ECONOMIC AND EFFICACY EVALUATIONS OF NAPROPAMIDE, DCPA, AND HAND-WEEDED TREATMENTS IN NEWLY ESTABLISHED STRAWBERRIES (*FRAGARIA X ANANASSA* DUCH. 'REDCHIEF')

by

SUSAN FAYE HENNING

B.S., Horticulture, College of Agriculture,
Kansas State University, 1978

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

in Crop Protection

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1981

Approved by:

[signature]

TABLE OF CONTENTS

	Page
LIST OF TABLES	iii
ACKNOWLEDGEMENTS	iv
INTRODUCTION	1
LITERATURE REVIEW	2
MATERIALS AND METHODS	7
1979 Field Studies	7
1980 Field Studies	9
Economic Evaluations	9
Statistical Procedures	10
RESULTS	11
DISCUSSION	22
CONCLUSIONS	25
LITERATURE CITED	26
APPENDIX	30

Bioassay Study to Determine Soil Profile Movement and Longevity of DCPA and Napropamide Residues.

ILLEGIBLE DOCUMENT

THE FOLLOWING DOCUMENT(S) IS OF POOR LEGIBILITY IN THE ORIGINAL

THIS IS THE BEST COPY AVAILABLE

LIST OF TABLES

Table		Page
1	Weed count variations throughout the 1979 growing season in newly established strawberry plantations.	12
2	Visual weed ratings during 1979 and 1980 in strawberries established April 15, 1979	13
3	Weed biomass as an indicator of weed control in a new strawberry plantation established in 1979.	14
4	Correlation coefficients for weed control and yield components in strawberries.	16
5	Effect of weed biomass and strawberry plant density on yield of newly established strawberries.	17
6	Labor statistics related to weed control treatments in a newly established strawberry plantation.	18
7	Relationship of weed control treatment to weed control cost components.	19
8	Effects of weed control treatment on weed control costs, gross income, and income above weed control cost	21

Appendix Table		
1	Percent dry matter reduction[z] (%DMR) as affected by soil profile depth.	33
2	Emergence count as affected by soil profile depth. . . .	33

LIST OF FIGURES

Appendix Figure		Page
1	Dry matter vs. $\log_{10}$[DCPA(kg ai/ha) + 1]	34

ACKNOWLEDGEMENTS

The author would like to express sincere appreciation to Dr. Thomas Schueneman for technical assistance and advice throughout this study.

Special thanks goes to Dr. Neil Miles, major professor, for his valuable suggestions and assistance throughout this study and constructive review of this manuscript.

Sincere appreciation goes to Dr. Loren Moshier, Assistant Professor of Agronomy, for technical assistance in the bioassay study and review of this manuscript.

Special thanks also goes to R.W. Campbell and H.E. Thompson for critical review of this manuscript.

A special acknowledgement of gratitude is expressed to my family for their encouragement and support during this period of graduate study.

INTRODUCTION

Weed control in strawberries (Fragaria x ananassa) requires a large labor input, especially when done by hand. In a matted row growing system, hand labor becomes tedious, cost restrictive, or may be unavailable.

Weed control chemicals reduce weed populations and labor expenditures. Some Kansas strawberry growers are reluctant to use herbicides due to crop injury risk and inadequate weed control.

Irrigation by Kansas strawberry growers has increased yields and weed control problems.

DCPA (dimethyl tetrachloroterephthalate), a strawberry herbicide widely recommended and applied by Kansas extension and growers, offers annual grass and certain annual broadleaf weed control. New herbicides such as napropamide [2-(α-napthoxy)-N,N-diethylpropionamide] give more effective and longer season weed control than DCPA, without crop injury.

This study was undertaken to; (i) compare DCPA and napropamide for weed control and, (ii) compare cost/benefit economics of hand weeding versus chemical weed control in newly established strawberries.

LITERATURE REVIEW

Weed control research has revealed the effects of weed competition on yield, quality, and harvesting costs, as well as control methods that reduce labor requirements. An average annual loss of 10%, $18.2 billion, in agricultural production can be attributed to weed interference and control (46). A 1974 report, showed Arkansas fruit growers lost $52 per acre due to weed competition and control (10). Since 1950, manual labor has decreased 40% with an increase in mechanical power and herbicide use of 30% and seven fold, respectively (45). Although manual labor has reduced for agronomic crops, hand weed control in horticultural crops consumes a large amount of time and money.

Weed control is time consuming but probably the most important aspect of strawberry production (28). This shallow rooted crop does not compete well with weeds for nutrients and water. Lawson and Wiseman (26) in Scotland studied "critical periods" and physiological effects of weed competition in strawberry plantings. Weed competition reduced stolon and runner production. If weeds were removed by the times of stolon emergence, mid-June, stolon growth was relatively unaffected. Prolonged weed competition weakened main crown growth and reduced branch crown size and number. Unrestricted runner growth in weed-free plots reduced yields due to reduced crown and flower stalk formation. Light weed competition during late summer increased fruit production by restricting runner development. Hensley (15) confirmed that fruit production was increased by reducing runner number.

Meador, Doll, and Courter (28) reported most of commercial strawberry fields in Arkansas were directly harvested by customers. Weed free plantings were preferred by customers and were achieved only through high labor input or the use of herbicides. Gradual decline in Arkansas acreage since World War II was attributed to shortages of labor skilled in proper shallow cultivation to prevent crop damage. Preemergent herbicides reduce the need for mechanical weed control and also prevent mechanical plant damage.

Carlson (9) in 1945, first used 2,4-D [2,4-dichlorophenoxy acetic acid] in strawberry weed control, followed by Denisen (11) with sesone [2-(2,4-dichlorophenoxy) ethyl sodium sulfate] in 1953. Since then, many herbicides have been evaluated for weed control in strawberry plantations (18, 23, 25, 29, 38, 42, 44, 49, 50, 51).

A two-year study by Henne (14) in northwest Ohio compared cultivation, hoeing and, herbicide applications as weed control practices in transplanted tomatoes. Yields were similar between all treatments, but herbicide use resulted in the highest net return per acre. A study in potatoes showed weed control costs with herbicides were 45% of those with mechanical and hand methods (33). Hand-weeding labor in a forestry nursery was reduced 75% when diphenamid (N,N-dimethyl-2,2-diphenyl acetamide) herbicide was used (27).

Irrigation of Kansas strawberry fields increased yields by 25 to 50%, but also has increased weed populations, especially crabgrass (Digitaria sp.) (5, 30). However Kansas strawberry producers use herbicides only after they have demonstrated weed control value and do not cause crop phytotoxicity (16). A survey revealed that 50% of Sedgwick County growers relied on herbicides and 50% relied on mechanical and hand cultivation for weed control (16). Research supporting herbicide use in Kansas strawberry plantations to reduce labor and weed control expense was undertaken only once in 1953 by Al-Sabagh (1), who found 2,4-dichlorophenoxy ethyl sulfate reduced labor from 156.4 to 46.4 hours per hectare.

