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ANTIDOTES FOR THE PROTECTION OF WHEAT FROM DAMAGE BY TRI-ALLATE

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A.M. Blair

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SUMMARY

The results of sixteen experiments are presented in which protectants (antidotes) were tested for their potential to protect wheat (Triticum aestivum L) against damage from tri-allate. A seed dressing of 1,8-naphthalic anhydride(NA) at 0.5-1.0% (weight of protectant as percentage of weight of seed) sometimes gave good protection from tri-allate applied pre-planting at 1 kg ai/ha but not generally from higher doses. N,N-diallyl 2,2-dichloroacetamide (R25788) as a seed treatment at 0.5-1.0% sometimes gave protection from tri-allate but not in all cases. When R25788 was mixed in the spray tank with tri-allate protection was less good. R4115 (1-2% seed treatment) gave good protection from tri-allate at 1 kg ai/ha in most experiments but could cause marked damage in the absence of the herbicide. R29148 protected from tri-allate damage only if it was ground up or using methyl-cellulose as a 'sticker'.

Results were variable between experiments and the prospect of complete reliable protection seems unlikely at present.

INTRODUCTION

Tri-allate is used to control wild oats (Avena fatua L) in winter wheat but crop tolerance is somewhat marginal (Holroyd, 1976). A greater safety margin could lead to greater reliability of this herbicide in practice.

There have been many reports recently of maize (Zea mays L) being treated with crop protectants (antidotes) to avoid damage particularly from thiocarbamate herbicides such as EPTC (Burnside, Wicks & Fenster, 1971; Chang, Bandeen & Stephenson, 1972). Miller, Nalewaja & Pudelko (1973) also were able to reduce tri-allate damage to wheat using seed treatments of 1,8-naphthalic anhydride (NA) or N,N-diallyl 2,2-dichloroacetamide (R25788). These two protectants are now in use commercially and this report describes a series of experiments designed to examine whether these protectants could protect wheat from tri-allate damage. In addition, two other antidotes, not available commercially were tested: R4115 (chemistry undisclosed) and 2,2,5-trimethyl-N-dichloroacetyl-oxazolidene (R29148).

MATERIALS AND METHODS

a) Materials

Four seeds of winter wheat (var. Atou unless recorded) were planted per pot (8.9 cm diameter) at 2.5 cm depth in a sandy loam soil (4.2% o.m.). John Innes base fertilizer (2.5 g/kg soil), fritted trace elements (0.25 g/kg), DDT (0.5 g/kg) and $MgSO_4$ (1.0 g/kg) were added to the soil. The seed had been treated with a commercial mercuric seed dressing.

Protectant formulations used were: NA as the technical product (> 95% w/w ai); R25788 as either a wettable powder (20% w/w ai) or an emulsifiable concentrate (720 g ai/l); R4115 as a water soluble powder (20% w/w ai) and R29148 as the technical product (98.7% w/w ai). The herbicide tri-allate was formulated as an emulsifiable concentrate (400 g ai/l).

b) Methods

Protectant seed treatments were applied by shaking measured weights of seed plus protectant in a plastic bag to give the nominal concentration (weight of protectant expressed as a percentage of seed weight). The actual amount retained on the seed may have been less but it proved impossible to accurately measure this because of the seed debris created by shaking. Where the protectant was applied as a tank mix the herbicide and protectant were mixed prior to spraying. In some experiments methylcellulose was tried as a 'sticker' to improve the retension of the protectant on the seed (Bardner, 1958). In this case 0.15 ml of 3% methylcellulose per 5 g seed was shaken with the seed in a glass bottle and then the appropriate amount of protectant added, shaken and allowed to dry. Where R29148 was ground prior to use, this was done using a pestle and mortar. In one experiment a visual estimate of powder coating the seeds was used to divide seeds into categories e.g. good and poor.

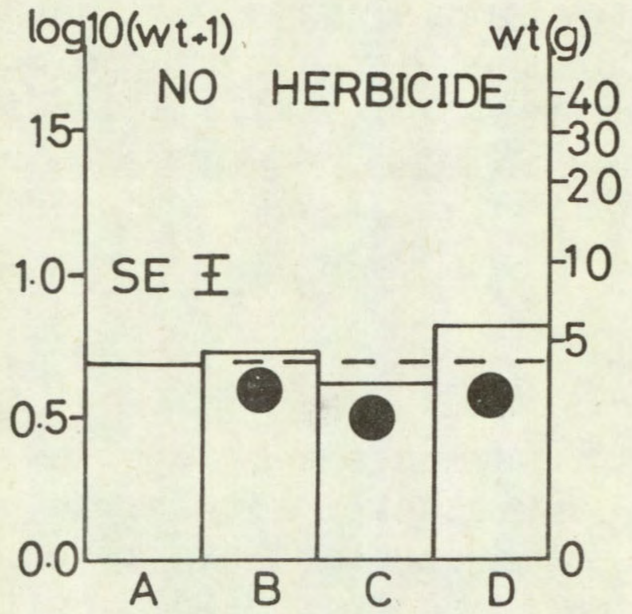
Tri-allate, a volatile herbicide, requires incorporation and was applied to soil in trays (2.5 cm depth) using a sprayer fitted with an 8002E 'Teejet' fan nozzle set to pass 30 cm above the soil surface and delivering 440 l/ha at 210 kN/m^2. The herbicide was then incorporated by shaking the treated soil in a plastic bag which was then sealed. Treated soil was only used to cover the seeds and not through the depth of the pot.

Pots were fully randomised within replicates in a glasshouse and grown for 4-5 weeks. Pots were watered from above and given extra nutrient as required. Additional illumination was provided by fluorescent lighting to give a minimum light period of 14 hours. In one experiment (Fig. 4) pots were kept outside and watered as required.

Assessment of effects was made after 4-6 weeks by recording symptoms and visual damage and by measuring the fresh weights of the plants cut at the soil surface. These fresh weights are presented as histograms (Fig. 1-16). Data have been transformed for analysis of variance to $\log_{10}$ (fresh weight + 1) and all standard errors apply to transformed data.

RESULTS

Tri-allate alone caused marked stunting and distortion of seedlings coupled with a darker green colouration of foliage. Wax formation appeared to be affected causing some leaves to adhere together.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30
20
10
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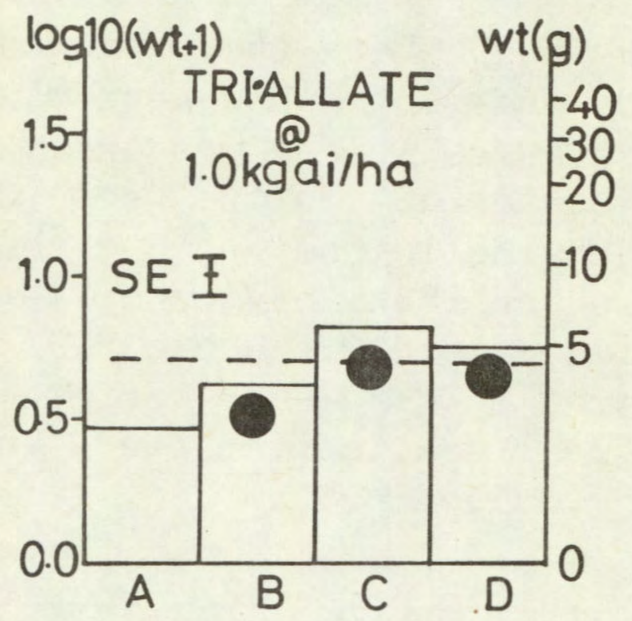
A
B
C
D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wt(g)
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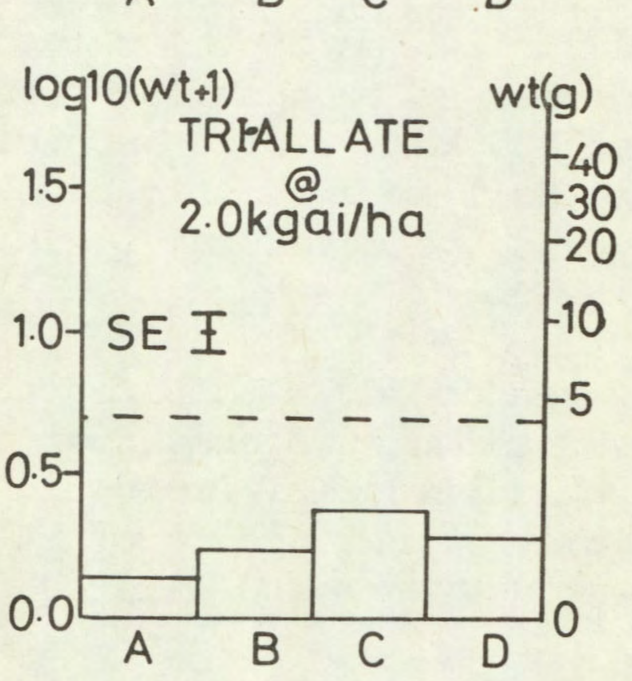
0
A
B
C
D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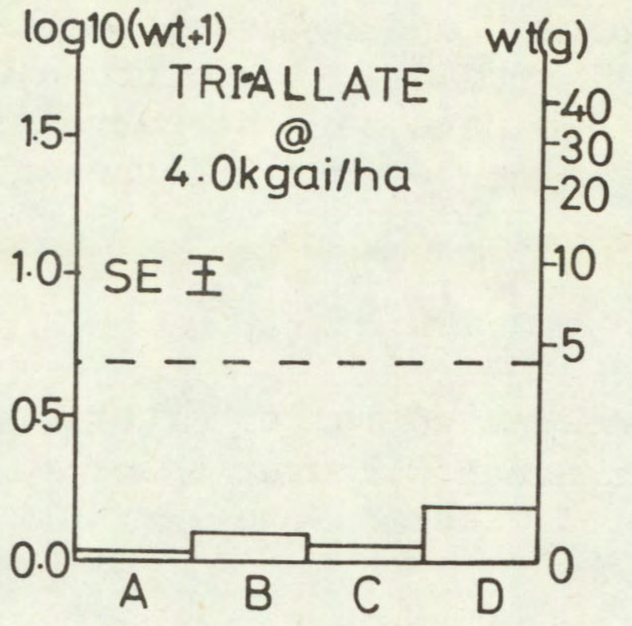
5
0
A
B
C
D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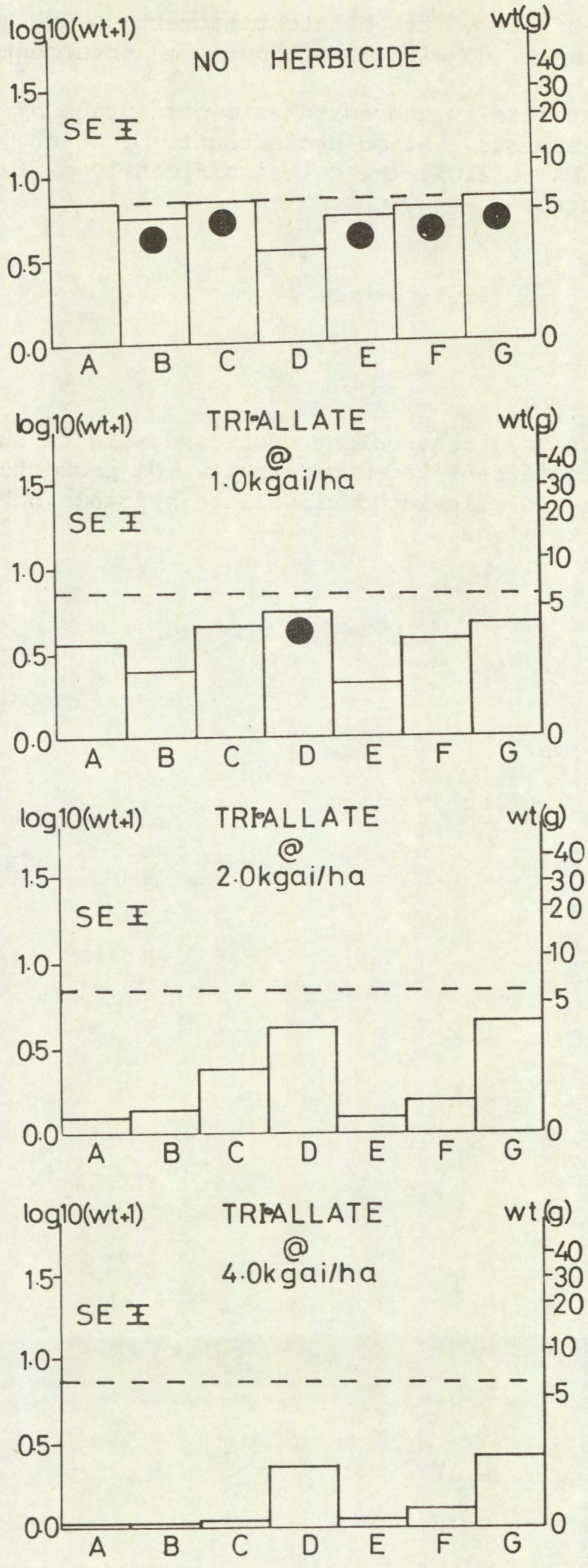
40
30
20
10
5
0
A
B
C
D

Fig. 1 The effect of tri-allate treatment on the total fresh weight of wheat (g) with or without seed treatment with NA.

The protectant dose is expressed as a percentage by weight of the seed treated. Treatments: A, no protectant; B, NA at 0.125%; C, NA at 0.5%; D, NA at 2.0%; ●, not significantly different from untreated control; -----, untreated control level; ⊥ ± SE.

