

Morphological features of polyploidy populations of *Astragalus adsurgens* PALL. collected from the Loess Plateau in China and Hokkaido in Japan.

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Abstract

Morphological features of polyploidy populations and their hybrids of *Astragalus adsurgens* PALL. were studied. Plants were grown in an experimental field in 1993 and an unheated glasshouse in 1994 at Obihiro University.

The cultivated populations showed significantly higher values in plant height, stem diameter and DM weight per stem than the wild populations. Leaflet numbers per leaf were 13 to 15 in the wild populations from China, but 20 to 23 in others. There was no significant difference between the wild populations of diploid and tetraploid in inflorescence length. Inflorescence length of diploid and tetraploid was significantly lower than that of hybrids. Pentaploid showed significantly higher values in floret length, standard width, wing length, leaflet length and pollen grain volume.

With respect to the wild populations of diploid from China and tetraploid from Japan, it is reasonable that they are considered the same species taxonomically, although further studies are needed.

Key words : *Astragalus adsurgens*, Loess Plateau, morphology, polyploid.

Introduction

Astragalus adsurgens PALL., perennial and leguminous forage crop, is distributed in Japan, China, Siberia in Russia and North America (Ohwi, 1978; Okuyama, 1966). Two types of *A. adsurgens* have been found in China; the cultivated type with an erect growth

form and the creeping wild type. These are taxonomically considered the same species, but generally considered as different ecotypes.

Fu *et al.* (1982) pointed out that karyotypes of the cultivated types were partially different from those of the wild types in China. The chromosome number is $2n=2x=16$ in the wild and cultivated types of China (Fu *et al.*, 1982)

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and $2n=4x=32$ in the wild type of Japan (Sakai, 1935).

The wild populations naturally grow in high mountainous zones at an altitude of about 2000 m in the Loess Plateau in China and in restricted sites of calcareous rock in Japan. The cultivated populations are widely used as an important forage legume in the semi-arid regions in China (Li, 1987), because of its high tolerance to dry and cold stress (Hongo *et al.*, 1992). However, there still remains the undesirable agronomic characteristics in this population such as woody stems and poor palatability (Ma, 1986). On the contrary, the wild populations have useful features of leafiness and fine stems (Liu, 1990). In order to improve the cultivated populations, it may be desirable to use the wild populations as an important gene source for the development of new varieties in the future.

In the course of genetical studies of *A. adsurgens*, artificial populations of triploid and pentaploid have been obtained (Kita *et al.*, 1995). In this study, morphology of these polyploidy populations and their hybrids were studied.

Table 1. Eight populations of *A. adsurgens* used in this study

Population	Type	Collected place	Growth form	Ploidy
A. Yunwu M.	wild	China	creeping	2x
B. Wutai M.	wild	China	creeping	2x
C. Kefuxi	cultivated	China	erect	2x
D. Shadawang	cultivated	China	erect	2x
E. Oshima I.	wild	Japan	creeping	4x
F. Oobira M.	wild	Japan	creeping	4x
G. Hybrid*	-	-	-	3x
H. Hybrid*	-	-	-	5x

* ; Hybrids were obtained from cross pollination between A and E populations.

Materials and method

Eight populations were used (Table 1). Two

wild populations (Yunwu Mountain and Wutai Mountain) and two cultivated populations ('Kefuxi' and 'Shadawang') are the same as the previous report (Kita *et al.*, 1994). The two wild populations were collected at Oshima Island and Oobira Mountain in Hokkaido, northern Japan in 1992. Plants of these populations were grown in an experimental field at Obihiro University in 1993. The measurements of morphological features were recorded.

By reciprocal cross pollination between diploid populations of Yunwu Mountain and tetraploid populations of Oshima Island, triploid and pentaploid hybrids were obtained in 1993 (Kita *et al.*, 1995). The seeds of these hybrids and their parents were sown in 1994. Plants were grown in polyethylene pots with 22-cm diameter in an unheated glasshouse at Obihiro University. The measurements of morphological features were recorded.

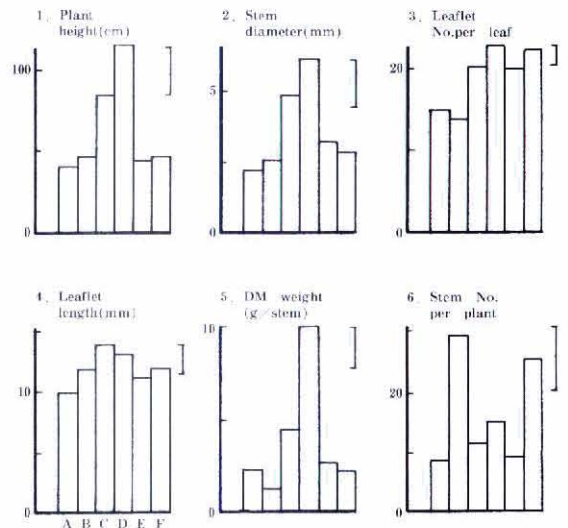


Fig. 1. Morphological features of vegetative organs in *A. adsurgens* populations.