DCPA (6.7 to 10.1 kg/ha) is suggested for weed control in strawberries by Kansas State University (31). DCPA is widely used by Kansas vegetable growers because of its broad spectrum, short residual, and non-phytotoxicity to several crops (16). Its use in vegetable crops has lead to its adaptations in strawberries. Preemergent use of DCPA controls grassy and broad-leafed weeds for up to nine weeks (32). Germinating seeds are killed when DCPA is absorbed throughout the plant. DCPA, when incorporated mechanically or by irrigation, is absorbed on soil organic matter and does not leach further. DCPA is degraded by microorganisms and chemical hydrolysis, but not by light.

In Arkansas (39), DCPA in combination with diphenamid or fluorodifen (ρ-nitrophenol-α,α,α-trifluoro-2-nitro-ρ-tolylether) gave better weed control than DCPA (9.0 kg/ha) alone in established strawberries.

In a forestry study (27), DCPA (13.4 kg/ha) gave effective and safe weed control. A follow-up to this study (27) indicated DCPA "was highly variable in control effectiveness." Due to inconsistent weed control with DCPA, other herbicides were used.

Napropamide offers a possible alternative to DCPA. Napropamide, a preemergent herbicide with a half life of 8 to 12 weeks, is readily absorbed by plant roots and translocated throughout the plant (4, 32). Microbial degradation of napropamide is slow and leaching does not occur. Napropamide activity persists in the soil up to one year after application (36, 40, 56). Horticultural use of napropamide has been investigated for tomato, pepper, eggplant, potato, petunia, ageratum, and gladiolus (6, 36, 40, 41, 55, 56). Napropamide gave good weed control, especially grassy weeds, and in most cases, increased crop yield. Napropamide controlled redroot pigweed (Amaranthus retroflexus) better than prostrate pigweed (Amaranthus blitoides) (19). In a tomato and pepper study, napropamide controlled weeds better under increased soil moisture levels but, no difference was found between preplant incorporated and surface applied treatments (36). In a Canadian study (12), napropamide (2.2 to 4.5 kg/ha, surface applied) gave 90% weed control in strawberries with no crop damage. Lange (22) reported weed control by napropamide applied preemergent through trickle irrigation emitters.

Several studies have compared DCPA and napropamide (7, 17, 47). Holt (17) found napropamide (3.4 kg/ha) and DCPA (13.4 kg/ha) controlled weeds in pine seedling nurseries for 2 months and 5 weeks, respectively. Hand labor decreased 70% following napropamide and 40% following DCPA applications. Burgis (7) found no significant differences in weed control between DCPA (11.8 kg/ha) and napropamide (3.5 kg/ha). Smith and Mitchell (47) also found no significant differences in weed control between DCPA (9.0 kg/ha) and napropamide (4.5 kg/ha).

Toeh, Chua, and Wong (52) conducted weed control studies in kailan (Brassica alboglabra L.) and chinese cabbage (Brassica pekinensis Rupr.). No significant differences were found between napropamide (1.1 kg ai/ha), DCPA (9 kg ai/ha), and handweeded plots. Napropamide (0.55 kg ai/ha) gave better weed control than DCPA (4.5 kg ai/ha) in chinese cabbage.

Herbicide residues can be detected by bioassay or chemical-analytical techniques (8, 20). Bioassays are inexpensive, easier, measure biologically active herbicide residues, and require little technical equipment as compared to analytical methods. Bioassays measure growth reduction of an indicator organism relative to herbicide concentration (34). A sensitive bioassay species exhibits a 50% growth reduction, total or plant part response, at the normal herbicide rate (53). Field and greenhouse bioassays have been used. Keys and Friesen (21) found a 0.99 to 0.85 correlation between a sunflower bioassay and gas-liquid chromatograph findings for picloram (4-amino-3,5,6-trichloropicolinic acid) combined with 2,4-D and MCPA [[(4-chloro-o-tolyl)oxy] acetic acid(2-methyl-4-chlorophenoxy acetic acid)].

Romanowski (40) found fall sown wheat was severly injured in tomato plots in which a spring application of napropamide (2.2 and 4.5 kg/ha) was made.

Greenhouse bioassays use field soil samples from varying depths to check herbicide persistence and leaching in the soil profile. Hamilton (13) used 400 ml soil samples, surface irrigated with 150 ml water (field capacity), and planted with twenty sorghum (Sorghum bicolor L.) seed. Ten plants per pot were allowed to develop, with height and fresh weight recorded 13 to 17 days after emergence. Parker (37) placed pregerminated sorghum seeds in a row across leveled soil samples in petri dish halves and taped on a transparent lid. Dishes were placed 15° from vertical allowing roots and shoots to grow along the lid for 40 hr at 24 C, after which root and shoot lengths were recorded. Rapid and reproducible results were obtained with EPTC (s-ethyl dipropylthiocarbamate), diallate [s-(2,3-dichloroallyl)diisopropylthiocarbamate], and CDAA [N,N-diallyl-2-chloroacetamide(2-chloro-N,N-diallylacetamide)].

MATERIALS AND METHODS

Field investigations were conducted in 1979 and 1980 at the Kansas State University Horticultural Research Center near Wichita, Kansas. The fine sandy loam soil belonging to the Canadian-Waldeck association had a pH of 5.9, effective calcium carbonate equivalent of 1,120 kg/ha, available phosphorus of 112 kg/ha, exchangeable potassium of 423 kg/ha, and 0.9% organic matter. The plot area had been in a herbicide study that had been abandoned due to heavy weed infestation.

1979 Field Studies

A March 22 fertilizer application consisted of 448 kg of 18-46-0 and 179 kg of 0-0-60 per ha. The study area was rototilled 23 cm deep in April. A starter solution (2.7 kg of 10-50-10/379 l of water) was applied at planting at the rate of 235 ml/plant. Urea was supplied through the irrigation system on May 2 at a rate of 56 kg N/ha and August 24 at a rate of 34 kg N/ha.

'Redchief' strawberry plants were set on April 15 at a spacing of 0.6 m between plants in rows centered in treatment plots. Plots were 1.2 by 3.7 m with border spaces of 1.2 m on each side and 1.8 m on each end. Treatments were replicated six times in a randomized block design. Treatments included a weedy check; season-long weeding; weeding June and later; DCPA applied at 10.1 kg ai/ha, post-transplant-preemergent to weeds (PoI); DCPA applied at 10.1 kg ai/ha, PoI, post-transplant plus mid-season (June 20); napropamide applied at 1.1 kg ai/ha pre-plant incorporated (PPI) plus 3.4 kg ai/ha PoI mid-season; and napropamide applied at 1.1 kg ai/ha post-transplant surface applied (PoS) plus 3.4 kg ai/ha PoS midseason.

Original napropamide rate recommendations of 1.1 kg ai/ha were modified to 4.5 kg ai/ha with second application of 3.4 kg ai/ha on June 20.

Season-long weeded plots were tractor cultivated and hand hoed on May 22 and 25. All weeded treatments were hoed on June 7, 15, July 2, 26, and, September 15. Labor was determined per plot with a digital stopwatch.

Herbicide treatments were applied with a bicycle sprayer equipped with flat fan nozzles 46 cm above the soil surface in 0.9 m bands on both sides of the center plot line. The calibrated sprayer applied 250 ml of water per plot at 1.1 kg/cm^2 pressure.