None of the NA treatments alone decreased weights but all doses of tri-allate significantly damaged wheat. NA protected from tri-allate at 1 kg ai/ha and alleviated tri-allate symptoms but did not protect from 2 and 4 kg ai/ha.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wt(g)
NO HERBICIDE
SE ±
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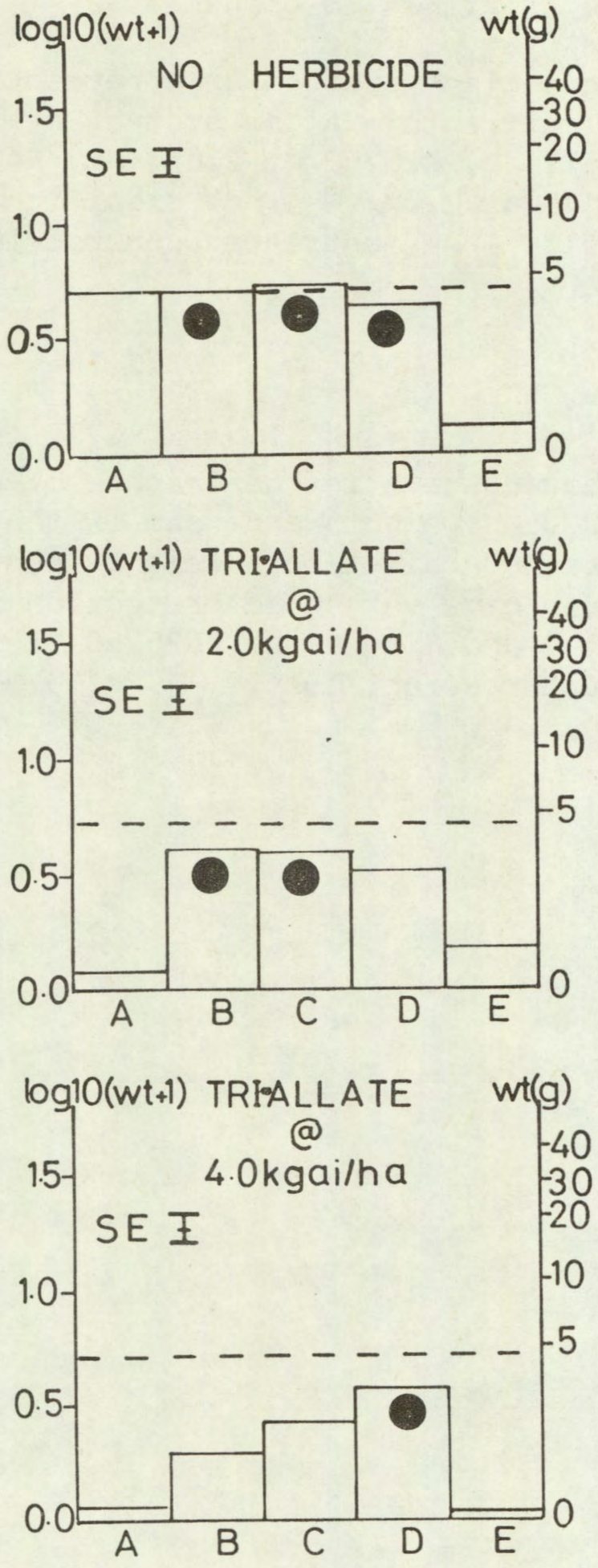
1·0
0·5
0·0
40
30
20
10
5
0
A B C D E F G
log10(wt+1)
TRIALLATE @ 1·0kgai/ha
SE ±
wt(g)
log10(wt+1)
TRIALLATE @ 2·0kgai/ha
SE ±
wt(g)
log10(wt+1)
TRIALLATE @ 4·0kgai/ha
SE ±
wt(g)

Fig. 2 The effect of tri-allate on wheat with and without seed treatments of R25788 or R4115.

The protectant dose is expressed as a percentage by weight of the seed treated. Treatments: A, no protectant; B, R25788 at 0.125%; C, R25788 at 0.5%; D, R25788 at 2.0%; E, R4115 at 0.125% F, R4115 at 0.5%; G, R4115 at 2.0%; ● , not significantly different from untreated control; -----, untreated control level; $\pm$ SE.

R25788 at 2% damaged wheat in the absence of herbicide. All doses of tri-allate reduced weights and none of the seed treatments completely protected against both weight loss and symptoms. However although R4115 did give very good protection from visual symptoms of tri-allate at 1 and 2 kg ai/ha, R25788 at 2% was the only treatment to counter weight loss.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wt(g)
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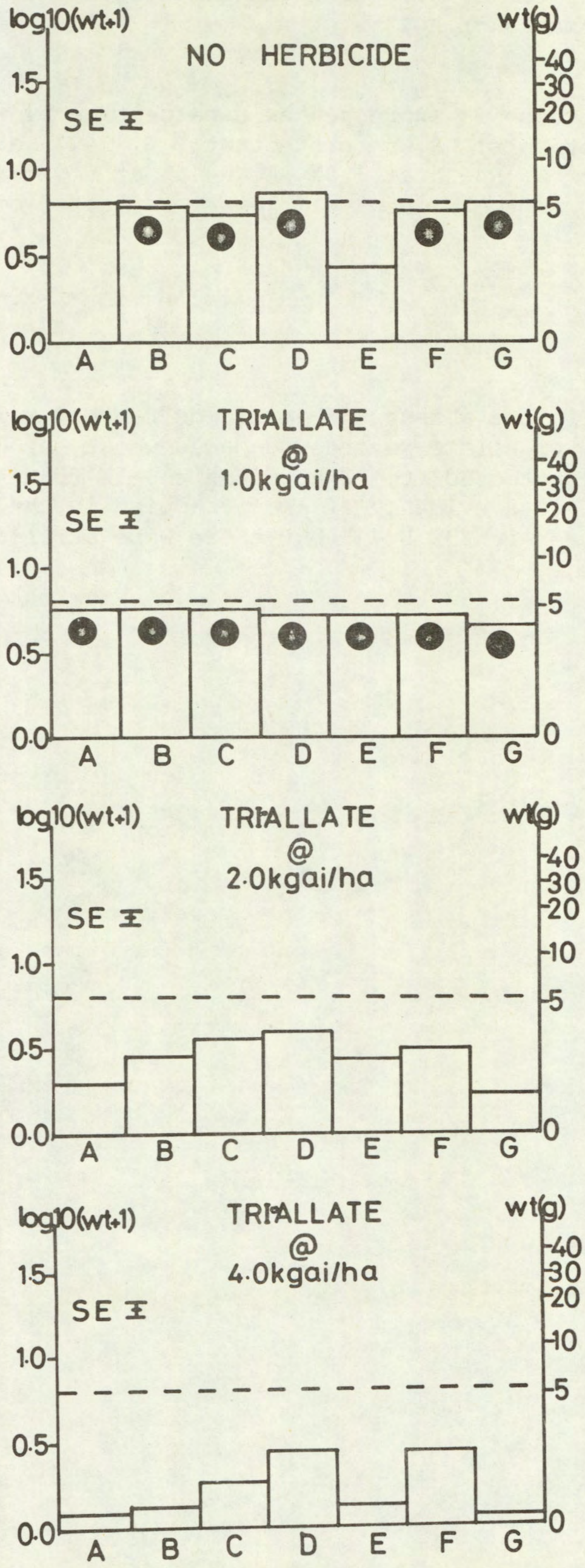
1.0
0.5
0.0
40
30
20
10
5
0
A
B
C
D
E
log10(wt+1) TRI-ALLATE @ 2.0kgai/ha
wt(g)
SE
log10(wt+1) TRI-ALLATE @ 4.0kgai/ha
wt(g)
SE

Fig. 3 The effect of tri-allate on wheat with and without seed treatments of R4115.

The protectant dose is expressed as a percentage by weight of the seed treated. Treatments: A, no protectant; B, R4115 at 0.75%; C, R4115 at 1.5%; D, R4115 at 3.0% E, R4115 at 6.0%; ●, not significantly different from untreated control; ----, untreated control level; $\overline{+}$ $\underline{+}$ SE.

R4115 at 6.0% in the absence of herbicide reduced weights significantly. Both doses of tri-allate severely damaged wheat but 0.75 and 1.5% significantly protected from 2 kg ai/ha and 3% from 4 kg ai/ha. There was much less evidence of leaf trapping in the cases where the seed was treated with 3% R4115 but there were still some effects.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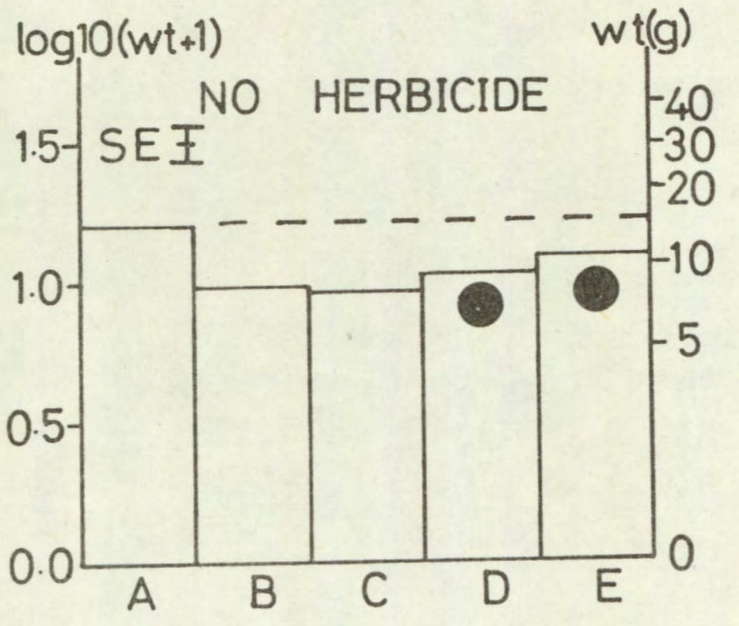
wt(g)
NO HERBICIDE
SE ±
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A B C D E F G
TRIALLATE @ 1.0kgai/ha
TRIALLATE @ 2.0kgai/ha
TRIALLATE @ 4.0kgai/ha

Fig. 4 The effect of tri-allate on wheat with and without seed treatments of NA, R25788 or R4115.

The protectant dose is expressed as a percentage by weight of the seed treated. Treatments: A, no protectant; B, R25788 at 0.5%; C, R25788 at 2.0%; D, R4115 at 0.5%; E, R4115 at 2.0%; F, NA at 0.5%; G, NA at 2.0%; ●, not significantly different from untreated control; ----, untreated control level; ⊥ ± SE.

In this experiment in which plants were grown in pots outside, a seed treatment of 2% R4115 reduced plant weights alone. Tri-allate at 1 kg ai/ha did not reduce plant weights alone but protectants countered most of the herbicide symptoms. None of the seed treatments completely protected from tri-allate at 2 kg ai/ha: R4115 was the most effective, reducing the degree of visual damage by about 50%. R4115 and NA at 0.5% gave significant although incomplete protection from tri-allate at 4 kg ai/ha.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wt(g)
NO HERBICIDE
SE I
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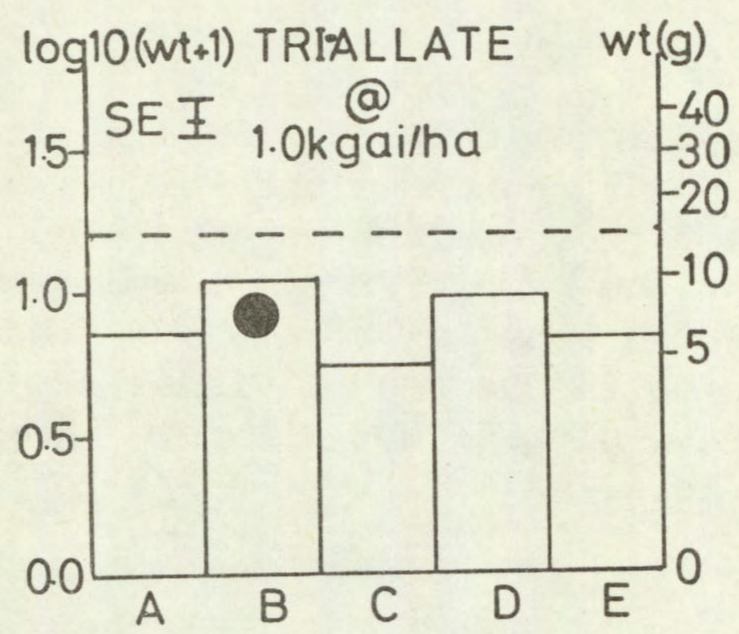
0·0
40
30
20
10
5
0
A
B
C
D
E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TRIALLATE
@
1·0kgai/ha
wt(g)
SE I
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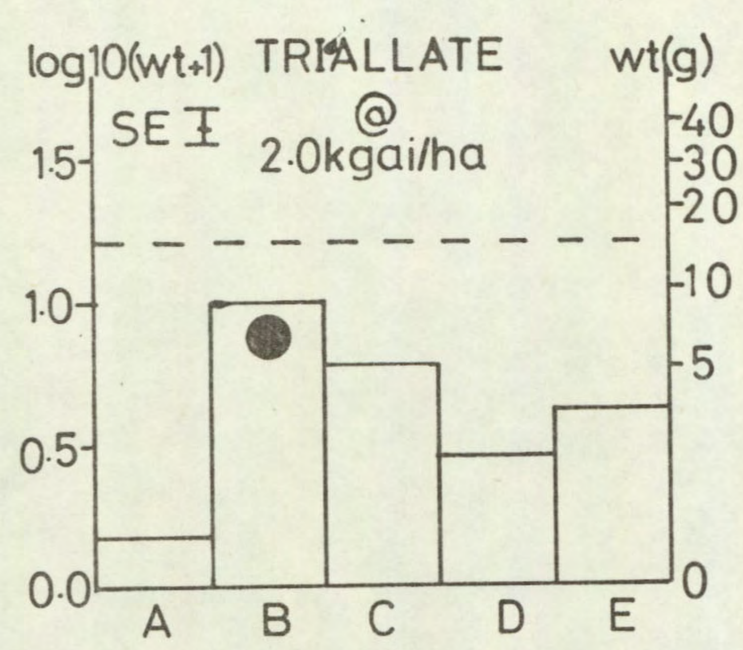
1·0
0·5
0·0
40
30
20
10
5
0
A
B
C
D
E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TRIALLATE
@
2·0kgai/ha
wt(g)
SE I
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1·0
0·5
0·0
40
30
20
10
5
0
A
B
C
D
E

