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メタデータ	言語: English
	出版者:
	公開日: 2022-06-07
	キーワード (Ja):
	キーワード (En):
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URL	http://hdl.handle.net/20.500.12099/5536

Res. Bull. Fac. Agr. Gifu Univ. (55) : 259—265, 1990.

Genecological Studies on Japanese Lawn Grass (*Zoysia japonica* Steud.) with Special Reference to the Seed Propagation Characteristics

(2) Seed Productivity*

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(Received July 31, 1990)

SUMMARY

In parallel with the previous study, seed productivity was investigated using the same materials described in the previous paper. The number of fertile seeds produced per unit area was estimated by multiplying the number of heading stems, the number of setting seeds per head, and fertility of seeds surveyed. Investigations were carried out in 1985 and 1986.

Significant differences in fertile seed productivity were observed both between and within local populations. Statistically, 40 local populations were classified into four major groups, A-D. Group A, consisting of a Hokkaido population, showed an extremely large number of fertile seeds with about 600 per 100cm^2 on average. In contrast, Group D, consisting of two populations from southernmost Kyushu, produced no seed at all.

Between these extremes, Group B, consisting of five populations of Hokkaido and northernmost Honshu origin, produced 200-300 fertile seeds per 100cm^2 on average. Group C, consisting of 32 residues, derived from a wide range of localities. From these, two further subgroups (high mountain pasture and southern Kyushu) were distinguishable. They produced fertile seeds with 100-170 and below 50 per 100cm^2, respectively.

Considering these groups and subgroups throughout, it can be concluded in general that northern Japan has the most clones with high seed productivity, followed by the clones of the central high mountain regions, whereas southern Japan has many clones with poor seed productivity.

Among three components used for estimation of fertile seed productivity, heading stem density showed a particularly high correlation to the number of fertile seeds produced. Accordingly, this was belived to be the primary component contributing to fertile seed productivity. On the other hand, seed productivity observed in 1985 and 1986 showed a close correlation suggesting a fairly stable genotype -environment interaction in this trait under observation.

INTRODUCTION

In Japanese lawn grass, scaly rhizomes and flat stolons provide the principal means of spreading

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*Contribution from the Institute for Development of Mountain Regions, Faculty of Agriculture, Gifu University, No. 89.

A part of this work was presented at the 42nd Annual Meeting of the Japanese Society of Grassland Science, April 1987.

to form a dense sward in nature[1]. Nevertheless, in the light of reports by Sugawara et al[2]., Iwata[3], and Mitamura et al[4]., propagation by sexual means also play a definite role in establishing or regenerating *Zoysia* sward. Taking this into consideration, seed propagating potential may well have some ecological significance in the persistence of this widespread species.

On the other hand, development of new strains with high seed propagation efficiency is an urgent demand from a practical point of view[5]. Here, basic information concerning seed propagation characteristics may be helpful for this kind of breeding program.

In this series of studies, therefore, the authors emphasized clarification of intraspecific variability in the above-mentioned characteristics. In this regard, there are two major problems with this grass species, fertile-seed productivity and germinability. This paper mainly is concerned with the former problem, and we will report elsewhere concerning the latter one.

MATERIALS AND METHODS

A detailed description of the materials used in this study has been given in the previous paper[6]. In brief, they are about 290 clones which were collected from 40 local populations in 1981. At the time of this study, each clone formed a fairly dense turf in separate plots of 60cm×80cm which had been established in the uniform field of IDMR, Gifu University.

To estimate the number of fertile seeds produced per unit area, heading stems in a 10cm×10cm quadrat were counted with 3 replications, and the number of setting seeds per head was counted for 5 random heads in each plot. Then, the seed fertility percentage was determined by sorting out fertile seeds (grains) from randomly sampled 100-seed lots with 5 replications using 80% ethanol solution. Finally, these components were multiplied. These investigations were carried out from summer to autumn both in 1985 and 1986.

RESULTS

1. Fertile seed productivity

Figure 1 shows the approximate number of fertile seeds produced per unit area of each clone belonging to the different local populations. In this figure, the results from 1985 and 1986 experiments are averaged because of a high positive correlation recognized between them.

