Effect of sowing date on weed spectrum in field peas

Z. Munakamwe, G.D. Hill and B.A. McKenzie
Department of Agricultural Sciences, PO Box 84, Lincoln University, Lincoln 7647
New Zealand

Abstract

Low base temperature (4 °C) means that peas can be sown early in spring before most weeds emerge. This experiment aimed to determine the variation in weed spectrum during the season and compare the influence of fully leafed and semi-leafless pea canopies on the weed spectrum. The trial was conducted at Lincoln University in the 2007/2008 growing season. Sowing dates were 9 August, 13 September and 15 October 2007. Sub-plots were two pea genotypes, conventional (PRO 7035) and semi-leafless (Midichi) and two herbicide treatments (0 and 500 g a.i.ha^{-1}) of cyanazine. Weed counts were taken during the season. There was distinct variation in the weed spectrum over time. Major early weeds were *Stellaria media*, *Stachys* spp, *Spergular avensis,* and *Achillea millefolium*. Major mid season weeds were *Chenopodium* spp. *Rumex* spp. with *Polygonum aviculare*, and *Taraxacum officinale* as minor weeds. Major late weeds were *Solanum* spp, *Trifolium* spp and minor weeds were *Polygonum convolvulus*, *Galium aparine*, *Vicia sativa*, *Elytrigia repens* and *Avena fatua*. *Coronopus* spp was present in relatively large numbers throughout the season. Variation in the weed spectrum was mostly related to base temperatures e.g. chickweed probably had high counts early in the season because of its low base temperature. The problematic weed of process peas, *Solanum* spp., only occurred late in the season meaning they could be successfully controlled by early sowing.

Additional Key words: Base temperature, *Solanum* spp., cyanazine, weed spectrum.

Introduction

A major determinant of sustainable pea production is weed management. For optimum yields, peas generally require a higher level of weed management than more competitive crops such as barley (*Hordeum vulgare* L.) or canola (*Brassica napus* L.) (Harker, 2001). In organic production this can be difficult and growers try to control weeds by intercropping (Munakamwe, 2004), crop rotation, mechanical and hand weeding, use of appropriate sowing dates, competitive crop genotypes (Radosevich *et al*., 1997) and often high seeding rates. This research focused on sowing dates to examine the extent that they can be used to control weeds.

The trend in crop production is for early sowing to optimise yield (Barrett and Witt, 1987). Early growth allows earlier canopy closure and gives a greater competitive edge to the crop against some weeds. This competitive advantage is due to the weed's light requirement for growth and shading by the crop. Herbicides used to control foxtail species in wheat can be substituted by crop management practices related to sowing date (Khan *et al*., 1996). Yield is also increased because crops have a longer growing season and hence intercept more radiation.

The trial reported here examines the effect of sowing date and pea genotype on weed growth and pea yield in weedy and weed free environments aiming at determining variation in the weed spectrum during the growing season.

Materials and Methods

The trial was conducted on a Templeton silt loam soil (New Zealand Soil Bureau, 1968) at the Horticulture Research Area, Lincoln University, Canterbury (43 ^{o} 38'S, 172 ^{o} 28' E.) in 2007/08. Soil quick tests (MAF) were done to establish soil available nutrient levels (Table 1). Treatments were arranged in a split plot design with three replicates. Main plots were sown on 9 August, 13 September and 15 October 2007. Sub-plots were a factorial combination of two pea genotypes, conventional (Pro 7035) and semi-leafless (Midichi) and two herbicide treatments (cyanazine at 0 and 500 g a.i. ha^{-1}). The total number of plots was 54. Each plot was 2.1 m wide x 10 m long.

Table 1: MAF soil quick test for paddocks H14, Horticulture Research Area, Lincoln University.

