ESTABLISHMENT AND GROWTH OF CHICORY (*CICHORIUM INTYBUS*) UNDERSOWN IN CONVENTIONALLY CROPPED CEREALS

Anita GUNNARSSON
R&D Dept., Hushållningssällskapet Skåne (Rural Economy and Agriculture Society Scania),
Box 9084, 291 00, Kristianstad, Sweden
Email: Anita.gunnarsson@hushallningssallskapet.se

Abstract. *Chicory is suitable as an undersown catch crop for several reasons, but establishment in conventional cropping systems is often unsatisfactory. This project examined establishment of chicory undersown in conventional cereals. Field trials were performed in summer barley and winter wheat, combined with evaluations of tests conducted by practical farmers in their fields (seven fields of cereals). In summer barley, early sowing on the soil surface followed by rolling (ESR) gave more chicory plants and more biomass than early sowing with seed incorporated with coulters or late sowing on the surface. With ESR as sowing method, weed harrowing gave the best results for chicory establishment and biomass (34 plants m^{-2} and 1520 kg fresh weight ha^{-1}) and an equivalent weed effect to herbicides. Harmony Plus was the most selective herbicide and Starane XL, Hussar and Legacy were the least selective. After winter wheat, number of chicory plants and amount of biomass in October were greater when herbicides (Baccara or Lexus WG + Boxer EC + Legacy) were used only in the autumn. After summer barley, chicory biomass in October was deemed too low to achieve the desired effect on N losses, soil structure and improvement of soil organic matter except on one farm, in an irrigated winter barley field where chicory was undersown in early April and herbicides were only used in autumn (2.1 tonnes chicory dry matter ha^{-1}). Therefore further research should focus on these conditions. Another conclusion was that combining a few field trials with evaluation of tests carried out by farmers in their own fields can increase knowledge faster than working with field trials alone.*

Key words: e*stablishment, chicory, undersown, cereals.*

INTRODUCTION

Chicory has been found to be suitable as undersown catch crop because it does not reduce yield of the cereal main crop but grows fast in autumn after cereal harvest [1],[2]. It is more effective in capturing nitrogen (N) from leaching than ryegrass because the roots penetrate further into the soil (2.5 m compared with 1 m for ryegrass [3]) and provides fast return of plant-available N to the next crop [4]. Chicory has, at least as a perennial crop, also been proven to improve structure, e.g. four years of chicory gave a better pre-pre-crop effect than red clover and alfalfa leys in a compacted soil [5]. Chicory is easy to establish when undersown in organically grown cereals, but in conventional cropping establishment is often unsatisfactory. The aim of this project was to examine establishment of chicory undersown in conventional cereals.

MATERIALS AND METHODS

Establishment of chicory (seed rate 4 kg ha^{-1}) was studied in field trials in spring barley with a split block design [6], with four blocks, three establishment methods in columns and 12 weed control methods in rows. Establishment methods were: early sowing on the surface followed by rolling (ESR), early sowing with seed incorporated with conventional seed coulters (ESI) and late sowing on the surface (LS). Dates for sowing were 6 May in ESR and ESI (26 days after sowing of barley [DAS]) and 16 June in LS (57 DAS; cereal development stage, decimal code (DC) 37). The weed control methods were: untreated control, weed harrowing at DC 13 (2 May) and 10 regimes with chemical herbicides applied on 7 May.

Two more field trials with chicory undersown in winter wheat were performed in trials originally designed for examining control of common windgrass (*Apera spica-venti*) and dicot weeds. Furthermore tests carried out by five commercial farmers, using a strip design without replicates in their practical fields, were evaluated. In these farmers' tests, chicory was undersown (rate 4 kg ha^{-1}) in seven fields of cereals: spring barley (1), winter barley (1), winter wheat (2), winter rye (2) and triticale (1). There were no weed harrowing treatments for comparison in the winter wheat field trials or the farmers' tests.