It is evident from Fig. 1 that a great variation exists both between and within populations. When the populations are pooled, the number of fertile seeds produced per unit area ranged from about 900 to nil. That of the population averages from about 600 to 10 with the different degree of variations.

Variance analysis using the yearly variance as a replication item, revealed significant differences both between and within populations (Table 1).

According to Turkey's test, populations examined are classified into four major groups, A, B, C, and D. Group A, consisting of just one population (No.8 in Fig. 1), produced an extremely large number of fertile seeds with about 600 per 100cm^2 ranging from about 400 to 900. This population has its origin in southernmost Hokkaido. The other extreme was found in southernmost Kyushu populations (No. 39, 40) which produced no seed at all, though a few stems headed out. These populations were classified as Group D.

Group B consists of five populations (No. 1, 2, 5, 7 and 9) which produced 200-300 fertile seeds with considerable variations between clones. Of these, four (No. 1, 2, 5 and 7) also have a southern Hokkaido origin and an additional one (No. 9) is derived from northernmost Honshu.

Group C contains 32 residues derived from a wide range of habitats. Although these populations fall into the same group statistically, some characteristic tendencies are observable among them.

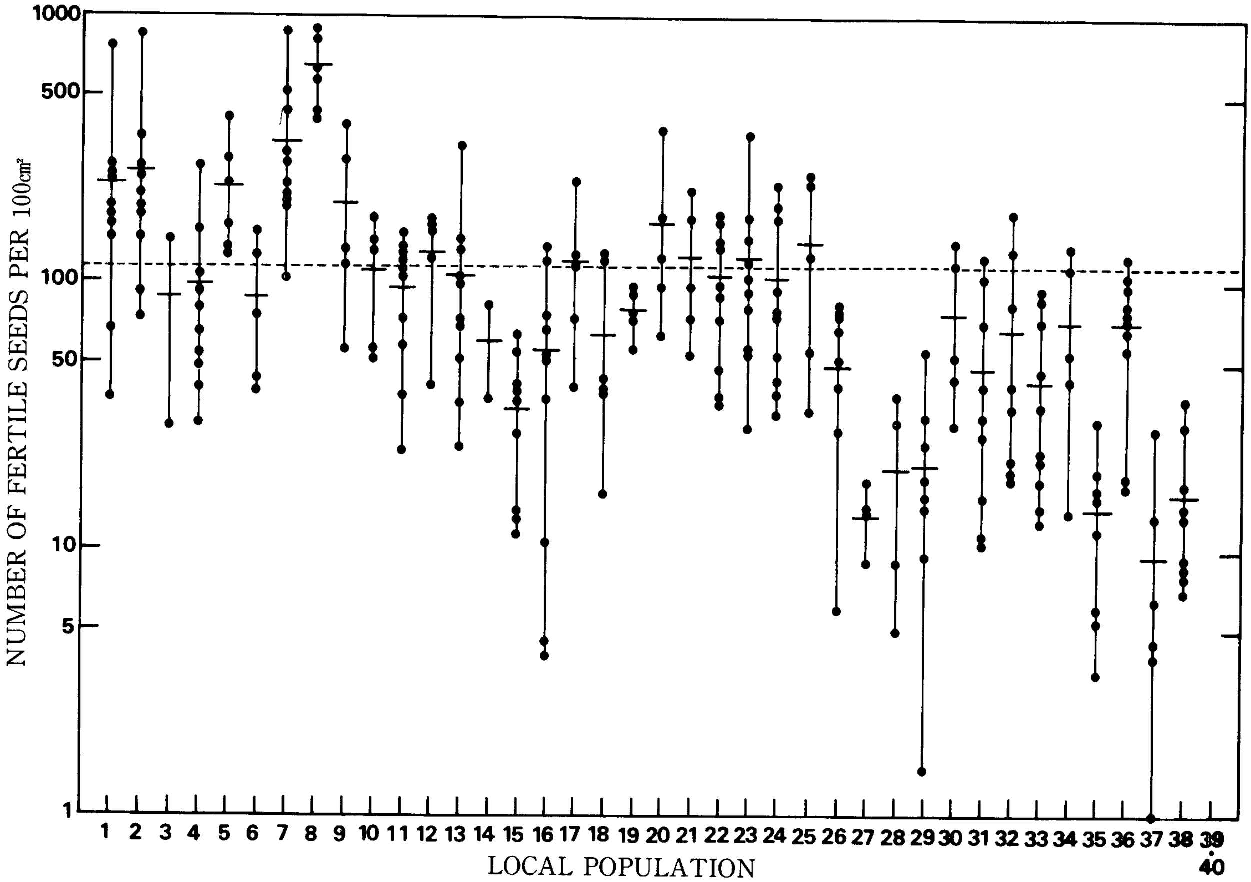

Fig. 1. Variation in the approximate number of fertile seeds observed between and within the local populations at the uniform field of IDMR.