Experiment	pH	Olsen-soluble P (µg ml^{-1})	Ca	Mg	K	Na	Sulphate (µg g^{-1})
1	6	15	7	21	10	6	4

Ca, Mg, K, and Na as mg g^{-1} of soil

Husbandry

Land was prepared by conventional methods i.e. disking, rolling and harrowing. Soil was tilled to a depth 25 cm. Seed was drilled with an Öyjord cone seeder at a depth of 5 cm in 15 cm rows at 100 plants m^{-2} at the above sowing dates. Cyanazine was applied pre-emergence to target plots at 500 g a.i. ha^{-1} with a knapsack sprayer. Wakil, a formulated mixture of Metalaxyl, Fludioxonil and Cymoxanil for control of *Peronospora* spp (downy mildew), *Pythium* spp and *Ascochyta* spp, was applied to all seed at the equivalent of 2 kg t^{-1} of seed before sowing. All sowing rates were corrected for the laboratory germination percentage and expected field emergence for each pea variety.

Irrigation was applied, based on crop requirement, as determined by Time Domain Reflectometry (TDR) in the 0 – 20 cm soil layer, when the soil reached 50 % of field capacity. At each irrigation a mini boom irrigator applied 30 mm of water and a total of 120 mm was applied. The peas were sprayed with Alto (cyproconazole) 100 SL at 250 ml ha^{-1} to combat powdery mildew (*Erysiphe* spp) and with copper oxychloride at 1 kg ha^{-1} for downy mildew control.

Measurements and analysis

At 3 weeks after emergence (WACE) a 0.2 m^2 sample was taken from each plot using a 0.1 m^2 quadrat. Samples were used for weed measurements. Weeds were sorted by taxa (species or genus depending on similarity) and counted. Uncommon taxa were pooled and their total count recorded. A weed species was defined as major if it had a mean count of at least 10 weeds m^{-2} and as minor if it had a mean count of at least 2 plants m^{-2} but less than 10 plants m^{-2}. A weed species was defined as 'Others' if it had a mean of less than 2 counts m^{-2} and these were bulk-counted together.

All data were subjected to analysis of variance (ANOVA). Genstat 10.1. (Copyright 2007, Lawes Agricultural Trust, Rothamsted Experimental Station) was used for statistical analysis. Means were separated at the 5% level of significance using least significance difference (LSD) for sowing date main effects, herbicide, genotype and interactions.

Results

Climate

Climate data was from the Broadfields Meteorological Station about 1.5 km from the experimental site. The 2007/08 growing season was generally dry, with January rainfall being just 38% of the long-term average (Figure 1). Substantial rain fell at the end of the season in February (104 mm). The season was generally cool and mean temperatures, except in September, were lower than long-term means (Figure 2).

