QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
DIVISION OF PLANT INDUSTRY BULLETIN No. 524

RESPONSE BY SOME TROPICAL PASTURE LEGUMES TO VERNOLATE

By D. R. Bailey, M.Agr.Sc.

SUMMARY

In pot experiments silverleaf desmodium (*Desmodium uncinatum*), greenleaf desmodium (*Desmodium intortum*), and glycine (*Glycine javanica*) tolerated the preplant herbicide vernolate (N-propyl-di-N-propylthiolcarbamate) at rates up to 4 lb a.i./ac. Siratro (*Phaseolus atropurpureus*) and *Dolichos axillaris* were less tolerant. In the field, vernolate at 4 lb a.i./ac reduced the dry-matter yield of siratro top-growth by 47%. Monocotyledonous weeds were satisfactorily controlled, but even at 32 lb a.i./ac, blue billygoat-weed (*Ageratum houstonianum*) was only partially controlled.

The extent of vernolate damage to silverleaf desmodium was negatively correlated with the percentage organic carbon and the cation exchange capacity (CEC) of the soil. Percentage carbon and CEC were themselves highly correlated. Clay content had no influence on vernolate damage to silverleaf desmodium.

I. INTRODUCTION

The current interest in legume-based pastures in Queensland has created a demand by both seed-growers and pasture research workers for selective chemical weed control in pure stands of tropical legumes. There has been comparatively little reported in the literature concerning the effect of pre-emergence herbicides on tropical pasture legumes. Riepma (1965) tested the effect of pre- and post-emergence applications of neburon on rubber plantation cover crops of *Centrosema pubescens* and *Pueraria phaseoloides.* He found that *P. phaseoloides* was adversely affected by pre-emergence applications of neburon but *C. pubescens* was more tolerant. Earlier screening trials had shown CDAA, EPTC, CDEC and dichlobenil to be selective, but they gave only short-term weed control. Hazard (1967) has given screening results with pre-emergence chemicals on 12 tropical legumes. All herbicides were selective on some of the legumes, but none gave control of all of the weed species encountered. Trifluralin and R1607 (vernolate) were among the chemicals tested.

The purpose of this paper is to extend the preliminary information given by Bailey (1967) on the effect of the preplant herbicide, N-propyl-di-N-propylthiolcarbamate (vernolate), on some tropical pasture legumes. Three pot experiments and one field experiment are reported. The response of *Phaseolus atropurpureus* cv. Siratro to vernolate was studied in the field because crops of siratro seed at present enjoy a good profit margin, and an effective herbicide to aid establishment would be readily accepted by seed-growers.

In another experiment, *Desmodium uncinatum* was grown in a range of soils to assess the importance of soil properties in determining plant reaction to vernolate. Finally, five species of legume were tested in a single experiment because earlier results had indicated that some tropical legumes may be more tolerant than others to vernolate.

II. MATERIALS AND METHODS

Soils.—Soils for the pot experiments were bulked from several random sites in the field. An exception was the coarse river sand used in experiment 2, which was taken from a heap of builders' sand. The 10 soils used in experiment 2 were dried for approximately 68 hr at 40°C in a forced-draught dehydrator and then passed through a 2 mm sieve, while soils in experiments 1 and 4 were screened through a ⅜ in. square-mesh sieve before potting.

Management of pot experiments.—Experiments were carried out in a lath-house with a corrugated, translucent fibre-glass roof. Block positions were changed and pot positions re-randomized within each block several times during the course of each experiment to minimize inter-pot shade differences. The pots were watered overhead to maintain 60% of the water-holding capacity, based on oven-dry (OD 105°C) soil weight. Experiments 1 and 4 were watered once or twice a week, but watering was required once every 1 or 2 days in experiment 2 because of the small size of the pots. To control caterpillars and fungi, plants were regularly dusted with a 2% DDT, 40% sulphur, 7% copper oxychloride mixture.

