EVALUATION OF ENERGY USAGE FOR MACHINERY OPERATIONS IN THE DEVELOPMENT OF CEREAL CLOVER BICROPPING SYSTEMS.

J V G DONALDSON, J HUGHES, S D DIXON

IACR Long Ashton Research Station, Department of Agricultural Sciences, University of Bristol, Long Ashton, Bristol, BS18 9AF. UK.

R O CLEMENTS

IGER, North Wyke Research Station, Okehampton, Devon, EX20 2SB. UK.

ABSTRACT

The adoption of a Wheat Clover bicropping system in its initial establishment year shows increased energy usage (and a significant loss in crop production) compared with conventional grown wheat, large savings in energy usage are made in later years particularly when second and subsequent (continuous wheat) crops are grown; in these crops the savings in labour and machinery costs alone will virtually offset the loss of crop value due to lower output each year whilst the bicropping system remains viable.

INTRODUCTION

A joint project (AIR 3 CT 93-0893) between five European Contractors began in the Spring of 1994 to study the exploitation of a sustainable low-input and reduced-output system for arable crops. Four of the sites (including IACR - Long Ashton) would study large-scale whole system testing to compare winter wheat grown over a 3 year period; the wheat would be grown with or without a clover understorey.

In the Spring of 1993, two fields in grass leys of approximately 4 ha each were designated for the project. After the first silage cut in May 1993 one field would be glyphosated, ploughed and then sown to a clover ley, subsequently this field would be direct seeded, using a Hunter Rotaseeder, to winter wheat in October 1993. The comparison field would receive fertiliser for a further cut for silage during the summer and then would be glyphosated, ploughed and sown to winter wheat using conventional farm cultivators and drills. This field would then be managed according to local best farming practice to maximise output.

This paper ascribes an Energy Value Factor for each mechanical operation in each field to allow comparisons to be made between the two systems, to ensure that the concept of "low-input" is true in terms of "energy" as well as the financial cost of variable inputs of fertiliser, pesticides etc.

MATERIALS AND METHODS

The Energy Value Factor (Donaldson *et al,* 1994) is calculated according to the formula

$$\underset{(kW\ hr^{-1}\ ha^{-1})}{\textit{Energy Factor}} = \frac{\textit{Tractor (kW) power required} \times 10}{\underset{\textit{Speed}}{\textit{Forward}}\ (km\ hr^{-1}) \times \underset{\textit{Width}}{\textit{Implement}}\ (m) \times \dfrac{\textit{Field Efficiency (\%)}}{100}}$$

This formula has already been successfully applied to measure the farming systems comparison in the Long Ashton Research Station LIFE experiment (Jordan & Hutcheon, 1994 and Donaldson *et al,* 1994). A tractor of suitable size (kw) is chosen to match the working requirements of the implement, the forward speed (km hr^{-1}) is measured mid run, and a figure for field efficiency (Witney, 1988) is calculated but with reference to local practice and experience. The working width of the implement (m) will be the effective working width, for example the working width of a baler is not the width of the balers pick-up reel but the width of crop cut from which the swath was produced.

All field operations for both fields were recorded in diary form, with all the relevant information required to calculate the Energy Factor for each mechanised operation.

After harvest of the grain, the straw is baled and removed in the bi-cropping field, the clover is allowed to grow and is then grazed tightly by sheep to achieve minimum impedance to the Rotaseeder when drilling the winter wheat. (Depending on the growth of the clover, it could be cut and baled for silage in early September.)

RESULTS

Using the above guidelines energy usage figures were calculated for the two fields for the establishment year, the first wheat crop and where necessary predicted for the second wheat crop.

As 1995 figures are as yet not to hand it is assumed that a conventionally grown second wheat will yield 12.5% less than a first wheat (Nix 1994). It is further assumed that the yield of the bicropped wheat in the second year is likely to be comparable with the yield in the first year.