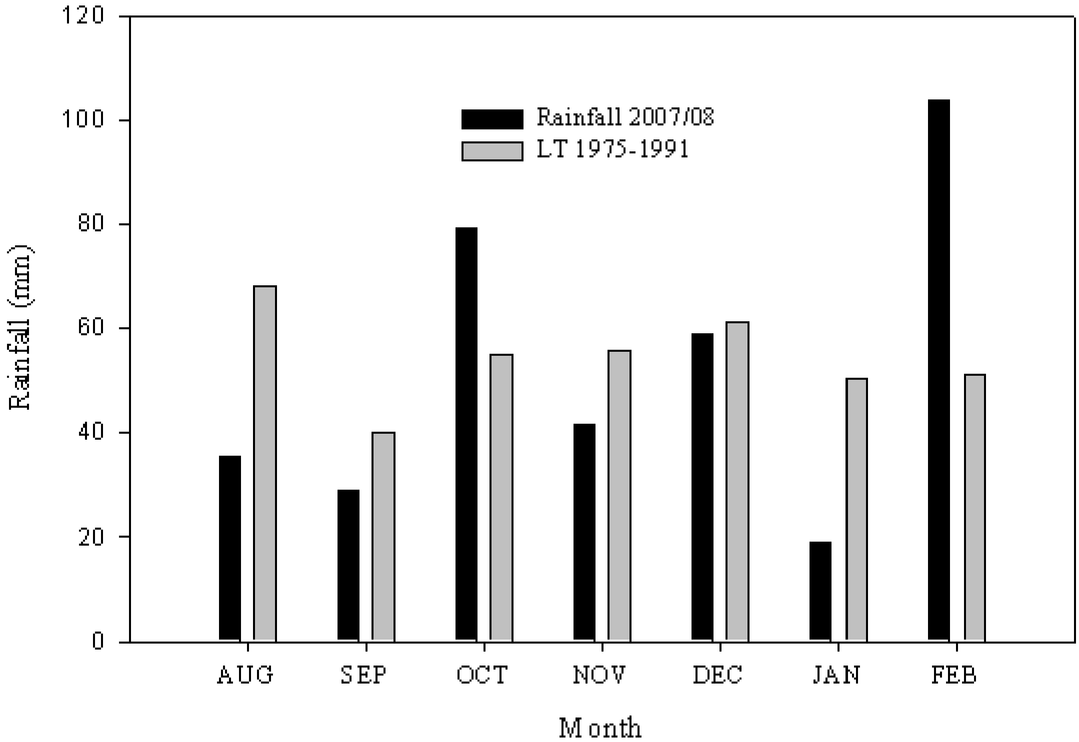

Figure 1: Rainfall data for Broadfields, Canterbury in the 2007/08 growing season and long-term mean 1975 – 1991.

Weed Spectrum

Weed counts were taken three times during the growing season and there was distinct variation in the weed spectrum over time. In the October count major weeds were *Coronopus* spp., *Lolium* spp., *Spergular arvensis* (spurrey), *Stellaria media* (chickweed), *Stachys* spp. (stagger weed) while *Achillea millefolium* (yarrow) were minor weeds. Other species present were *Rumex* spp, *Chenopodium* spp and *Cirsium arvense*. Pea genotype had no effect on counts of all weeds or the total count. However, sprayed plots had significantly lower weed counts than unsprayed plots of all but one major weed species and on *Achillea millefolium* a minor weed. In the October counts there were no significant interactions between any of the treatments (Table 2).

In November major weeds were *Coronopus* spp., *Stellaria media* (chickweed), *Urtica urens* (nettle), and *Rumex* spp. (docks) with means of 38, 18, 14, and 19 plants m^{-2} respectively (Table 3). Minor weeds were *Lolium* spp., *Spergular arvensis*, *Dactylis glomerata*, *Chenopodium* spp and *Capsella bursa-pastoris* (shepherd's purse). Other weeds present were *Erodium cicutarium* (storksbill), *Cirsium arvense* (Californian thistle), *Taraxacum officinale* (dandelion) *Ranunculus* sp. (Buttercup), *Polygonum aviculare*, *Hordeum murinum* (barley grass), *Bromus willdenowii* (prairie grass), and *Avena fatua* (wild oat). Generally weed counts were lower in sprayed than in unsprayed plots and there were several significant herbicide by pea genotype interactions for most major weeds. To summarise the interactions, the difference in weed counts between the cyanazine sprayed plots and unsprayed was highest in the no pea control plots, followed by Midichi plots and the lowest was in Pro 7035 plots.