Application of herbicide.—Herbicides in experiment 1 were applied to the soil surface by a single traverse of an Oxford Precision Sprayer at 25 p.s.i. and in a volume of 30 gal/ac. Vernolate and 2,6-dinitro-NN-dipropyl-4-trifluoromethylaniline (trifluralin) were applied just before sowing the legume seed, and immediately incorporated to a depth of approximately 2 in. by thorough mixing. The day after sowing, N-butyl-N′-(3,4 dichlorophenyl)-N-methylurea (neburon) was sprayed onto a smooth soil surface but not incorporated.

In experiment 2, vernolate was added to soil in plastic bags and incorporated by vigorous shaking. The bags were then sealed and let stand for 2 days before potting. Herbicide rates were calculated on oven-dry soil weights.

Vernolate was applied to a weed-free surface just prior to sowing in experiment 3, at 25 p.s.i. in a volume of 60 gal/ac with an Oxford Precision Sprayer, and immediately incorporated by rotary hoeing to a depth of 2–3 in.

In experiment 4, herbicide was incorporated into the top 2 in. layer (2·5 lb oven-dry soil) by mixing in a concrete mixer. Chemical quantities were calculated in pounds per acre on an area basis.

Sowing.—Then germinated legume seeds were sown at approxmiately ¼ in. depth in experiment 1. Species tested were *Glycine javanica* (*G. wightii*) cv. Tinaroo (glycine), *Desmodium uncinatum* cv. Silverleaf (silverleaf desmodium) and *Desmodium intortum* cv. Greenleaf (greenleaf desmodium). Equal amounts (0·93 g) of *Panicum maximum* var. *typica* (guinea grass) and *Hyptis capitata* (knobweed) seed were also sown in each pot to gauge the effect of herbicides on weed growth. Three days after weed counts had been taken the pots were weeded and then kept clean until the end of the experiment.

In experiment 2, silverleaf desmodium seed was broadcast on the soil surface, and once established, thinned to two plants per pot. Siratro was sown at 25 lb/ac in two rows spaced at 1 ft centres down each plot in experiment 3, and legume seed was broadcast on the soil surface the day after potting in experiment 4, then later thinned to five plants per pot. Species tested were glycine, silverleaf desmodium, greenleaf desmodium, siratro, and *Dolichos axillaris*.

In all experiments the legume seed was inoculated with the appropriate strain of *Rhizobium*.

Data recording.—Dry-matter yields (95°C) of legume top-growth and weed counts were taken in experiment 1. Green yield of legume top-growth was recorded in experiment 2 and each pot rated for vernolate damage as follows:

0 = No damage.
1 = Slight leaf puckering.
2 = Slight stunting and leaf puckering.
3 = Stunting and leaf puckering.

Legume emergence counts were taken from the central 10 ft section of each row in experiment 3 and weed counts in two randomly located 16 in. x 16 in. quadrats in each plot. In the same experiment three random 2 ft x 3 ft quadrats were centred over the legume rows, herbage was cut at ground level and sorted into legume and weeds, and then the material was dried at 95°C. In experiment 4, dry-matter yields of legume top-growth were obtained.

Details of individual experiments are given in Table 1.

III. RESULTS

(a) Experiment 1

Legume yields expressed as percentages of the appropriate untreated control are presented in Table 2, together with guinea grass and legume counts. Knobweed counts have not been tabulated because they were too variable to give precise information.