Napropamide (1.1 kg ai/ha) was applied on April 10 and directly incorporated with a rototiller 13 cm deep.

Napropamide PoS and the two DCPA treatments were applied on April 28 after an additional rototilling and irrigation incorporated with 11 cm of water.

All plots were hand hoed on June 15 in preparation for the June 20 remaining split applications of DCPA (10.1 kg ai/ha), and napropamide (3.4 kg ai/ha) treatments. DCPA and napropamide PPI treatments were incorporated 6 cm deep with a rake, similar to the action of a shallow discing. All plots were overhead irrigated five hours after herbicide application, wetting the profile to 30 cm.

A biwall trickle irrigation system with 30.5 cm emitter spacing was laid on the center line of each plot on April 19. The study area was irrigated 2 hr/day at 0.35 to 0.42 kg/cm^2, emitting water at about 2 l/min per 30 m.

Strawberry plants were deblossomed throughout the growing season to encourage runner development.

Weed counts were taken on May 22, June 11, July 6, and July 24. All weeds in a 0.09 m^2 area centered over the third strawberry plant in each plot were counted. Total weed numbers and weed species were recorded.

Weed populations were visually rated on June 4, August 15 and, September 15 with a rating scale of 1, no weeds, to 9, 100% plot cover by weeds.

Biomass samples were harvested from weed rating areas in each plot September 15 to compare visual ratings with weed biomass. Samples consisted of all weeds harvested in a 0.09 m^2 randomly selected area in each plot and dried for 24 hr at 60 C. Total, grassy, and broadleaf weed biomass weights were recorded.

Crop phytotoxicity observations were made on May 22, June 11, July 6 and 24.

Average runner number per plant was recorded on June 11 and July 24.

The study area was mowed to 28 cm and matted rows narrowed to 43 cm in September.

1980 Field Studies

Treatments of 1979 were repeated on March 25 on the existing strawberry plots, except napropamide treatments were changed from a split application to a preemergent treatment. Herbicides were incorporated by overhead irrigation 27 hr after application. A broadcast fertilizer application of 34 kg N/ha was made on April 11.

On June 9, weed ratings, strawberry plant counts/0.09 m^2 and, visual density ratings were taken. Yield data (g/plot) were recorded on May 27 and 30, and June 3 and 6. Plots were destroyed after yield data were completed.

Economic Evaluations

Gross income was based on fruit yield using $1.10/kg, the standard value for the area. Income above weed control cost was computed as an estimate for net income. The following formula was used:

Income above weed control costs = gross income - weed control costs.

Net income was only estimated, because planting, fertilizer and other costs were assumed to be common to all treatments and were not recorded. Weed control costs were computed as follows:

(1) Herbicide cost = kg product/ha x $/kg product. Retail product prices were used.

(2) Fuel cost = liters diesel/ha x $0.24/liter. Fuel cost was obtained from the Farmer's Coop. Assn., Manhattan, KS. Standard fuel consumption figures of 3.27 l/ha for cultivation and 0.93 l/ha for herbicide application were used (35).

(3) Labor cost = average hours per treatment x $3.10/hr. The federal minimum wage was $3.10/hr.

(4) Machine labor was recorded in the field. The following equation was to derive total machine hours:

Total machine hours = field hours x 1.3.

The factor, 1.3, was used to include "traveling time to and from the field, adjusting equipment, maintenance, lubrication, and for small irregularly shaped fields" (24).

Statistical Procedures

Analysis of variance was used to determine significant differences among treatment means and Duncan's multiple range test was used to seperate significantly different means (48). Correlation coefficients were computed to measure mutual relationships between two variables such as weed biomass and yield (48).

RESULTS

Weed control was measured by weed counts, visual ratings, and weed biomass.

Weed counts were significantly higher for weedy check as compared to all other treatments on June 11 and July 6 (Table 1). Weed counts taken on July 24 were significantly higher for weedy check and DCPA plus hoeing treatment, whereas napropamide and hoed treatments had the lowest weed counts of all. Weed counts were not significantly different for napropamide and hoed treatments.

Early season visual ratings in the weedy check on June 11 were significantly higher than all other treatments (Table 2). Napropamide PPI had higher weed ratings than other herbicide treatments on June 11, but all were greater than hoed treatments. As the season progressed, the weedy check and DCPA split application treatments were not significantly different (August 15 and September 15). Late season napropamide evaluations (September 15) showed significantly better weed control than the weedy check and DCPA split application treatment and were comparable to hoed treatments. June 4, 1980 weed ratings were taken before cultivation of the hoed treatments. Weed populations were significantly lower in hoed treatments as compared to the weedy check in 1980 even though they had not been hoed. Significantly better weed control was achieved by napropamide than all other treatments. Napropamide PoI effectively controlled weeds in 1980 but provided only fair control as PPI in 1979.

The weedy check and DCPA split application treatment were not significantly different in total weed biomass (Table 3), but napropamide and hoed treatments were comparable and less than the weedy check. Grassy weeds posed more of a problem than broadleaf weeds as indicated by high grassy weed bio-

Table 1. Weed count variations throughout the 1979 growing season in newly established strawberry plantations.

Treatment[y]	Herbicide rate (kg ai/ha)	Weed Counts[z] May 22	June 11	July 6[x]	July 24
		---(no./m^2)---			
Weedy check	---	954a	1345a	667a	570a
Hoed full season[w]	---	952a	0c	0c	0c
Hoed June and later[w]	---	597ab	0c	0c	0c
DCPA(PoI) + hoeing	10.1	287b	373bc	373b	524a
DCPA(PoI)	10.1 + 10.1	434b	404bc	208c	237b
Napropamide(PPI + PoI)	1.1 + 3.4	703ab	796b	79c	138bc
Napropamide(PoS)	1.1 + 3.4	344b	552b	88c	94bc

[z]Total weed numbers per square meter expressed as an average of 6 replication. Counts in each column followed by the same letter are not significantly different at the 5% Duncan's multiple range test.

[y]PPI=preplant incorporated; PoS=postplant surface applied; PoI=postplant incorporated.

[x]All plots were cleaned of weeds on June 15, 1979, for the second application of herbicides.

[w]Hoed treatment weed counts were taken after hoeing on June 11, July 6, and July 24, weed numbers were assumed to be zero.

Table 2. Visual weed ratings during 1979 and 1980 in strawberries established April 15, 1979.

Treatment[y]	Herbicide rate (kg ai/ha)	Visual Weed Ratings[z]			
		June 11	Aug. 15	Sept. 15	June 4[x]
Weedy check	---	8.3a	9.0a	9.0a	8.8a
Hoed full season	---	1.0d	1.8d	5.1b	5.6b
Hoed June and later	---	1.0d	2.0d	4.7b	5.3b
DCPA(PoI) + hoeing	10.1	3.6c	1.8d	5.7b	5.2b
DCPA(PoI)	10.1 + 10.1	3.5c	8.8a	9.0a	6.2b
Napropamide(PPI + PoI)	1.1 + 3.4	6.1b	3.4c	4.3b	2.1c
Napropamide(PoS)	1.1 + 3.4	2.7c	4.8b	5.5b	2.8c

[z]Visual weed ratings: 1=no weeds to 9=100% plot cover by weeds. Ratings in each column followed by the same letter are not significantly different at the 5% Duncan's multiple range test.

