

Seed Dispersal in *Pinus densiflora* SIEB. et Zucc. Stand at Tsukuba, Ibaraki Prefecture*

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Synopsis

Seed dispersal in the *Pinus densiflora* artificial forest was recorded in relation to weather condition such as wind velocity and air humidity. Total number of seeds was 2093 per 2.5m², which were trapped in a period from December 1984 to September 1986. Anemochore seeds were caught in larger number than that of zoochore seeds. The *P. densiflora* seeds were released in a period from October to June in next year. The number of *P. densiflora* seeds fallen into the stand was 107.6 m⁻²·year⁻¹ from 1985 to 1986, and 157.6 m⁻²·year⁻¹ from 1986 to 1987. *P. densiflora* seedlings emerged from the seeds were 5.9 individuals m⁻² in 1987 as 3.7% to all dispersed seeds. No seedlings survived on the forest floor in the experimental year. The number of dispersed *P. densiflora* seeds was related to relative air humidity and daily maximum wind velocity. High dispersal of *P. densiflora* seeds was observed when the weather condition was over 10m·sec⁻¹ in the daily maximum wind velocity and below 60% in the daily mean relative humidity.

Key words: Seed dispersal, *Pinus densiflora*, wind velocity, air humidity, seedling survivorship.

Introduction

This paper describes the floristic composition of seeds fallen into the forest of *Pinus densiflora* Sieb. et Zucc in Tsukuba, Ibaraki Prefecture. In this paper, the period of seed dispersal, emergence of *P. densiflora* seedlings and disseminule form of trapped seeds were

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also treated. In particular, we tried to get information on the relationship between weather condition and seed dispersal of *P. densiflora*.

From autecological view point of this species, many studies have been carried out. For example, GOO and HIRAMATSU (1953) reported that *P. densiflora* seeds were germinable after 90 days of fertilization. INOUE (1959) reported the maximum distance of dispersal of *P. densiflora* seeds was about 85m from the mother trees. According to NAITO (1984), *P. densiflora* seeds dispersed 200m distance from the mother tree down a seasonal wind in Miyagi Prefecture. KASHIWAGI (1986) described that the effective cumulative temperature for germination of the seed population was from 75°C · day to 200°C · day. HASEGAWA and FURUKAWA (1953) showed that *P. densiflora* seeds were able to germinate without exposure to light. WASHITANI and SAEKI (1986) reported that the light through foliage inhibited the germination of *P. densiflora* seeds. According to NAKAMURA (1980), *P. densiflora* seeds were able to germinate under the pine forest floor, though seedlings were withered in a year after germination.

Concerning to species composition of the dispersed seeds in the *Pinus* stand, Nakagoshi et al. (1982) studied it in southern Hiroshima Prefecture.

This study is an attempt to learn the relationship between seed dispersal and tree population dynamics in the *P. densiflora* forest in temperate of Japan.

Study Site and Methods

The study site was situated at 36° N in latitude and 140° 5' E in longitude, and 30m above sea level. The climatic conditions near the study site are as follows: 13.7°C as annual mean air temperature, 1,014mm as annual precipitation, and Warmth Index was 113.9, which indicates warm-temperate zone. The area of studied stand was ca. 4ha in the campus of University of Tsukuba. The forest was dominated by 30-years old *P. densiflora* trees which were 10.5m in mean height, 11.8cm in mean diameter at breast hight (DBH), and 2,750 individuals per ha (YAMASHITA and HAYASHI, 1987). The stand included the species of *Viburnum dilatatum* THUNB., *Quercus serrata* MURRAY, *Eurya japonica* THUNB., *Quercus myrsinaefolia* BLUME and *Rhus javanica* L. in the shrub layer, and *Pleioblastus chino* MAKINO, *Oplismenus undulatifolius* ROEMER and *Ophiopogon japonicus* KER-GAWLER in the herbaceous layer.

Nine circular seed traps (0.6m in diameter) were regularly set up in a 20m X 20m permanent quadrat in the forest. The height of the top of traps was fixed about 0.6m above the ground. Seeds collection was made from December 1984 to June 1987 at a month interval, and apparently sound seeds were counted for each species. All of the seeds were identified to species and their disseminule form was examined. In particular, *P. densiflora* seeds caught by traps were collected at a week interval in fruiting season from October 1986 to June 1987. Emergent and withered seedlings of *P. densiflora* were counted from 12 April to 22 August 1987 in an experimental site which was subdivided into two 2m × 10m grids. Counting of

seedling emergence and mortality was carried out by marking the seedlings with glassfiber poles and traced their fate in the quadrat.

