畑多年性雑草ムラサキカタバミに関する生理生態学的研究：I
鱗茎の形成深度と発芽・発生(農学部附属展場)

Physiological and Ecological Studies on *Oxalis corymbosa* DC, a Perennial Weed in Upland Fields

1. Relation between soil depth and bulb formation, germination and growth of the weed

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I. INTRODUCTION

Oxalis corymbosa DC is a serious perennial weed of upland field which is widely distributed in the Kanto district and southward in Japan. It has vigorous propagation and stunts crops very severely (Kasahara, 1947). The fact that the weed reproduces by numerous bulbs formed deep in the soil adds to the difficulty of obtaining complete control. In Okinawa Prefecture, as well as in other prefectures of Japan, the weed causes considerable reductions in potential crop yields, thus there continues to be a strong demand for the establishment of effective control measures. To the author's knowledge, however, there has been little carried out on the physiological and ecological characteristics of the weed, the only reports available at the writing of this paper being those of Kataoka et al. (1963), Urasaki (1967) and Nakama (1974). In the present study, therefore, consideration was given to the necessity of investigating into these least studied aspects for more proper control of the weed, and the experiments conducted covered the following subjects; vertical distribution of bulbs in soil, effects of planting depths on germination and growth, saturation levels of soil, germination and growth of bulbs, frequency distribution of different weights, and germination of bulbs of different weights.

II. MATERIALS AND METHODS

Trial 1. Vertical distribution of bulbs in soil: A field infested uniformly with moderate populations of Oxalis corymbosa DC, which had lain fallow for two years (earlier planted to sugar cane), was selected for this investigation. Sample plots of 1 m^2 were removed every 5 cm depth in the upper 35 cm layer of the soil extending from ground surface to subsoil and the

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profile of each plot was investigated as to the number of bulbs present. This investigation was carried out in the two representative soils of Okinawa, a limestone type called "Maage" and a marlstone type called "Jaagaru".

Trial 2. Effects of planting depths on germination and growth: In September 1972 a set of 1/2000 a Wagnel pots were filled with Maage and each pot was planted with 10 bulbs (0.3 - 0.5 g) every 5 cm depth of the 30 cm soil contained. This trial was replicated thrice and the bulbs at various depths were observed for germination and growth.

Trial 3. Saturation levels of soil: In January 1973 a set of 1/5000 a Wagnel pots were filled with Jaagaru and each pot was planted with 5 bulbs (0.5 g). Using the method described by Ueki et al. (1946), the pots were saturated with tap water to various, predetermined levels 5 cm, 10 cm, 15 cm, 20 cm and full (soil surface) taken from the bottom. This trial was replicated twice and observations were made.

Trial 4. Frequency distribution of bulbs of different weights: In October 1972 bulbs in their early growth stages of Oxalis corymbosa DC were collected randomly from the upper 20 cm layer of the Jaagaru soil. The bulbs were weighed and investigated to determine their frequency distribution on a weight basis.

Trial 5. Germination of bulbs of different weights: In October 1973 bulbs of different weights were placed on moistened cotton and filter paper laid out in 15 cm-diameter Shares and transferred to an incubator kept at 28 C. This germination test was repeated twice. The number of the bulbs in each weight class, which were placed on the cotton-filter paper Shares, was 235 in the 0.1 - 0.2 g, 99 in the 0.3 - 0.5 g, 85 in the 0.6 - 1.0 g, 56 in the 1.1 - 1.5 g, 57 in the 1.6 - 2.0 g and 41 in the 2.0 - 2.5 g. This trial was continued for 28 days after the placement of the bulbs on the cotton-filter paper Shares.

III. RESULTS AND DISCUSSION

The vertical distribution of parent and daughter bulbs in Maage and Jaagaru is shown in Fig. 1. In both soils, the distribution showed increased concentrations with shallower depths. Some 72% of the daughter bulbs were found to be occurring within the upper 10 cm of the soil profile while the parent bulbs showed a 56% distribution within the top 5 cm of Maage and a 73% distribution within the same depth of Jaagaru, respectively. In both soils, these percentages decreased gradually with commensurate increases in depth, as given by the corresponding approximate exponential functions in Fig. 1.