TABLE 1. Energy factors for each operation during the establishment year, March 1993 - September 1993

Operation	Energy Factor (kw hr^{-1} m ha^{-1})	
	Conventional	Bicropping
Top dressing	14	14
Round-up (glyphosate) spray	-	10
First cut silage	149	149
Mow	(33)	(33)
Ted	(31)	(31)
Row up	(43)	(43)
Big bale	(36)	(36)
Remove bales	(6)	(6)
Top dressing	14	-
Plough	-	114
Springtine	-	32
Speedkult	-	26
Ring roll	-	21
Drill clover	-	31
Ring roll	-	28
Herbicide spray	-	10
Second cut silage	149	-
Round-up spray	10	-
Top clover	-	36
Top clover	-	36
TOTAL	**336**	**507**

( ) - Included in total above - First cut silage

TABLE 2. Energy factors for each operation when growing first wheat crop, September 1993 - August 1994.

Operation	Energy Factor (kw hr^{-1} ha^{-1})	
	Conventional	Bicropping
Plough	114	-
Springtine	32	-
Speedkult	26	-
Drill winter wheat	33	-
Direct drill winter wheat	-	57
Chain harrow	-	12
Basal fertiliser	14	14
Herbicide Spray	-	10
Top Dressing	14	-
Herbicide spray	10	-
Top dressing	14	14
Herbicide/fungicide spray	10	-
Growth regulator spray	10	-
Fungicide spray	10	-
Aphicide spray	10	10
Combine	54	39
Big bale straw	36	30
Remove bales	6	4
TOTAL	**393**	**190**

TABLE 3. Energy factors for each operation when growing of second wheat crop, September 1994 - August 1995.

Operation	Energy Factor (kw hr^{-1} ha^{-1})	
	Conventional	Bicropping
Sub soil	77	-
Ring roll	21	-
Plough	98	-
Springtine	32	-
Speedkult	26	-
Drill winter wheat	33	-
Direct drill winter wheat	-	57
Herbicide spray	-	10
Herbicide & aphicide spray	10	-
Slug pellets	-	4
Basal fertiliser	14	14
Top dressing	14	-
Herbicide spray	-	10
Growth regulator spray	10	-
Top dressing	14	14
Fungicide spray GS 35	10	-
Herbicide spray	10	-
Top dressing	14	-
Fungicide spray GS 39-45	10	10
Fungicide spray GS 59	10	-
Combine	54	39
Big bale straw	36	30
Remove straw	6	4
TOTAL	**499**	**192**

GS - Growth Stage

TABLE 4. Total Energy factors for each season

Year	Energy Factor (kw hr^{-1} ha^{-1})	
	Conventional	Bicropping
1. Clover establishment/ silage production	336	507
2. First wheat crop	393	190
3. Second wheat crop	499	192
TOTAL	**1228**	**889**
Percentage %	100	72

TABLE 5. Crop Production/Value for each system

Year/Crop	Conventional		Bicropping	
	t/ha	Value £/ha	t/ha	Value £/ha
1. First cut silage	21.3	479.25	21.3	479.25
Second cut silage	14.4	324.00	-	-
Autumn grazing (Sheep)	-	-		37.50
Sub Total		**803.25**		**516.75**
2. First wheat crop				
Grain	8.27	909.70	4.86	534.60
Straw	4.70	94.00	1.65	33.00
Autumn grazing (Sheep)	-	-	-	37.50
Sub Total		**1003.70**		**605.10**
3. Second wheat crop (Estimated figures[1])				
Grain	7.24	796.40	4.86	534.60
Straw	3.56	71.20	1.65	33.00
Autumn grazing (Sheep)	-	-	-	37.50
Sub Total		**867.60**		**605.10**
TOTAL		**2674.55**		**1726.95**
Percentage %		100		65

DISCUSSION

The summary of energy usage figure for the first three years (Table 4) show that overall considerable energy savings are being made on mechanical operations in the bicropping system, some 28% less than in the conventional system.

In the initial establishment year (Table 1), the bicropping has a higher total energy factor due to the mechanical operations for establishing the clover; this also coincides with the loss of crop production (second cut silage) that is obtainable in the conventional system.