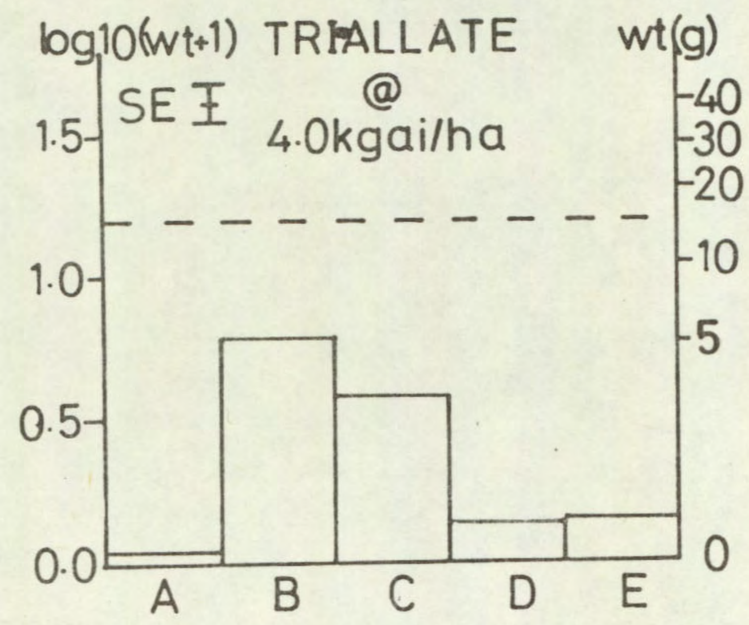
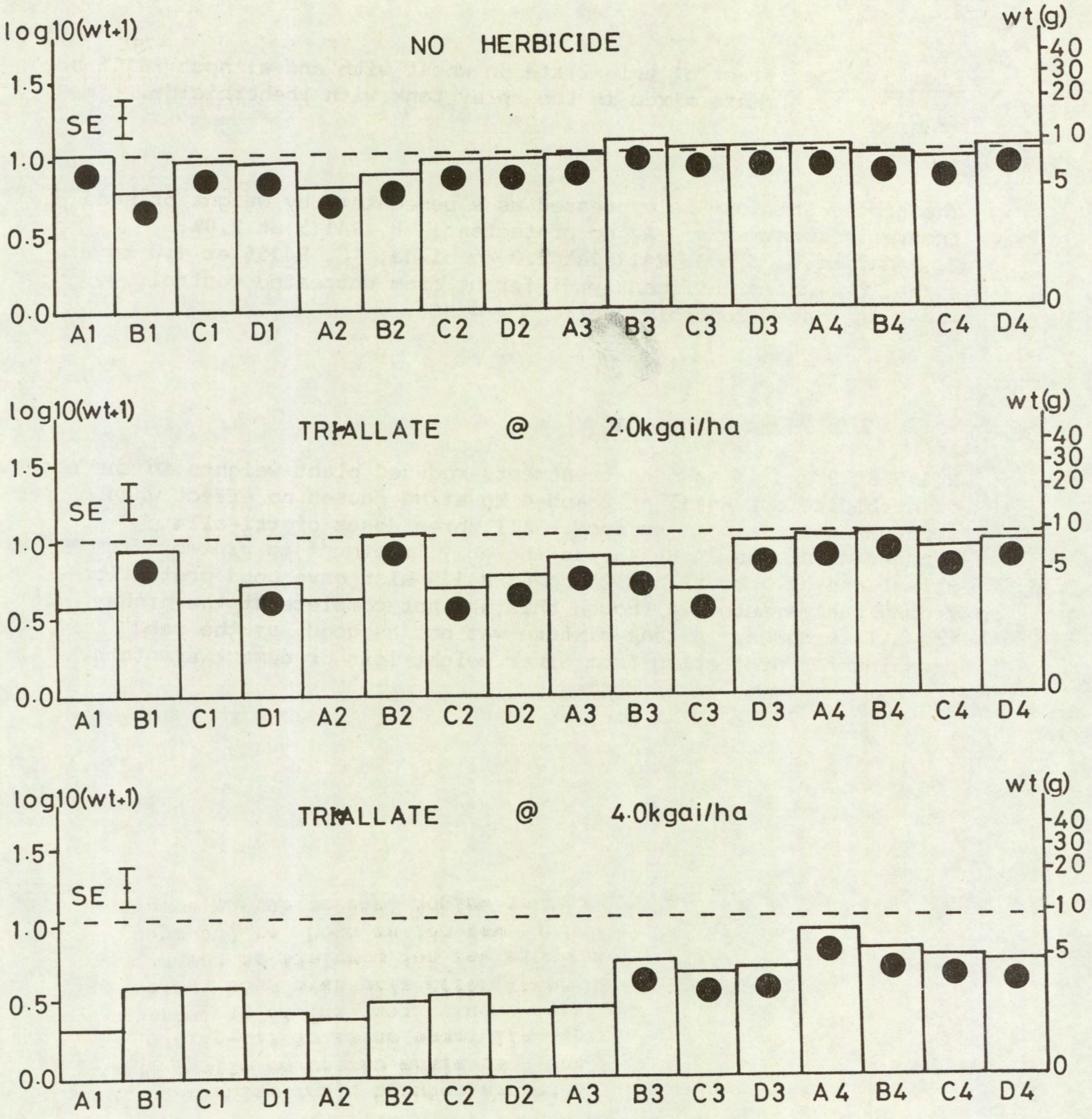

log10(wt+1)
TRIALLATE
@
4·0kgai/ha
wt(g)
SE I
1·5
1·0
0·5
0·0
40
30
20
10
5
0
A
B
C
D
E

Fig. 5 The effect of tri-allate on wheat with and without R4115 seed treatments mixed in the spray tank with theherbicide.

The protectant dose is expressed as a percentage by weight of seed treated. Treatments: A, no protectant; B, R4115 at 2.0%; C, R4115 at 4.0%; D, R4115 at 2.0 kg ai/ha; E, R4115 at 4.0 kg ai/ha; ●, not significantly different from untreated control; ----, untreated control level; ± SE.

R4115 at 2 and 4% as seed treatments reduced plant weights in the absence of herbicide but R4115 at 2 and 4 kg ai/ha caused no effect when sprayed onto the soil surface. All three doses of tri-allate damaged wheat and 2% R4115 was the only treatment to protect from tri-allate at 1 kg ai/ha. 2 and 4% R4115 also gave good protection from visual symptoms although this was not complete at the higher tri-allate doses. A tank-mixture was not as good as the seed dressing for protecting from either weight loss or damage symptoms.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wt(g)
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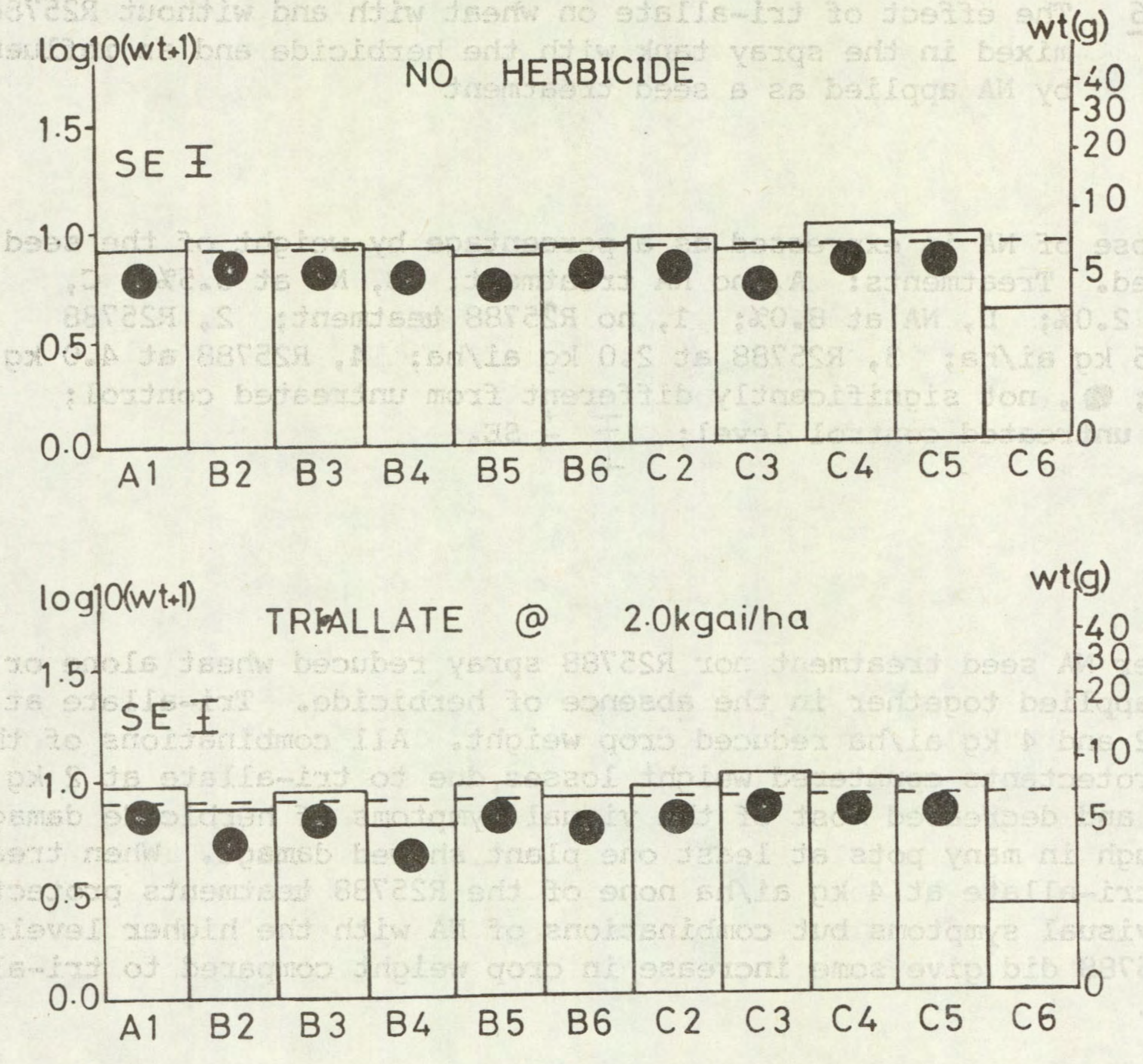
1.0
0.5
0.0
40
30
20
10
5
0
A1 B1 C1 D1 A2 B2 C2 D2 A3 B3 C3 D3 A4 B4 C4 D4
log10(wt+1)
wt(g)
TRIALLATE @ 2.0kgai/ha
SE
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A1 B1 C1 D1 A2 B2 C2 D2 A3 B3 C3 D3 A4 B4 C4 D4
log10(wt+1)
wt(g)
TRIALLATE @ 4.0kgai/ha
SE
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A1 B1 C1 D1 A2 B2 C2 D2 A3 B3 C3 D3 A4 B4 C4 D4

Fig. 6 The effect of tri-allate on wheat with and without R25788 mixed in the spray tank with the herbicide and as influenced by NA applied as a seed treatment

The dose of NA is expressed as a percentage by weight of the seed treated. Treatments: A, no NA treatment; B, NA at 0.5%; C, NA at 2.0%; D, NA at 8.0%; 1, no R25788 treatment; 2, R25788 at 0.5 kg ai/ha; 3, R25788 at 2.0 kg ai/ha; 4, R25788 at 4.0 kg ai/ha; ●, not significantly different from untreated control; ----, untreated control level; ⊥ ± SE.