The number of daughter bulbs per parent, as encountered in various depth, is set forth in Table 1. There were more individuals in Maage than in Jaagaru with the occurrence always high in both soils, especially at depth 25 cm or deeper. This suggests that ploughing, as a means of dispersion, can break up only a small proportion of the daughter bulbs encountered in these depth below plough-level with the result that most of the bulbs remain concentrated around the

parents and their weak growth delays the formation of new parent populations.

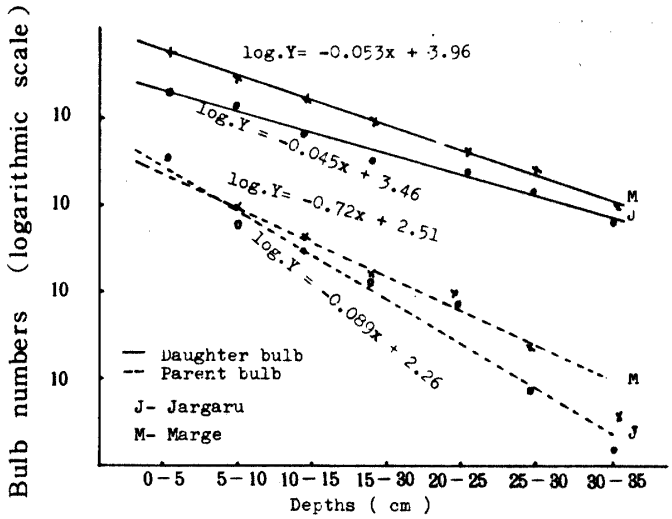

Fig. 1. Relationships between soil depth and depth at which bulb formation of *Oxalis corymbosa* DC cccurs

Table 1. Daughter bulb numbers per parent

Depths (cm) / Soils	0-5	5-10	10-15	15-20	20-25	25-30	30-35
Jaagaru	6.3	24.1	24.2	27.4	35.8	202.0	168.0
Maage	31.0	38.7	48.6	58.1	59.7	132.8	

The germination-growth relationship between bulbs in various depths is set forth in Table 2. In this Table, days prior to germination, daughter bulb numbers and leaf numbers are expressed, respectively, as corresponding regression lines which indicated better degrees of growth with shallower depths. The straightline decreases in bulb numbers showed different trends from those indicated by the exponential decreases in Fig. 1. This suggests that the favorable effects of shallower depths on growth trends had been spread in the field by earlier cultivations and built up over a considerable number of years.

The correlations between these characters are set forth in Table 3. Strong correlations were evident between the days prior to germination, leaf numbers, daughter bulb numbers and varying depths. The correlation of the leaf numbers with the daughter bulb numbers was found to be much stronger, as given by the form $r = 0.983$, indicating that increases in the leaf numbers are involved, to a greater degree, in the formation of the daughter bulbs. On the other hand, a contrasting trend was noted in the correlations between the germination percentage, plant height,

fresh weight, and varying depths. A possible explanation for this is the significant balance existing between the mean values obtained for two layers adjacent to depths 25 cm or deeper.

Table 4 sets forth the effects of various saturation levels of the soil on bulb germination and growth. The complete non-occurrence of bulbs at the full saturation level (soil surface) led us to arrange various lower levels for observation of germination and growth under different conditions of saturation. The degrees of germination and growth increased with lower saturation levels and it was also found that the saturation level conditions worked in favor of growth at the 5 cm but less at both the 10 cm and the 15 cm. There was a further fall in growth at the 20 cm and no bulbs were to be seen under the full level conditions.