In the second season when first wheat crops are grown, savings in energy usage are seen in the bicropping system (Table 2); in this system the wheat is established by non-inversion tillage using the Rotaseeder, further savings are made through less interventions to apply pesticides, plant growth regulators and the number of Nitrogen top dressings.

The third season of cropping, with second wheat also shows the same savings as the second year for the bicropping system, although the conventional system does show a somewhat higher energy use due to the need to sub soil. However the saving of energy usage of over 60%, 192 compared to 449 kW hr^{-1} ha^{-1} has to be set against a loss of crop production value of about 30%, £605 compared to £867 for the conventional - a smaller reduction than with the first wheat when the conventional crop produced over £1,000 ha^{-1} output.

If the energy factor figures are used as an indicator of fixed costs (excluding rents) then according to Nix (1994) an arable farm of 100-200 ha would have labour, power and machinery costs in the order of £370 ha^{-1}, a 60% saving on which would represent £220 ha^{-1} thus virtually negating the crop production value loss on the bi-cropping system when growing second and subsequent wheat crops.

REFERENCES

Donaldson, J. V. G; Hutcheon, J. A; Jordan, V. W. L; Osborne, N. J. (1994) Evaluation of energy costs for machinery operations in the developments of more environmentally benign farming systems. *Aspects of Applied Biology 40, Arable farming under CAP reform*. pp 87-92.

Jordan, V. W. L; Hutcheon, J. A. (1994) Economic viability of less-intensive farming systems designed to meet current and future policy requirement: 5 year summary of LIFE project. *Aspects of Applied Biology 40, 1994. Arable farming under CAP reform*. pp 61-68.

Nix, J. (1993) Farm Management Pocket Book (24th edition 1994). Wye College, University of London.

Nix, J. (1994) Farm Management Pocket Book (25th edition 1995). Wye College, University of London.

Witney, B. (1988) Choosing and Using Farm Machinery. *Longman Scientific & Technical*. pp 412.

HETEROPTERA DISTRIBUTION AND DIVERSITY WITHIN THE CEREAL ECOSYSTEM

S.J. MOREBY

The Farmland Ecology Unit, The Game Conservancy Trust,
Burgate Manor, Fordingbridge, Hampshire, SP6 1EF, U.K.

ABSTRACT

Heteroptera are one of the many arable insect groups that use the crop during part of their annual life cycle. Within British agriculture Heteroptera are not generally regarded as cereal pests and can even be termed "beneficial" with respect to their occurrence in the diet of many farmland bird species. Farming practices can make the field a harsh, inhospitable environment for non-target arthropods and this paper details the movement and distribution of Heteroptera within cereal fields during the summer. Possible benefits of integrated control methods for Heteroptera are discussed.

INTRODUCTION

On farmland, all or part of the life-cycles of many arthropod species, depend on non-cropped habitats for shelter and food at some time of the year. However uncropped areas (excluding woodland) can account for as little as 2% of habitats on farmland (Sotherton 1984) Agricultural practices can make arable fields harsh, inhospitable environments. However many non-pest species are found in, and are often reliant on the crop habitat during one or more life stages. Many arable insect species from a wide variety of Orders and Families e.g. ground beetles (Coleoptera: Carabidae) use the crop during part of the year and another, less well studied group exhibiting similar spatial and temporal patterns are the plant bugs (Hemiptera: Heteroptera).

The Heteroptera contain many species which overwinter in non-cropped habitats and then disperse from the field boundary into the field during the spring and summer when the crop and associated weed flora can provide a temporary but favourable habitat. In Britain Heteroptera are not generally regarded as cereal pests, and can even be termed "beneficial" because of their occurrence in the diet of many farmland birds (Potts, 1986). This paper uses Heteroptera as an example of a non-pest group and details their movement and distribution within cereal fields during the summer.