Data of air humidity and wind velocity near the experimental site were available from the Report of Experimental Forest of the Agricultural and Forestry Research Center, University of Tsukuba (1988, 1989).

Results and Discussion

The number of seeds caught in the traps from December 1984 to September 1986 was 2,093 per 2.5m² consisting of 26 species (Table 1). The total number of trapped seeds of important species per square meter was 288 for *Solidago altissima* L., 189 for *P. densiflora* and 116 for *Miscanthus sinensis* ANDERSS. Seasonal change of the number of trapped seeds is shown in Table 1 during the experimental periods. The most seeds were caught during winter both in 1985 and 1986. *Phytolacca americana*, however dispersed the seeds from August to December by birds. A considerable number of seeds of *Rhus javanica* and *Eurya japonica* also fell into the stand in the some season.

The seed population includes both seeds produced in the stand and those migrated from distant places by wind such as *Betula platyphylla* var. *japonica* HARA and *Ulmus parvifolia* JACQUIN, and by birds such as *Dendropanax trifidus* MAKINO, *Phytolacca americana* L. and *Albizia julibrissin* DURAZZINI.

The seed population consisted of 14 species of anemochores and 12 species of zoochores in disseminule form composition. The seedlings germinated from zoochore seeds were abundant in the forest floor, though a number of anemochore seeds were caught by the traps. This may due to difference of survival rate of seedlings between zoochores and anemochores seeds which store different amount of reserve substance. It seems that the seedlings germinated from zoochore seeds are more tolerative under gloom condition for survival than those from anemochore seeds. NAKAGOSHI et al. (1982) described that about 70% of total species was zoochores in the seeds collected for a year at *P. densiflora* forests in Hiroshima. In our study, because the experimental area was surrounded by grassland, larger number of anemochores seeds were caught than that of zoochores.

The trees of *P. densiflora* released their seeds in a period from October to June in next year. The number of sound dispersed seeds was 107.6m⁻² · year⁻¹ from 1985 to 1986 (Table 1), and 157.6m⁻² · year⁻¹ from 1986 to 1987 (Fig. 1).

The maximum seed dispersal of *P. densiflora* was occurred from November to December, which about 60% of total seeds were dispersed. RIM and SHIDEI (1975) reported that 67% of total seeds dispersed during the period from October to December in Kyoto. The result is similar to mine.

P. densiflora seeds were dispersed from October to June in the next year, because the northern part of Kanto District including Tsukuba has dry and windy weather condition in this season. The meteorological condition in this season is expected to affect the unholding

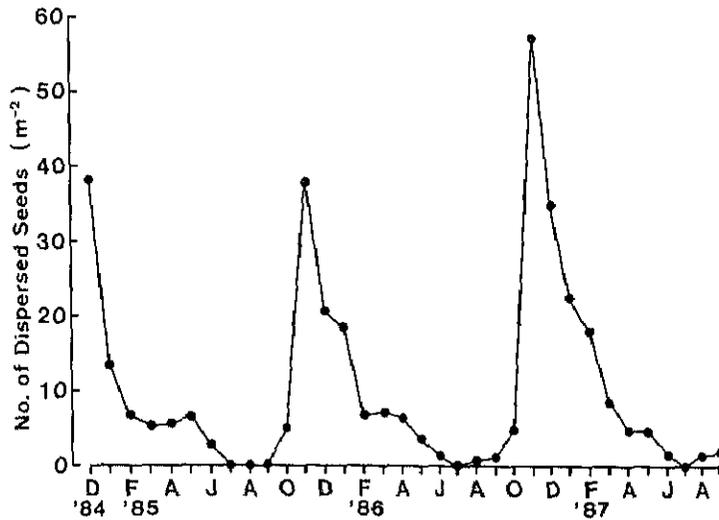


Fig. 1. Monthly change of the number of *Pinus densiflora* seeds (m⁻²) caught by traps in the period from December 1984 to September 1987.

of the pine cones because release of seeds from a parent tree is possible after unholing of cones. INOUE (1959) mentioned that the dispersal of *P. densiflora* seeds occurred in the fine day of dry and wind condition. KOHLERMANN (1950) described that the pine trees released seeds when the air humidity attained 55-65% and 2~3m · sec⁻¹ in wind velocity in winter in Germany. Then, the relationship between the number of dispersed seeds of *P. densiflora* and the relative air humidity and the daily maximum wind velocity was examined from October 1986 to May 1987 (Fig. 2). The maximum seed dispersal occurred from 10 to 17 November including two days when the wind velocity was 10m · sec⁻¹ at the maximum and 60% in daily mean relative humidity. When the air humidity exceeded 60%, only a small number of seeds were dispersed even though the maximum wind velocity is more than 10m · sec⁻¹ like as the period from 17 to 24 November. The number of dispersed seeds was also few when the maximum wind velocity was small, though the mean relative humidity were less than 60% (Fig. 3). Thus, it was obvious that the seed dispersal of *P. densiflora* increased when the atmospheric conditions were less than 60% in the mean relative humidity and over 10m · sec⁻¹ in the maximum wind velocity.