TABLE 1

EXPERIMENTAL DETAILS

Treatments	Pots and Plots	Soil	Sowing Date	Basal Fertilizer	Measurements
EXPERIMENT 1 (3 replicates) 3 species (glycine, silverleaf desmodium, and greenleaf desmodium). Herbicides (vernolate 0, 1, and 2 lb a.i./ac; trifluralin 0, $\frac{3}{4}$ and $1\frac{1}{2}$ lb a.i./ac; neburon 0, 2 and 4 lb. a.i./ac).	$8\frac{1}{2}$ in. diam. plastic pots containing 8·15 lb (OD) soil	Red brown sandy clay loam of basaltic origin	Sept. 19, 1966	2·63 g/pot $Na_2HPO_4 \cdot 12H_2O$ and 0·43 g/pot KC1	Weed counts Oct. 4 and 5, 1966. Legume D.M. Oct. 31, 1966.
EXPERIMENT 2 (4 replicates) Vernolate 0, $\frac{1}{2}$, 2, 4, 8 and 32 p.p.m. (Silverleaf desmodium sown; two 0 p.p.m. treatments per block.)	$2\frac{1}{4}$ in. diam. waxed paper pots containing 180 c.c. of soil	Details shown in Table 3	Dec. 21, 1966	Watered with a solution containing all plant nutrients	Legume damage rating and green matter Jan. 27, 1967.
EXPERIMENT 3 (4 replicates) Vernolate 0, 4, 8, 16 and 32 lb a.i./ac. (Siratro sown; one plot hand-weeded per block May 30, 1967).	6 ft x 12 ft plots ..	Reddish brown silty clay loam of alluvial origin (1·13% organic carbon 0–8 in.)	April 10, 1967	Nil	Legume counts May 24, 1967. Weed counts and herbage D.M. June 26 and 27, 1967.
EXPERIMENT 4 (4 replicates) 5 species (glycine, silverleaf desmodium, greenleaf desmodium, siratro, and *Dolichos axillaris*). Vernolate rates (0, 4, 8, 16 and 32 lb a.i./ac).	$8\frac{1}{2}$ in. diam. plastic pots containing 8·35 lb (OD) soil	As in experiment 3 ..	Oct. 20, 1967	Watered with "Liquifert"*	Legume D.M. Dec. 22, 1967

* "Liquifert" a soluble fertilizer mixture, registered trade name of A.C.F. and Shirleys Fertilizers Ltd.

TABLE 2

EFFECT OF TREATMENTS ON LEGUME GROWTH AND GUINEA GRASS EMERGENCE IN EXPERIMENT 1

Treatment (lb a.i./ac)		Species	Legume: D.M. yield as a percentage of the untreated	Legume: Mean no. of plants surviving per pot at harvest	Legume: Visual damage showing in surviving plants	Guinea grass No. per pot ± SD
Untreated	0	Glycine	*	10·0	Nil	
	0	Silverleaf desmodium	†	9·8	Nil	18 ± 5
	0	Greenleaf desmodium	§	9·6	Nil	
Vernolate	1	Glycine	106	10·0	Nil	
	1	Silverleaf desmodium	100	9·0	Trace	5 ± 3
	1	Greenleaf desmodium	95	10·0	Nil	
	2	Glycine	91	9·7	Ni	
	2	Silverleaf desmodium	88	8·7	Slight	6 ± 3
	2	Greenleaf desmodium	87	9·3	Slight	
Trifluralin	¾	Glycine	103	10·0	Slight	
	¾	Silverleaf desmodium	64	9·3	Moderate	2 ± 2
	¾	Greenleaf desmodium	63	7·3	Moderate	
	1½	Glycine	28	8·3	Moderate	
	1½	Silverleaf desmodium	19	5·0	Moderate	0·2 ± 0·2
	1½	Greenleaf desmodium	0‡	0	..	
Neburon	2	Glycine	98	9·7	Trace	
	2	Silverleaf desmodium	87	9·3	Slight	5 ± 4
	2	Greenleaf desmodium	19	2·0	Trace	
	4	Glycine	66	7·0	Moderate	
	4	Silverleaf desmodium	73	9·0	Moderate	4 ± 3
	4	Greenleaf desmodium	0‡	0	..	
L.S.D.						
$P = 0{\cdot}05$			29			
$P = 0{\cdot}01$			40			

*, †, § Mean D.M. yield per pot—5·75, 4·66, and 4·56 g, respectively.

‡ Excluded from analysis.

Vernolate had only a slight adverse effect on the legumes, whereas trifluralin at 1½ lb/ac caused severe damage and completely killed greenleaf desmodium. Glycine tolerated the ¾ lb/ac rate of trifluralin but both desmodiums were damaged. Even at 2 lb/ac, neburon killed a high proportion of the greenleaf desmodium plants, and at 4 lb/ac killed all. Glycine and silverleaf desmodium were more tolerant of neburon, but even so, the 4 lb rate caused damage. All herbicides reduced guinea grass numbers, with trifluralin being the most effective.