[y]PPI=preplant incorporated; PoS=postplant surface applied; PoI=postplant incorporated.

[x]June 4, 1980 ratings followed a March 25, 1980 reapplication of herbicides, DCPA 10.1 kg ai/ha, napropamide 4.5 kg ai/ha (PPI) changed to (PoI), and napropamide 4.5 kg ai/ha (PoS).

Table 3. Weed biomass as an indicator of weed control in a new strawberry plantation established in 1979.

Treatment[y]	Herbicide rate (kg ai/ha)	Weed Biomass[z]		
		Total	Broadleaf	Grassy
		----------	(g/m^2)	----------
Weedy check	---	1217.0a	50.6b	1166.4a
Hoed full season	---	220.6b	46.3b	174.3c
Hoed June and later	---	179.7b	8.6b	171.1c
DCPA(PoI) + hoeing	10.1	264.7b	61.3b	203.4c
DCPA(PoI)	10.1 + 10.1	1435.4a	699.4a	736.0b
Napropamide(PPI +PoI)	1.1 + 3.4	312.0b	47.3b	264.7c
Napropamide(PoS)	1.1 + 3.4	423.9b	74.2b	349.7c

[z]Dry weights of above-ground plant parts harvested on September 9, and recorded as an average per treatment. Weights in each column followed by the same letter are not significantly different at the 5% Duncan's multiple range test.

[y]PPI=preplant incorporated; PoS=postplant surface applied; PoI=postplant incorporated.

mass in all treatments, but grassy weed biomass was significantly reduced in all treatments as compared to the weedy check. Broadleaf weed growth proliferated in the DCPA split application treatment.

Weed biomass provided the best indicator of weed control and subsequent yield (Table 4) as compared to visual weed ratings and weed count. Yield was positively correlated to strawberry plant density.

High weed biomass leads to lower strawberry plant density and yield (Table 5). Significantly higher strawberry plant densities and yields were found in the napropamide and hoed full season treatments as compared to the weedy check and DCPA split application treatment which had the lowest yields and strawberry plant densities. No significant differences were found between yields of full season and June and after hoed treatments.

No plant phytotoxicity was recorded for either DCPA or napropamide.

Labor requirements for weed control treatments ranged from 204 to 1384 hr/ha. June and after hand hoed treatment required the most labor input followed by DCPA plus hand hoeing and the hand hoed full season treatment (Table 6). Labor hours recorded for the weedy check came from hand-hoe labor on June 15, an attempt to gauge normal growth related to the second application of the herbicides, DCPA and napropamide. Napropamide use significantly reduced labor inputs from 544 to 900 hours at a savings of $1686.40 to $2790.00. Napropamide PPI significantly reduced labor input, but not as much as DCPA split application and surface applied napropamide. Labor for herbicide treatments was approximately one-sixth that required by hoed treatments.

Higher labor input (Table 6) was reflected in higher labor cost (Table 7) for hoed treatments. Labor makes up the largest percentage of total weed control cost followed by herbicide and fuel.

Gross income was increased up to 13 times by controlling weeds, with

Table 4. Correlation coefficients for weed control and yield components in strawberries.

Components	Correlation Coefficient[z]
Total weed biomass vs. yield	-0.90
Strawberry plant density vs. yield	0.84
Total biomass vs. visual weed rating	0.68
Weed count vs. yield	-0.49
Visual weed rating vs. yield	-0.42

[z]A correlation coefficient of 1.0 or -1.0 is assumed to represent a perfect correlation between two components.

Table 5. Effect of weed biomass and strawberry plant density on yield of newly established strawberries.[z]

Treatment[y]	Herbicide rate (kg ai/ha)	Weed Biomass[x] (g/m^2)	Strawberry Plant Density[w] ($no./m^2$)	Strawberry Yield (kg/ha)
Weedy check	---	1217.0a	34c	1017.0c
Hoed full season	---	220.6b	72ab	11994.0a
Hoed June and later	---	179.7b	57ab	8640.0ab
DCPA(PoI) + hoeing	10.1	264.7b	52bc	7623.0b
DCPA(PoI)	10.1 + 10.1	1435.4a	52bc	2948.0c
Napropamide(PPI + PoI)	1.1 + 3.4	312.0b	75a	8131.0b
Napropamide(PoS)	1.1 + 3.4	423.9b	73ab	9656.0ab

[z]Data in each column followed by the same letter are not significantly different at the 5% Duncan's multiple range test.

[y]PPI=preplant incorporated; PoS=postplant surface applied; PoI=postplant incorporated.

[x]Dry weights of above-ground plant parts harvested on September 9, and recorded as an average per treatment.

[w]Strawberry plants per square meter on June 4, 1980.

Table 6. Labor statistics related to weed control treatments in a newly established strawberry plantation.

Treatment[z]	Herbicide rate (kg ai/ha)	Labor Hours Invested[y] (hrs/ha)	Labor Savings[x] Hours/ha	$/ha
Weedy check	---	500	604	1872.40
Hoed full season	---	1104	---	-------
Hoed June and later	---	1384	-280	-868.00
DCPA(PoI) + hoeing	10.1	1255	-151	-468.10
DCPA(PoI)	10.1 + 10.1	211	893	2768.30
Napropamide(PPI + PoI)	1.1 + 3.4	560	544	1686.40
Napropamide(PoS)	1.1 + 3.4	204	900	2790.00

[z]PPI=preplant incorporated; PoS=postplant surface applied; PoI=postplant incorporated.

[y]Labor hours invested represents labor hours recorded for treatment plots, hoeing and machine labor hours recorded per plot were converted to hours per hectare.

[x]Labor savings is expressed as savings in labor hours and dollars per hectare as compared to the hoed full season treatment.

Table 7. Relationship of weed control treatment to weed control cost components.

Treatment[y]	Herbicide rate (kg ai/ha)	Weed Control Cost Components[z] Labor[x]	Fuel[w]	Herbicide[v]	Total
		($/ha)			
Weedy check	---	1551.60	0.00	0.00	1551.60
Hoed full season	---	3422.19	0.82	0.00	3423.01
Hoed June and later	---	4288.91	0.00	0.00	4288.91
DCPA(PoI) + hoeing	10.1	3894.03	1.04	128.34	4023.41
DCPA(PoI)	10.1 + 10.1	654.77	2.07	256.68	913.52
Napropamide(PPI + PoI)	1.1 + 3.4	1734.93	1.04	107.89	1843.86
Napropamide(PoS)	1.1 + 3.4	631.58	0.22	107.89	739.69

[z]Components of weed control cost were figured as an average of six replications and converted to $/ha.

[y]PPI=preplant incorporated; PoS=postplant surface applied; PoI=postplant incorporated.

[x]Labor cost= ($hours_n$ x $3.10 per hour)/6. Total replications = 6, n = replicate number. Hand labor time was recorded per plot and converted to hours per hectare. Machine labor hours x 1.3 = total machine hours.

[w]Fuel cost = fuel(gal) x $0.939/gal. Fuel cost(gal) was converted to cost(l). Gallons of fuel derived from standard tables (35).

