories, a pair of A-chromosome was found to break into two fragments at the point of centromere occurring at the stage of diplotene or early diakinesis (Fig. 7 and 8). The frequency of P.M.C. having such chromosome fragments are different in different individuals. In most plants occurrence of such fragmentation is very low, however, in 2 plants from strain No. 51 as much as 40-50% of P. M.C. were found to contain chromosome fragments. Furthermore, in one plant belonging to strain No. 48 nearly all P.M.C. appeared to have chromosome fragmentation.

Table 1. Occurrence of accessory chromosomes in 41 strains of rye in Korea.

Strain unmber	Place of origin		n	Number of acc. chr.					Percentage of plants with acc. chr.(%)	Average number of acc. chr. per plant.
	Province	Place		0	1	2	3	4		
1	Seoul city	Sinnae-dong.	50	35	0	15	0	0	30.0	0.60
2—a	Kyunggi-do	Paldang.	50	49	0	1	0	0	2.0*	0.04
2—b	〃	Paldang.	50	46	0	4	0	0	8.0	0.16
4	〃	Pyukje-myun, Koyang-gun.	36	20	1	13	0	2	44.4	0.97
5	〃	Chori-myun No. 1, Paju-gun.	31	15	0	16	0	0	51.6	1.03
6	〃	Chori-myun No. 2, Paju-gun.	34	13	0	20	0	1	61.8**	1.29
7	〃	Pubal-myun, Ichon-gun.	20	12	1	6	0	1	40.0	0.85
8	〃	Hobob-myun, Ichon-gun.	26	15	0	11	0	0	42.3	0.85
11	Kangwon-do	Su-myun No.1 Chunsung-gun.	38	32	0	6	0	0	15.8	0.32

12	〃	Su-myun No.2, Chunsung-gun.	25	15	0	9	0	1	40.0	0.88
13	〃	Su-myun No.3 Chunsung-gun.	42	25	1	13	0	3	40.5**	0.93
14	〃	Daehwa-myun, Pyungchang-gun.	21	18	0	3	0	0	14.2	0.29
15	〃	Pangrim-myun, Pyungchang-gun.	37	27	0	10	0	0	27.0	0.54
16	〃	Okgye-myun, Myungju-gun.	42	29	3	10	0	0	31.0	0.55
17	〃	Sonsang-myun, Myungju-gun.	21	20	0	1	0	0	4.8*	0.10
18	〃	Samchog-gun.	38	27	1	8	0	2	28.9	0.63
21	Chungchong Namdo	Puyo No. 1	42	27	3	11	1	0	35.7	0.67
22	〃	Puyo No. 2	47	18	0	24	0	5	61.7	1.45
23	〃	Puyo No. 3	44	19	0	20	0	5	56.8	1.36
24	〃	Puyo No. 4	43	14	0	24	1	4	67.4**	1.56
25	〃	Umam-myun, Sosan-gun.	42	28	0	13	0	1	33.3*	0.71
31	Chungchong Pukdo	Puki-myun, Chongwon-gun.	47	22	2	22	0	1	53.2	1.06
32	〃	Hwanggum-myun, Yongdong-gun.	45	22	0	18	0	5	51.1	1.24
41	Cholla Pukdo	Chonju No. 1	34	20	0	13	0	1	41.2	0.88
42	〃	Chonju No. 2	40	26	0	14	0	0	35.0*	0.70
43	〃	Asan-myun, Kochang-gun.	48	23	3	21	0	1	52.1**	1.02
44	〃	Kosu-myun, Kochang-gun.	31	19	0	10	0	2	38.7	0.90
51	Cholla Namdo	Imgok-myun, Kwangsan-gun.	36	20	0	14	0	2	44.4	1.00
61	Kyungsang Pukdo	Yechon	30	8	4	14	0	4	73.3**	1.60
62	〃	Yongmun-myun, Yechon-gun.	34	17	1	16	0	0	50.0**	0.97
63	〃	Pukhu-myun, Andong-gun.	47	19	1	25	0	2	59.6	1.26
71	Kyungsang Namdo	Daechun-myun, Kimhae-gun.	27	21	1	4	0	1	22.2	0.48
72	〃	Chinyong No.1 Kimhae-gun.	41	31	0	9	0	1	23.9	0.54
73	〃	Chinyong No.2 Kimhae-gun.	36	22	0	14	0	0	38.9	0.78
74	〃	Kochang No.1	20	16	0	3	1	0	20.0	0.45
75	〃	Kochang No.2	26	18	0	7	1	0	30.8	0.65
76	〃	Sanchun-myun No.1 Sanchun-gun	31	18	0	13	0	0	41.9**	0.84
77	〃	Sanchung-myun No.2 Sanchong-gun	39	24	1	13	0	1	38.5	0.79
78	〃	Hapchon-myun No.1 Hapchon-gun.	24	19	0	5	0	0	20.8	0.42
79	〃	Hapchon-myun No.2 Hapchon-gun.	33	20	0	13	0	0	39.4	0.79
80	〃	Sangnam-myun, No.1 Miryang-gun.	27	18	0	9	0	0	33.3	0.67
81	〃	Sangnam-myun, No.2 Miryang-gun.	51	41	1	9	0	0	19.6*	0.37

