SEED POPULATION DYNAMICS, GERMINATION AND DORMANCY IN *XANTHIUM*

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Summary. Studies of Noogoora burr *(Xanthium pungens)* seed population dynamics in New South Wales revealed wide fluctuations in seed production, depending on local flooding, and high levels of predation by birds and mice. Survival rate in the seed reservoir was 33%. Dormant upper seeds of Noogoora burr germinated readily at high temperature in light after storage in soil. In contrast, Bathurst burr *(X. spinosum)* germination was favoured by field storage above ground and was not influenced by light or temperature variations. Disturbance of soil during summer may be a practical method of reducing the survival rate of Noogoora burr soil seed reserves.

INTRODUCTION

The size of the seed population of any species for a given area and time will depend on the rate of recruitment from the seed rain, the rates of immigration and emigration, the rate of germination and the rate of loss through seed death or predation (Harper 1977). A knowledge of these rates for a weed would enable prediction of the effects of proposed control strategies or biological control agents. In this paper the results of such a study for Noogoora burr seed populations and of an experiment to examine factors affecting *Xanthium* seed germination and dormancy are presented.

MATERIALS AND METHODS

Seed population dynamics. Data were collected at Topar and Mt Gap in western New South Wales, Darlington Point in the south west and Wellington *(X. italicum)* in the central west of New South Wales. In May 1979 and May 1980, samples of burrs from plants, litter and soil (0 to 5 cm) were obtained from 25 random 0.25 m^2 quadrats in a 25 m^2 sample area at each site. Burrs were separated from litter and soil and the number of viable seeds determined by germination in a glasshouse. Burrs were cut open after 98 days in order to determine the number of dormant seeds remaining. Losses due to predation were determined by examining burrs for damage and seed removal.

The equation $R_2 = S(R_1 + Y - P.Y)$ was used to represent the dynamics of Noogoora burr seed populations where R = the seed reservoir in years 1 and 2, Y = the seed produced in year 1, P = the rate of loss in Y due to predation by birds and mice (assumed to occur before seed enters the reservoir) and S = the survival rate of seed after entry into the seed reservoir.

Seed germination and dormancy. Burrs of Noogoora, Hunter River *(X. italicum)*, Californian *(X. orientale)*, South American *(X.cavanillesii)* and Bathurst burr were collected during May 1979. Fifty burrs per species per treatment were prepared for field storage in June 1979 by enclosing in shade cloth bags. At Topar and

Mt Gap bags of burrs were either buried in soil at 10 cm depth, covered with litter, or secured to a metal stake 1 m above ground to represent those remaining on the plant. On retrieval in June and September 1980 soil bags were recovered in darkness and prepared for germination under green safelight. Germination conditions were factorial combinations of two light treatments (continuous darkness and 12/12 hours light/dark) and two temperature regimes (25/15°C and 35/25°C). Results of germination up to three weeks are presented.

RESULTS AND DISCUSSION

Seed population dynamics. Variability in the contribution by new seed and losses due to predation resulted in large differences in seed input to the seed reservoir between sites (Table 1).

Table 1. Noogoora burr seed population dynamics

Attribute	Site			
	Darl.Pt.	Topar	Mt Gap	Wellington
	(seeds m^{-2})			
Seed reservoir, June 1979 (R_1)	76	186	165	143
Gain from 1979 seed crop (Y)	714	845	72	701
Loss due to predation (P.Y)	664	0	32	378
Seed reservoir after net gain (R_1+ Y-P.Y)	126	1031	205	466
Survival rate in seed reservoir (S)	0.36	0.34	0.24	0.36
Seed reservoir, June 1980	45	349	50	166

At Mt Gap, Noogoora burr germinated after rain in October 1978 but most plants succumbed to drought. Local flooding after a January storm at Topar provided sufficient moisture to sustain plants to maturity. Birds ate seeds at Mt Gap and Wellington, while birds and mice ate seeds at Darlington Point. No predation occurred at Topar although remains of burrs indicated predation by mice in previous years.

Knowledge of the probabilities of attaining given levels of Y and P will allow prediction of effects of mechanical, chemical or biological control methods or their combinations on Noogoora burr seed populations. The usefulness of these methods will depend on whether they can reduce seed populations to a level below which density dependent mortality of plants occurrs. According to Holloway (1964) almost total seed destruction of Noogoora burr would be necessary to achieve such a result.

The mean survival rate of seed was 33%. Assuming that the survival rate remains constant, the annual input of new seed (Y-P.Y) into the seed reservoir (R) would need to equal 2R if a constant given level of seed in the reservoir were to be maintained. If annual inputs of Y ceased it would take from three to six years for the seed reservoir to fall below one seed m^{-2} on the sites examined. Further development of the model will be based on the relationship between Y and the long term sequence of flooding.