RESULTS AND DISCUSSION

ESR gave the highest number of chicory plants (34 chicory plants m^{-2}; $p<0.01$) and largest amount of biomass (1.5 t ha^{-1} of fresh biomass ≈ 150 kg dry matter (DM) ha^{-1}; $p<0.01$) at the end of October (64 days after harvesting of barley) (Table 1). However, in 22 previous Swedish trials with undersown ryegrass as a catch crop in summer barley, the aboveground biomass was 1040 kg DM ha^{-1} [7], i.e. seven-fold the amount we achieved in the field trial with chicory undersown in barley. Weed harrowing gave the best results for chicory establishment and an equivalent weed control effect to herbicides.

In the rows without weed control there were 13 plants m^{-2}, in the weed harrowed rows 35 plants m^{-2} and in the rows with chemical herbicides 3-18 plants m^{-2}. The higher number of plants in weed harrowed plots compared with the untreated control and also compared with the herbicide treatments indicates that the positive effect of improved seedbed conditions obtained by weed harrowing overshadowed the negative effects of herbicides on survival of plants. However, the fewer plants in the other treatments compared with weed harrowing were partly compensated for by faster growth per plant, resulting in biomass only being significantly lower with chemical weed control by Starane XL, Hussar and Legacy compared with the weed harrowing treatment. In the Harmony Plus plots, the number of chicory plants was not significantly reduced compared with weed harrowing, but biomass was 25% lower (difference not significant).

Table 1

Summary of one-way ANOVA results for the establishment method of early sowing on the surface followed by rolling (ESR). Number of chicory plants, biomass (fresh weight) and weed cover on 16 October (barley harvested 13 August). Values within columns followed by different letters are significantly different ($P<0.05$; Tukey's test)

Weed control: Dose, method	Chicory plants		Weed cover (0-100)
	No. m^{-2}	g m^{-2}	
Untreated	13.0 b	84.0 ab	10.5 a
Weed harrowed, DC 13	34.5 a	152.5 a	5.0 b
2 Ariane S[1]	5.0 b	42.0 ab	6.2 ab
1 Starane XL[2]	3.0 b	19.5 b	5.0 b
12 g Express 50 SX[3]	11.5 b	96.5 ab	5.2 b
100 g Hussar[4]	4.0 b	19.5 b	5.5 ab
1,5 MCPA[5]	8.0 b	57.0 ab	6.8 ab
15 g Gratil 75 WG[6]	6.5 b	46.0 ab	5.5 ab
0.4 Starane 180[7]	8.0 b	46.5 ab	5.5 ab
75 ml Primus[8]	12.5 b	84.5 ab	4.8 b
15 g Harmony Plus[9]	17.5 ab	114.5 ab	5.8 ab
0.15 Legacy[10]	7.0 b	26.0 b	5.8 ab
P-value	0.000	0.009	0.042
Tukey's HSD	19.1	120.7	5.2
R^2 (%)	73	66	72
R^2 adjusted (%)	58	51	60
SEM	3.8	24.3	1.0
CV, %	71	74	35

Active substances: concentration in g/L, g/kg or %: [1)] MCPA + klopyralid + fluroxipyr (200 + 20 + 40g); [2)] Fluroxipyr + florasulam 100 + 2,5 g; [3)] Tribenuron methyl 50 weight-%; [4)] Iodosulfuron (50 g); [5)] MCPA (750 g); [6)] Amidosulfuron (75 weight-%) ; [7)] Fluroxipyr (180 g); [8)] Florasulam (50 g L^{-1}); [9)] Tribenuron methyl + thifensulfuron methyl (17 + 33 weight-%); [10)] Diflufenican (500 g)

In the field trials in winter wheat, chicory had most plants and biomass when herbicides were used only in the autumn (1.25 Baccara or 50 g Lexus WG + 1.5 Boxer EC + 15 g Legacy + surfactant), although Harmony

Plus had acceptable selectivity for chicory (results not shown; for details see [8]). Early sowing of chicory in the spring was an advantage compared with waiting until after the chemical weed treatments in the spring. In the best treatments in winter wheat, the number of chicory plants was equivalent to that achieved with the best treatments in summer barley. The biomass was less than half that in summer barley, but the measurements were made in late August-early September and should therefore not be compared with those in barley, which were made on 16 October.