Emergence and mortality of seedlings on forest floor were observed from 12 April to 22 June 1987. The mean total number of seedlings were 5.7m⁻² ± 3.09 in a period (Fig. 3). Seedling emergence initiated on 20 April and attained its maximum on 3rd May. After 3rd May, the seedlings withered rapidly and all seedlings were died out by 22 August. The number of seedlings emerged was 3.7% for total seeds fell into the stand. In the experimental year, no seedling succeed to establish in the stand. Factors influencing on seedling death were described in detail by SUYAMA and NAKAMURA (1988). In the *P. densiflora* stand, the seedling

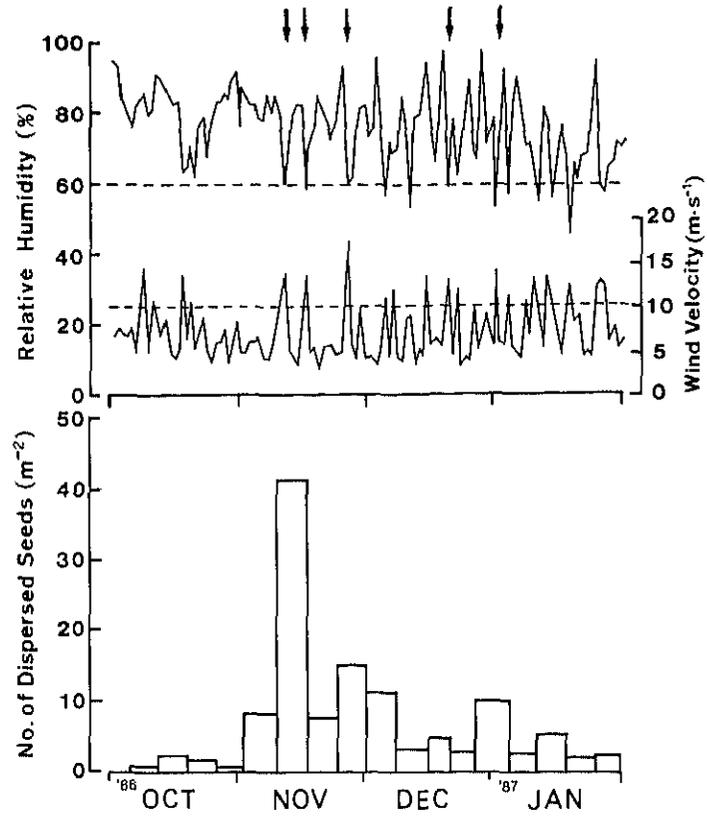


Fig. 2. The number of *Pinus densiflora* seeds caught in the traps and the changes of daily mean relative air humidity (upper line) and in daily maximum wind velocity (lower line) during the period from October 1986 to January 1987. Arrows indicate the day of less than 60% in air humidity and over $13\text{m} \cdot \text{sec}^{-1}$ in wind velocity.

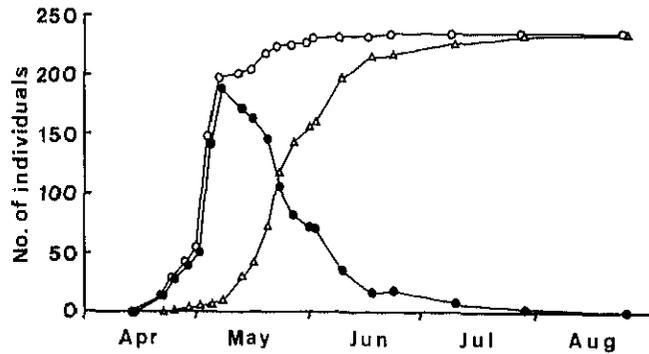


Fig. 3. Cumulative emergent (○) and withered (△) numbers of *Pinus densiflora* seedlings, and survived seedlings (●) in the stand from 12 April to 22 August in 1987.

emergence from migrated seeds and their mortality are seemed to be repeated as long as the canopy is closed.

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