8-1979

Effects of common cocklebur control systems on soybean yields, costs, and returns

Harri Jose Lorenzi

To the Graduate Council:

I am submitting herewith a thesis written by Harri Jose Lorenzi entitled "Effects of common cocklebur control systems on soybean yields, costs, and returns." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant, Soil and Environmental Sciences.

Larry S. Jeffery, Major Professor

We have read this thesis and recommend its acceptance:

Vernon H. Reich, Billy J. Trevana

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

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We have read this thesis and recommend its acceptance:

Vernon H Reich

Billy J. Trevena

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EFFECTS OF COMMON COCKLEBUR CONTROL SYSTEMS ON SOYBEAN YIELDS, COSTS, AND RETURNS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Harri Jose Lorenzi

August 1979

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to the following persons:

Dr. Larry S. Jeffery, his major professor, for providing guidance and assistance throughout the course of this study, in preparation of this manuscript, and the overall training in Weed Science which was excellent preparation for professional objectives.

Dr. Vernon H. Reich and Dr. Billy J. Trevena for their aid and suggestions and for serving on author's graduate committee. Also Dr. Reich for his guidance on the statistical analysis of this research.

His fellow graduate students for their fellowship and aid and particularly James Lothrop for his aid in the field research used in this study and in correcting this manuscript.

His wife for her aid and understanding throughout his graduate study.

ABSTRACT

Common cocklebur (Xanthium pensylvanicum Wallr.) and other common weeds growing in soybean fields must be controlled in order to obtain maximum soybean yields. Many methods for achieving good weed control are available, however the cost and returns from these various systems are important, since partial weed control or even total control may or may not be economically favorable. The efficiency of weed control methods in soybeans should always be evaluated in conjunction with a detailed study of economic returns.

Field studies were conducted in Tennessee during 1975 and 1976 under conventional tillage cropping at two locations, and during 1978 under no-tillage cropping at one location. These studies were conducted to determine: (1) the efficiency of various weed control systems for control of common cocklebur and other weeds, and (2) the effects of various levels of control of common cocklebur and other weeds on soybean yields, and the cost and returns from each level of control.

In the conventional tillage experiments profluralin at 0.8 kg/ha was applied to the whole experimental area to control annual grasses and followed by sequential applications of pre and postemergence herbicides followed by between row cultivation to control cocklebur and other annual broadleaf weeds. Naptalam + dinoseb (Dyanap) at rate of 5.0 kg/ha was applied preemergence followed by postemergence applications at the second trifoliate stage of the soybeans of either bentazon at the rate of 0.8 kg/ha, or dinoseb at 0.8 kg/ha, or Dyanap at 2.5 kg/ha. These combinations

were followed either by bentazon at 0.8 kg/ha or cultivation when the soybeans were 30-70cm tall, with other cultivations as needed later in the season. Also as separate treatments either linuron at 0.5 kg/ha or metribuzin at 0.6 kg/ha were applied at the preemergence stage or Dyanap at 4.2 kg/ha was applied at the cracking stage. None of these were followed by a postemergence treatment at the second trifoliate stage. These treatments were followed by either bentazon or cultivation when soybeans were 30-70cm tall plus other cultivation as needed later in the season.

In the no-tillage experiment, glyphosate at 1.7 kg/ha was applied at planting over the whole experimental area. This was followed by metribuzin at 0.6 kg/ha and alachlor at 2.2 kg/ha applied preemergence singly or mixed to each plot. Thirty days later two new postemergence herbicides coded as RH-6201 at 2.2 kg/ha and HOE-29152 at 0.6 kg/ha, were applied singly or in combination over plots previously treated with the preemergence herbicides.

Under conventional tillage all weed control methods increased yields, except Dyanap applied preemergence with no further treatment. Greatest soybean yields were produced with practices most effective for cocklebur control. The inclusion of the third treatment of bentazon or cultivation when the soybeans were 30-70cm tall followed by cultivation later in the season resulted in maximum yields. A postemergence treatment applied at second trifoliate stage of soybeans was not necessary if linuron was the preemergence treatment and bentazon was applied when soybeans were 30-70cm and followed by timely cultivation later in the season. A single postemergence application of bentazon when the soybeans were 30-70cm tall followed by cultivation later in the season was enough to produce maximum yields, even when no prior treatment was made. (In all treatments profluralin had controlled the annual grasses.)