[v]Herbicide cost = kg per hectare(product) x cost per kg product.

full season hoeing having a significantly higher gross income, $13,321.33, followed by the surface applied napropamide treatment at $10,550.43 (Table 8). Hoed full season and napropamide treatments had significantly higher income above weed control costs while the weedy check and DCPA split application treatment had the lowest income above weed control costs.

Table 8. Effects of weed control treatment on weed control costs, gross income, and income above weed control cost.

Treatment[z]	Herbicide rate (kg ai/ha)	Weed Control Costs[y]	Gross Income[x]	Income above weed control costs[w]
		($/ha)		
Weedy check	---	1551.60	1124.51g	-427.09d
Hoed full season	---	3423.01	13321.33a	9898.32a
Hoed June and later	---	4288.91	9515.18c	5226.27bc
DCPA(PoI) + hoeing	10.1	4023.41	8324.91e	4301.50bc
DCPA(PoI)	10.1 + 10.1	913.52	3394.25f	2480.73cd
Napropamide(PPI + PoI)	1.1 + 3.4	1843.86	8898.25d	7054.39ab
Napropamide(PoS)	1.1 + 3.4	739.69	10550.43b	9810.74a

[z]PPI=preplant incorporated; PoS=postplant surface applied; PoI=postplant incorporated.

[y]Weed control costs = $(\text{Fuel}_n + \text{Labor}_n + \text{Herbicide}_n)/6$. Total replications = 6, n = replicate number.

[x]Gross income = $(\text{Yield(kg)}_n \times \$1.10/\text{kg})/6$. Total replications = 6, n = replicate number.

[w]Income above weed control costs = gross income - weed control costs. Income above weed control costs was an indicator of net income since all other production costs were assumed to be equal. Costs in the same column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

DISCUSSION

Increase in gross income up to 13 times and yield up to 11 times over the weedy check and reductions in the subsequent year's weed population indicate weed control in newly established strawberries is essential.

Low strawberry plant density is caused by interspecific competition between weed and the strawberry plant. Lawson and Wiseman (26) suggested uncontrolled runner development can limit yield due to intraspecific competition. Findings from this study, however, indicate high yield is associated with high strawberry plant density. Runner development in these treatments could have been limited to some extent by weed competition in the herbicide plots and cultivation in the hoed treatments. Lawson and Wiseman (26) may have been referring to a critical level of runner population above which yield is reduced. The highest strawberry plant density, 75 plants/m^2, in this study may have been below this critical level.

Even though yields of full season hoeing and June and later hoeing were not significantly different, the additional 3,354 kg/ha recorded for the full season hoed treatment may be important to the grower. Additional yield may reflect the importance of early season establishment of strawberry plants in the absence of weed competition. Full season hoeing may be chosen by the grower to reduce total labor input by 280 hr or labor cost by $868.00. Higher labor input was required for the June and later hoed treatment due to high weed population build up before the first hoeing. This intense high labor input for the June and later hoed treatment may be another reason to use full season hoeing.

DCPA applications reduced labor input as compared to hoed treatments but

July 24 weed counts demonstrate the need for a second application of DCPA or hoeing to provide season-long weed control. Although continued weed control by DCPA was expected with second application, a decline was actually observed. Other studies have suggested weaknesses in weed control by DCPA (3, 27, 39, 54). Measures of DCPA's weed control could have appeared higher than normal because grass control by DCPA permitted broadleaf proliferation. Although grassy weed biomass was high in all treatments, DCPA findings proved controlling broadleaf weeds prevent reductions in yields and gross income.

Results from this study demonstrate that napropamide can give weed control as effective as labor intensive hand hoed weed control and result in comparable high yields and gross incomes. Other research comparing herbicides to hoeing found similar results (14, 27, 43). Early season weed control evaluations of napropamide PPI reflect the below normal application rate more than surface applied napropamide due to dilution of the herbicide by soil incorporation. If napropamide rates had been correct in an early season application, labor costs could have been reduced further and gross incomes may have exceeded the full season treatment.

The best way to reduce weed control cost and increase returned income is to reduce labor input. Even though gross income was significantly higher for the hoed full season treatment as compared to surface applied napropamide, income above weed control costs were not significantly different due to a reduction in labor input by six times with herbicide use.

Significant differences for income above weed control cost would also be reflected in net income, assuming production costs were the same for all treatments except weed control cost, the variable in this study.

Although net incomes would be similar for hand labor and chemical weed control, labor shortages may limit production by hand labor means as occurred in Arkansas (10) due to shortages of skilled labor after World War II. Hand labor or mechanical cultivation may also cause mechanical damage to the strawberry plant and trickle irrigation tubing.

CONCLUSIONS

This study emphasizes the importance of weed control in newly established strawberries to encourage plant establishment and runner development for increased yield and gross income.

Herbicides can be as effective and economical as hand hoed weed control because labor input is drastically reduced. Napropamide proved to be the superior herbicide in weed control effectiveness over DCPA which gave inadequate weed control comparable to the weedy check.

LITERATURE CITED

1. Al-Sabagh, S.S.M. 1953. Some effects of sodium 2,4-dichlorophenoxy ethyl sulfate (Crag Herbicide 1) on Blakemore strawberry plants. Master's Thesis, Kansas State College, Manhattan, Kansas.

2. Americanos, P.G. 1976. Weed control in peppers, eggplants, beans, squash, melons and watermelons. Agr. Res. Inst., Necosia, Cyprus, Technical Paper, pp. 1-11.

3. Anonymous. 1975. Tolerance of strawberries to new herbicides. U.K. Long Ashton Agr. and Hort. Res. Sta. Rep., 25 pp.

4. Anderson, W.P. 1977. Weed science: principles. West Publishing Co., New York. 598 pp.

5. Atteridg, G.C. 1957. Some effects of several preemergence herbicides on hairy and smooth crabgrass and the cultivated strawberry. Master's Thesis, Kansas State College, Manhattan, Kansas.

6. Barry, J.R. and H.S. De Valcourt. 1975. Efficacy studies with Devrinol for weed control in transplanted peppers, eggplants, and sweet potatoes. HortScience 10:146.

7. Burgis, D.S. 1974. In-the-row weed control for peppers on full bed mulch. Proc. South. Weed Sci. Soc. 27:194-198.

8. Burrill, L.C., J. Cardenas, and E. Locatelli. 1976. Field manual for weed control research. International Plant Protection Center, Corvallis, Oregon. 59 pp.

9. Carlson, R.F. 1947. Control of weeds in strawberry plantings by the use of 2,4-dichlorophenoxyacetic acid. Proc. Amer. Soc. Hort. Sci. 49:221-223.

10. Chandler, J.M. 1974. Economic losses due to weeds. South. Weed Sci. Soc. Res. Rep. 27:194-214.

11. Denisen, E.L. 1953. Controlling weeds in strawberries with sodium 2,4-dichlorophenoxyethyl sulfate. Proc. Amer. Soc. Hort. Sci. 61:185-194.

12. Dion, A. 1976. Weed control in strawberries. Weed Abstr. 25:18.

13. Hamilton, K.C. 1979. Persistence of annual applications of herbicides in winter-planted safflower (Carthanmus tinctorius). Weed Sci. 27:655-657.