Table 2. Effects of planting depths on germination and growth

Depths (cm)	Germination (%)	Days prior to germination	Plant height (cm)	Leaf numbers	Fresh weight (g)	Daughter bulb numbers
1	100	12.9	8.7	26.4	12.0	92.4
5	97	13.6	8.9	21.9	12.3	75.9
10	97	21.2	8.6	13.5	11.5	46.2
15	100	25.7	8.5	10.3	10.7	37.6
20	90	34.8	8.4	4.9	11.0	26.0
25	90	53.4	5.1	2.4	9.4	12.6
30	57	62.9	4.4	1.4	6.9	8.9

Table 3. Correlations between various characters based on varying planting depths

	Days prior to germination	Leaf numbers	Bulb numbers	Germination percentage	Plant height	Fresh weight
Depths	−0.964**	−0.964**	−0.930**	−0.662**	0.721*	−0.795**
Days prior to germination		−0.883**	−0.844**	−0.704**	−0.795**	−0.829**
Leaf numbers			0.983**	0.525*	0.606**	0.733**
Bulb numbers				0.476	0.542	0.784**
Germination percentage					0.706**	0.659**
Plant height						0.574**

* Significant at 5% level

** Significant at 1% level

Table 4. Effects of varying saturation levels of soil on germination and growth

Saturation level (cm)	Germination (%)	Days prior to germination	Fresh weight (g)	Daughter bulb numbers
Full	0	–	–	–
20	20	20.0	2.1	0
15	100	14.1	4.5	25.0
10	80	14.6	4.8	18.4
5	100	14.8	9.3	43.1

Fig. 2 gives the weight distribution of bulbs. Bulbs in their early growth stages fell in the range from 0.1 to 2.5 g and gradual weight reductions started at 0.3 g as a peak until individuals above 2.0 g showed a marked decrease to 0.4 %. A relationship in the mode of logarithmic normal distribution was found to exist between the bulb numbers and the bulb weights, as shown in Fig. 2.

In Okinawa, the aerial parts of the weed die during the April-August period and new shoots emerge and grow in September. The presence of numerous small bulbs observed in this investigation might be accounted for by the coincidence of the investigation with the early growing phase, that is, October.

Fig. 3 gives the results of the germination test run on a weight basis. Most of the bulbs tested germinated within a period of 3 to 4 days after the bulbs were placed on the cotton-filter paper Shares. Individuals varying from 0.3 to 2.0 g showed a final germination percentage as high as 80 to 100. The diurnal germination percentage recorded 4 to 8 days after the placement of bulbs on the cotton-filter paper Shares ranged from 60 to 80, a considerably high performance for any such short period. In contrast, bulbs 2.1 g or above were low in both the diurnal and final germination percentages. Nevertheless, in view of the individuals in this weight class comprising less than 1% of the whole population under observation, it is probable that a large percentage of the bulbs, with the exception of those 0.2 g or below, germinate approximately at the same time. Kataoka et al. (1963) and Urasaki (1967) stated that dormant daughter bulbs during the summer sprout upon issuance from dormancy between the fall and the following spring. This statement is related to the fact that in the present investigation small individuals varying from 0.1 to 0.2 g showed a germination percentage as low as 18, suggesting the possibility that a considerable number of such immature bulbs still remained dormant in October when they were in their early stages of growth.