The predicted adjusted yields ranged from 509-1748 kg/ha with 0% control of cocklebur to 2528-3161 kg/ha with 100% control.

Total costs of production ranged from $142-167/ha with no cocklebur control to $207-228/ha with 100% control. An additional investment of $18-24/ha was required to increase common cocklebur control from 60 to 95%.

Net returns were increased with all common cocklebur control measures, except where Dyanap was applied at either the preemergence or cracking stage without a subsequent treatment. Maximum net returns were obtained in all experiments when Dyanap was applied at the cracking stage and metribuzin was applied preemergence, if these treatments were followed by bentazon applied when the soybeans were 30-70cm tall and were cultivated later in the season. A single application of bentazon when the soybeans were 30-70cm tall, followed by cultivation later in the season with no prior treatments was enough to produce maximum net returns in each experiment, except at Ames Plantation in 1976. Bentazon applied when the soybeans were 30-70cm tall followed by cultivation later in the season contributed for maximum net returns when Dyanap was applied at the cracking stage, and when metribuzin was applied in preemergence.

Failure to provide any control of common cocklebur resulted in net returns ranging from $-21 to $185/ha, according to the predicted regression equation developed to estimate the effects of these two variables. Control of 95% of common cocklebur resulted in net returns ranging from $310 to $416/ha.

According to these results the best cocklebur control systems for conventional tillage soybeans were: either Dyanap applied at the cracking stage or metribuzin applied preemergence, both followed by bentazon applied when the soybeans were 30-70cm tall followed by cultivation later in the season.

Under no-tillage cropping none of the weed control measures tested significantly increased soybean yields or net returns when compared to the untreated control. This was partially due to poor soybean stands resulting from severe rabbit damage. Predicted adjusted yields of 509 kg/ha were calculated for 0% of weed control and 1547 kg/ha for 100% control. Maximum weed control was provided by all herbicide combinations that included metribuzin + RH-6201. These combinations provided an average of 90% weed control.

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CHAPTER I

INTRODUCTION

Common cocklebur (*Xanthium pensylvanicum* Wallr.) is one of the most serious weeds in soybean (*Glycine max* L.) fields in Tennessee. It competes aggressively with soybeans and drastically reduces yields. It delays harvesting, makes the harvesting operations more difficult and reduces seed quality.

Common cocklebur and other common weeds can be controlled successfully in soybean fields with herbicides applied preemergence or postemergence or with herbicide combinations applied sequentially. Cultivation can be added to the system to lengthen the control period. The success of these systems is very important to Tennessee farmers. An equally important but often ignored consideration is the economics of the various weed control systems. The high cost of weed control, especially when herbicide combinations are involved makes the choice of an efficient and economical method very important.

Weed control is a major problem in no-tillage farming. Usually a wide spectrum of weeds exist in a no-tillage situation, and mechanical weed control methods cannot be used effectively because of interference from trash and refuse remaining on the soil surface. Therefore, herbicides must be used.

The amount of published information concerning the economics of various weed control systems in soybeans is limited, therefore the objectives of these experiments were:

1. Determine the efficiency of various weed control systems for control of common cocklebur in conventional tillage cropping of soybeans;
2. Determine the effects of various levels of control of common cocklebur on soybean yields, costs, and returns from soybean production under conventional tillage cropping;
3. Determine the individual and combined effects of various components (herbicides) of a total weed control system on weeds and soybean yields in a small grain-soybean double cropping program under no-tillage cropping;
4. Determine the effects of various levels of weed control on soybean yields, production costs, and returns from soybean production under no-tillage farming.

CHAPTER II

LITERATURE REVIEW

I. WEED COMPETITION

Weeds reduce the value of the soybean crop approximately 10 to 17% annually in the United States in spite of the efforts made to control them (19, 22). Weeds reduce yields by competing with soybeans for nutrients, light, and moisture (15, 9). They also reduce the quantity and quality of harvested soybean seed by delaying harvest and by decreasing the efficiency of harvesting equipment (13).