Broken line and horizontal bar indicate an average value for all, excluding No. 39 and 40, populations and for each population, respectively.
Population numbers correspond to those in Table 1 and Fig. 1 in the previous paper[6].

Table 1. Analysis of variance for the mean number of fertile seeds produced in 1985 and 1986.

Source	D.F.	S.S.	M.S.	(F_0)
Between popul.	37	7726461	208823	16.32**
Within popul.	228	2917204	12795	2.34**
Replication	266	1456393	5475	
Total	531			

** Significant at 1% level.
L. S. D. (p : 0.01) for between populations = 156.6
for within population = 102.4

First, all populations originating from the central mountain pastures (No. 20-25) resemble each other both in population means and in variability within it. They produced about 100-170 fertile seeds per 100cm² on average. Interestingly, they roughly correspond to those from northern Honshu (No. 10-13). Second, nine of ten populations producing less than 50 fertile seeds are those from the warm regions of Japan. Thus, four (No. 33, 35, 37 and 38) are southern Kyushu in origin and five (No. 26-29 and 31) came from western Honshu and Shikoku. The only exception is No. 15, which is derived from a rather northern region. All these populations are characterized also by a relatively little variation within them.

Table 2. The number of heading stems, percentage of fertile seeds, and their correlations to the number of fertile seeds produced per unit area (10 cm × 10 cm)

Year	No. of heading stems/100 cm²		Percent fertile seed	
	Mean±S. D. (Range)	r	Mean±S. D. (Range)	r
1985	4.8±4.4 (0.7−25.4)	+0.97**	43.9±13.0 (15.7−64.9)	+0.54**
1986	6.0±5.3 (0.8−30.4)	+0.99**	46.7±12.7 (22.4−67.0)	+0.54**