14. Henne, R.C. 1979. Weed control system for transplanted tomatoes. Proc. Northeast. Weed Sci. Soc. 33:166-169.

15. Hensley, J.G. 1973. Early runner production of strawberries as influenced by blossom removal and source of plants. HortScience 8:250.

16. Holmes, C.M. 1973. The use of herbicides in horticultural applications in Sedgwick County, Kansas. Master's Thesis. Kansas State University, Manhattan, Kansas.

17. Holt, H.A., S.H. Wickhan, S.L. Sherrick, T.R. Withrout, and J.R. Wichman. 1976. Weed control in Indiana State Nurseries. Proc. North Centr. Weed Cont. Conf. 31:106.

18. Illnicki, R.D., C.R. Smith, and J.F. Ellis. 1963. The response of three varieties of strawberries to several herbicidal treatments. Proc. Northeast. Weed Cont. Conf. 17:178-179.

19. Jachsetta, J.J., S.R. Radosevich, and C.L. Elmore. 1979. Differential susceptibility of two pigweed (Amaranthus spp.) species to napropamide. Weed Sci. 27:189-191.

20. Jacques, G.L. and R.G. Harvey. 1979. Persistence of dinitroaniline herbicides in soil. Weed Sci. 27:660-665.

21. Keys, C.H. and H.A. Friesen. 1968. Persistence of picloram activity in soil. Weed Sci. 16:341-343.

22. Lange, A., H. Kempen, B. Fischer, and J. Schlesselman. 1976. Chemical weed control with drip irrigation. West. Weed Sci. Soc. 29:53-58.

23. Lange, A.H., W.A. Humphrey, and V. Voth. 1973. Relative phytotoxicity of 16 herbicides to strawberries. Univ. California Agr. Ext. Prog. Rep. MA-59, 6 pp.

24. Langemeier, L.N., O.H. Buller, and J.L. Kasper. 1975. Labor requirements for eastern Kansas crops. Kansas State Univ. Agr. Exp. Sta. Bull. 587, 20 pp.

25. Langer, C.A. 1973. The use of pronamide and terbacil in strawberry weed control. Proc. Northeast. Weed Sci. Soc. 27:252-256.

26. Lawson, A.M. and J.S. Wiseman. 1976. Weed competition in spring-planted strawberries. Scottish Hort. Res. Inst. Rep. pp.315-354.

27. McDonald, S.E., J.A. Isaacson, and B.E. Fisher. 1974. Using diphenamid herbicide for seedbed weed control cuts hand-weeding labor 75 percent. Tree Planters' Notes. 25(3):15-17.

28. Meador, D.B., C.C. Doll, and J.W. Courter. 1979. Controlling weeds in strawberries. Proc. 1979 Illinois Strawberry School. pp.22-25.

29. Miller, C.J. and O.E. Schubert. 1974. Evaluation of glyphosate, metribuzin, and pronamide for quackgrass control prior to setting strawberries. Proc. West Virginia Acad. Sci. 46:61-69.

30. Morrison, F. 1976. Growing strawberries. Kansas State Univ. Coop. Ext. Bull. C-401, 15 pp.

31. Morrison, F., J.K. Greig, L.D. Leuthold, E.B. Nilson, C.E. Long, and W.A. Geyer. 1977. Chemical weed control in horticultural and forestry plants. Kansas State Univ. Coop. Ext. Bull. 316.

32. Mullison, W.R. (Chairman). 1979. Herbicide handbook. Weed Sci. Soc., 479 pp.

33. Murphy, H.J. 1979. Economic losses in potatoes due to weeds. Proc. Northeast. Weed Sci. Soc. 33:48-51.

34. Murray, D.S. and P.W. Santelmann. 1980. Are herbicides present? Crops and Soils. January:12-24.

35. Nilson, E.B. 1973. Conserving energy with herbicide use in row crops. Kansas State Univ. Coop. Ext. Bull. MF-335, 2 pp.

36. Pospichal, M.T., D.S. Burgis, and S.J. Lacascio. 1976. Evaluation of napropamide for weed control in tomatoes and peppers. Proc. South. Weed Sci. Soc. 29:171.

37. Parker, C. 1966. The importance of shoot entry in the action of herbicides applied to the soil. Weeds 14:117-121.

38. Regan, J.B., R.D. Illinicki, L.C. Liu, and H.P. Wilson. 1966. Some promising new herbicides for weed control in strawberries. Proc. Northeast. Weed Cont. Conf. 20:143-149.

39. Rom, R.C. and R.E. Talbert. 1971. Field evaluation of herbicides in fruit and nut crops, 1970. Mimeograph Series, Univ. of Arkansas Agr. Exp. Sta. 191, 23 pp.

40. Romanowski, R.R. and A Borowry. 1976. Soil persistence of metribuzin and napropamide. Proc. North Centr. Weed Cont. Conf. 31:108.

41. Sanok, W.J., G.W. Selleck, and J.F. Creighton. 1979. Weed control and phytotoxocity with herbicides in five tomato varieties. Proc. Northeast. Weed Sci. Soc. 33:332-335.

42. Schubert, O.E. and C.E. Hickman. 1971. Effect of herbicide treatments on weed control and yield of Midway strawberries. Proc. Northeast. Weed Sci. Soc. 25:403-410.

43. Schweizer, E.E. 1980. Herbicides applied sequentially for economical control of annual weeds in sugarbeets (Beta vulgaris). Weed Sci. 28:152-159.

44. Scott, D.H., W.C. Shaw, and R.V. Ruppenthal. 1954. Evaluation of several chemicals for weed control in strawberry fields. Weeds 1:192-207.

45. Shaw, W.C. 1978. Herbicides: the cost/benefit ratio-public view. Proc. South. Weed Sci. Soc. 28:28-47.

46. Shaw, W.C. 1981. Integrated pest management systems technology in weed science. Weed Sci. (In Press).

47. Smith, E.M. and C.D. Mitchell. 1976. Weed control in hort crops. North Centr. Weed Cont. Conf. Res. Rep. 31:83.

48. Snedecor, G.W. and W.G. Cochran. 1978. Statisical methods. Iowa State University Press, Ames, Iowa. 593 pp.

49. Stadlebacher, G.J. and J.D. Riggleman. 1963. Weed control in newly established strawberry plantings. Proc. Northeast. Weed Cont. Conf. 17:192-193.

50. Talbert R.E. and J.M. Kennedy. 1974. Field evaluation of herbicides in small fruit and nut crops. Univ. Arkansas Agr. Exp. Sta. Mimeo 224, 10 pp.

51. Talbert, R.E. and J.E. Vaile. 1969. Evaluation of herbicides for strawberries. Proc. South. Weed Sci. Soc. 22:231.

52. Teoh, T.S., S.E. Chua, and S.H. Wong. 1978. Weed control useing preemergence herbicides in the cultivation of direct-sown Brassica alboglabra L. and transplanted Brassica pekinensis rupr. Singapore J. of Primary Industries. 6:34-51.