(b) Experiment 2

Table 3 shows the mean damage rating for silverleaf desmodium grown in 10 soils containing 32 p.p.m. of vernolate. Even at 32 p.p.m. only slight reductions in yield were recorded (Bailey 1967), and for this reason, green yields

TABLE 3

SOIL PROPERTIES AND DAMAGE RATING FOR SILVERLEAF DESMODIUM GROWN IN SOME NORTH QUEENSLAND "SOILS" CONTAINING VERNOLATE

Soil Description	pH¶	Organic Carbon‡ %	Texture § Clay %	Silt %	Sand %	Cation Exchange Capacity m-equiv. 100 g	Damage Rating†
1. Brownish-grey clay loam ..	4·9	2·90	20·0	8·1	72·0	14·0	1·25
2. Very dark grey loamy sand + OM	5·0	4·53	12·6	10·5	76·4	22·5	1·00
3. Light brown loam ..	4·6	2·00	15·9	10·1	74·0	9·5	0·50
4. Grey-brown sandy loam ..	5·1	3·33	19·4	9·6	71·0	16·0	1·00
5. Yellowish-brown clay loam	4·5	2·08	42·1	27·3	30·6	14·0	2·25
6. Light brown silty clay loam	4·1	1·60	34·3	32·7	32·9	16·0	2·00
7. Grey coarse river sand ..	6·9	0·07	0·4	0·2	99·4	0·5	2·25
8. Dark brown peat ..	4·6	11·70	7*	64*	11*	48·5	0
9. Reddish-yellow clay loam	4·8	0·93	36·0	25·8	37·1	7·5	1·50
10. Yellowish-grey loam ..	5·7	3·91	27·5	23·0	49·5	15·5	1·75

¶ 1 : 2·5 soil/water suspension ‡ Walkley and Black § Bouyoucos hydrometer method

† Damage rating for silverleaf desmodium grown in soil containing 32 p.p.m. of vernolate. See text for rating details.

* Average values only; high organic matter content prevented precise analysis.

TABLE 4

SIMPLE CORRELATION COEFFICIENTS AMONG THREE SOIL PROPERTIES AND DAMAGE RATING FOR SILVERLEAF DESMODIUM GROWN IN SOME NORTH QUEENSLAND "SOILS" CONTAINING VERNOLATE

Soil Property	Damage Rating†	Organic Carbon	Clay
Organic carbon	− 0·73*	..	..
Clay	− 0·45	− 0·34	..
Cation exchange capacity ..	− 0·67*	0·98**	− 0·42

* $P < 0{\cdot}05$ ** $P < 0{\cdot}01$

† Damage rating for silverleaf desmodium grown in soil containing 32 p.p.m. of vernolate.

have not been presented. Damage was evident in the river sand (soil 7) at all levels of vernolate but absent from all other soils at 8 p.p.m. and below. Even at 32 p.p.m., there was no damage in the peat (soil 8).

Simple correlation coefficients between damage rating and soil properties are given in Table 4. The extent of damage was negatively correlated ($P<0{\cdot}05$) with the percentage organic carbon and the cation exchange capacity (CEC) of the soil; i.e. damage decreased as organic matter and CEC increased. Table 4 shows that CEC was very strongly correlated with the percentage organic carbon, but not with clay content. The relationship between legume damage and organic carbon, for the 10 soils, is shown in Figure 1.