Neither NA seed treatment nor R25788 spray reduced wheat alone or when applied together in the absence of herbicide. Tri-allate at both 2 and 4 kg ai/ha reduced crop weight. All combinations of the two protectants countered weight losses due to tri-allate at 2 kg ai/ha and decreased most of the visual symptoms of herbicide damage although in many pots at least one plant showed damage. When treated with tri-allate at 4 kg ai/ha none of the R25788 treatments protected from visual symptoms but combinations of NA with the higher levels of R25788 did give some increase in crop weight compared to tri-allate alone.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wt(g)
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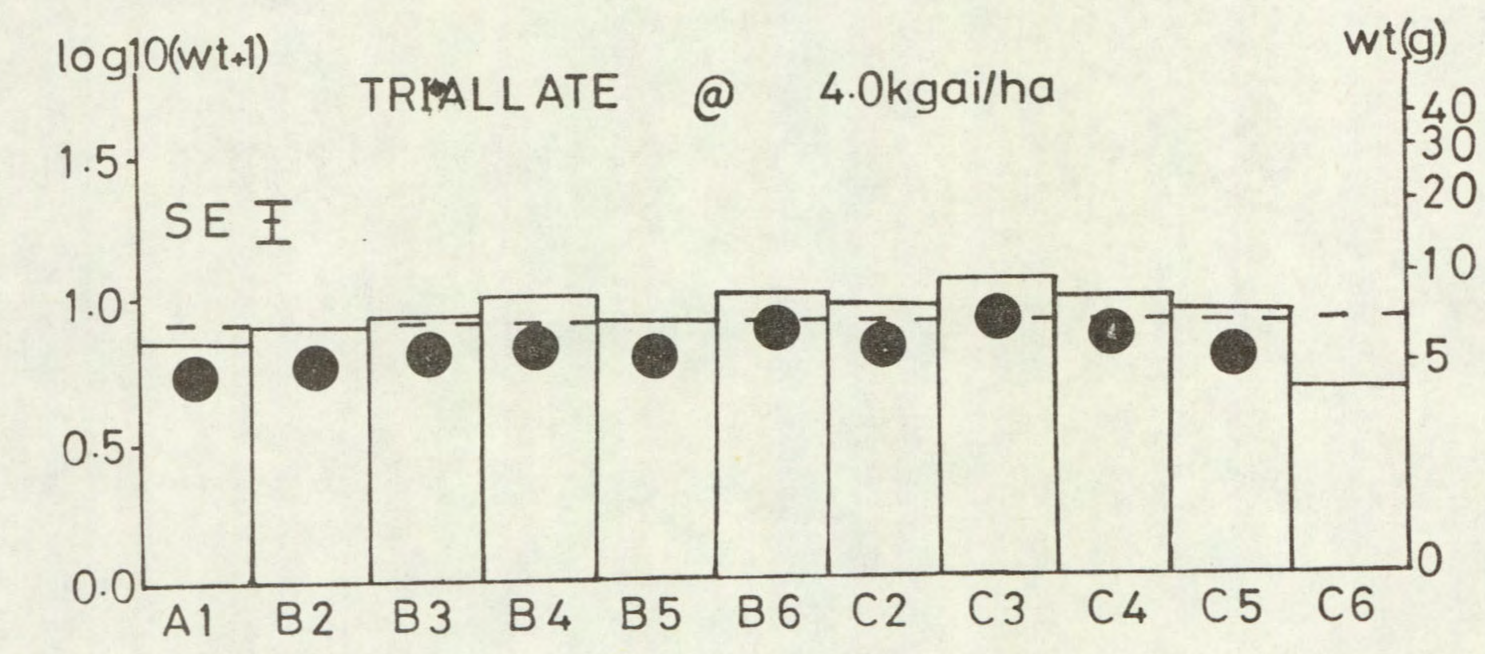
1.0
0.5
0.0
40
30
20
10
5
0
A1 B2 B3 B4 B5 B6 C2 C3 C4 C5 C6

log10(wt+1)
wt(g)
TRIALLATE @ 2.0kgai/ha
SE
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A1 B2 B3 B4 B5 B6 C2 C3 C4 C5 C6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TRIALLATE @ 4.0kgai/ha
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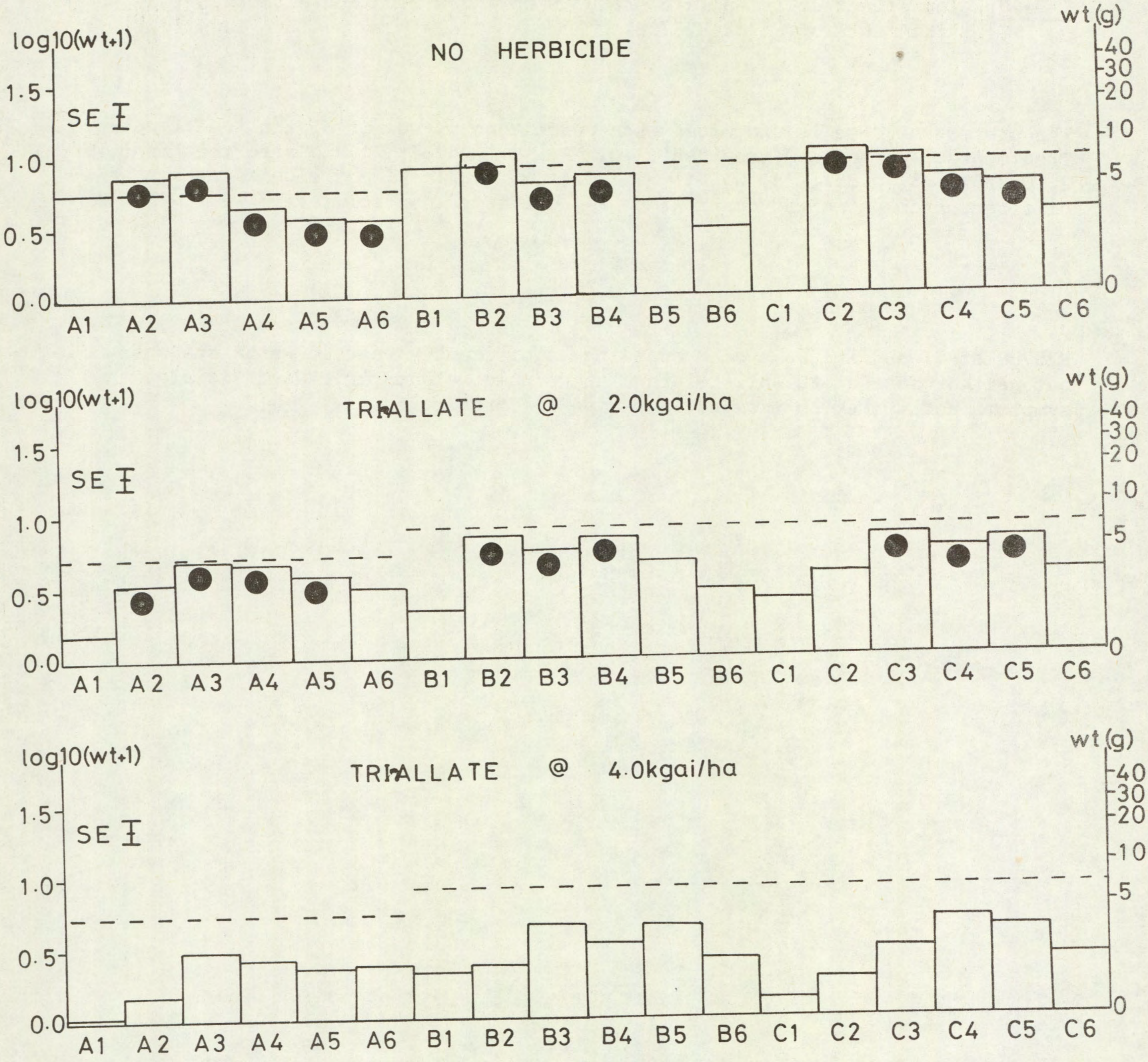
1.0
0.5
0.0
40
30
20
10
5
0
A1 B2 B3 B4 B5 B6 C2 C3 C4 C5 C6

Fig. 7 The effect of tri-allate granules on wheat with and without seed treatments of NA or R25788.

The protectant dose is expressed as a percentage by weight of the seed treated. Treatments: A, no seed treatment; B, NA; C, R25788; 1, no seed treatment; 2, 0.125%; 3, 0.25%; 4, 0.5%; 5, 1.0%; 6, 2.0%; ●, not significantly different from untreated control; ——, untreated control level; ⊥ ± SE.

R25788 at 2% applied as a seed dressing significantly reduced weights alone but neither dose of tri-allate granules reduced weights or caused visible symptoms and therefore there was no scope for protection.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0.0
40
30
20
10
5
0
A1 A2 A3 A4 A5 A6 B1 B2 B3 B4 B5 B6 C1 C2 C3 C4 C5 C6
log10(wt+1)
wt(g)
TRIALLATE @ 2.0kgai/ha
SE
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 A3 A4 A5 A6 B1 B2 B3 B4 B5 B6 C1 C2 C3 C4 C5 C6
log10(wt+1)
wt(g)
TRIALLATE @ 4.0kgai/ha
SE
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 A3 A4 A5 A6 B1 B2 B3 B4 B5 B6 C1 C2 C3 C4 C5 C6

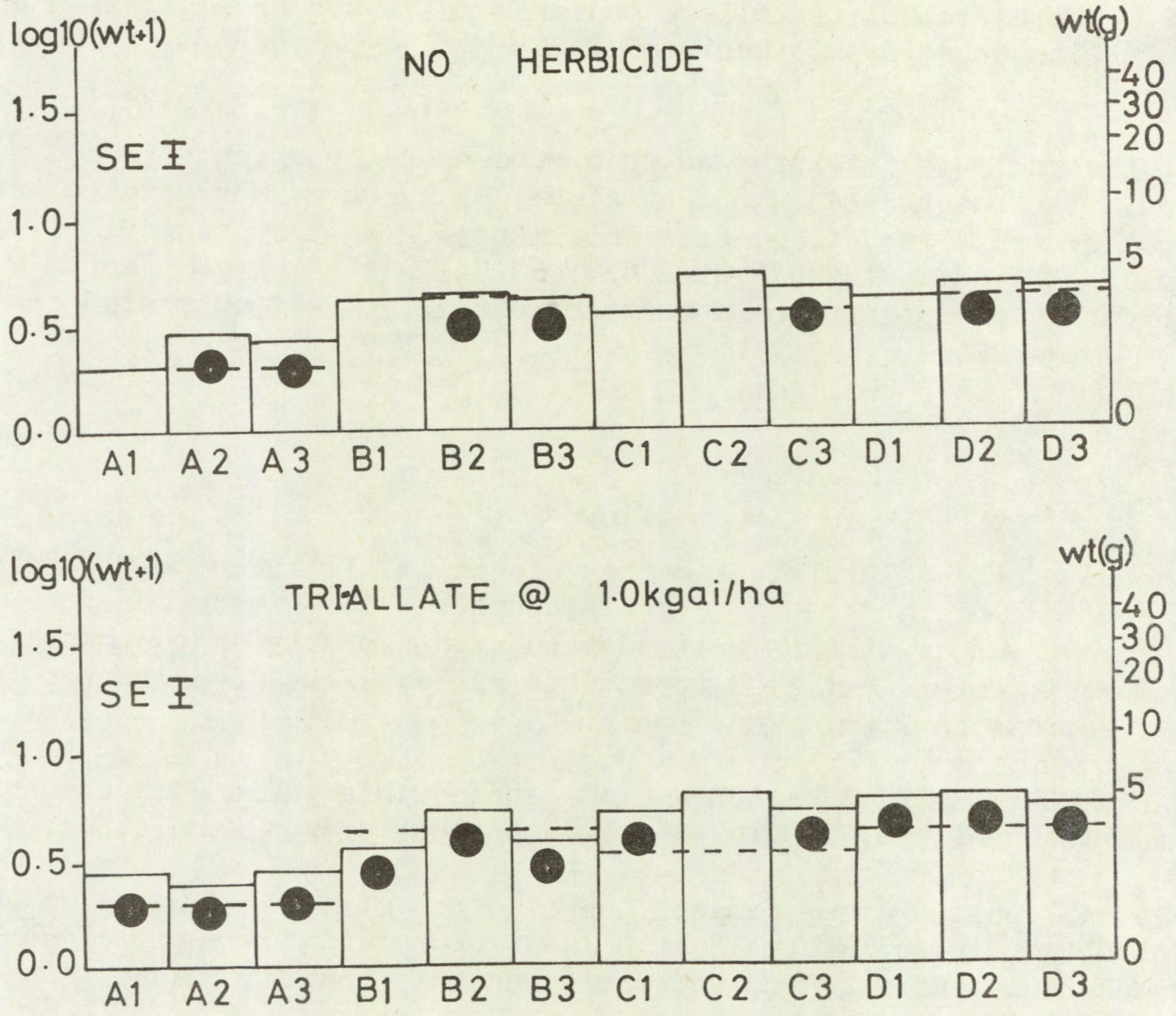
Fig. 8 The effect of tri-allate on three cultivars of wheat with and without seed treatments of R4115

The protectant dose is expressed as a percentage by weight of seed treated. Treatments: A, wheat cv Atou; B, wheat cv Maris Huntsman; C, wheat cv Cappelle; 1, no seed treatment; 2, R4115 at 0.5%; 3, R4115 at 1.0%; 4, R4115 at 2.0%; 6, R4115 at 4.0%; ●, not significantly different from untreated control; ----, untreated control level; ⊤ ± - SE.

Both doses of tri-allate reduced the weights of all three cultivars of wheat and none of the seed treatments countered the higher dose. None of the seed treatments damaged Atou significantly in the absence of the herbicide and all seed treatments except 4% R4115 protected from tri-allate at 2 kg ai/ha.

For Maris Huntsman R4115 at 3% and 4% damaged this variety in the absence of tri-allate while 0.5%, 1.0% and 2.0% protected from 2 kg ai/ha.