MATERIALS AND METHODS

Study area

The study was carried out on an 11 km² arable estate in northern Hampshire between 1983-85 on which up to 65% of the area was sown to cereals. The estate was sub-divided into three discrete areas by natural barriers (roads and a railway embankment). Each area contained a block of cereal fields which were sprayed in accordance with the normal farming practice and a block in which the headlands were selectively sprayed according to the guidelines laid down for Conservation Headlands (Rands, 1985; 1986; Sotherton *et al.*, 1989).

Spatial distribution

Heteroptera samples were collected 3m into cereal field headlands and 12m and 50m into the field. Samples were collected with a $0.2m^2$ sweep net and 50 sweeps were taken at each distance. They were collected on, or around, the 23 June each year. To reduce possible variation between fields all sampling was carried out over a six-hour period (10 a.m.-4 p.m.) by the same individual. In the three years of the study a total of 36, 34, and 33 fields were sampled respectively. All Heteroptera were identified to species. Analysis was carried out on the numerically dominant species *Calocoris norvegicus* and four groups or guilds containing two or more species; grass-feeding Stenodemini, predatory Nabidae and *Anthocoris* spp., total *Other* species and the total number of Heteroptera.

All blocks contained three crop types (spring barley, winter barley and winter wheat) and each block had a minimum number of four fields of each crop. For each heteropteran group, differences between crop types, pesticide regimes and distances into the field were compared. The collected data were transformed (log n+1), and analyses of variance (ANOVA) using genstat 5 (Genstat 5 Committee) were carried on the transformed means for pesticide regimes, crop types and distance.

RESULTS

Between cereal crop types

Out of 45 comparison analyses conducted to detect significant differences in mean numbers of Heteroptera between the three crop types during 1983-85, only three such tests were significant. No differences were found in 1983. In 1984 significantly more predatory species occurred in winter wheat compared to winter barley ($P<0.05$); and in 1985 both spring barley and winter wheat contained significantly more *Other* species compared to winter barley ($P<0.01$) (Tables 1-3).

Between pesticide treatments on headlands

Higher numbers of Heteroptera were found in the headlands where selective pesticide inputs were used compared to those that were fully sprayed. However few of these differences were significant. In 1983 three groups were significantly more numerous in the selectively sprayed fields, namely *C. norvegicus* and Total Heteroptera ($P<0.05$), and *Other* species ($P<0.01$) (Table 1). In 1984, this was the case for *C. norvegicus* and Total Heteroptera ($P<0.05$) (Table 2). No differences were detected between treatment regimes in 1985 (Table 3).

Spatial distribution within fields

All the heteropteran groups were found in higher numbers at 3m into cereal fields compared to distances further into the crop and in most cases these densities were significantly greater than those found at 12m and 50m. Densities at 12m were also often higher than those found at 50m with many of the differences being significant (Tables 1-3).

DISCUSSION

Cereal fields are temporary habitats in arable ecosystems existing for only 6-9 months during which time destructive and disruptive events (pesticide applications, cultivations, harvesting) occur. Arable field-dwelling Heteroptera therefore are generally restricted to species that overwinter in the field boundary and move into the developing crop in spring or early summer when the crop-weed species form a suitable habitat (Moreby, 1994). Of the Heteroptera species or groups studied, only *C. norvegicus* successfully exploited cereal crops as a food source after the newly hatch nymphs moved out of the field boundary in the early summer. The unlimited supply of suitable food plants, (cereals and weed species) and the dilution effect with movement into the crop could explain the significant differences in densities between distances close to and far from the overwintering site. The grass-feeding Stenedomini, seemed to be dependent for food on tall grass species such as *Poa trivialis*, *Alopecurus myosuroides* and *Lolium* spp. and were not able to use the developing cereal as a suitable food source (Moreby, 1994). The groups of predatory Heteroptera and *Other* Heteroptera were also most numerous at 3m, but very low densities were found at all sites, particularly 12m and 50m. The scarcity of individuals could have resulted in most distance comparisons being non-significant. The final group, total Heteroptera, closely mirrored the distribution patterns found for *C. norvegicus* due to the numerical dominance of this single species over all the other groups.