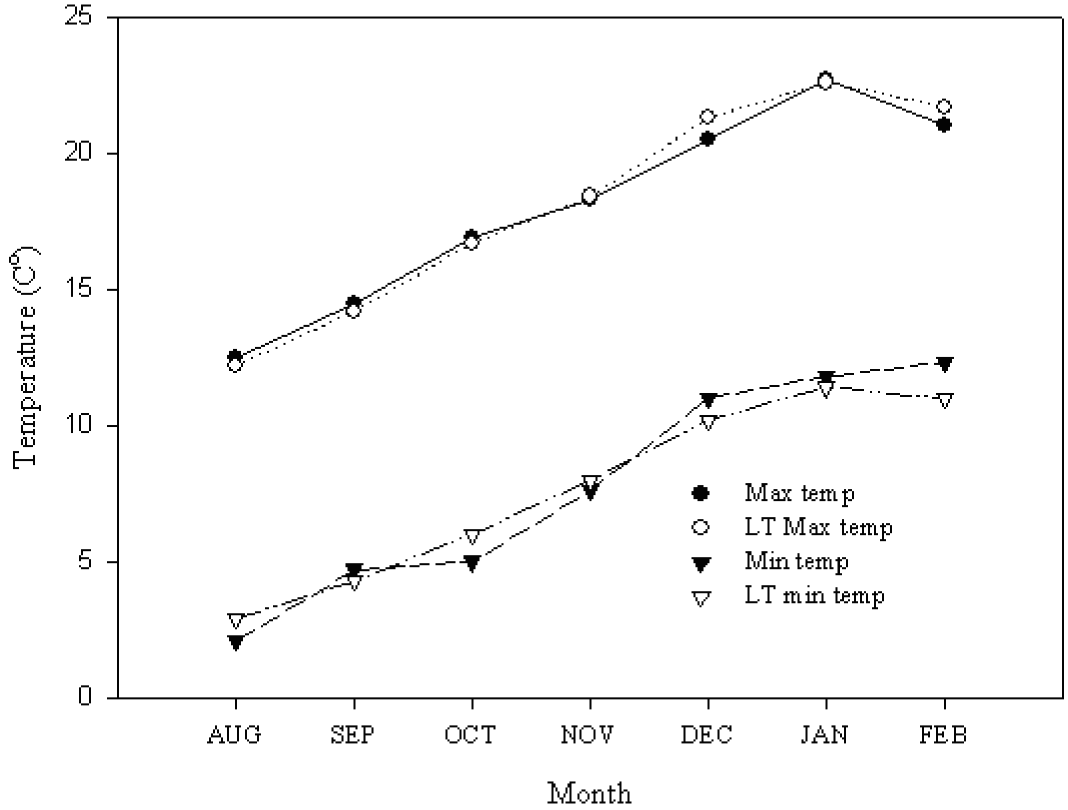

Figure 2: Temperature data for Broadfields, Canterbury in the 2007/08 growing season and the long-term mean 1975 – 1991.

In December major weeds were *Coronopus* spp., *Chenopodium* spp. *Rumex* spp., *Lolium* spp., *Stellaria media*, *Solanum* spp., and *Trifolium repens*. There were no minor weeds. The 'other' weeds were *Erodium cicutarium*, *Polygonum convolvulus* (cornbind), *Galium aparine* (cleavers), *Vicia sativa* (vetch), *Poa annua* (annual poa), *Festuca arundinacea* (tall fescue), *Elytrigia repens* (couch), *Taraxacum officinale* (dandelion) and *Avena fatua* (wild oat) (Table 4).

As in October, pea genotype did not influence weed counts. Herbicide had no effect on weeds counted except for *Coronopus* spp., and *Rumex* spp., where unsprayed plots had nearly three and eight times higher counts respectively than sprayed plots.

Discussion

Past crop history might have affected weed seed bank and environmental effects such as temperature probably caused the variation of weed spectrum at the different sowing dates. Environmental effects such as temperature might have caused variation in the weed spectrum at the different sowing dates. *Stellaria media* was present throughout the season and it grew well over a wide range of environments. Even early in the season, when temperatures were quite low, it was present in large numbers. This was due to its low reported base temperature (-3.3 ^{o}C) (Storkey and Cussans, 2000). Soil temperature is a primary determinant of seed germination and survival, especially where soil freezes. Air and soil temperature are therefore important determinants of species distribution and ecological interactions. Zimdahl (2007) reported that common chickweed survives well in cold climates because it continues to grow in the winter without injury. When the temperature is below freezing common chickweed is often erect, and it continues to flower although flowers are cleistogamous and the self-pollinated seeds formed are fertile. Similarly, Harker *et al.* (2007) reported that Red stem filaree (*Erodium* spp) germinated at relatively low soil temperatures and therefore could be a serious competitor of peas.

Another weed of similar interest was *Chenopodium album. Chenopodium album* is one of the most widely distributed weed species in the world and ranks among the top three important weeds of cereals in New Zealand (White and Hill, 1999; Isaac 2001). Contrary to the findings of Myers *et al.* (2004) that it is an early weed, in this research it was classified as a mid to late season weed.

Achillea millefolium was also classified as an early to mid season weed, and could have had a major role in reducing the yield of early sown peas. It is considered a common, successful, aggressive weed on arable land in New Zealand and can cause significant crop losses in a variety of crops by choking them out by its dense growth (Bourdôt and Field, 1988). Hartley *et al.* (1984) reported that the success of this weed is also attributed to its persistent, vigorous rhizomes. Bourdôt and Butler (1985) reported that it grew throughout the year and spread laterally, by rhizome extension, particularly in the winter months in Canterbury. Weeds classified as late were *Trifolium repens and Solanum* spp. Nightshades have a base temperate of 6 ^{o}C (Olivier and Annandale, 1998) and this explains why they usually grow late in the season when temperatures are warmer. Myers *et al.* (2004) also reported nightshades were late weeds. Isaac (2001), reported higher *Trifolium repens* counts in late sown crops than in early sown crops confirming that it is a late weed. The reason why it is a late weed could not be established but that could be linked to its seed size and perenniality.