**Significant at 1% level. n=38 for both years.

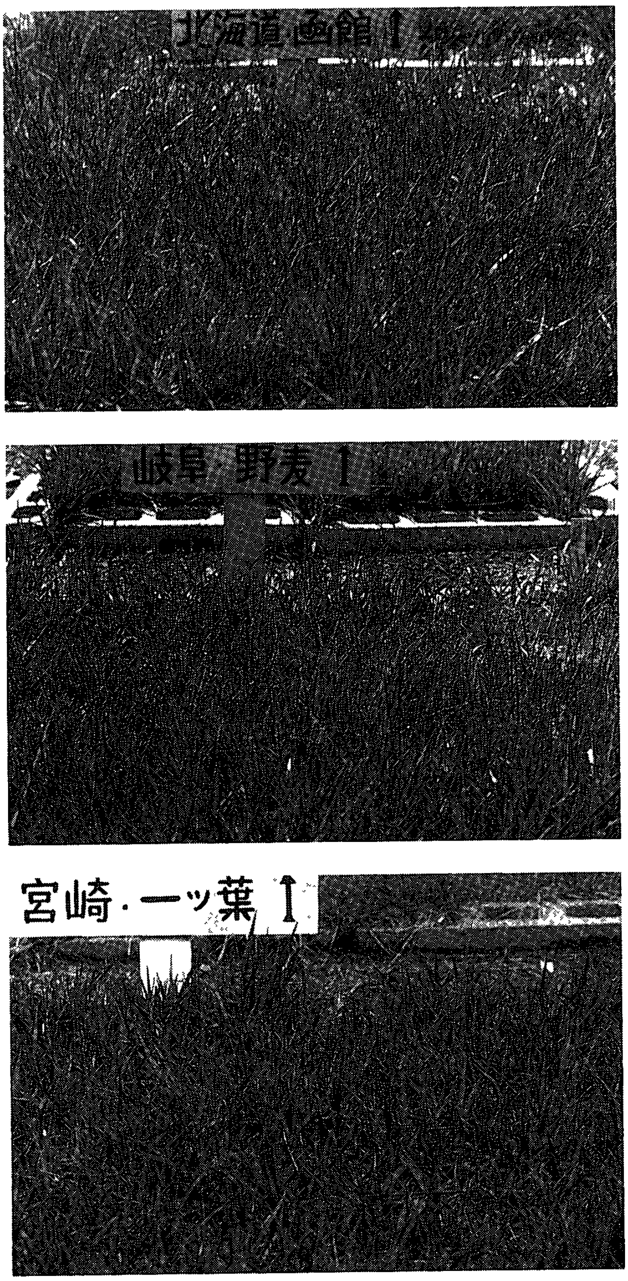

Fig. 2. Photographs showing the heading conditions of some representative clones.
Top : Clone No. 8-4, Middle : Clone No. 22-2, Bottom : Clone No. 35-6.
(Photographs were taken on July 12, 1987)

2. Components contributing to fertile seed productivity

The number of fertile seeds produced per unit area was estimated from the three components described above. Of these, the number of seeds (spikelets) per head was fairly constant throughout populations and years averaging about 40. In contrast, the other two varied greatly both between and within populations. To determine the relative importance of these components for fertile seed production, correlations between each component and the number of fertile seeds produced were calculated on the population level for the respective years. The results are given in Table 2.

As indicated in Table 2, the heading stem number showed a very close correlation to fertile seed number for both years, whereas there was only a rather weak correlation between seed fertility and fertile seed number, albeit significant. Accordingly, the number of heading stems (heading density) is believed to be the primary component contributing to the differences in fertile seed productivity among local populations.

3. Yearly changes in seed productivity

As illustrated in Fig. 3, fertile seed number of 38 populations showed a strong correlation between 1985 and 1986. Clones, regardless of populations, also showed a high correlation of r = +0.79 (n=284) for the two years. Though only two years have been studied so far, the result would indicate that the seed productivity in this species is a characteristic having a fairly stable genotype-environment interaction.

DISCUSSION

In genecological study, the clinal or ecotypic variation within a species is a main interest and not a few evidences have been reported in this regard. For *Zoysia japonica,* Forbes et al[7]., Kitamura[8], Ikeda et al[9,10]., and Yamada et al[11]. reported experimental data suggesting intraspecific differentiation of this species, but these are mainly concerned with vegetative characteristics. With these reports as a background, the authors undertook the present study.

In this study, 40 local populations tested were divided into four major groups (A-D) based on their fertile seed productivity. Further, mountain pasture and southern Kyushu groups were subdivided within a Group C, which contained the largest number of populations. Considering these groups throughout, it can be said in general that the southern Japan has the most clones with high seed productivity, followed by the clones of the central high mountain region, whereas the southern Japan has many clones with low seed productivity. A similar tendency in seed productivity in this species was recognized by Ikada et al[10]. in their own materials.

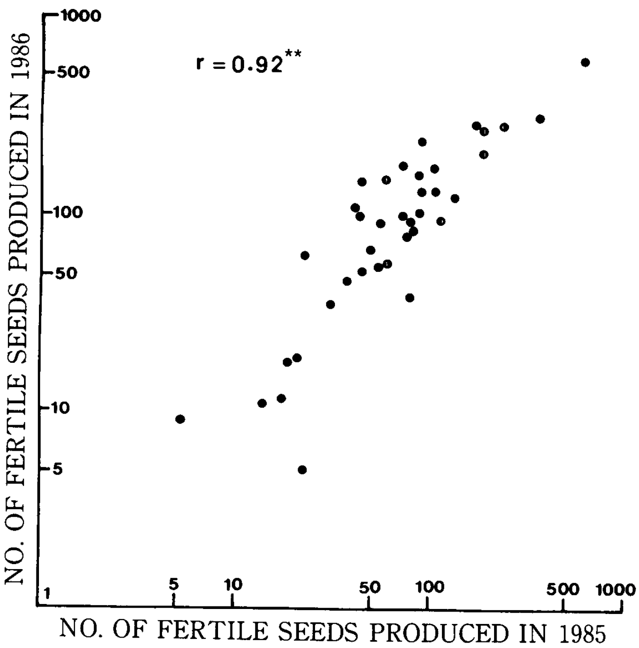

Fig. 3. Correlation between the approximate numbers of fertile seeds of local populations produced in 1985 and those in 1986.