While it undoubtedly failed to collect many individuals, the use of a sweep net as the method of collection did allow good comparisons to be made between sites and distances for *C. norvegicus* and the Stenedomini because these were predominantly found feeding on the higher, more nutritious parts of their food plants. However, while the predatory and other Heteroptera were predominantly to be found on the crop floor or low down in the cereal canopy on the weeds these two groups could have been greatly under-estimated. However similarly low densities were found in cereal field headlands at 3m (Moreby, 1994) using a D-Vac suction sampler (Dietrick, 1961).

The different cereal varieties did not seem to affect numbers of Heteroptera to any significant degree. However, favourable weather conditions resulting in an early ripening crop such as winter barley could result in the cereal quickly declining in suitability in July-August. Growth/development trials conducted throughout the summer found significantly greater survival of *C. norvegicus* on cereals, ranked in the order of spring barley - winter wheat - winter barley (Moreby S.J., unpub. data).

Direct or indirect decreases in numbers of many beneficial and other non-target arthropods caused by pesticide use are well documented (Potts & Vickerman, 1974; Vickerman & Sunderland, 1977; Coombes & Sotherton, 1986; Potts, 1986; Sotherton *et al.*, 1987; Inglesfield, 1989; Somerville & Walker, 1990; Chiverton & Sotherton, 1991; Davis *et al.*, 1991). Toxic effects of pesticides against Heteroptera are less well studied. Direct effects of fungicides and herbicides lead to low levels of mortality. However herbicides can cause significant indirect mortality via their effect on food plants (Moreby, 1991; 1994). As a result, the lower numbers of Heteroptera in the fully sprayed fields were not unexpected. Insecticides commonly used to control cereal aphids have also been shown to be toxic to Heteroptera (Moreby, 1991).

The use of integrated control methods has the potential of increasing numbers of cereal-dwelling Heteroptera, and reduced pesticide rates and/or the use of more selective compounds, particularly insecticides, would benefit Heteroptera directly. Enhancement of natural enemies to reduce insecticide application against Aphididae would have benefits on heteropteran survival and the resulting biocontrol would only have a limited impact on Heteroptera as many aphid-specific predators, such as the larvae of Syrphidae, Coccinellidae and Neuroptera prey on sedentary colonies of aphids rather than individual, relatively fast moving heteropteran nymphs. Planting of flower-rich strips to attract winged, beneficial species could also provide a supplementary food source particularly if planted next to early ripening cereals such as winter barley. However the use of less nitrogen could reduce the nutritional quality of the cereal and as for cereal aphids, Heteroptera could find cereals in such farming systems employing low levels of nitrogen fertiliser less suitable as host plants for shorter periods. Later sowing of crops could have benefits to Heteroptera following reduced pesticide use and perhaps a better synchrony between more favourable cereal growth stages and dispersing nymphs. While minimal tillage is unlikely to have any effect on Heteroptera since most species overwinter in the field boundary, mechanical weeding or organic production systems could have similar effects to herbicides and remove potential food plants which the use of Conservation Headlands help to preserve.

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REFERENCES

Chiverton, P.A; Sotherton, N.W. (1991) The effects on beneficial arthropods of the exclusion of herbicides from cereal crop edges. Journal of Applied Ecology **28**, 1027-1040.

Coombes, D.S.; Sotherton, N.W. (1986) The dispersion of polyphagous predators from their overwintering sites into cereal fields and factors affecting their distribution in the spring and summer. Annals of Applied Biology **108**, 461-474.