It was also observed that grasses tended to be more prevalent later in the season than earlier. Isaac (2001) reported perennial weeds were more prevalent in late sown crops and these findings support this. These late weeds could do considerable damage to late sown peas. One such grass, *Avena fatua*, caused considerable damage to peas and was referred to as one of the greatest crop competitors of all. Contrary to this Blackshaw *et al*. (2007) reported *Avena fatua* emerged early in the spring, in Canada, and recommended producers delay seeding of spring sown crops to control the first flush of wild oat seedlings. However, they pointed out that this practice was seldom effective with weed community management because of the diversity of emergence patterns among different weed species.

Conclusions

Weed spectrum changed over the season. Early sowing could possibly control problem weeds of peas (particularly *Solanum* spp) by avoiding competition from this weed. Herbicide use can enhance yield but could be replaced by other effective cultural methods such as early sowing. *Coronopus didymus, Stellaria media* and *Lolium* spp were present in relatively large numbers throughout the season hence they need to be watched throughout the growing season.

Table 2: October weed counts (m^{-2}) in field peas grown in Canterbury in the 2007/08 growing season.

	Coronopus spp.	*Lolium* spp	*Spergula arvensis*	*Stellaria media*	*Stachys* spp.	Others	*Achillea millefolium*	Total count
Herbicide (H)								
0 g a.i. ha^{-1}	233	43	29	112	18.9	42	3	524
500 g a.i. ha^{-1}	39	9	1	40	3.3	19	2	116
Significance	***	***	**	*	NS	NS	NS	***
LSD		14	18	63	-	-	-	95
Type (T)								
No pea	128	20	13	68	15	33	5	282
Midichi	147	22	12	95	10	25	3	372
Pro 7035	133	37	20	65	8.3	33	0	307
Significance	NS	NS	NS	NS	NS	NS	NS	NS
LSD	-	-	-	-	-	-	-	-
Grand mean	136	26	15	76	11	31	3	320
CV (%)	45	52	112	78	160	67	204	28
Significant interactions	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Table 3: November weed counts (m^{-2}) of field peas grown in Canterbury in the 2007/08 growing season.

	Coronopus spp.	*Lolium* spp	*Spergula arvensis*	*Stellaria media*	*Chenopodium* spp	*Achillea millefolium*	*Urtica urens*	*Rumex* spp	*Capsella bursa-pastoris*	Others	Total count
Herbicide (H)											
0 g a.i. ha^{-1}	64	2	7	34	13	1	22	35	10	22	209
500 g a.i. ha^{-1}	12	3	1	2	4	2	6	3	2	21	55
Significance	***	NS	*	***	*	NS	***	***	*	NS	***
LSD	11	-	5	7	9	-	5	6	6	-	26
Type (T)											
No Pea	59	2	7	17	17	1	19	30.6	6	26	184
Midichi	21	3	3	22	3	2	22	16	1	8	101
Pro 7035	34	1	2	16	6	2	1	9	11	29	111
Significance	***	NS	NS	NS	***	NS	***	***	*	**	***
LSD	14	-	-	-	11	-	6	7	8	13	32
Grand mean	38	2	4	18	8	2	14	19	6	21	132
CV (%)	54	134	231	71	199	299	67	55	187	90	36
Significant interactions	HxT*	HxT*	Nil	HxT*	Nil	Nil	HxT***	HxT***	Nil	HxT**	HxT**

Table 4: December weed counts (m^{-2}) of field peas grown in Canterbury in 2007/08 growing season.

