# SEEDLING EMERGENCE OF WHEAT AS AFFECTED BY SOWING DEPTH, SEED SIZE AND SOWING DATE

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## ABSTRACT

A factorial field experiment investigated the effects of sowing time, seed size and depth of sowing on the emergence of Rongotea wheat. Varying the time of sowing from early May to late June did not affect the total population established but decreased emergence rate.

Within a seed lot, seed size showed a significant interaction with sowing depth. Both rate of, and total, emergence from small seed (TSW 36 g) was reduced in comparison with large seed (TSW 53 g). With 2 cm sowing depth the reduction was up to 10%, but at 5 cm sowing depth the reduction reached almost 20%.

It is suggested that one of the main reasons for the reduced emergence from deep sowings was the higher proportion of 'failed' seedlings: plants in which germination had occurred but the seedling was not able to reach the soil surface. We recommend that the drilling depth of wheat should not exceed 4-5 cm so that an optimum plant population for high yields can be established.

*Additional Key Words: Rongotea, failed seedlings, Fusarium nivale*

## INTRODUCTION

Ear population has a major influence on wheat yields (Hampton *et al.,* 1981). The desired ear population is most efficiently achieved by establishing an optimal plant population. Recent work in Canterbury (Scott, 1977; Dougherty *et al.,* 1979; Nourafza and Langer, 1979) and in the Manawatu (Hampton, 1981b) has shown that for medium to heavy soils, or for light soils with irrigation, a plant population of about 250-300 plants/m² at GS 1 (Tottman and Makepeace, 1979) produces an ear population of 600-800/m². Populations lower than this can sometimes still produce the required number of ears if the nitrogen supply is adequate at GS 1-2 but, if the crop density is initially too low, the greater number of ears produced per plant is not enough to compensate for the initial low plant population (Nourafza and Langer, 1979). Tillering is a process which is difficult to manipulate consistently (Scott, pers. comm.) therefore, achieving an optimal ear population by the establishment of 250-300 plants per m² at GS 1 is preferable and more economical than nitrogen application.

Hampton and McCloy (unpub. data, cited by Hampton *et al.,* 1981) found that the standard practice of sowing wheat on a weight per unit area basis gave populations ranging from less than 100 to over 600 plants per m². This practice pays little attention to the proportion of seedlings which emerge because sowing rates are often excessive and loss of 20-40% of the seeds has no obvious effects on the crop (Perry, 1976). However, with the recognition of the role of plant populations in cereal production and with sowing arranged on a seed number basis, predictable and reliable emergence becomes important in the establishment of the crop (Hampton, 1981a).

Factors affecting emergence and establishment include germination, seedling vigour, seed size, diseases, seedbed, time of sowing and sowing method, including drilling depth and speed (McCloy, 1980).

The laboratory germination of most New Zealand cereal seed lines is 90% or greater (McCloy, 1980) but a limited amount of data is available as to their field establishment (Hampton, 1981a). The experiment described in this paper aimed to determine the effects of seed size, sowing depth and sowing date on the emergence of winter-sown wheat in Canterbury.

## MATERIALS AND METHODS

The experimental design was a 3 sowing times x 2 seed sizes x 2 planting depths factorial randomised block with four replications. The 3 sowing dates were 6th May (T1), 25th May (T2) and 15 June (T3) to give a range from early to late for conventional winter wheat. The two nominal planting depths of 2 and 5 cm are the recommended optimum and maximum drilling depths for autumn-sown wheat in a good seedbed (McCloy, 1980). A single line of wheat (*Triticum aestivum* L.) cv. 'Rongotea' with a thousand seed weight (TSW) of 45.8 g was sieved to give three seed size fractions (small, medium, large) which by weight were 37%, 17% and 46% respectively of the original bulk. Medium seed was discarded and the small and large seeds, with TSW of 35.7 ($\pm$0.7) g and 52.6 ($\pm$0.4) g respectively, were retained.