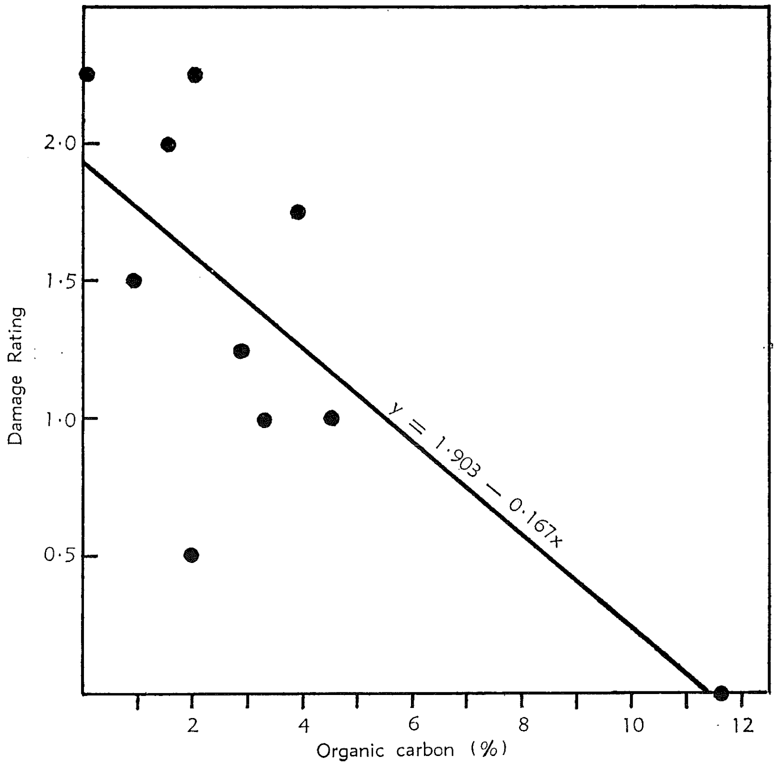

Fig. 1.—Relationship between damage rating and soil organic carbon content for silverleaf desmodium grown in 10 north Queensland "soils" containing 32 p.p.m. of vernolate.

TABLE 5

EFFECT OF TREATMENTS ON SIRATRO AND WEED EMERGENCE IN EXPERIMENT 3

Treatment	Siratro (No./20 ft of row)	Weed (No./3·55 sq ft)			
		Monocots		Dicots	
Untreated	160	(8·75)‡	76†	(9·35)	87†
Hand-weeded	156	(5·33)	28	(4·47)	20
Vernolate 4 lb a.i./ac	154	(4·45)	19	(8·93)	79
Vernolate 8 lb a.i./ac	164	(2·51)	6	(9·87)	97
Vernolate 16 lb a.i./ac	162	(1·48)	2	(8·08)	65
Vernolate 32 lb a.i./ac	150	(1·63)	2	(7·39)	54
L.S.D.					
$P = 0{\cdot}05$	n.s.	(2·25)		(2·49)	
$P = 0{\cdot}01$		(3·11)		(3·44)	

n.s. Not significant. ‡ $\sqrt{x + \frac{1}{2}}$ transformation. † Re-transformed data.

(c) Experiment 3

Weed numbers and siratro emergence counts are shown in Table 5. The number of siratro plants emerging was not affected by vernolate nor was the number of dicotyledonous weeds. *Ageratum houstonianum* (blue billygoat-weed) was the principal broadleaf weed, with lesser amounts of *Richardia brasiliensis* (Mexican clover) present. Vernolate effectively controlled monocotyledonous weeds, guinea grass and species of *Cyperus* (Table 5). The effectiveness of vernolate on these two weeds improved up to 16 lb/ac, but no difference was apparent between 16 and 32 lb/ac.

TABLE 6

Effect of Treatments on Siratro and Weed Yields in Experiment 3

Treatment	Siratro (D.M. lb/ac)	Weed (D.M. lb/ac)	Siratro Plus Weed (D.M. lb/ac)
Untreated	450	253	703
Hand-weeded	531	17	548
Vernolate 4 lb a.i./ac	237	243	480
Vernolate 8 lb a.i./ac	173	225	398
Vernolate 16 lb a.i./ac	109	168	277
Vernolate 32 lb a.i./ac	79	100	179
L.S.D.			
$P = 0{\cdot}05$	157	89	189
$P = 0{\cdot}01$	217	123	262

Dry-matter yields of siratro and weed top-growth are presented in Table 6. Siratro growth was markedly suppressed by vernolate; plants growing in the 16 and 32 lb/ac plots were severely stunted. Blue billygoat-weed comprised the greatest part of the weed bulk and only at 32 lb/ac of vernolate was its growth appreciably reduced.