Among the common weeds, Xanthium pensylvanicum Wallr. (Common cocklebur), has been shown by many authors (2, 11, 6) to be one of the most serious weeds in the southeastern United States. It may decrease soybean yields by 50 to 80%, even though it is not included in the world's ten worst weeds (8). It is listed as number 1 to 3 in each of the southeastern states, according to a weed survey presented in the 1977 annual Research Report of the Southern Weed Science Society (10).

Davis et al. (5) reported that in the southeastern and delta regions of the United States, soybean and common cocklebur seedlings often emerge simultaneously. Their growth rate is similar until midseason when common cocklebur surpasses soybeans in height and forms a dense canopy over the soybeans. Hicks et al. (7) found that reduced light penetration into soybean canopies probably reduced yields.

Davis et al. (5) found that a single common cocklebur plant may occupy a root profile area with a radius of 4.3m and a depth of 2.9m, grow to a height of 152cm, and may have a top growth dry matter weight of 590 g. It requires approximately 150 kg of water to produce 454 g of dry matter (17). Vengris (20) reported that common cocklebur may have higher mineral requirements than soybean.

Barrentine (2) reported that full-season competition by common cocklebur at 3,300, 6,600, 13,000, and 26,000 plants/ha reduced the 2-year average soybean yields 10, 28, 43, and 52%, respectively. Competition from common cocklebur at 100,000 plants/ha for 4, 6, 8, 10, 12, and 16 weeks after soybean emergence reduced soybean seed yields 10, 36, 40, 60, 80, and 80% respectively. When common cocklebur was removed during the first 4 weeks after soybean emergence, no further removal was required to obtain maximum soybean yield.

Gosset (4) obtained soybean yield reductions of 50% from common cocklebur plant density of 46,000 plants/ha. Waldrep and McLaughlin (21) found soybean yield reductions of 15 to 100% with common cocklebur densities of 2,000 to 64,000 plants/ha.

The amount and seasonal distributions of soil moisture affect the competitive relationship between soybeans and weeds (22). Staniforth (18) found that foxtail reduced soybean yield by an average of 5% regardless of the soil moisture level throughout the season. Little yield reduction occurred if moisture was limited in early season, but was adequate in late season. The greatest reduction (average, 15%) occurred when moisture was ample during early growth but limited in late season. Thus, if conditions are such that few weeds emerge and compete in the early growth stages, soybeans are capable of providing severe competition to weed growth later in the season.

McWhorter and Hartwig (11) reported that common cocklebur reduced the yield of six soybean varieties by 63% to 75% when plots were hand-harvested. The variety 'Semmer' showed the lowest percentage yield reduction when hand-harvested, while the same variety and the variety 'Bragg' showed 53 to 57% reduction respectively when machine harvested.

McWhorter and Anderson (13) showed that sequential herbicide applications were more effective than single applications for common cocklebur control. Effective control increased soybean seed grades by reducing discounts due to unfavorable factors such as moisture content and foreign material in harvested seed. They concluded that the use of all herbicide practices increased net returns, but the greatest returns followed use of sequential treatments.

Anderson and McWhorter (1) found that at least 70% control of common cocklebur was required to avoid weight deductions due to seed moisture levels exceeding 13%. When adjusted for various weight discounts, soybean yields were 1170 kg/ha without control of common cocklebur and 1890 kg/ha for 100% control. They concluded that soybean yields increased about 6% for each 10% increase in common cocklebur control.

II. ECONOMIC ASPECTS

Nalewaja (14) pointed out that weed control practices have a very favorable energy input:output ratio because of the large increase in crop yields obtained from controlling weeds compared to the ratio for other agricultural operations. The energy input for weed control generally is not proportional to the competitive ability of the weed infestation.

Assuming that a tolerable level of weed infestation exists, economic threshold studies will determine when control must be implemented to achieve maximum net returns. Barrentine and Oliver (3) have conducted combined economic threshold studies with critical duration to provide data for tables giving percent yield loss with various periods of weed competition at particular densities. According to these tables and assuming a potential gross income of $150 per acre (30 bushels per acre at $5 per bushel) a saving in lost production of $28.50 exists when cockleburs are controlled during the first 6 weeks rather than 12 weeks.