53. Truelove, B. 1977. Research methods in weed science. South. Weed Sci. Soc., Auburn Printing Inc., Auburn, Alabama.

54. Watschke, T.L., J.M. Duich, and M.S. Welterlen. 1979. Crabgrass control with single and split application of preemergence herbicides. Proc. Northeast. Weed Sci. Soc. 33:270-273.

55. Wilfret, G.J. and D.S. Burgis. 1976. Nutsedge (Cyperus rotundus L.) control using herbicides under fallow conditions. Proc. South. Weed Sci. Soc. 29:237-243.

56. Wilfret, G.J. and D.S. Burgis. 1977. Weed control in petunia, ageratum, and gladiolus grown in open fields. Proc. South. Weed Sci. Soc. 30:197-204.

APPENDIX

BIOASSAY STUDY TO DETERMINE SOIL PROFILE MOVEMENT AND LONGEVITY OF DCPA AND NAPROPAMIDE RESIDUES.

MATERIALS AND METHODS

Soil samples were collected from four replications of the four herbicide treatments with a 7.6 cm diameter bulb planter in two 15.2 cm segments to a total depth of 30.5 cm. Each 15.2 cm segment was divided in half to make a total of four samples which represented 0 to 7.6, 7.6 to 15.2, 15.2 to 22.9, and 22.9 to 30.5 cm profile depths. Sampling times were 24 hr, 2 weeks and, 4 weeks after application for all herbicide treatments and additional eight week and one year sample for DCPA one application. For split application treatments of DCPA and napropamide, samples were taken 24 hr, 2, 4, 8, 16 week, and 10 months after the second application. Samples were sealed in plastic bags and frozen within 1 to 2 hr after sampling.

Bioassay standards were conducted to find a sensitive plant species. A Funk's sorghum hybrid, G623GBR, showed a 50% dry matter reduction at the normal napropamide rate, as compared to an untreated bioassay sample and was chosen for bioassay tests. Napropamide was used to find a sensitive bioassay species, because residue carryover and movement in the profile had not been thoroughly studied.

Soil for bioassay standards was collected outside the study area similar in soil type to the field samples and ground to pass through a 6.4 mm screen. Two 1600 g samples, one for each DCPA and napropamide received no herbicide and represented the 0.0 kg ai/ha bioassay standards. A 0.4% DCPA standard solution was prepared and pipetted onto four seperate 1600 g soil samples to achieve the bioassay standard concentrations of 2.5, 5.0, 10.1, and 20.2 kg ai/ha. A 0.2% napropamide standard solution was pipetted onto four seperate 1600 g samples to achieve concentrations of 1.1, 2.2, 4.5, and 9.0 kg ai/ha. The treated soil was thoroughly mixed in a plastic bag. After equilibration for 24 hr, the treated soil was evenly divided into four-237 ml paper cups, 5.1 cm deep and 9.5 cm in diameter, representing four replications. Prior to filling, five-3.2 mm holes were punched in the bottom of each cup and fine mesh screen was placed over the drainage holes to prevent elluviation of soil from the cup.

After thawing field samples for 24 hr at 27 C, the four field replications were removed from the plastic bags, combined and seperated into four greenhouse replications of 400 g of soil per cup. The napropamide bioassay experiment was conducted from March 18 to May 8 and the DCPA experiment from April 22 to May 18. Twenty sorghum seeds were planted 6.4 to 9.5 mm deep in each cup. Cups were misted until the entire soil mass was moistened. The cups were spaced 2.5 cm apart on sand filled greenhouse benches in a randomized complete block design for each herbicide and maintained at 27 to 32 C. Cups were misted twice daily to maintain adequate moisture for sorghum germination and growth.

Emergence counts were taken 10 days after initial watering. Dry matter weights were obtained after harvested above ground plant parts were dried 36 hr at 38 to 43 C. Dry matter data from all herbicide bioassay treatments were expressed as the percent of untreated sample (0.0 kg ai/ha).

Data were analyzed by analysis of variance at a .05 significance level. Data were described as a sub-sub plot design for analysis. Treatment was considered the main plot with subdivisions of sampling time and soil profile depth.

RESULTS

Bioassay data included dry matter weights, percent dry matter reduction, and emergence counts for sorghum grown in napropamide and DCPA standard and field samples.

A significant relationship was found between soil profile depth and percent dry matter reduction (%DMR). Emergence count was affected by soil profile depth and time of herbicide application. Since soil profile depth and time of herbicide application affected emergence count, it was regarded as a more sensitive measure of herbicide concentration than %DMR. Herbicide concentration, estimated by %DMR (Appendix Table 1) and emergence count (Appendix Table 2), was higher in the 0 to 7.6 cm depth for DCPA (10.1 kg ai/ha), DCPA (10.1 + 10.1 kg ai/ha), and napropamide PoS treatments than depths 7.6 to 15.2, 15.2 to 22.9, and 22.9 to 30.5 cm. The highest herbicide concentration for napropamide PPI was found in the 7.6 to 15.2 cm depth. Presence of herbicide residues was not indicated in the 15.2 to 30.5 cm depth for any treatment.

The relationship between dry matter and $\log_{10}$(herbicide concentration + 1) was described by the curve and equation in Appendix Figure 1 for DCPA. A quadratic fit to the regression curve was highly significant ($P>.01$).

DISCUSSION

Higher concentrations of herbicide were found in the 0 to 7.6 cm depth for the two DCPA treatments and napropamide PoS because they were either shallowly incorporated or irrigated in. Herbicide concentration was highest in the 7.6 to 15.2 cm depth for napropamide PPI due to mechanical incorporation. Both DCPA and napropamide remain where they were applied. Absence of herbicide residues in the 15.2 to 30.5 cm depth show that leaching

Appendix Table 1. Percent dry matter reduction[z] (%DMR) as affected by soil profile depth.

Profile Depth (cm)	DCPA + hoeing	DCPA (spl. appl.)	Napropamide PPI	Napropamide PoS
	(%DMR)			
0 to 7.6	58.5	85.0	41.8	48.5
7.6 to 15.2	-7.5	-7.3	58.2	24,3
15.2 to 22.9	-36.4	-6.3	52.3	21.8
22.9 to 30.5	-8.9	-10.9	39.8	16.1

$$^{z}\%DMR = \frac{\text{DM of untreated standard} - \text{DM of sample}}{\text{DM of untreated standard}} \times 100\%$$