Farmers' field tests indicated that undersowing of chicory in spring barley higher than 15 cm gave poor establishment of chicory. These tests also showed that a good water supply was important for the ability of the chicory seedlings to compete with the cereal plants.

Of all field trials and farmers' tests, chicory achieved the greatest biomass in October (2.1 t DM ha^{-1}) in a farmer's test field with winter barley where the chicory was sown with disc coulters in early April in good soil moisture conditions, the barley crop was irrigated and the barley was harvested early. Herbicides were only used in the autumn (1.7 Boxer + 0.7 Baccara). According to the farmer, the barley was relatively weak in spring but the yield was good.

CONCLUSIONS

In spring barley field experiment:

- early sowing followed by rolling (ESR) in combination with weed harrowing gave the best results for chicory establishment and growth and an equivalent weed control effect to the best herbicide regimes
- Harmony Plus was the most selective herbicide and Starane XL, Hussar and Legacy were the least selective.

Chicory biomass in October after barley was deemed too low to give the desired effect on N losses, soil structure and improvement of soil organic matter. The only exception to this was in a farmer's test in an undersown in the beginning of April and herbicides were only used in autumn. Therefore further research should irrigated winter barley field, where chicory was focus on these kinds of conditions.

Another conclusion was that combining a few field trials with evaluation of tests carried out by farmers in their own fields increased knowledge faster than working with field trials alone.

ACKNOWLEDGEMENTS

I am grateful to The Royal Swedish Academy of Agriculture and Forestry (KSLA) and Skåneförsöken (through The Swedish Farmers' Foundation for Agricultural Research, SLF), which funded the work, and to Henrik Hallqvist (Swedish Board of Agriculture), who gave important inputs concerning, among other issues, the herbicide regimes.

REFERENCES

1. Karlsson Strese E.M., Umaerus M. and Rydberg I. (1996) Strategy for catch crop development I. Hypothetical ideotype and screening of species. *Acta Agriculturae Scandinavica Section B-Soil and Plant Science* 46(2):106-111.
2. Karlsson-Strese E.M., Rydberg I., Becker H.C. and Umaerus M. (1998). Strategy for catch crop development II. Screening of species undersown in spring barley (*Hordeum vulgare* L.) with respect to catch crop growth and grain yield. *Acta Agriculturae Scandinavia Section B-Soil and Plant Science* 48(1): 26-33.
3. Rydberg I. (1998). Influence of undersown catch crops on yield of spring barley and amount of leachable nitrogen. Uppsala, Sweden: *Agraria* 107. Doctoral thesis. Swedish University of Agricultural Sciences.
4. Thorup-Kristensen K. (2006). Effect of deep and shallow root systems on the dynamics of soil inorganic N during 3-year crop rotations. *Plant and Soil* 2006 288(1-2):233-248.
5. Löfkvist J. (2005). Biological sub-soiling – field trials testing the ability of six different species to act as subsoilers. *Paper III in Modifyling soil structure using plant roots. Doctoral thesis,* 60. Uppsala: Swedish University of Agricultural Sciences.
6. Forkman J. (2012) *Handbok i statistik för fältförsök 2012*. SLU, Fältforsk. 67 pp. Available the 1 March 2015 at: http://www.slu.se/PageFiles/37382/Fhandbok/Handbok_Statistik_v4.pdf.

7. Wallgren, B. and Lindén, B. (1993). Fånggrödors och plöjningstidpunkters inverkan på kvävemineralisering och kväveupptagning. *Rapport nr 45, Institutionen för Växtodlingslära, Sveriges Lantbruksuniversitet*.
8. Gunnarsson, A. (2014). Etablering av Cikoria (*Cichorium intybus*) undersådd i konventionell höst- och vårsäd. *Hushållningssällskapet i Kristianstad. Rapport nr 3*, 2014 (29 sid). Available at www.hushallningssallskapet.se