Standard ISTA germination tests on these two seed lots revealed no difference from the 95% germination of the bulk seed sample. Seed had been treated with Baytan F17 and was further treated with Mesurol to prevent bird damage. The field experiment was conducted at Lincoln College, Canterbury, on a fertile Wakanui silt loam soil previously in prairie grass/white clover pasture. The cultivated soil was sprayed with paraquat on 3 May. One thousand seeds per plot were sown with a 10 coulter Oyjord drill at 11 kph. To avoid drilling where the tractor wheels had passed, the two outside coulters were removed so that all coulters were sowing into soil of similar physical condition. Each plot measured 1.5 m x 3 m.

For the first sowing the seedbed was weed free and the soil was moist, loose and rubbly, which McCloy (1980) suggested was ideal for wheat. However, as there was no further cultivation after the first sowing, weathering compacted the soil and the subsequent sowings were drilled into a more compacted, slightly crusted soil. No fertiliser or chemicals were applied with the seed at or after sowing.

**Measurements**

Plots were visited at noon each day, once a day for sowing one, and then every second or third day with later sowings as the rate of emergence slowed down. Initial emergence was assessed as appearance of the first coleoptile or leaf over the whole plot. An emergence rate index (ERI) was calculated from equation (1) using daily emergence counts and total emergence was said to have been completed when two successive counts showed no change.

$$ERI = \sum_{i=1}^{x} fi\,(x-i)\;..... \qquad (1)$$

where fi is percentage emergence on ith day.

x is total number of days in which emergence was completed; $(x-1)$ is weightage factor for ith day.

The actual planting depth was determined by digging up 24 plants per plot for each sowing time. Sampling was across 4 rows, 2 plants from either end and 2 from the centre of the row. Depth was measured to the nearest millimetre, and taken from the point where the coleoptile emerged from the seed, so as to negate any effects of seed orientation in the soil.

**Statistical analysis**

The experiment was analysed using Genstat to determine differences among sowing dates, depths and seed sizes, together with any significant interactions.

## RESULTS

**Sowing date**

T1 seedlings started to emerge on 20 May, 14 days after drilling and total emergence was completed by 26 May. The ERI values for each treatment are shown in brackets on Figure 1. Seedlings from T2 initially emerged 18 days after drilling (13 June) and total emergence was completed in 34 days. At T3 the seedlings first emerged 24 days after drilling on 9 July and completed emergence 42 days after drilling.

The mean ERI values for sowing T1, T2 and T3 were 106, 56 and 24 respectively. T2 and T3 had much reduced ERI's, representing both the longer time for initial emergence and the slower rate subsequently (Figure 1).

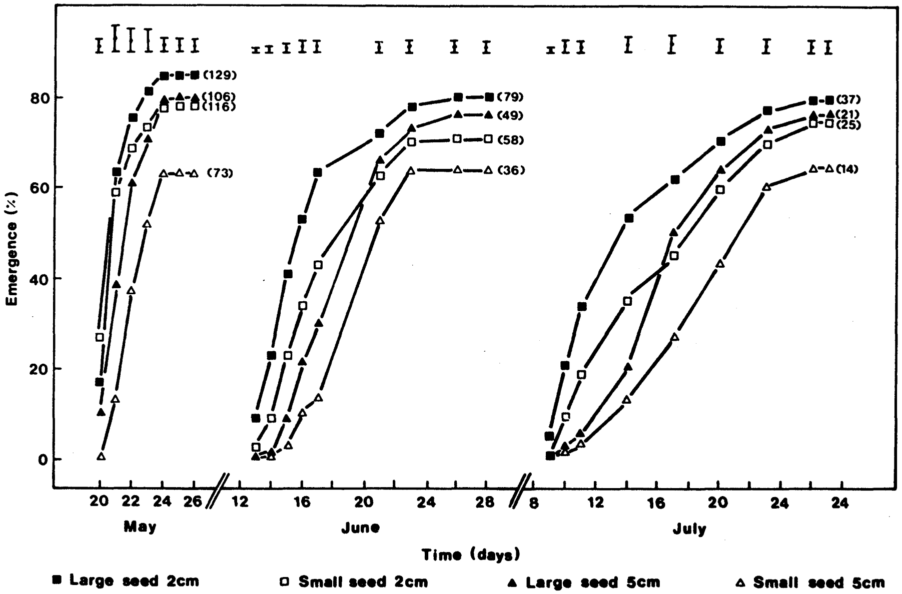


**Figure 1: Effect of sowing depth, seed size and sowing date on emergence (%) of Rongotea wheat in the field. ERI values shown in brackets. I = 2 x SE$\bar{x}$.**

Delays in sowing reduced rate of emergence but had no effect on total emergence.