1. Materials for Strain No. 2-a(in 1962) and No. 2-b(in 1963) were collected from same rye field.
2. Highest(**) and lowest(*) frequency of accessories in each Province are indicated.

Table 2. Number of accessory chromosomes in 1526 plants of rye.

	Number of acc. chr.					Total
	0	1	2	3	4	
Number of plants	948	24	504	4	46	1526

Table 3. The frequency of accessory chromosomes in 41 strains of rye.

Percentage of plants with acc. chr.	2	10	20	30	40	50	60	70	80
Number of strains	2	3	6	13	6	7	3	1	

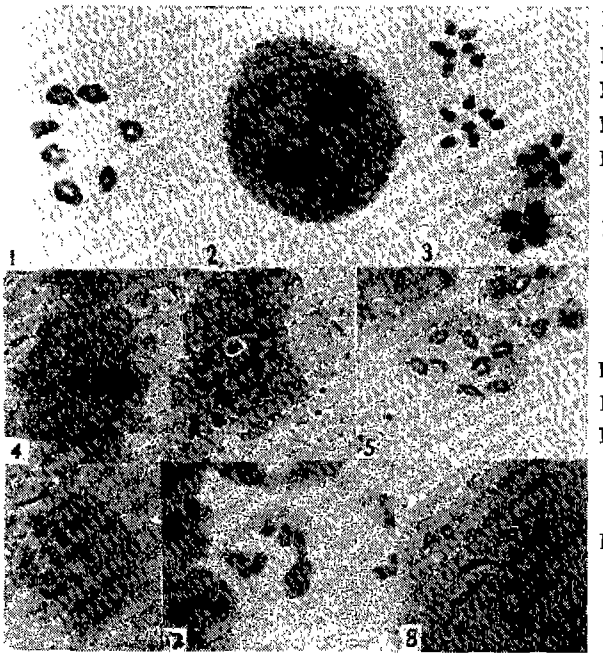


Fig. 1-8. Meiosis in P.M.C. of rye.
Fig. 1-3. Meiosis in plants having 14 A-chromosomes.
Fig. 1. Diakinesis. X 1700.
Fig. 2. Metaphase I. X 1450.
Fig. 3. Anaphase I. X 1000.
Fig. 4-6. Meiosis in plants having various number of accessory chromosomes in addition to 14-A-chromosomes.
Fig. 4. 2n=14+1 acc. chr. Left: Metaphase I. Right: Anaphase I. Two small chromatids of accessory chromosome due to early separation are found in Anaphase I. X 800.
Fig. 5. Diakinesis in 2n=14+2 acc. chr. X 850.
Fig. 6. Early diakinesis in 2n=14+4 acc.chr. X 800.
Fig. 7. Diakinesis in 14 A-chromosomes. A bivalent of A-chromosome has been broken into two fragments. X 1050.
Fig. 8. Diplotene in 2n=14+4 acc. chr. Two fragment of A-chromosome are found in addition to two pairs of accessory chromosomes.

DISCUSSION

The history of cultivation of rye in Korea has not been fully understood. According to the most reliable record German breeder introduced rye to Rangok Meadow where cultivation of rye was commenced for the first time about fourty years ago. Also another strains of rye might be introduced from other foregin country later. Since frequency of accessories in rye in foregin country are known to be not so high as Korea it may be assumed that environment of Korea might play an important role to increase the accessories and to keep in equilibrium at such high frequency.

It has been suggested that climatic and edaphic factors may be important in relation to geographical distribution of accessories. Fröst(1958) reported that the geographical distribution of accessories in *Centaurea scabiosa* largely coincides with a difference in humidity, the frequency of accessory chromosomes being higher in arid regions.

In *Festuca pratensis* Bosemark(1956) found a marked positive correation between a number of accessory chromosomes and clay contents of the soil.