A ; Yunwu M., B;Wutai M.,
C ; 'Kefuxi', D;'Shadawang',
E ; Oshima I., F;Oobira M.

];LSD at $p=0.01$.

Results

Morphology of vegetative organs

Morphological features of six populations grown in the field were measured in 1993. The cultivated populations ('Shadawang' and 'Kefuxi', which is an early-maturing variety of 'Shadawang') showed significantly higher values in plant height, stem diameter and DM weight per stem (Fig. 1). These differences were mostly due to its large and erect growth form. Plant height of 'Shadawang' was 115 cm, compared with that of 39 to 46 cm in the wild populations. Leaflet numbers per leaf were 13 to 15 in the wild populations from China, but 20 to 23 in the others. All populations showed almost the same values in leaflet length, compared with variable values in stem numbers per plant.

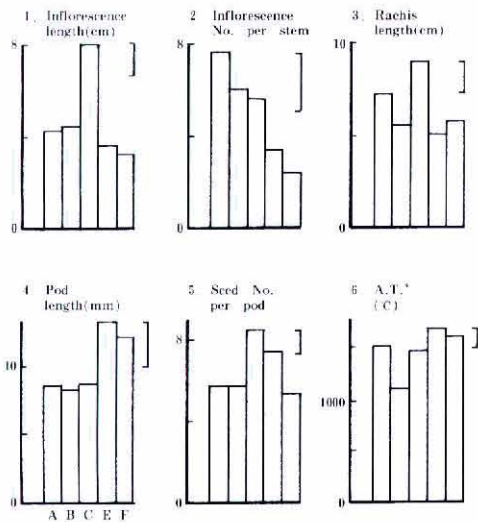


Fig. 2. Morphological features of inflorescence in *A. adsurgens* populations.

A-F; The same populations as in Fig. 1.

*A.T.; Accumulated temperature above 5 °C until flowering.

] ; LSD at $p=0.01$.

Morphology of inflorescence

Morphological features of inflorescence are shown in Fig. 2 for the five populations, except 'Shadawang', which failed to flower. The cultivated population ('Kefuxi') showed significantly higher values in inflorescence length (Fig. 2). There was no significant difference between the wild types of diploid and tetraploid in inflorescence length. Inflorescence numbers per stem were significantly higher in diploid than in tetraploid. The reverse trend was observed in pod length. Seed numbers per pod were 8.4 in 'Kefuxi', compared with that of 5.4 to 7.4 in the wild populations. Accumulated temperatures above 5 °C toward flowering were 1500 to 1700 °C in all populations, except Wutai Mountain population.

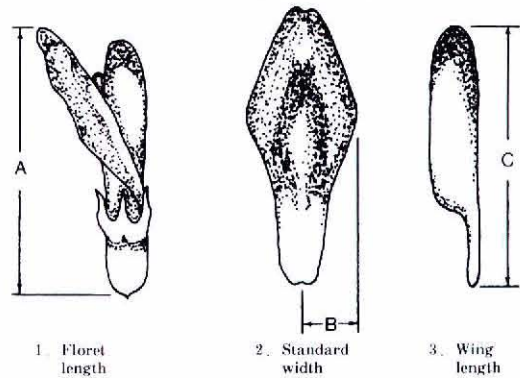


Fig. 3. Measuring sites of floret and petal of *A. adsurgens*.

Morphology of floret and petal

Morphological features of four ploidy populations including 3x and 5x hybrids grown in an unheated glasshouse were measured in 1994. Measuring sites of florets and petals are shown in Fig. 3 and those for a series of ploidy populations in Fig. 4. Inflorescence length of diploid and tetraploid was significantly lower than that of the hybrids (Fig. 5). Pentaploid showed significantly higher values in floret length, standard width, wing length and leaflet length. Pollen grain volume was 2 to 3 × 10⁻⁶

mm^3 in diploid and triploid, $5 \times 10^{-6} \text{mm}^3$ in tetraploid, and $9 \times 10^{-6} \text{mm}^3$ in pentaploid.

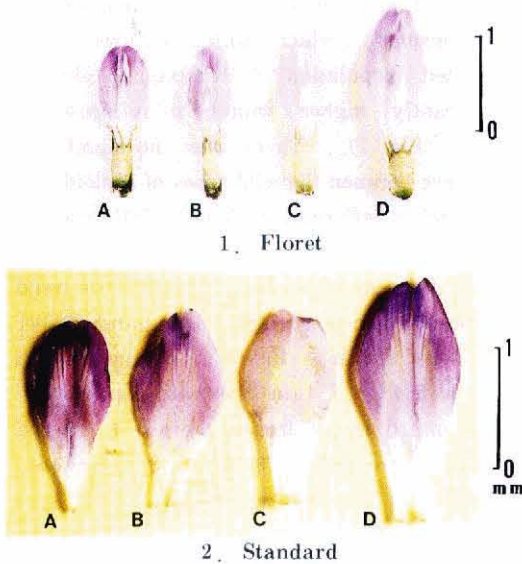


Fig. 4. Floret and standard of *A. adsurgens*.

A;Diploid, B;Triploid.
C;Tetraploid, D;Pentaploid.