Waldrep and McLaughlin (21) studied the effect of various cocklebur densities on gross returns in soybean production. According to their study, if a farmer has the potential to produce 30 bushels per acre of soybeans and has as few as one cocklebur plant spaced every 4 feet in the soybean row, he stands to lose about $28 per acre each year. If the number of cocklebur plants in the same area is 8 or more the yield reduction was 100%. No harvestable beans were found on these plots, therefore they calculated a loss of $75 per acre with soybeans priced at $2.50 per bushel was calculated.

McWhorter and Anderson (13) showed that a herbicide investment of $2 to $6/ha will greatly increase returns in soybean production. Herbicide costs of $8 to $18/ha resulted in even greater returns to land, farm overhead and management. The greatest production costs (not including land costs) for soybeans are for machinery, labor, and seed. The expense of herbicides and their application was a relatively small portion of the total input costs required for soybean production. McWhorter and Anderson also reported that of the increased production expenses due to the use of herbicides, 80% was for the purchase of the chemicals. Returns due to herbicide usage increased more than three dollars for each one dollar invested.

McWhorter and Anderson (12) reported that a modest investment of $5 to $10/ha for herbicide will greatly increase returns in soybean production. Higher herbicide costs may be required for the highest returns. They also reported that although the costs for herbicides and their application are a relatively small portion of the total cost of soybean production these investments may result in a two to three-fold increase in net returns.

Anderson and McWhorter (1) found production costs for soybeans ranged from $65/ha without control of common cocklebur up to $83/ha for 100% control. An additional $15/ha was required to increase common cocklebur control from 50 to 95%. They also found that failure to provide any control of common cocklebur resuted in a net return of

$63/ha. Greatest returns were achieved when common cocklebur control was complete. Control of 95% of common cocklebur resulted in a net return of $119/ha, almost twice that obtained with no control. They remarked that if a higher soybean price of $0.26/kg is assumed, the porportional advantage for complete control of common cocklebur declines. However, the absolute net return increased to $235/ha without control and $402/ha with 100% control, or an estimated increase of $167/ha for the improved control. They concluded that net returns from a given land area in soybean production are greatest when cocklebURS are completely controlled.

CHAPTER III

METHODS AND MATERIALS

I. FIELD RESEARCH

Two experiments were conducted each year at Milan and Ames Plantation, in west Tennessee, during 1975 and 1976 to evaluate the effectiveness of various preemergence and postemergence weed control practices for common cocklebur (Xanthium pensylvanicum Wallr.) in soybeans grown under conventional tillage. Another experiment was conducted during 1978 at Knoxville under no-tillage farming conditions to determine the individual and combined effects of various components (herbicides) of a total weed control system and to determine the economic returns of each component.

Conventional Tillage Experiments

These experiments were conducted by the University of Tennessee research workers Dr. Larry Jeffery, Mr. Tom McCutchen, and Mr. John T. Connell. 'Forrest' soybeans were grown on a Loring silt loam at Ames Plantation and 'Pickett 75' soybeans were grown at Milan Field Station on a Collins silt loam soil.

Both soils are suitable for soybean production and were very well infested with common cocklebur. To uniformize the infestation mature cocklebur seeds were broadcast over the experimental areas 6 months before planting.

Prior to seedbed preparation the experimental areas were fertilized by broadcast fertilizer application according to soil test results. A seedbed was prepared using practices commonly used in the area.

The experimental design was a randomized complete block design with 3 replications. The plots were 4 rows 1.0m wide and 18m long, except for the experiment at Milan in 1976 that had plots 9m long. Yield was obtained from the two central rows.