Incidentally, the yearly mean temperature in provenance of the present materials ranges from around 7℃ to 18℃, and this showed negative correlation of $r = -0.56$ to fertile seed productivity of local populations tested. This may suggest that seed productivity of local populations is attributed, at least in part, to the difference in local temperature in which the populations originated. In other words, this may imply that more seeds are allowed to recruit the seed bank of low temperature regions. This was further supported by our seed dormancy study which we intend to publish as a separate report. At the same time, it should be noted here again that the inconsistency observed in some populations within the same group is difficult to explain. It might have resulted from other factors such as the microclimate prevailing for the particular habitat and/or the biotic factor mentioned in the previous paper[6].

From a practical point of view, Yeam Do Yi et al[12]. and Yu Tal Young et al[13]. rendered a great contribution by developing a pretreatment for germination promotion of this species. Concomitantly but independently, one of the present authors[14] also devised a method by which the germination is efficiently regulated. Assuring the application of these pretreatments, only strains with high seed productivity are desirable. Thus, the clones of northern (mainly Hokkaido) origin may have an outstanding value for this purpose. In this connection, however, if a strain combining high seed productivity with easy germinability is required, the breeding program may be accompanied by certain difficulties. We will consider this problem later in our separate report concerning the variability in seed germination.

Finally, it should be emphasized that the results obtained here are from one specific experimental field. To confirm the present data, it is therefore necessary to conduct genecological research at different sites including the original habitats of the present materials. Also, it is important to observe *in situ* heading behavior in as many localities as possible.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to the staffs of IDMR of Gifu University and to Mrs. S. Nishino for assistance in the experimental works.

A part of this work was supported by a Grant-in-Aid from the Ministry of Education, Culture and Science of Japan (No. 60304029).

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シバ (*Zoysia japonica* Steud.) の種子繁殖形質に関する種生態学的研究

(2) 種子生産性

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山地開発研究施設

(1990年7月31日受理)

要　　約

前報と同じ場所で，同じ材料について，1985年と1986年における種子の生産性を調査した。10cm×10cm内の出穂茎数，1穂あたりの着粒数，および稔実歩合を栄養系ごとに調べ，これら3要素を乗じて，単位面積（100cm²）あたりの稔実生産数を推定した。結果は両年度を平均して示した。

稔実生産数についての有意な差が，地方集団間にも集団内にも認められ，地方集団はこの形質に関していくつかの混系を含み，かつ集団としての特異性をもつことが明らかにされた。供試40集団は統計的にA～Dの4群に大別された。A群は北海道の1集団からなり，他とかけ離れて多数の稔実を生産した(約600粒)。対照的にD群は九州南端からの2集団を含み，全く稔実を生産しなかった。

これら両極端の間にあって，B群は北海道からの4集団と本州北端からの1集団からなり，200～300粒の稔実を生産した。C群は広域からの残余の32集団を含み，その中から高海抜放牧地亜群と，南九州亜群が区別でき，前者は100～170粒，後者は50粒以下の稔実生産によって特徴づけられた。

これらの群，亜群全体を通じて考えると，概して，北日本には稔実生産性の高い栄養系を高頻度で含む集団が多く，中部高海抜地がこれに次ぎ，南西日本の集団は稔実生産性の低い栄養系を多く含む傾向が認められる。一方，この傾向に合わない集団の存在も指摘された。

稔実生産の推定に用いた3要素の中で，出穂茎の密度が稔実生産数との間に極めて高い相関を示したことから，この形質が稔実生産性の変異に第一義的に関与すると考えられた。また，1985，1986両年の調査結果の間に高い相関がみられたことから，稔実生産性はかなり安定した遺伝子型―環境の相互作用をもつ形質であることが示唆された。最後に，場所を変えての同様の研究・観察の必要性が強調された。

岐阜大農研報 (55)：259―265，1990.