(d) Experiment 4

Legume yields from treated pots expressed as percentages of the appropriate untreated control are depicted in Figure 2. Silverleaf and greenleaf desmodium were more tolerant of vernolate than *Dolichos axillaris* or siratro, and glycine was intermediate between these two groups. The species/vernolate rate interaction was not significant ($P>0{\cdot}05$), indicating that the pattern of yield response by each legume was similar for all vernolate rates (Figure 2).

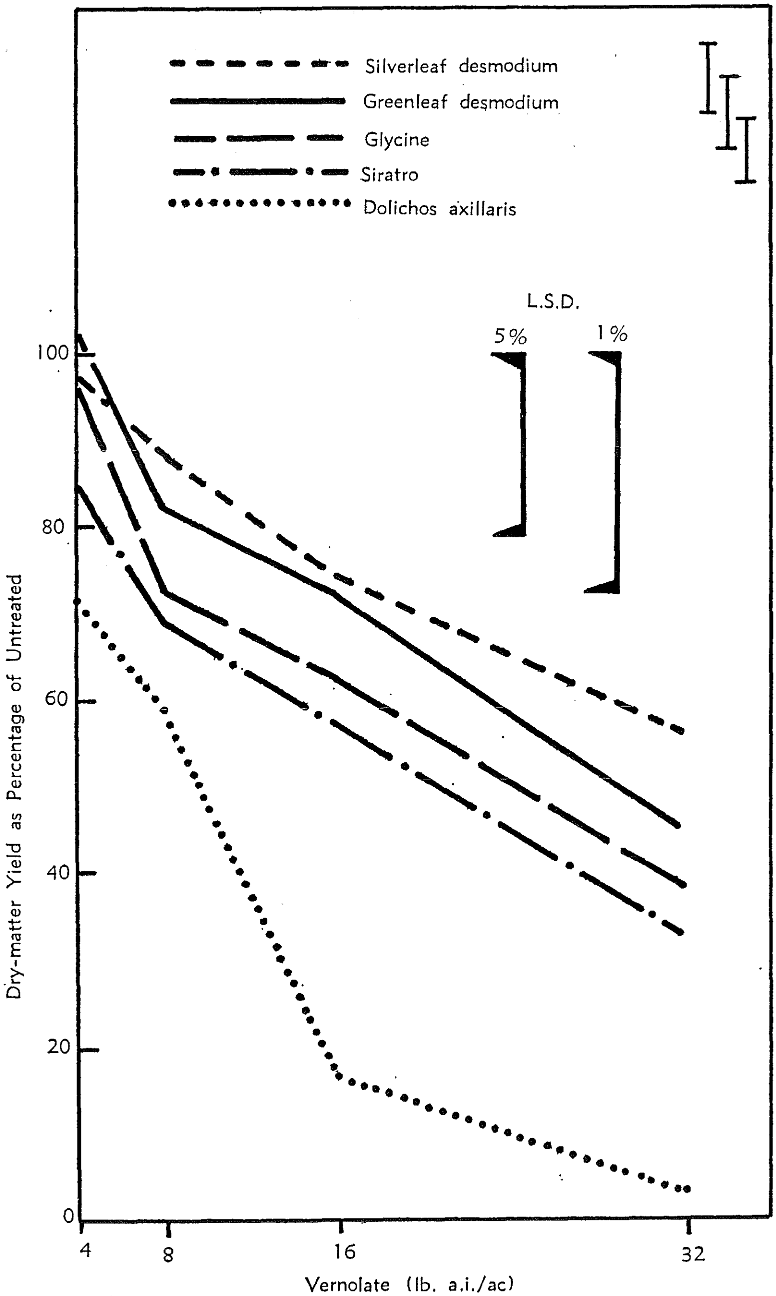

Fig. 2.—Effect of vernolate on the top-growth yield of legumes in experiment 4. Vertical lines connect species whose mean response do not differ significantly at $P<0\cdot05$.