R4115 at 4% applied alone damaged Cappelle but at 1.0%, 2.0%, 3.0% protected from tri-allate at 2 kg ai/ha. Protection from visual herbicide symptoms was better for Atou and Maris Huntsman than for Cappelle.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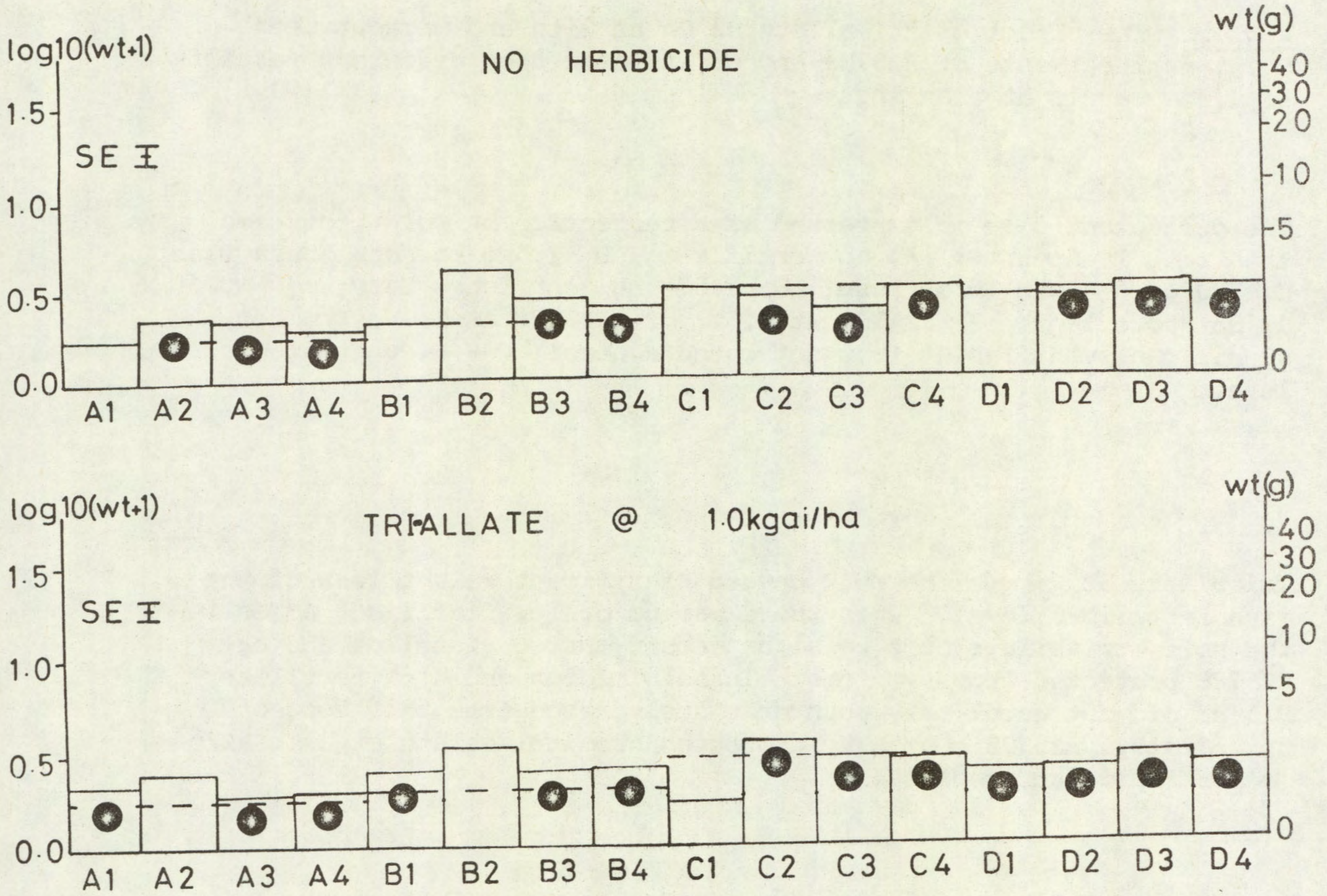
0.0
40
30
20
10
5
0
A1 A2 A3 B1 B2 B3 C1 C2 C3 D1 D2 D3
log10(wt+1)
TRIALLATE @ 1.0kgai/ha
wt(g)
1.5
SE I
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 A3 B1 B2 B3 C1 C2 C3 D1 D2 D3
log10(wt+1)
TRIALLATE @ 2.0kgai/ha
wt(g)
1.5
SE I
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 A3 B1 B2 B3 C1 C2 C3 D1 D2 D3

Fig. 9 The effect of tri-allate on wheat with and without seed treatments of R25788 and as influenced by different fertilizer levels at planting.

The protectant dose is expressed as a percentage by weight of seed treated. Treatments: A, no fertilizer; B, 2.5 g/kg John Innes Base; C, 5.0 g/kg John Innes Base; D, 7.5 g/kg John Innes Base; 1, no protectant; 2, R25788 at 0.5%; 3, R25788 at 1.0%; ●, not significantly different from untreated control; ----, untreated control level; ± - SE.

Tri-allate at 2 kg ai/ha only caused significant weight loss at the high fertilizer level. When there was no or low fertilizer added to the soil, tri-allate at 2 kg ai/ha caused marked visual damage but R25788 protected from symptoms. In both medium and high fertilizer R25788 did not completely counter visual damage from this dose of tri-allate. R25788 generally protected from tri-allate at 1 kg ai/ha in all fertilizer regimes.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NO HERBICIDE
wt(g)
1.5
SE ±
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 A3 A4 B1 B2 B3 B4 C1 C2 C3 C4 D1 D2 D3 D4

log10(wt+1)
TRIALLATE @ 1.0kgai/ha
wt(g)
1.5
SE ±
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 A3 A4 B1 B2 B3 B4 C1 C2 C3 C4 D1 D2 D3 D4

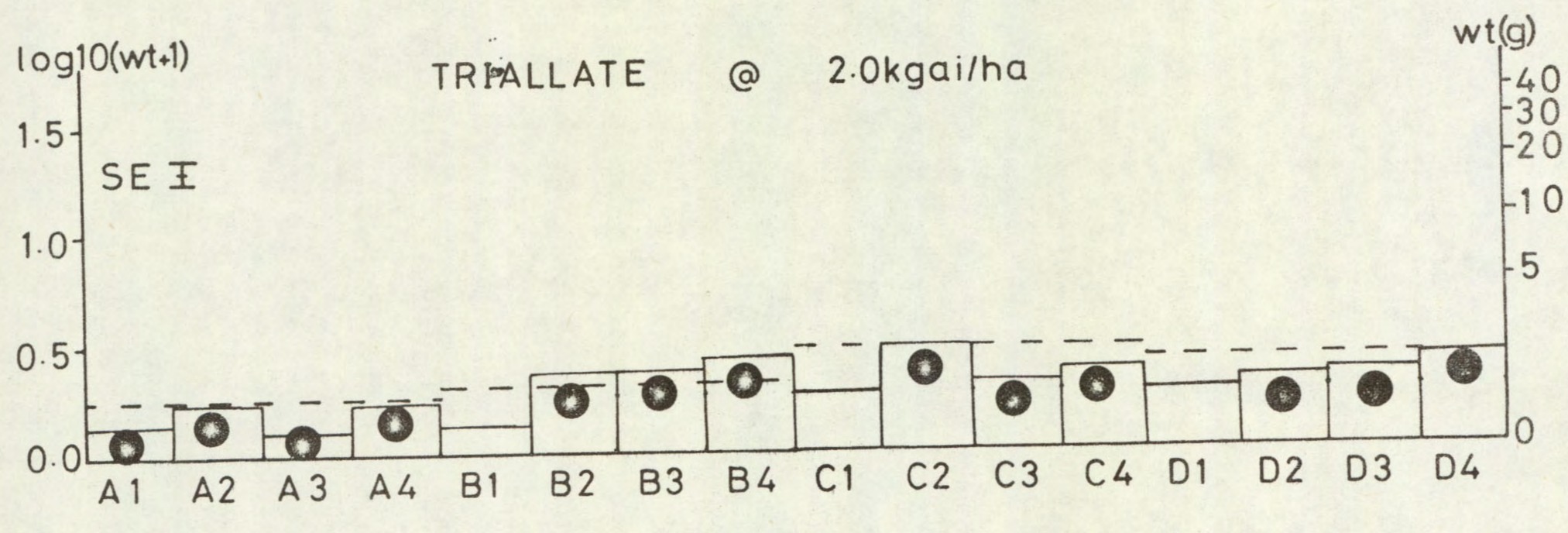
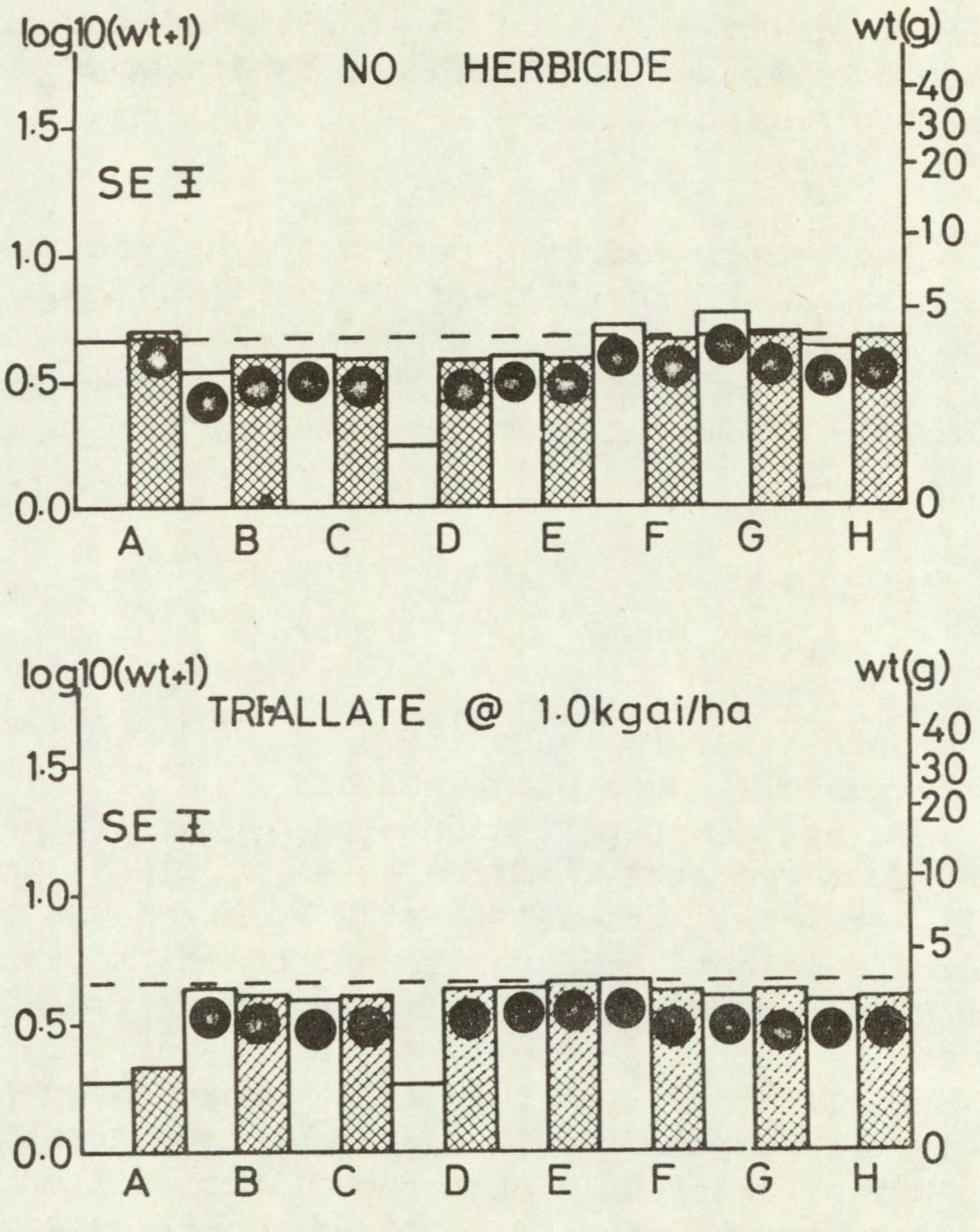

log10(wt+1)
TRIALLATE @ 2.0kgai/ha
wt(g)
1.5
SE ±
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 A3 A4 B1 B2 B3 B4 C1 C2 C3 C4 D1 D2 D3 D4

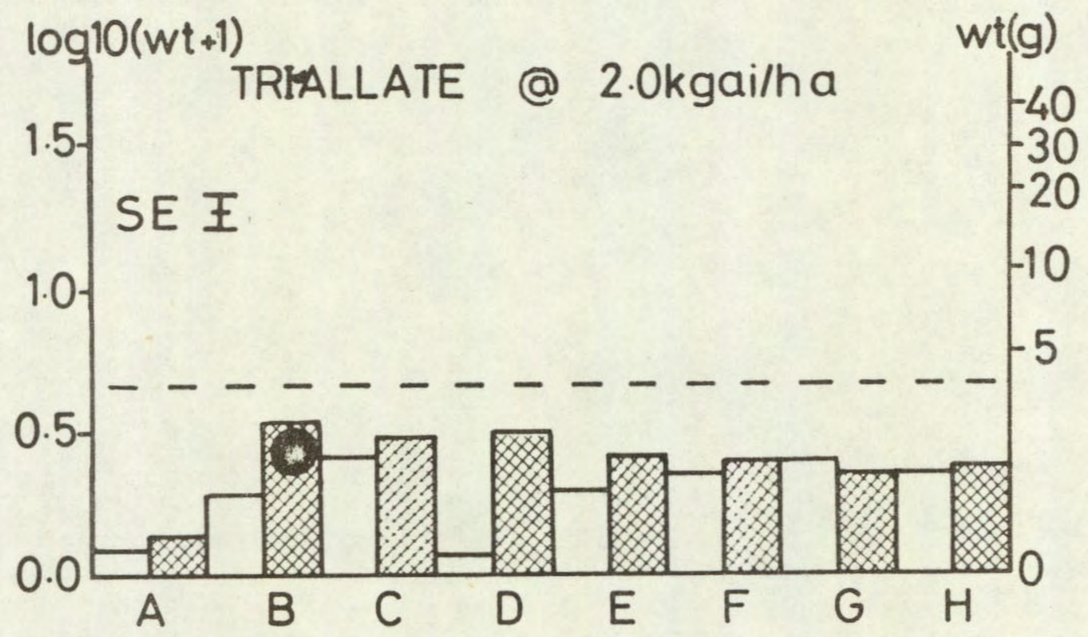
Fig. 10 The effect of tri-allate on wheat with and without seed treatments of NA and as influenced by different fertilizer levels at planting.