Davis, B.N.K.; Lakhani, K.Y.; Yates, T.J. (1991) The hazards of insecticides to butterflies of field margins. Agriculture, Ecosystems & Environment **36**, 151-161.
Dietrick, E.J. (1961) An improved backpack motorised fan for suction sampling of insects. Journal of Economic Entomology **54,** 394-395.
Inglesfield, C. (1989) Pyrethoids and terrestrial non-target organisms. Pesticide Science **27**, 387-428.
Moreby, S.J. (1991) Laboratory screening of pesticides against *Calocoris norvegicus*, a non-target heteropteran in cereals. Tests of Agrochemicals and Cultivars No. 12, (Annals of Applied Biology **118**, Supplement) 8-9.
Moreby, S.J. (1994) The influence of agricultural practices on Heteroptera in arable field margins. Unpublished M.Phil Thesis, University of Southampton.
Potts, G.R. (1986) The Partridge: Pesticides, Predation and Conservation. Collins, London, pp. 274.
Potts, G.R.; Vickerman, G.P. (1974) Studies of the cereal ecosystem. Advances in Ecological Research **8**, 107-197.
Rands, M.R.W. (1985) Pesticide use on cereals and the survival of grey partridge chicks: a field experiment. Journal of Applied Ecology **22**, 49-54.
Rands, M.R.W. (1986) The survival of gamebirds (Galliformes) chicks in relation to pesticide use on cereals. Ibis **128**, 57-64.
Somerville, L.; Walker, C. Eds (1990) Pesticide Effects on Terrestrial Wildlife. London: Taylor & Francis. 404pp.
Sotherton (1984) The distribution and abundance of predatory arthropods overwintering on farmland. Annals of Applied Biology **105**, 423-429.
Sotherton, N.W.; Moreby, S.J.; Langley, M.G. (1987) The effects of the foliar fungicide pyrazophos on beneficial arthropods in barley fields. Annals of Applied Biology **111**, 75-87.
Sotherton, N.W.; Boatman, N.D.; Rands, M.R.W. (1989) The 'Conservation Headland' experiment in cereal ecosystems. The Entomologist **108**(1&2), 135-143.
Vickerman, G.P.; Sunderland, K.D. (1977) Some effects of dimethoate on arthropods in winter wheat. Journal of Applied Ecology **14**, 767-777.

TABLE 1. Mean number of Heteroptera (± S.E.) collected by 50 sweeps in cereal fields taken on 23rd June 1983 and significant differences between crops, treatments and distances.

Treatments	Distance	*Calocoris norvegicus*	P	Predatory species	P	Stenodemini	P	Other Heteroptera	P	Total Heteroptera	P
Selectively sprayed cereal fields											
n=20	3m	123.65 ± 38.82	1. ***	0.25 ± 0.16	1. *	1.05 ± 0.46	1. **	0.90 ± 0.29	1. ***	125.80 ± 38.82	1. ***
			2. ***		2. NS		2. **		2. NS		2. ***
	12m	10.15 ± 4.53	3. ***	0.05 ± 0.05	3. NS	0.05 ± 0.05	3. NS	0.10 ± 0.07	3. NS	10.50 ± 4.52	3. ***
	50m	0.10 ± 0.07		0.10 ± 0.07		0.30 ± 0.13		0.45 ± 0.25		0.95 ± 0.32	
Fully sprayed cereal fields											
n=16	3m	54.63 ± 23.31	1. ***	0.19 ± 0.10	1. *	2.56 ± 0.96	1. ***	0.19 ± 0.10	1. NS	57.56 ± 23.37	1. ***
			2. ***		2. NS		2. ***		2. NS		2. ***
	12m	3.81 ± 1.67	3. ***	0.00 ± 0.00	3. NS	0.31 ± 0.25	3. ***	0.06 ± 0.06	3. NS	4.19 ± 1.88	3. ***
	50m	0.00 ± 0.00		0.06 ± 0.06		0.44 ± 0.16		0.13 ± 0.13		0.63 ± 0.22	
Crop differences		NS		NS		NS		NS		NS	
Treatment differences		*		NS		NS		**		*	

* = P ≤ 0.05 ** = P ≤ 0.01 *** = P ≤ 0.001 NS = Not Significant

1. = 3m vs. 12m 2. = 3m vs. 50m 3. = 12m vs. 50m sb = spring barley wb = winter barley ww = winter wheat

TABLE 2. Mean number of Heteroptera (± S.E.) collected by 50 sweeps in cereal fields taken on 26th June 1984 and significant differences between crops, treatments and distances.