Seed germination and dormancy. The most important factor in depletion of weed seed populations in soil is loss of dormancy resulting in germination leading to either emergence or death (Roberts 1972). A knowledge of factors affecting

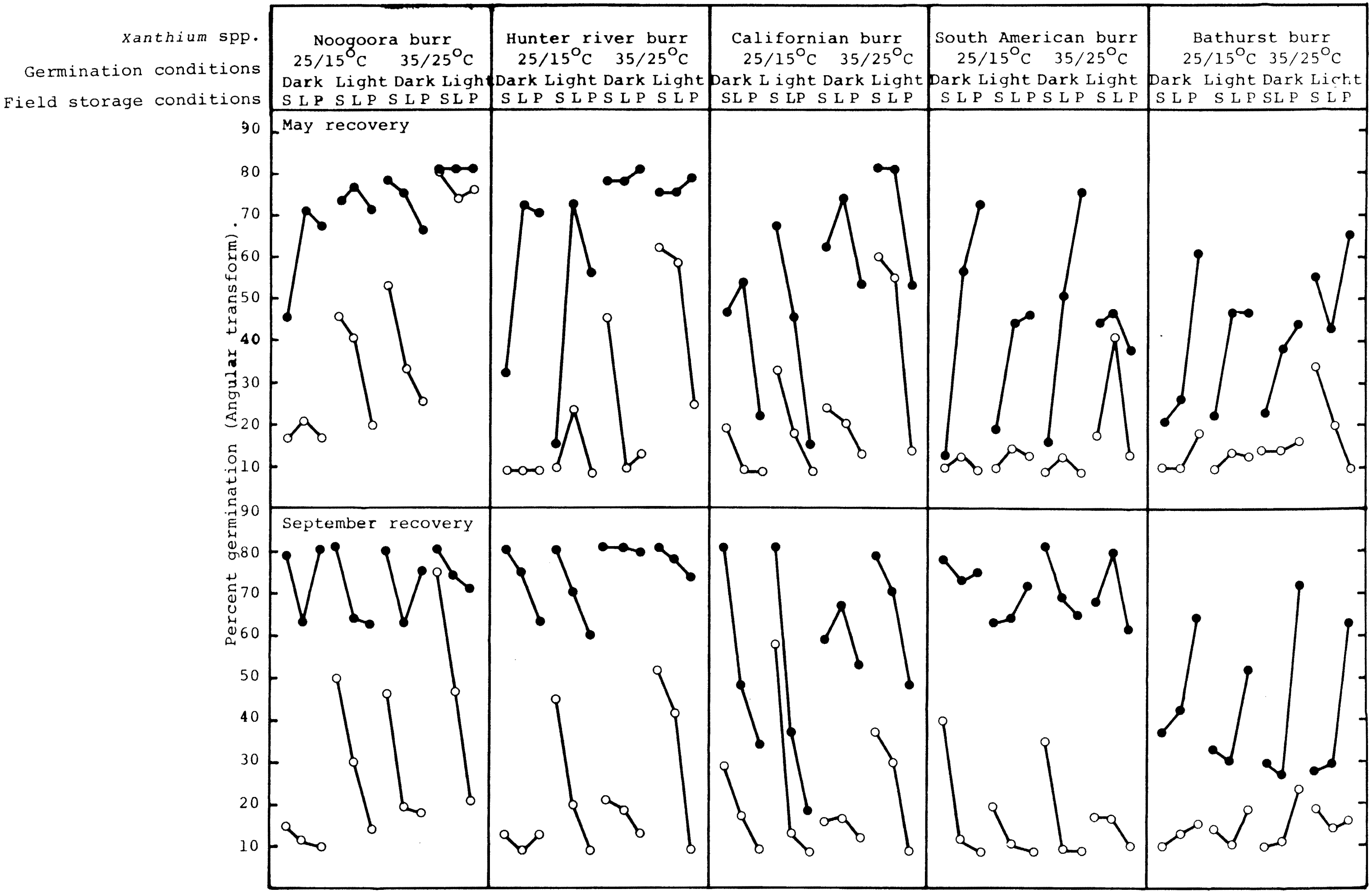

Figure 1. Effect of field storage and laboratory germination conditions on the germination of *Xanthium* seeds in burrs. Lower seeds = ●, upper seeds = ○ L.S.D. (P = 0.05) = 20.2. Field storage conditions - S = in soil, L = in litter, P = on plant.

dormancy levels in nature therefore may lead to methods of depleting the seed reservoir.

Dormancy of upper seeds was most readily overcome by storage in soil and these seeds germinated most readily when exposed to light at the high temperature level (Figure 1). After recovery in September, uppers of Hunter River burr germinated more readily in light while those of South American burr germinated more readily in dark.

Lower seeds of all species were initally less dormant than uppers. Secondary dormancy in lower seeds was induced by storage in soil. This effect was overcome by overwintering and by high temperature during germination and was most marked in Hunter River and South American burr. Lower seeds of South American burr germinated more readily in darkness after recovery in May. Storage on simulated plants induced secondary dormancy in lower seeds of Californian burr which was partially overcome by high temperature but not by overwintering. Bathurst burr lower seeds germinated most readily after storage on simulated plants and this response was not altered by season of recovery or germination conditions.

Two types of dormancy were recognized: (a) The innate dormancy of upper seeds which was overcome by exposure to light and high temperature during germination after storage in soil. Endogenously produced ethylene in the presence of small quantities of oxygen is known to overcome dormancy in *Xanthium* upper seeds (Esashi *et al.* 1976). Soil storage could favour this response by retention of ethylene near the seed. (b) Secondary dormancy in lower seeds was shown to be induced by anaerobic conditions during moist storage at high temperature (Davis 1930). This type of dormancy was overcome in all species except Bathurst burr by germination at high temperature or by overwintering in soil. It is suggested that the burr, by restricting aeration, may modify dormancy responses in Bathurst burr.

The fate of burrs above ground depends largely on the activity of predators. Losses in burrs buried in soil depend on dormancy levels and are due mainly to untimely germination. This process could be accelerated by soil disturbance or by chemical means. Egley (1980) increased emergence and decreased viable seeds of *Xanthium* in soil by injection of ethylene.

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