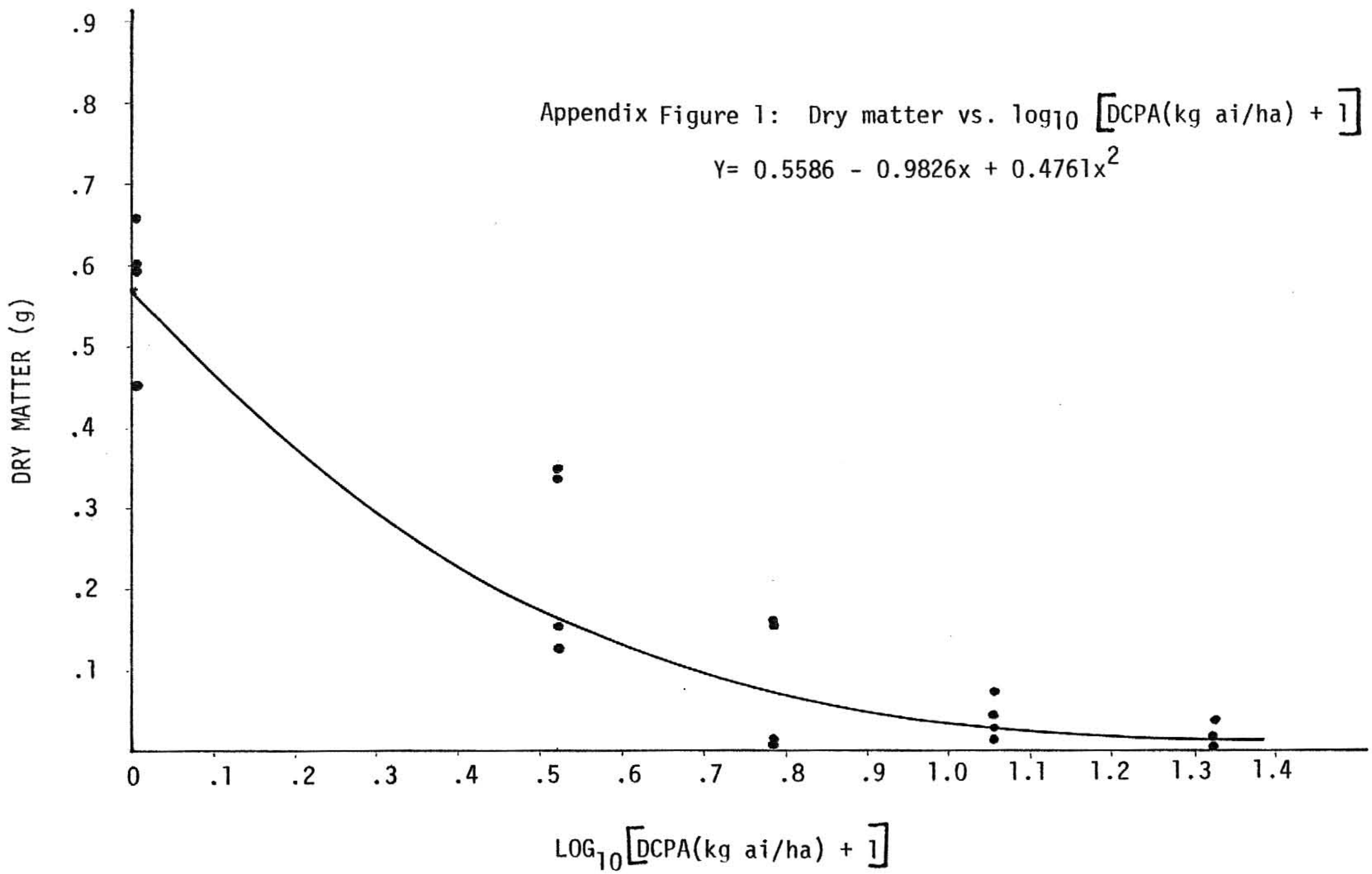
DM = dry matter

Appendix Table 2. Emergence count as affected by soil profile depth.

Profile Depth (cm)	DCPA + hoeing	DCPA (spl. appl.)	Napropamide PPI	Napropamide PoS
	(no. plants/cup)			
0 to 7.6	6	6	18	12
7.6 to 15.2	14	13	17	18
15.2 to 22.9	13	14	18	19
22.9 to 30.5	13	13	18	18

Appendix Figure 1: Dry matter vs. $\log_{10}$ [DCPA(kg ai/ha) + 1]

$Y = 0.5586 - 0.9826x + 0.4761x^2$



of DCPA and napropamide did not occur.

A narrow range of dry matter readings and high variability in field bioassay data makes the relationship in Appendix Figure 1 insensitive and nearly useless for predicting herbicide concentrations in field samples. For example, dry matter readings of field samples were far above that estimated by the curve.

Variability in samples could be attributed to soil moisture, texture, and structure differences between the standard and field samples. Field samples represented the soil structure and texture of the profile to a depth of 30.5 cm while standard samples represented soil collected from only 0 to 15.2 cm. Change of soil structure or texture may influence specific surface area and thus herbicide concentration/g soil. Dispensing of the herbicide onto standard soil samples with a pipette may have prevented uniform distribution of the herbicide throughout the four standard replications.

Although bioassay procedures of this study were similar to those used successfully by Hamilton (13) in detecting diuron, prometryn, and trifluralin residues, different techniques maybe needed to detect residues of DCPA and napropamide.

ECONOMIC AND EFFICACY EVALUATIONS OF NAPROPAMIDE, DCPA AND HAND-WEEDED TREATMENTS IN NEWLY ESTABLISHED STRAWBERRIES (*FRAGARIA X ANANASSA* DUCH. 'REDCHIEF')

by

SUSAN FAYE HENNING

B.S., Horticulture, College of Agriculture,
Kansas State University, 1978

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

in Crop Protection

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1981

ABSTRACT

Weed control was evaluated on an economic and efficacy basis among DCPA(dimethyl tetrachloroterephthalate), and napropamide[2-(α-napthoxy)-N,N-diethylpropionamide], and hand-weeded treatments in a newly established strawberry (*Fragaria x ananassa* Duch. 'Redchief') plantation.

Weed biomass was the best indicator of weed control. Grassy weeds posed the most serious weed problem. During 1979, the establishment year, hoed treatments and napropamide (4.5 kg ai/ha) treatments were not significantly different in weed control effectiveness. The DCPA (10.1 + 10.1 kg ai/ha) split application treatment gave inadequate weed control and was not significantly different than the weedy check.

Weed ratings taken in 1980 showed significantly better weed control in all treatments compared to the weedy check. Hoed treatments showed that weed control in the previous year reduced weed populations in 1980. DCPA did not give adequate weed control, but napropamide at the recommended rate of 4.5 kg ai/ha gave significantly better weed control than all other treatments.

Yield and runner numbers were negatively correlated with weed biomass and positively correlated with each other. A reduction in weed biomass significantly increased yield and number of runners. Yield was increased 3 to 11 times by using some form of weed control. The highest yield was recorded for the full season hoed treatment followed by surface applied napropamide. No significant difference was found between hoed and napropamide treatments for yield. The weedy check and DCPA split application treatments were not significantly different and had the lowest yields.

Economic evaluations included weed control costs, gross income, and income above weed control costs. Labor expense comprised the largest component of weed control followed by herbicide and fuel expenses. Highest labor input was recorded for the June and after hoed treatment and DCPA plus hoeing. Weed buildup prior to the first hoeing was the cause of the high labor input. Labor savings from 544 to 900 hr/ha were realized by using a herbicide and resulted in a savings of $1686.40 to $2790.00/ha.

Gross income was increased 3 to 13 times over the weedy check by using some method of weed control.

Income above weed control cost was highest for hoed and napropamide treatments and lowest for DCPA split application treatment and the weedy check.

This study shows that not only comparable weed control can be achieved from hand labor weed control and an effective chemical weed control technique but also comparable yields, gross incomes, and returned incomes can be realized. Before a hand labor technique is employed labor force availability must be evaluated. Even when an adequate labor force is available, workers could be involved in a more productive activity than hoeing.