Treatments	Distance	*Calocoris norvegicus*	P	Predatory species	P	Stenodemini	P	Other Heteroptera	P	Total Heteroptera	P
Selectively sprayed cereal fields											
n=17	3m	68.00 ± 25.06	1. ***	1.18 ± 0.64	1. NS	11.18 ± 4.52	1. ***	2.88 ± 0.24	1. NS	83.12 ± 26.98	1. ***
			2. ***		2. NS		2. ***		2. NS		2. ***
	12m	8.53 ± 3.07	3. **	0.47 ± 0.31	3. NS	0.82 ± 0.26	3. NS	1.88 ± 0.58	3. NS	11.71 ± 3.63	3. **
	50m	0.35 ± 0.15		0.24 ± 0.24		0.65 ± 0.26		1.12 ± 0.45		2.35 ± 0.72	
Fully sprayed cereal fields											
n=17	3m	31.12 ± 10.14	1. ***	1.29 ± 0.89	1. NS	3.29 ± 2.00	1. **	2.18 ± 0.73	1. **	37.88 ± 11.20	1. ***
			2. ***		2. *		2. **		2. **		2. ***
	12m	1.18 ± 0.54	3. NS	0.29 ± 0.19	3. NS	0.47 ± 0.19	3. NS	0.53 ± 0.33	3. NS	2.47 ± 0.66	3. ***
	50m	0.41 ± 0.19		0.06 ± 0.06		0.65 ± 0.30		0.47 ± 0.26		1.59 ± 0.40	
Crop differences		NS		* wb/ww		NS		NS		NS	
Treatment differences		*		NS		NS		NS		*	

* = P ≤ 0.05 ** = P ≤ 0.01 *** = P ≤ 0.001 NS = Not Significant

1 = 3m vs. 12m 2 = 3m vs. 50m 3 = 12m vs. 50m sb = spring barley wb = winter barley ww = winter wheat

TABLE 3. Mean number of Heteroptera (± S.E.) collected by 50 sweeps in cereal fields taken on 1st July 1985 and significant differences between crops, treatments and distances.

Treatments	Distance	*Calocoris norvegicus*	P	Predatory species	P	Stenodemini	P	Other Heteroptera	P	Total Heteroptera	P
Selectively sprayed cereal fields											
n=17	3m	66.24 ± 15.62	1. *** 2. ***	0.82 ± 0.37	1. ** 2. NS	0.71 ± 0.25	1. NS 2. NS	1.77 ± 0.41	1. ** 2. **	69.53 ± 15.48	1. *** 2. ***
	12m	3.35 ± 1.19	3. **	0.00 ± 0.00	3. NS	0.24 ± 0.11	3. NS	0.29 ± 0.17	3. NS	3.94 ± 1.25	3. *
	50m	0.53 ± 0.23		0.24 ± 0.11		0.24 ± 0.18		0.29 ± 0.29		1.35 ± 0.56	
Fully sprayed cereal fields											
n=17	3m	44.63 ± 19.68	1. *** 2. ***	0.38 ± 0.16	1. NS 2. NS	1.44 ± 0.99	1. ** 2. **	1.06 ± 0.55	1. NS 2. NS	47.50 ± 20.00	1. *** 2. ***
	12m	8.56 ± 4.22	3. **	0.13 ± 0.09	3. NS	0.19 ± 0.14	3. NS	0.69 ± 0.30	3. NS	9.56 ± 4.37	3. **
	50m	1.44 ± 0.79		0.31 ± 0.15		0.19 ± 0.10		0.50 ± 0.20		2.44 ± 0.94	
Crop differences		NS		NS		NS		** sb/wb ** ww/wb		NS	
Treatment differences		NS		NS		NS		NS		NS	

* = P ≤ 0.05   ** = P ≤ 0.01   *** = P ≤ 0.001   NS = Not Significant

1 = 3m vs. 12m   2 = 3m vs. 50m   3 = 12m vs. 50m   sb = spring barley   wb = winter barley   ww = winter wheat