IV. DISCUSSION

In the field, vernolate at 4 lb/ac reduced the yield of siratro by 47% compared with the untreated control. Weed yields were similar on the treated and untreated plots, so it is unlikely that the relative response by siratro to vernolate was appreciably influenced by weed competition (Table 6). Siratro grown in the same soil in pots was reduced by only 15% by vernolate at 4 lb/ac. In the field, vernolate was incorporated about ½ in. deeper than in the pots, so herbicide concentration in the surface root zone should have been slightly higher in the pots.

Possibly repeated wetting and drying in the field resulted in pockets of high vernolate concentration causing greater root uptake by the legume. Hartley (1964) has discussed a similar situation comparing plant growth in herbicide solution held in sand and in the same freely mobile solution. He concluded that pockets of high herbicide concentration would develop in the sand culture, so plants would probably show more severe symptoms, or develop them more quickly, in sand than in free solution.

Silverleaf and greenleaf desmodium, and possibly glycine, appear to possess sufficient tolerance to allow field usage of vernolate at rates up to 4 lb/ac. Earlier, Bailey (1967) suggested that 16 lb/ac may have been safe on silverleaf desmodium, but assumed the chemical to be incorporated to a depth of 6 in. in the field. Incorporation down to 2–3 in. would approximate more closely to the usual field situation, and consequently the tolerance of silverleaf desmodium to vernolate was probably over-estimated by a factor of 2 or 3. Acceptable control of monocotyledonous weeds should be achieved with 4 lb/ac, but control of dicotyledonous species could be variable. Hazard (1967) tested the effect of this chemical on 13 different dicotyledonous weeds and found that, for satisfactory control, all required higher rates than either *Eragrostis cilianensis* or *Eleusine indica.* The count data given by Rawson (1966) also show that annual grasses were more susceptible to vernolate than annual broadleaf weeds. Haramaki (1963) reported that, in experiments with annual flowers, *Ageratum* sp. showed no permanent injury to vernolate at 10 lb/ac applied 10 days before transplanting; therefore it is perhaps not surprising that *Ageratum houstonianum* was only partially controlled by vernolate in experiment 3.

Experiment 2 showed that damage to silverleaf desmodium was correlated with the amount of organic carbon in the soil and also with its CEC. Percentage carbon and CEC were themselves highly correlated, but there was no relationship between clay content and CEC. These results suggest that vernolate was absorbed onto the organic matter, causing the concentration of herbicide available in the soil water to drop, and as a result plant uptake was reduced.

V. ACKNOWLEDGEMENTS

Soil analyses were done by the Agricultural Chemical Laboratory Branch of the Queensland Department of Primary Industries, and most of the data were statistically analysed by the Biometry Branch of the Department. The help of

Mr. B. L. Campbell, formerly of I.C.I.A.N.Z. Ltd., in the early part of experiment 4 is gratefully acknowledged. Samples of vernolate were made available by I.C.I.A.N.Z. Ltd.

REFERENCES

BAILEY, D. R. (1967).—The effect of soil-active herbicides on three tropical pasture legumes. *Aust. Weeds Res. Newsl.* 10:11-13.

HARAMAKI, C. (1963).—Pre-plant weed control in annual flowers. *Proceedings 17th North-eastern Weed Control Conference* 1963:213-17 (*Weed Abstracts* 14:1431).

HARTLEY, G. S. (1964).—Herbicide behavior in the soil. 1. Physical factors and action through the soil. In *"The Physiology and Biochemistry of Herbicides."* L. J. Audus. (Academic Press: London).

HAZARD, W. H. (1967).—Chemical weed control in tropical legumes; herbicide screening trials. *Aust. Weeds Res. Newsl.* 10:13-6.

RAWSON, J. E. (1966).—Weed control in peanuts; herbicide screening trials. *Aust. Weeds Res. Newsl.* 9:14-7.

RIEPMA, P. (1965).—Neburon, a selective herbicide for use in tropical legumes. *Weed Res.* 5:52-60.

(Received for publication July 1, 1969)

The author is an officer of Agriculture Branch, Queensland Department of Primary Industries, and is stationed at South Johnstone Research Station, South Johnstone.