**Effects of seeding depth and seed size**

Although the drill was at the same setting for each sowing date, different soil conditions meant the actual drilling depth differed between times of sowing (Table 1).

Seed size and sowing depth showed a significant interaction ($p < 0.01$) for ERI and total emergence. Large seed consistently emerged faster than small seed from the same depth and gave a greater total percent emergence. For example, at T1 with shallow sowing, bigger seed had a total emergence of 85% compared with 78% for the smaller seed (Figure 1).

**TABLE 1: Actual depth of seeding (mm) (±S.E.) for plots sown 6 May, 25 May and 15 June.**

| Sowing time | Nominal depth 20 mm | 50 mm |
|---|---|---|
| 6 May | 35 ± 4 | 54 ± 5 |
| 25 May | 42 ± 4 | 65 ± 6 |
| 15 June | 36 ± 5 | 62 ± 4 |

Increasing sowing depth reduced the rate and total emergence for both seed sizes. However at the deep sowing, emergence of small seed (63%) was significantly less than for large seed (79%). This resulted in there being no significant ($p < 0.05$) difference between total emergence of small seed sown shallow and large seed sown deep (Figure 1). At T3 the pattern was the same.

An interesting result from T2 showed deeply-sown large seed to give a significantly greater total emergence (77%) than small seed sown in shallow ground (70%). There was no difference in laboratory germination percentages (95%) between seed sizes.

While depth adversely affected seedling growth of both large and small seed, the mescocotyl was more elongated and spindly in the small-seeded treatments.

## DISCUSSION

**Sowing date**

Delaying the sowing date from early May to mid-June decreased emergence rate, probably because of cooler soil temperatures in June and July but did not reduce total emergence. It has been suggested (Anon., 1982) that this extended period in the soil exposes seedlings to pre-emergence attack by soil pests and diseases. However no disease was observed in either the early or late-sown plants. Our results agree with overseas work (Walker, 1980) that sowing date does not affect number of seedlings emerged, unless winter conditions are extremely severe.

Many workers (Habib and Makki, 1979; Sheath and Galletly, 1980; Walker, 1980) have found that earlier sowing significantly increased yields. Greater yields have been attributed to greater ear populations (Sheath and Galletly, 1980) but whether this was due to a greater number of plants/m$^2$ or ears/plant was not stated. The present study would suggest that earlier sowing does not increase total plant population. Therefore one of the reasons for increased yields from earlier sowing may be better performance per plant.

Lowe (1967), recommended that winter wheat in Canterbury should not be sown until after 1 June to avoid aphid attack and thus prevent the spread of barley yellow dwarf virus (BYDV). Our plots were closely monitored until the end of August and no evidence of any aphids on plants from the first two sowings was seen. It is possible that the advantages to be gained from increased potential yields with earlier sowings, outweigh the losses due to BYDV. In years when cereal aphids continue flying till mid-June, appropriate precautions can be taken. These will include the drilling of systemic insecticide granules with the seed or the application of insecticide in early spring (Close, 1969).

**Seed size and sowing depth**

When drilling cereals the objective should be to achieve from 2.5 to 3.7 cm of settled soil above the seed (Anon., 1982). Drilling deeper than 5 cm reduces both rate and total seedling emergence (Anon., 1982; Bremner *et al.,* 1963). Results from this trial suggest that the critical sowing depth is not greater than 4.2 cm (from T2), as sowing at 5-6 cm reduced rate and total emergence at each sowing date, an effect that was greater where small seed was used.

However, there has been some uncertainty (Bremner *et al.,* 1963) and disagreement as to the reasons why deep seeding affects emergence. Many workers believe that seeds fail to germinate at great depths (Bremner *et al.,* 1963) or, if germination does occur, non-emergence may be explained by the coleoptile being unable to reach the soil surface (Borse and Mahajan, 1980). Evidence from this experiment supports the idea of "failed" seedlings: cases where germination has occurred, but the seedling has not been able to make it to the soil surface. There were two forms of "failed" seedlings observed in this experiment. However, plots were not sampled quantitatively for these unemerged seedlings, so no estimate of their contribution to percent reduction in emergence can be given.