	Coronopus spp.	*Chenopodium* spp.	*Rumex* spp	*Lolium* spp	*Stellaria media*	*Solanum* spp	*Trifolium* spp	Others	Total counts
Herbicide (H)									
0 g a.i. ha^{-1}	61	17	26	20	19	27	66	31	266
500 g a.i. ha^{-1}	22	7	3	9	9	8	27	9	93
Significance	**	NS	***	NS	NS	NS	NS	NS	*
LSD	23	-	10	-	-	-	-	-	105
Type (T)									
No pea	53	12	18	5	12	23	77	20	220
Midichi	40	15	17	23	10	15	10	18	148
Pro 7035	32	8	8	15	20	13	52	22	170
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD	-	-	-	-	-	-	-	-	-
Grand mean	42	12	14	14	14	17	46	20	179
CV (%)	54	172		148	155	137	144	129	56
Significant interactions	Nil	Nil	HxT*	Nil	Nil	Nil	Nil	Nil	Nil

References

Barrett, M., and Witt, W.W. (1987). Alternative pest management practices. In Energy in Plant Nutrition and Pest Control (Z. R. Helsel, ed.), Vol. 2, pp.197-234 Elsevier Press, Netherlands.

Blackshaw, R.E., Anderson, R.L., and Lemerle, D. (2007). Cultural weed management. In Non-Chemical Weed Management, Principles, Concepts and Technology (M.K. Upadhyaya and R.E. Blackshaw, Eds). pp 35-47. Agriculture and Agri-Food Canada, Lethbridge.

Bourdôt, G.W., and Butler, J.H.B. (1985). Control of *Achillea millefolium* L. (yarrow) by rotary cultivation and glyphosate. *Weed Research* 25, 251-258.

Bourdôt, G.W., and Field, R.J. (1988). A review of the ecology and control of *Achillea millefolium* L. (yarrow) on arable in New Zealand *New Zealand Journal of Experimental Agriculture* 16, 99-108.

Harker, K.N. (2001). Survey of yield losses due to weeds in central Alberta. *Canadian Journal of Plant Science* **81**, 339-342.

Harker, K. N., Blackshaw, R E., and Clayton, G.W. (2007). Wild oat (*Avena fatua*) vs redstem filaree (*Erodium cicutarium*) interference in dry pea. *Weed Technology* 21, 235-240.

Hartely, M.J., Lyttle, L.A., and Popay, A.I. (1984). Control of Carlifonia thistle by grazing management. *Proceedings 37th New Zealand Weed and Pest Control Society Conference* pp 24-27.

Isaac, W. A. P. (2001). Contribution of crop morphological characteristics and density of selected crops to weed species composition and suppression. Unpublished MAgrSc thesis, Lincoln University, Canterbury, New Zealand.

Khan, M., Donald, W.W., and Prato, T. (1996). Spring wheat (*Triticum aestivum*) management can substitute for diclofop for foxtail (*Setaria* spp) control. *Weed Science* 44, 362-372.

Munakamwe, Z. (2004). Studies to reduce weed pressure in maize-legume intercrops by using reduced herbicide levels and effective basal fertilizer placement methods. Unpublished MSc. thesis, University of Zimbabwe, Harare.

Myers, M.W., Curran, W.S., van Gessel, M.J., Calvin, D.D., Mortensen, D. A., Majek, B.A., and Karsten, D.H. (2004). Predicting weed emergence for eight annual species in the northeastern United States. *Weed Science* 52, 913-919.

New Zealand Soil Bureau (1968). General survey of the soils of the South Island, New Zealand. *Soil Bureau Bulletin* 27.

Olivier, F.C., and Annandale, J.G. (1998). Thermal requirements for the development of green pea (*Pisum sativum*.L.). *Field Crops Research* 56, 301-307.

Radosevich S., Holt, J., and Ghersa, C. (1997). Weed Ecology - Implications for Management, 2nd.Ed. Johns Wiley & Sons, New York. pp 589.

Storkey, J., and Cussans, J.W. (2000). Relationship between temperature and the early growth of *Triticum aestivum* and three weed species. *Weed Science* 48, 467-473.

White, J.W., and Hill, G.D. (1999). Grain Legumes. *In* New Zealand Pasture and Crop Science (J. White and J. Hodgson, Eds), pp 235-247. Oxford University Press, Auckland.

Zimdahl, R. L. (2007). Fundamentals of Weed Science. 3rd Ed. Academic Press, London.