The protectant dose is expressed as a percentage by weight of seed treated. Treatments: A, no fertilizer; B, 2.5 g/kg John Innes Base; C, 5.0 g/kg John Innes Base; D, 7.5 g/kg John Innes Base; 1, no protectant; 2, NA at 0.5%; 3, NA at 2.0%; 4, NA at 8.0%; ●, not significantly different from untreated control; ——, untreated control level; $\overset{+}{\underset{-}{\mathrm{I}}}$ SE.

When there was no fertilizer in the soil, although none of the herbicide or protectant treatments reduced plant weights significantly, tri-allate symptoms were not completely countered by any of the protedants (80% of symptoms countered at 1 kg ai/ha level by all NA treatments). At the low fertilizer level, tri-allate at 2 kg ai/ha was the only treatment to decrease weights compared to untreated; in this soil 0.5% NA completely prevented all tri-allate symptoms from 1 kg ai/ha. When planted in medium fertilizer soil, tri-allate at 1 and 2 kg ai/ha reduced weights but all protectant treatments compensated for damage but not completely for symptoms - 0.5 and 2% NA countered tri-allate at 1 kg ai/ha in 80% of cases. In high fertilizer soil only tri-allate at 2 kg ai/ha reduced weights compared to untreated but 1 kg ai/ha caused visible damage for which 8% NA compensated in 80% of cases.


log10(wt+1)
wt(g)
NO HERBICIDE
SE I
1·5
1·0
0·5
0·0
40
30
20
10
5
0
A B C D E F G H

log10(wt+1)
wt(g)
TRIALLATE @ 1·0kgai/ha
SE I
1·5
1·0
0·5
0·0
40
30
20
10
5
0
A B C D E F G H


log10(wt+1)
wt(g)
TRIALLATE @ 2·0kgai/ha
SE I
1·5
1·0
0·5
0·0
40
30
20
10
5
0
A B C D E F G H

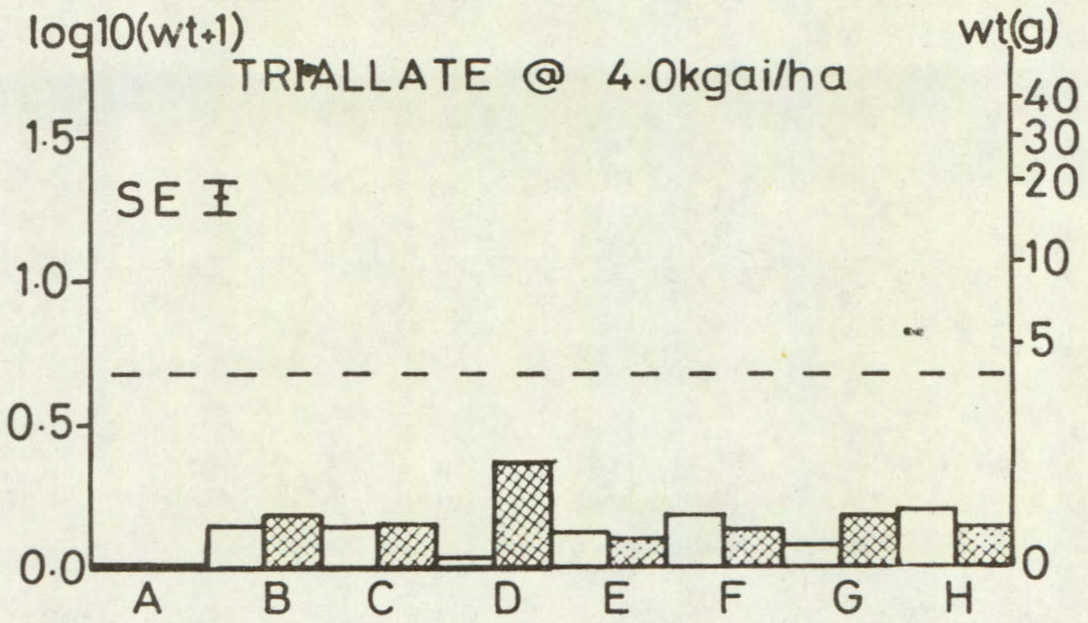
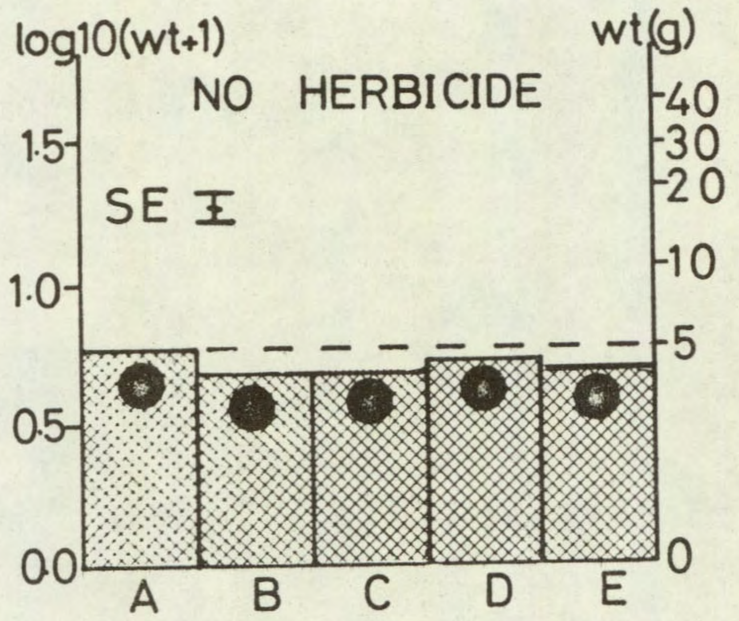
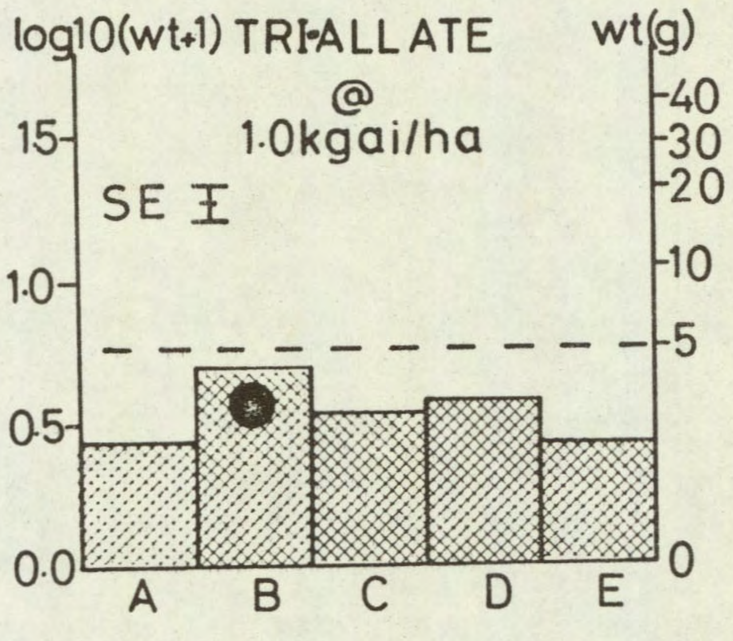

log10(wt+1)
wt(g)
TRIALLATE @ 4·0kgai/ha
SE I
1·5
1·0
0·5
0·0
40
30
20
10
5
0
A B C D E F G H

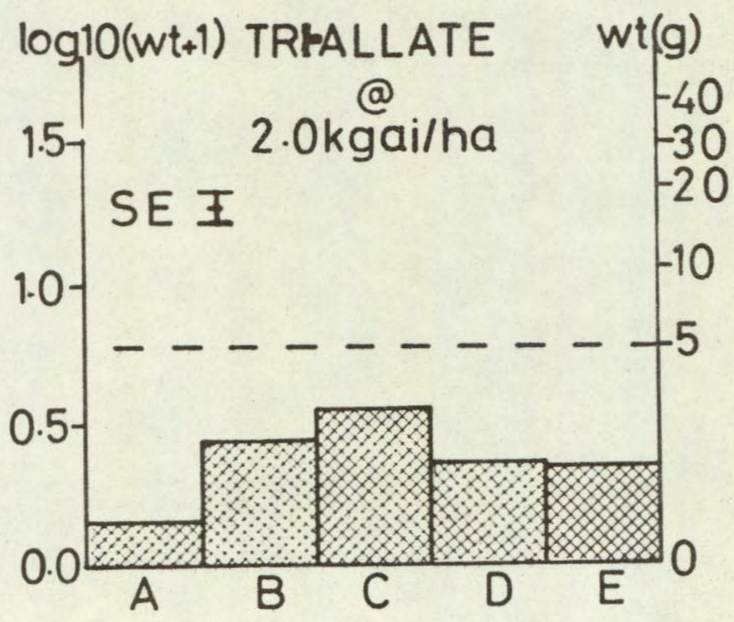
Fig. 11 The effect of tri-allate on wheat with and without seed treatments of NA or R25788 and as influenced by the use of methylcellulose as a 'sticker'.

The protectant dose is expressed as a percentage by weight of seed treated. Treatments: A, no protectant; B, R25788 at 1%; C, R25788 at 2%; D, R25788 at 4%; E, NA at 1%; F, NA at 2%; G, NA at 4%; H, NA at 8%; ● , not significantly different from untreated control; ——, untreated control level; □ - no methylcellulose; ▨ + methylcellulose; ⊤ ± SE.

A seed treatment of 4% R25788 damaged wheat when applied alone but not when applied with methylcellulose. Tri-allate at 1 kg ai/ha caused damage to wheat with or without methylcellulose treatment and R25788 alone at 4% was the only dressing not to give protection. Tri-allate at 2 kg ai/ha was only protected significantly by 1% R25788 + methylcellulose and there was no protection from tri-allate at 4 kg ai/ha. When meaned over all other factors, plants treated with methylcellulose were significantly less damaged than those not. All treatments alleviated symptoms caused by tri-allate at 1 kg ai/ha except 2% R25788 but at 2 kg ai/ha only 1% R25788 + methylcellulose , 2% R25788 and 2% NA + methylcellulose countered visible damage.


log10(wt+1)
wt(g)
NO HERBICIDE
SE ±
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A
B
C
D
E


log10(wt+1)
TRIALLATE
@
1.0kgai/ha
wt(g)
SE ±
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A
B
C
D
E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TRIALLATE
@
2.0kgai/ha
wt(g)
SE ±
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A
B
C
D
E

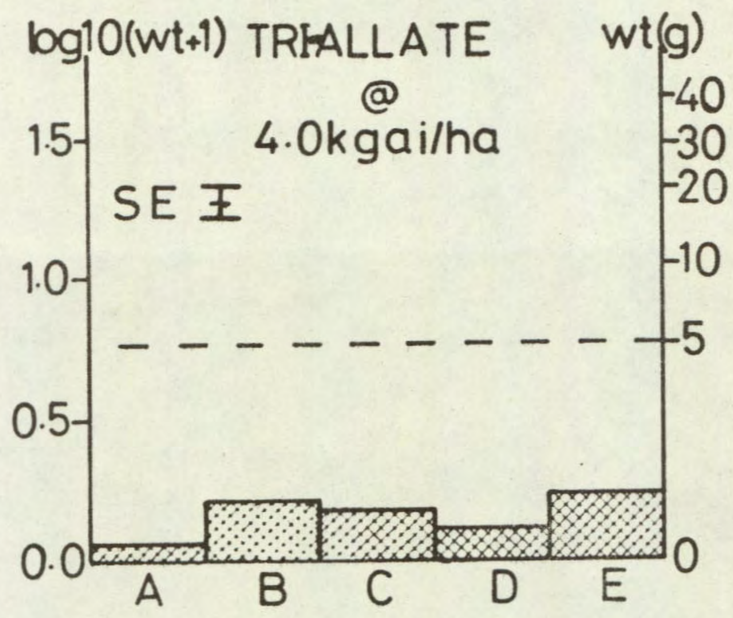
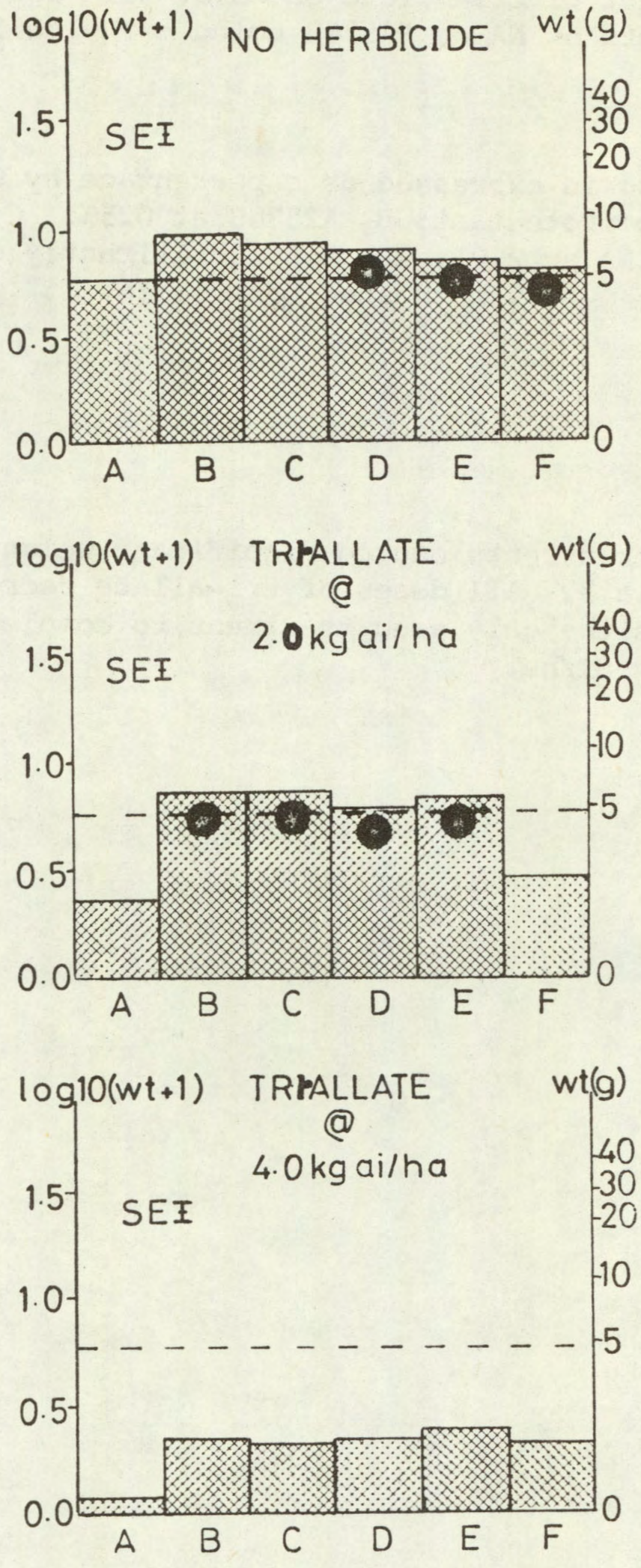