Discussion

Fu *et al.* (1982) observed partial differences in the morphology of pollen grains and karyotypes of the cultivated populations from those of the wild populations in China. He had suggested that it might be reasonable to classify the two populations of *A. adsurgens* as two different species. Ohwi (1978) reported that inflorescence length was longer in the wild population from China than those from Japan. Previously, this species had been given the botanical name *A. adsurgens* PALL. subsp. *fujisanensis* Miyabe et Tatewaki in Japan (Okuyama, 1966). However, the present name has been used in publications by Ohwi (1978) and Kitamura and Murata (1961).

With respect to morphological features, there were many significant differences between the cultivated (2x) and wild populations (2x

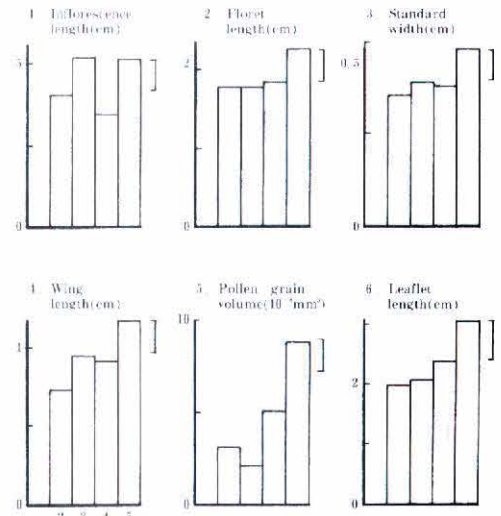


Fig. 5. Morphological features of inflorescence in heteroploidy population of *A. adsurgens*.

2;Diploid (2 X).
3;Triploid (3 X).
4;Tetraploid (4 X).
5;Pentaploid (5 X).
] ;LSD at $p=0.01$.

and 4x) and between hybrids (3x and 5x) and their parents (2x and 4x). There was little difference between the wild populations of diploid from China and tetraploid from Japan. Kita *et al.* (1994) suggested that the wild populations of 4x from Japan might be assumed to be autotetraploid of 2x from China and constructed homologous chromosomes. Therefore, it is reasonable that they are considered the same species taxonomically at present, although further studies are needed.

The wild population is a very important germ plasm source for early maturity, fine stem and improved palatability. At present, the erect cultivated population of *A. adsurgens* is late flowering and rarely reaches maturity to allow natural reseeding. Therefore, it may be invaluable to use the creeping wild types as an important gene source for the development of new varieties in the future. In this case,

attention must be paid to the drought resistance of the wild population of *A. adsurgens* (Hongo *et al.*, 1992).

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References

- Fu, X., Y. Liu & Y. Jia, 1982. Res. Bull. of Inner Mongolian Agr. College, 1 : 47-53 (In Chinese).
- Hongo, A., F. Kita, H. Takahashi, H. Zou, J. Cheng & Z. Zhao, 1992. Res. Bull. of Obihiro Univ. 18 : 41-48.
- Kita, F., A. Hongo, H. Zou, J. Cheng & Z. Zhao, 1994. Euphytica, 72 : 225-230.
- Kita, F., A. Hongo & K. Iwashita, 1995. Euphytica, In contribution.
- Kitamura, S. & G. Murata, 1961. Coloured Illustrations of Herbaceous Plants of Japan, pp. 113-114, Hoikusha, Tokyo (In Japanese).
- Li, J. (ed.), 1987. Herbage Plants in China, Vol. 1, pp. 205-213, Agr. Pub., Peking (In Chinese).
- Liu, J., 1990. M. Sc. thesis of the North Western Inst. Soil and Water Cons., Academia Sinica, 1-90 (In Chinese/English).
- Ma, X., 1986. Memoir of the North Western Inst. Soil and Water Cons., Academia Sinica, 3 : 9-35 (In Chinese/English).
- Ohwi, J., 1978. Flora of Japan, pp. 812-813, Shibundo, Tokyo (In Japanese).
- Okuyama, H., 1966. Colour Illustration of Alpine Flora in Japan, pp. 106-107, Sibundo, Tokyo (In Japanese).
- Sakai, K., 1935. Japan J. Genetics, 11 : 68-73.

中国の黄土高原と北海道から採取した ムラサキモメンズル倍数体の形態の特徴

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摘 要

ムラサキモメンズル倍数体とそれらの雑種の形態の特徴を調査した。植物体を1993年には圃場で、1994年には温室で育成した。

野生集団に比べて、栽培集団の方が、草丈、茎の直径、茎あたりの乾物重はあきらかに高かった。1葉あたりの小葉数は野生集団で13~15枚であったが、それ以外の集団では20~23枚であった。野生集団の2倍体より、それらの雑種の方が長い花序を持っていた。また、花の長さ、旗弁の幅、翼弁の長さ、小葉の長さ、花粉粒の体積において、5倍体の方があきらかに大きい値を示した。

中国の2倍体と日本の4倍体について、同一の種として分類すべきと思われるが、今後さらに研究する必要がある。

キーワード : ムラサキモメンズル, 黄土高原, 形態, 倍数体