The first form of observed "failed" seedlings were those where the leaves broke through the coleoptile before reaching the soil surface, tending to fold repeatedly (Plate 1). Of these, those seedlings that did reach the surface, often by chance, were spindly in comparison with "normally" emerged seedlings. Some did straighten up and their leaves unfolded but it is likely that they were disadvantaged in competing with those that had emerged normally.

The second form of "failed" seedlings observed were when the coleoptiles grew haphazardly through the soil (Plate 1) seemingly without a sense of direction and presumably until the seed reserves were exhausted. These symptoms were identical to those caused by the seed-borne cereal pathogen, *Fusarium nivale,* on winter wheat as reported and depicted by Richardson and Cook (1983). Seed infection by brown foot rot, the common name for *F. nivale,* can result in germination or emergence failure of affected seedlings (Richardson and Cook, 1983).

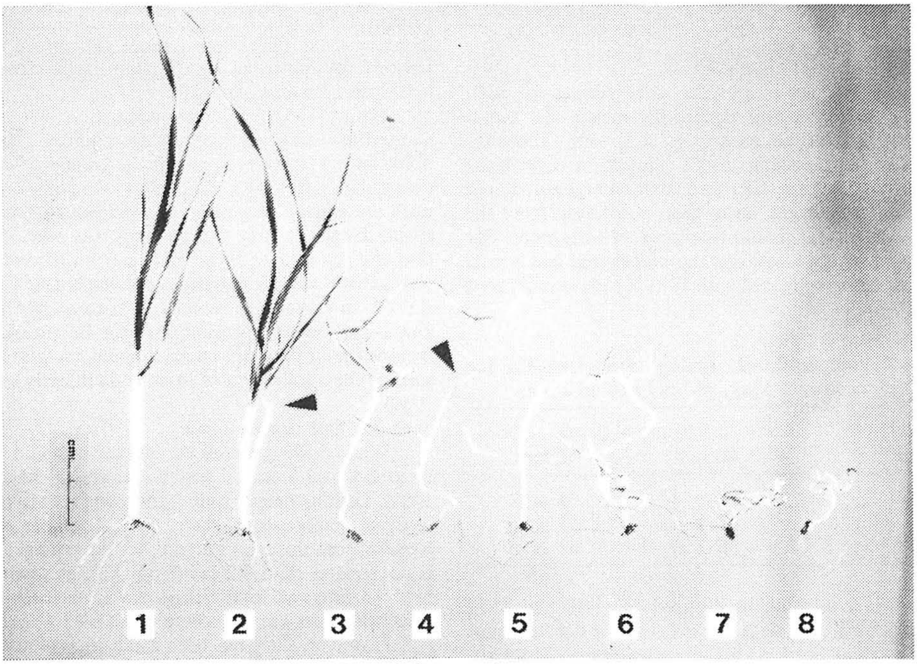


**Plate 1: Rongotea wheat seedlings showing effect of deep sowing.**
**1. Normally emerged seedling.**
**2. and 3. Emerged seedlings showing signs of leaf folding which occurs when coleoptile is broken below soil surface.**
**4. Seedling which has just emerged after repeatedly folding below soil surface. Arrow indicates emerged tips.**
**5, 6, 7, 8. Failed seedlings showing the general characteristics of repeated folding and growth in no singular direction.**

Subsequent work in the 1984 season (Goodman, unpubl. data) to determine the presence of *F. nivale* was inconclusive due to the exceptional dry winter, as *F. nivale* is reported to prefer cool, wet conditions (Richardson and Cook, 1983).

## CONCLUSIONS

Increased sowing depth, especially with small seed, reduced total emergence. Sowing date had no effect on total emergence. It is suggested that reduced total emergence with deep sowing was due largely to 'failed' seedlings rather than non-germination.

At drilling it is recommended that to establish an optimal plant population, a depth of 4-5 cm should not be exceeded, especially where small seed (TSW 36 g) is concerned.

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