log10(wt+1)
TRIALLATE
@
4.0kgai/ha
wt(g)
SE ±
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A
B
C
D
E

Fig. 12 The effect of tri-allate on wheat with and without seed treatments of NA or R25788 using methylcellulose as a 'sticker'.

The protectant dose is expressed as a percentage by weight of seed treated. Treatments: A, no protectant; B, R25788 at 0.5%; C, R25788 at 2.0%; D, NA at 0.5%; E,NA at 2.0%; ●, not significantly different from untreated control; ----, untreated control level; ▨ + methylcellulose; ⊥ ± SE.

None of the seed treatments caused significant weight reductions in the absence of tri-allate. All doses of tri-allate decreased weights and R25788 at 0.5% was the only seed treatment to completely protect from tri-allate at 1 kg ai/ha.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NO HERBICIDE
wt(g)
SEI
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A B C D E F
log10(wt+1)
TRIALLATE
@
2.0 kg ai/ha
wt(g)
SEI
log10(wt+1)
TRIALLATE
@
4.0 kg ai/ha
wt(g)
SEI

Fig. 13 The effect of tri-allate on wheat with and without seed treatments of R25788 with methylcellulose as a 'sticker'.

The protectant dose is expressed as a percentage by weight of seed treated. Treatments: A, no protectant; B, R25788 at 0.25%; C, R25788 at 0.5%; D, R25788 at 1.0%; E, R25788 at 2.0%; F, R25788 at 4.0%; ⊕, not significantly different from untreated control; ----, untreated control level; ▨ + methylcellulose; ⊥ ± SE.

None of the seed treatments decreased crop weights in the absence of herbicide but tri-allate at 2 and 4 kg ai/ha caused significant damage. All seed treatments except 4% R25788 + methylcellulose gave protection from 2 kg ai/ha but not against all symptoms. None of the treatments countered damage from tri-allate at 4 kg ai/ha.

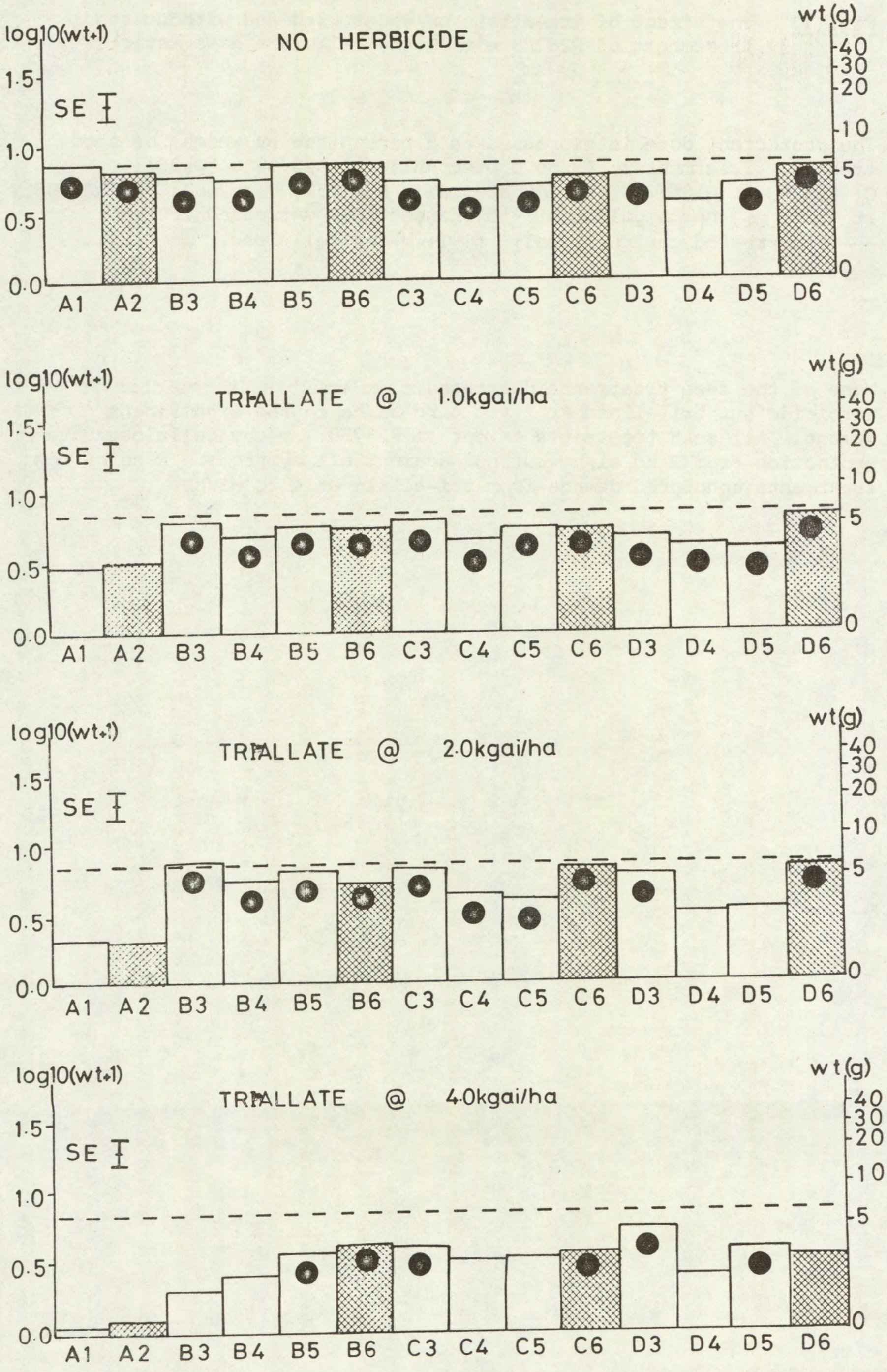
log10(wt+1)
wt(g)
NO HERBICIDE
SE
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 B3 B4 B5 B6 C3 C4 C5 C6 D3 D4 D5 D6
TRIALLATE @ 1.0kgai/ha
TRIALLATE @ 2.0kgai/ha
TRIALLATE @ 4.0kgai/ha

Fig. 14 The effect of tri-allate on wheat with and without seed treatments of R4115.

The protectant is expressed as a percentage by weight of seed treated. Treatments: A, no protectant; B, R4115 at 1%; C, R4115 at 2%; D, R4115 at 3%; 1, no seed treatment; 2, + methylcellulose ▨; 3, visually estimated poor seed coating; 4, visually estimated good seed coating; 5, random selection of coated seeds; 6, + methylcellulose ▨; ●, not significantly different from untreated control; ——; untreated control level; ⊤ ± SE.

All three doses of tri-allate with or without a seed treatment of methylcellulose reduced plant weights. All seed treatments significantly protected from tri-allate at 1 kg ai/ha and all treatments except those visually estimated as having poor or random coverings of 3% R4115 protected from tri-allate at 2 kg ai/ha. All treatments protected from 4 kg ai/ha except 1% poor and good, 2% good and random, and 3% good and + methylcellulose. All symptoms were not however alleviated at higher tri-allate doses.

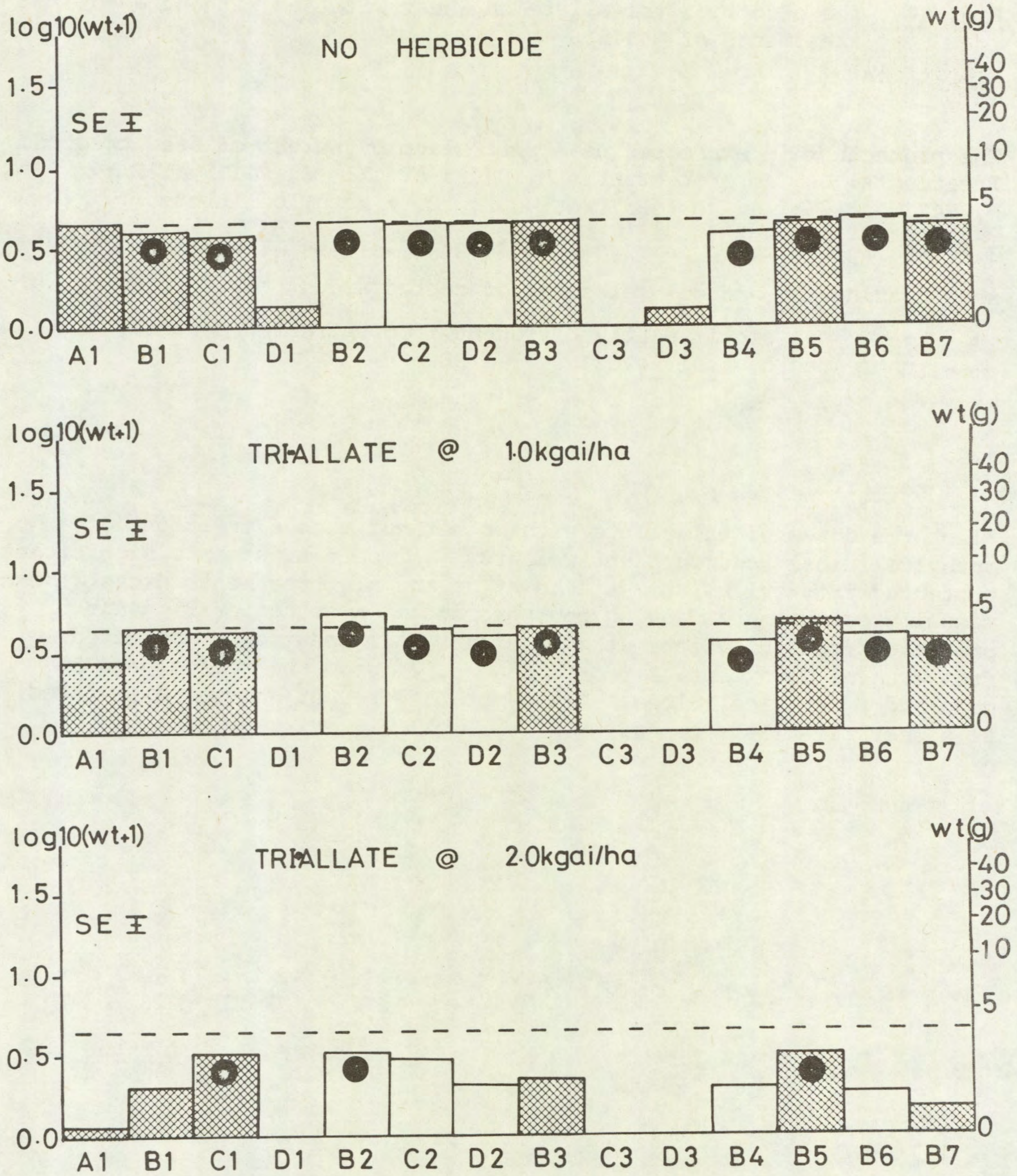
log10(wt+1)
wt(g)
NO HERBICIDE
SE ±
1·5
1·0
0·5
0·0
40
30
20
10
5
0
A1 B1 C1 D1 B2 C2 D2 B3 C3 D3 B4 B5 B6 B7
TRIALLATE @ 1·0kgai/ha
TRIALLATE @ 2·0kgai/ha
TRIALLATE @ 4·0kgai/ha

Fig. 15 The effect of tri-allate on wheat with and without seed treatments of R29148 and as influenced by methylcellulose as a 'sticker'.

The protectant is expressed as a percentage by weight of seed treated. Treatments: A, no protectant; B, R29148 at 0.5%; C, R29148 at 2.0%; D, R29148 at 8%; 1, R29148 + methycellulose ▨; 2, R29148 ground in mortar; 3, ground R29148 + methylcellulose ▨; 4, R25788 at 0.5%; 5, R25788 at 0.5% + methylcellulose ▨; 6, NA at 0.5%; 7, NA at 0.5% + methylcellulose ▨; ●, not significantly different from untreated control; ----, untreated control level; ⊥ - SE.