Attempt has been made to find the correlation between frequency of accessory in rye and climatic factors such as annual precipitation, annual mean temperature and annual mean humidity according to The Climatic Atlas of Korea (1962). It is, however, evident that no particular correlation exists between the frequency of accessories and climatic factors.

Furthermore, when two or more localities in adjacent area were compared marked differences in the frequency of accessories occurred in some regions: For instance, Strain No. 1, and No. 2; No. 11, and No. 12; No. 21, No. 22, 23, and 24; No. 72, and No. 73; and No. 78, and No. 76. Since rye fields where comparisons were made are so closely located each other that they seem to be exposed at almost same climatic conditions. Thus occurrence of difference in frequency of accessories may suggest that edaphic factors are more important than climatic factors for geographical distribution of accessories.

Very high frequencies of accessories were found in Yechon, Province of Kyungsang Puk-do and Puyo, Province of Chungchong Nam-do. A strain from Yechon showed the highest frequency of accessories(73.3%) in this investigation. Also, out of 4 strrains from Puyo three strains showed considerably high frequency of accessories ranging from 56 to 67%. This data for Puyo coincide with Müntzing's report(1957) in which he reported that the frequency of accessories in rye from Puyo (referred as Booyou in his report) was as high as 91.5%. It may be interesting to undertake further investigation to find the correlation between frequency of accessories and environmental factors in these areas.

On the other hand, rye in Paldang, Province of Kyunggi-do showed lowest frequency of accessories in Korea: Only 2% in 1953 and 8% in 1954. Rye field in Paldang is so closely located by the Han River that it is usually submerged in water during the rainy season of summer.

In 1965, an attempt has been made to investigate the relationship between the frequency of accessory chromosomes and soil components such as water content, pH, N, P, K, Mg and Ca in several adjacent localities in Paldang and other localities near Seoul. Interesting results found in this study will be published later on.

Since rye is not primary important cereal in Korea, no attention has been given to the breeding of rye. Consequently, many farmers have been cultivated their strain of rye unchaged such a long time, even 20 years. In such circumstances frequency of accessories in rye seems to reach the equilibrium state in the given strains. Therefore, it may be interesting problem in the ecological genetics to study the relationship between the frequency of accessories and the environmental factors.

Darlington(1956) stated that the accessories may represent centric fragments or telocentric arms of A-chromosomes produced by misdivision. Also several other workers believe that B-chromosomes may be arisen by fragmentation of A-chromosomes.

In *Oenothera hookeri* some populations contain two extra diminutive chromosomes, and Cleland(1951) suggest that they may have derived from a process of fragmentation.

In *Caltha palustris* certain small A-chromosomes undergo misdivision and produce two telocentric smaller chromosomes which look and behave like the ordinary B-chromosomes occurring in this species (Rees 1954).

According to Müntzing(1963), however, the accessory chromosomes in rye show no homology to the other chromosomes of the complement. Furthermore, Müntzing(1958) stated that origin of accessories in rye must be quite old since standard accessory chromosome in rye has same appearence in widely different population of the world.

The occurrence of chromosome fragmentation observed in present study may throw some light on the origin of accessory chromosomes in rye. It is desirable to carry out crosses between plant without accessory having fragments of A-chromosomes and normal plant without accessory, and trace the configuration and behavior of chromosomes in the following generations.

Our sincere thanks go to Professor P.T. Thomas, University College of Wales for his encouragement to undertake

the work on accessory chromosomes in rye. Also we wish to express our gratitudes to Professor Müntzing for his kind advice during the work.

We are greatly indebted to the local officials, teachers in provincial high schools, students in our Department and many farmers who kindly helped us to collect seeds of rye for this study.

摘 要

(1) 1962年서부터 韓國産 호밀의 附屬染色體의 頻度와 地理的 分布에 대해서 硏究하기 위하여 1526個體의 染色體 觀察을 하였다.

(2) 表1에서 보는 바와 같이 모든 41系統의 호밀에서 附屬染色體가 觀察되었으며 그 頻度는 最低 2%, 最高 73.3%였었다.

(3) 表2와 같이 各系統의 附屬染色體의 頻度中 30~40%가 가장 많았으며, 13系統이 이에 소속된다.

(4) 附屬染色體의 地理的 分布에 대하여 氣候要素보다 土壤要素가 더 많은 영향을 주는 것 같이 생각된다.

(5) 11個體의 植物에서 A 染色體가 centromere에서 切斷되어 두개의 染色體 切片으로 되는 것을 觀察하였다. 이 現象은 호밀의 B 染色體의 起源을 說明하는데 도움이 될 것이다.

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