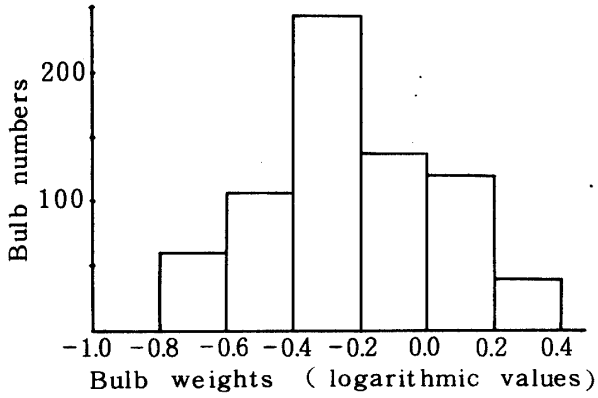

Fig. 2. Frequency distribution of bulbs of different weights

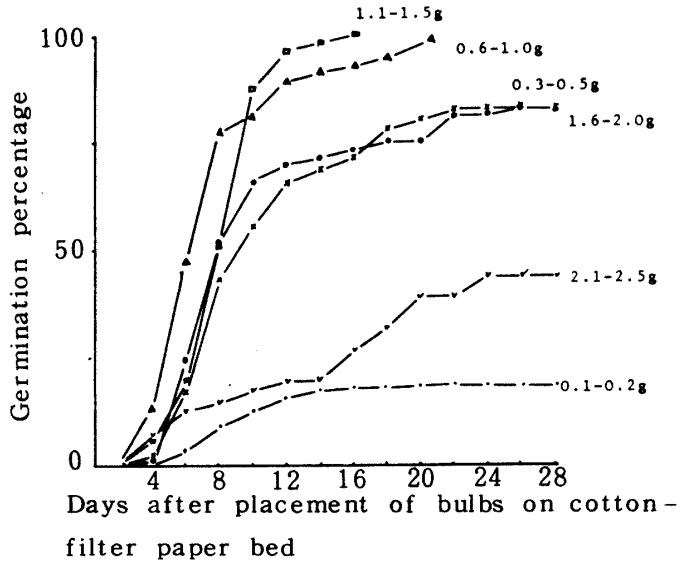

Fig. 3. Germination percentage changes with time in bulbs of different weights

IV. SUMMARY

In the present study, an attempt was made to elucidate certain physiological and ecological characteristics of the bulbous perennial weed of upland field Oxalis corymbosa DC in both soils of Maage and Jaagaru of Okinawa. In addition, the effect of each weight of bulbs on germination was studied. The results obtained are summarized as follows:

1. Approximately 72% of the bulbs under observation occurred within the upper 10 cm of the soil with the percentage as low as about 2 to 3 at depths 20 cm or deeper.

2. There were more daughter bulbs in Maage than in Jaagaru with a high percentage in both soils at depths 25 cm or deeper.

3. As to the days prior to germination, leaf numbers and daughter bulb numbers, there was a strong correlation between these three characters and varying depth. These same three characters were also correlated strongly among themselves, the correlation of the leaf numbers with the daughter bulb numbers being especially prominent, as given by the form $r = 0.987$.

4. Highest values on the germination percentage, fresh weight and daughter bulb numbers were obtained at the 5 cm saturation level with the degrees of growth progressively lower toward higher levels. No trace of germination was observed under the full saturation level conditions.

5. Bulbs in their early growth stages fell in the range from 0.1 to 2.5 g. A relationship in the mode of logarithmic normal distribution was evident after the peak 0.3 g.

6. The germination percentage in bulbs varying from 0.3 to 2.0 g ranged between 60 and 80 at the end of a 4-day period following the placement of the bulbs on the cotton-filter paper Shares, a considerably high performance for any such short period. In contrast, the diurnal germination percentage recorded for the weight classes below 0.2 g and above 2.0 g was significantly low.

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畑多年性雑草ムラサキカタバミに関する生理生態学的研究 619

I　鱗茎の形成深度と発芽・発生

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要　　約

畑多年性雑草ムラサキカタバミは沖縄における強害雑草の一つとされている。本研究の目的は色々な条件下にある沖縄の代表的土壌であるJaagaruとMaageにおいて，この雑草がどのような生理生態的特徴を示すかを調べることである。得られた結果は次のとおりである。

1. 両土壌における鱗茎の垂直土中分布は表層10㎝以内に72％が分布し，20㎝以上になると2～3％の分布にすぎなかった。
2. 親鱗茎一個当りの子鱗茎数はJaagaru土壌よりMaage土壌に多かった。
3. 出芽までの日数，葉数及び子鱗茎数は深土に対して高い相関があり，またそれらの調査項目間の相関も高く，特に葉数と子鱗茎数との相関係数は$r = 0.983$と高かった。
4. 出芽・生育と土壌水位との関係は5㎝区が最も良く，水位が高くなるにつれて次第に悪くなる。湛水区では発芽は全く認められなかった。
5. 鱗茎重は0.1～2.5ｇの範囲内にあり，0.3ｇをピークとして対数正規分布の関係が認められた。
6. 0.3～2.0ｇの鱗茎の一日当り発芽率は置床後4～8日間で60～80％であり，短期間にかなり高い発芽率を示した。0.2ｇ以下あるいは2.0ｇ以上の鱗茎の一日当り発芽率は非常に低かった。