All doses of tri-allate decreased crop weights as did R29148 at 8% and ground R29148 at 2% and 8% with added methylcellulose. In terms of plant weight there was significant protection from tri-allate at 1 kg ai/ha by all treatments except R29148 at 8% and ground R29148 at 8% and 2% all with added methylcellulose: in terms of herbicide symptoms there was protection by 2% R29148 + methylcellulose, 0.5, 2 and 8% ground R29148, 0.5% ground R29148 + methylcellulose, 0.5% R25788 + methylcellulose and 0.5% NA + methylcellulose. No treatment gave complete protection from both herbicide damage and weight loss due to tri-allate at 2 and 4 kg ai/ha.

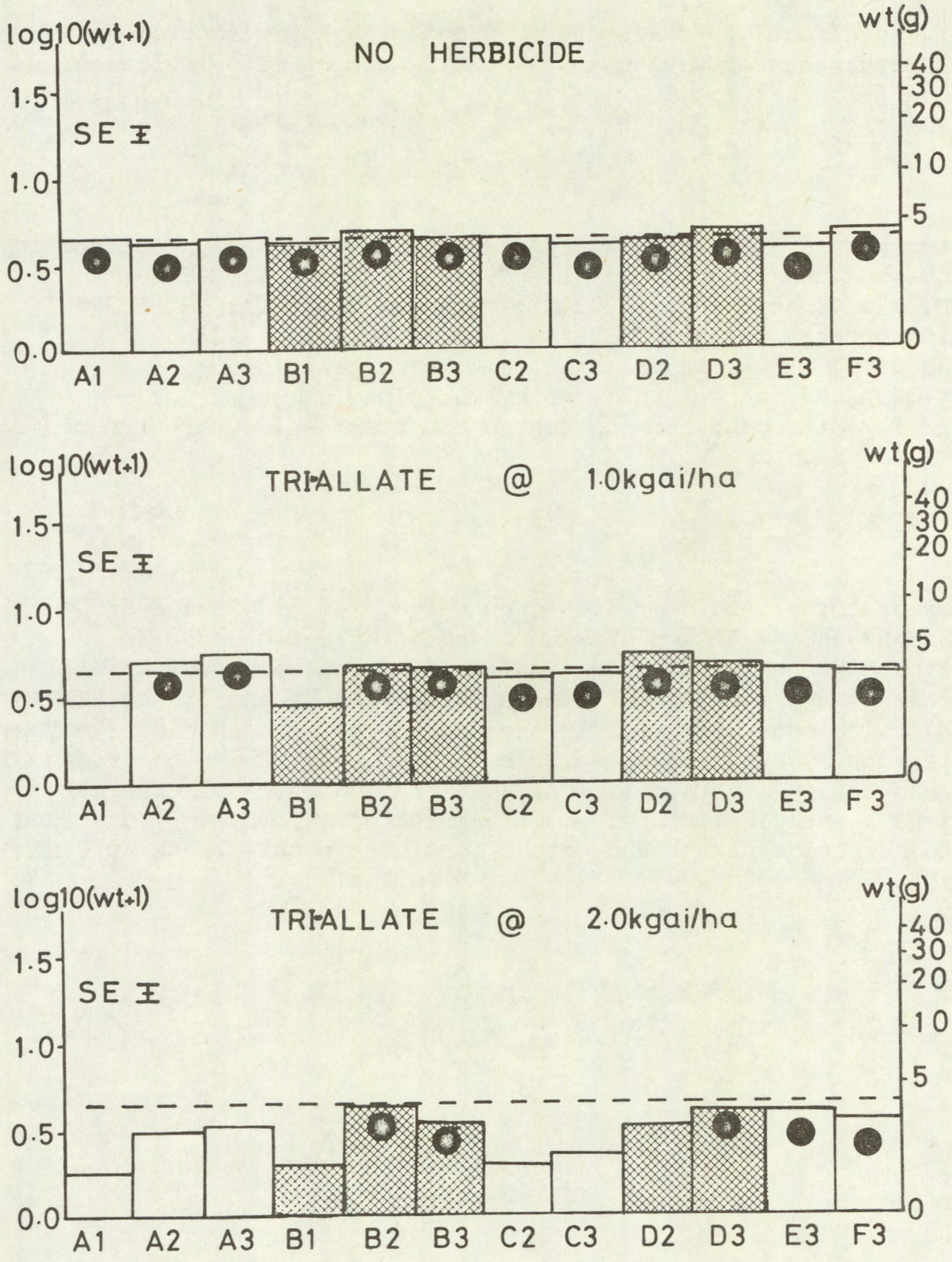
log10(wt+1)
wt(g)
NO HERBICIDE
SE ±
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 A3 B1 B2 B3 C2 C3 D2 D3 E3 F3
log10(wt+1)
wt(g)
TRIALLATE @ 1.0kgai/ha
SE ±
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 A3 B1 B2 B3 C2 C3 D2 D3 E3 F 3
log10(wt+1)
wt(g)
TRIALLATE @ 2.0kgai/ha
SE ±
1.5
1.0
0.5
0.0
40
30
20
10
5
0
A1 A2 A3 B1 B2 B3 C2 C3 D2 D3 E3 F3

Fig. 16 The effect of tri-allate on wheat with and without seed treatments of R29148, R25788 or NA and as influenced by methylcellulose as a 'sticker'.

The protectant dose is expressed as a percentage by weight of seed treated. Treatments: A, R29148 ground; B, R29148 ground + methylcellulose ▭; C, R29148; D, R29148 + methylcellulose; E, R25788; F, NA; 1, no protectant; 2, 0.25%; 3, 0.5%; ● , not significantly different from untreated control; ----- untreated control level; ± SE.

None of the seed treatments caused damage when applied in the absence of the herbicide. Tri-allate at 1 and 2 kg ai/ha significantly reduced weights. All seed treatments except that with methylcellulose alone protected wheat from tri-allate at 1 kg ai/ha in terms of plant weight but 0.5% ground R29148 + methylcellulose was the only treatment to also counter visible symptoms of damage. 0.25% ground R29148 + methylcellulose, NA and R25788 protected 80% of plants from herbicide damage. No treatment completely countered both herbicide symptoms and weight loss due to tri-allate at 2 kg ai/ha.

As tri-allate granules had no effect alone (Fig. 7) there was no scope for protection but there was no adverse effects of this treatment due to the presence of NA or R25788.

DISCUSSION AND CONCLUSION

In all experiments tri-allate damaged wheat by causing both weight loss and visual symptoms of twisting and deformity of the foliage. It is important that when plants are referred to as being protected from damage this should mean both against weight loss and visual symptoms. However, the experiments described all took place over a fairly short time scale with plants grown in pots in the glasshouse and longer term experiments would be required to assess whether any initial check to growth and consequent weight loss would be reflected in the subsequent plant yield.

Response in terms of protection was variable, and limited in degree in that the protection effect diminished as tri-allate dose increased. NA (0.5-1.0%) applied to the seed generally gave good protection from tri-allate at 1 kg ai/ha (Fig. 1, 4, 10, 11) but in some cases did not (Fig. 15, 16): when treated with tri-allate at 2 kg ai/ha protection was incomplete either in terms of weight loss or herbicide symptoms. The addition of methylcellulose did not markedly alter plant response to tri-allate damage (Fig. 1 , 12, 15, 16).

R25788 (0.5-1.0%) applied as a seed dressing also protected from tri-allate at 1 kg ai/ha (Fig. 4, 11) but not in all cases (Fig. 2, 15, 16). In one experiment (Fig. 9) R25788 protected from tri-allate at 2 kg ai/ha but in all other experiments protection from this particular treatment was incomplete. The addition of methylcellulose to the seed had no obvious benefit (Fig. 12, 13, 15, 16) except in one case (Fig. 11) where it improved the protection by R25788 at 1% from tri-allate at 2 kg ai/ha. When mixed in the spray tank with tri-allate the emulsifiable concentrate of R25788 at 2 and 4 kg ai/ha protected from tri-allate at 2 kg ai/ha and R25788 at 4 kg ai/ha protected from tri-allate at 4 kg ai/ha in terms of weight, but none of the protectant treatments countered visible damage symptoms.

A seed dressing of R4115 (1-2%) gave good protection from tri-allate at 1 kg ai/ha (Fig. 4, 5, 14) but in one experiment (Fig. 2) only against herbicide symptoms. However in two of these experiments (Fig. 4, 5) 2% R4115 also caused marked damage when applied in the absence of tri-allate. Protection was incomplete against tri-allate at 2 and 4 kg ai/ha. Methylcellulose applied to the seed with R4115 (Fig. 14) did not influence the degree of protection. When R4115 (same formulation) was mixed in the spray tank with tri-allate (Fig. 5) protection was not as good as the corresponding seed treatment.

R29148 only protected from tri-allate damage when the seed treatment was modified in some way (Fig. 15, 16) either by grinding with pestle and mortar to produce a finer powder and/or using methylcellulose.

The influence of other factors considered e.g. fertilizer levels (Fig. 9, 10) and varieties (Fig. 8) did not appear to have a major effect on protection in these exepriments.

Two field experiments were carried out in 1975 but establishment was very poor in a dry season and consequently results are not presented.

However even allowing for the variability there was no real indication of marked protection.

As there is still no clear indication of mode of action of these protectants it is difficult to predict the likely factors responsible for the variability. However if the mode of protectants becomes better understood it may be possible to modify treatments and make them more reliable in practice.

ACKNOWLEDGEMENTS

I should like to thank Dr K Holly for his helpful advice, Miss F M L Fulton and C P Hughes for their technical assistance. I should also like to thank Gulf Oil Chemicals Company and Stauffer Chemical Company for samples of their protectants and the relevant technical data.

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ABBREVIATIONS

ångström	Å	freezing point	f.p.
Abstract	Abs.	from summary	F.s.
acid equivalent*	a.e.	gallon	gal
acre	ac	gallons per hour	gal/h
active ingredient*	a.i.	gallons per acre	gal/ac
approximately equal to*	≃	gas liquid chromatography	GLC
aqueous concentrate	a.c.	gramme	g
bibliography	bibl.	hectare	ha
boiling point	b.p.	hectokilogram	hkg
bushel	bu	high volume	HV
centigrade	C	horse power	hp
centimetre*	cm	hour	h
concentrated	concd	hundredweight*	cwt
concentration	concn	hydrogen ion concentration*	pH
concentration x time product	ct	inch	in.
		infra red	i.r.
concentration required to kill 50% test animals	LC50	kilogramme	kg
cubic centimetre*	cm^3	kilo ($x10^3$)	k
cubic foot*	ft^3	less than	<
cubic inch*	in^3	litre	l.
cubic metre*	m^3	low volume	LV
cubic yard*	yd^3	maximum	max.
cultivar(s)	cv.	median lethal dose	LD50
curie*	Ci	medium volume	MV
degree Celsius*	^oC	melting point	m.p.
degree centigrade	^oC	metre	m
degree Fahrenheit*	^oF	micro ($x10^{-6}$)	µ
diameter	diam.	microgramme*	µg
diameter at breast height	d.b.h.	micromicro (pico: $x10^{-12}$)*	µµ
divided by*	: or /	micrometre (micron)*	µm (or µ)
dry matter	d.m.	micron (micrometre)*†	µm (or µ)
emulsifiable concentrate	e.c.	miles per hour*	mile/h
		milli ($x10^{-3}$)	m
equal to*	=	milliequivalent*	m.equiv.
fluid	fl.	milligramme	mg
foot	ft	millilitre	ml

† The name micrometre is preferred to micron and µm is preferred to µ.

millimetre*	mm
millimicro* (nano: $x10^{-9}$)	n or mμ
minimum	min.
minus	-
minute	min
molar concentration*	M (small cap)
molecule, molecular	mol.
more than	>
multiplied by*	x
normal concentration*	N (small cap)
not dated	n.d.
oil miscible concentrate	o.m.c. (tables only)
organic matter	o.m.
ounce	oz
ounces per gallon	oz/gal
page	p.
pages	pp.
parts per million	ppm
parts per million by volume	ppmv
parts per million by weight	ppmw
percent(age)	%
pico (micromicro: $x10^{-12}$)	p or μμ
pint	pint
pints per acre	pints/ac
plus or minus*	±
post-emergence	post-em
pound	lb
pound per acre*	lb/ac
pounds per minute	lb/min
pound per square inch*	lb/in^2
powder for dry application	p. (tables only)
power take off	p.t.o.
precipitate (noun)	ppt.
pre-emergence	pre-em.
quart	quart
relative humidity	r.h.
revolution per minute*	rev/min
second	s
soluble concentrate	s.c.
soluble powder	s.p.
solution	soln
species (singular)	sp.
species (plural)	spp.
specific gravity	sp. gr.
square foot*	ft^2
square inch	in^2
square metre*	m^2
square root of*	$\sqrt{\ }$
sub-species*	ssp.
summary	s.
temperature	temp.
ton	ton
tonne	t
ultra-low volume	ULV
ultra violet	u.v.
vapour density	v.d.
vapour pressure	v.p.
varietas	var.
volt	V
volume	vol.
volume per volume	v/v
water soluble powder	w.s.p. (tables only)
watt	W
weight	wt
weight per volume*	w/v
weight per weight*	w/w
wettable powder	w.p.
yard	yd
yards per minute	yd/min

* Those marked * should normally be used in the text as well as in tables etc.

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