The treatments applied were consistent within the same year. In the 1975 experiments Dyanap (dinoseb + naptalam) was applied preemergence at 5.0 kg/ha followed by either postemergence overtop applications with bentazon (0.8 kg/ha), or dinoseb (0.8 kg/ha), or Dyanap (2.5 kg/ha), or no herbicide treatment at all when the soybean was 8-15cm tall (second trifoliate stage). Soybeans treated preemergence with linuron at 0.8 kg/ha were not treated when they were in the second trifoliate stage. Some treatments did not receive a preemergence herbicide but were treated with Dyanap (4.2 kg/ha) at the cracking stage and did not receive a postemergence herbicide at the second trifoliate stage. When soybeans were 30-70cm tall each plot was either treated with a band application (30% of the area) of bentazon at 0.8 kg/ha plus cultivation between the bands, or only cultivation with no bentazon treatment, or left unmolested to the results of the previous treatment. A "weedy check" or untreated control and a "weed free check" completed the list of treatments for each experiment.

The weed free check was obtained by periodic cultivations and hand hoeing and was included strictly to give a measure of the yield potential for the experiment under each set of growing conditions.

In 1976 the treatments were kept the same as for 1975 except that a new preemergence treatment with metribuzin at 0.6 kg/ha was added with no postemergence treatments at the second trifoliate stage, and with the same treatments when the soybeans were 30-70cm tall.

Cultivation was used in the system when the soybeans were 15, 30 and 60cm tall following the applications of the overtop herbicides. Profluralin (0.8 kg/ha) was incorporated in the soil before planting each experiment to control annual grass weeds.

Percentage common cocklebur control was estimated visually in July or early August and recorded as early control, and in October and recorded as late control.

Soybeans were combine harvested and yields were adjusted to 13.5% moisture.

No-Tillage Experiment

This experiment was carried out by the author at the Knoxville Plant Science Farm during 1978. 'Essex' soybeans were planted in a small grain stubble on a Sequatchie loam soil, suitable for soybean production and very well infested with common weeds. A mixture of weed seeds was broadcast over the experimental area 6 months before planting to uniformize the infestation.

The experimental design was a randomized complete block design with 3 replications. The plots, 9m long, were planted with a

Allis Chalmers 2-row sod planter with fluted coulter, leaving 3 rows, 75cm wide, per plot. Yield was obtained from the central row.

No seedbed preparation practice was used before planting. The herbicide glyphosate at 1.7 kg/ha was applied to the whole experimental area at the time of planting to kill the weeds already present. Following this basic treatment the preemergence herbicides metribuzin at 0.6 kg/ha, alachlor at 2.2 kg/ha or a mixture of the two was applied to each plot. Thirty days after planting two new postemergence herbicides, RH 6201 at 2.2 kg/ha and HOE 29152 at 0.6 kg/ha were applied alone or in mixture over plots previously treated with the preemergence herbicides. A "glyphosate check," a "weedy check" and a "conventional tillage check" completed the list of treatments.

The percent of weed control was estimated visually for each weed species present 35 days after planting (recorded as early control) and 70 days after planting (recorded as late control).

The soybeans were hand-harvested, threshed with a stationary plot thresher, and the yields were adjusted to 13.5% moisture.

II. ECONOMIC STUDY

The data from the above experiments were used for the economic study. Input prices used for the economic analysis were those set forth in the "Farm Planning Manual" (1978 Revision) of the Agricultural Extension Service of the University of Tennessee (16). Input prices were held constant for each system. The herbicide prices were those that prevailed during 1978 according to the list "Herbicides for Soybeans" prepared by the Agricultural Extension Service of the University of Tennessee.

The fixed, variable, total, and interest costs per hour for selected machinery items used for soybean production are presented in Table 1. These costs are based on new cost, an estimated annual use rate, and a charge for repair and are adapted from the "Farm Planning Manual" (16). Expected life and repair percentages are based on research findings from several universities. Depreciation, housing, and insurance make up the fixed costs. Annual depreciation was calculated by dividing new costs by expected life. The combined annual cost of depreciation and insurance was divided by the estimated hours of annual use to get fixed cost per hour. Variable cost for machinery without engines consists only of repairs. Variable costs for machinery with engines include fueld and lubrication costs in addition to repair costs.

The components of production cost of soybeans under conventional tillage cropping excluding the weed control operations were based on the "Farm Planning Manual" (16) and are presented in Table 2. The same thing for no-tillage soybean planting is shown in Table 3.

Operating capital was assumed to be required for 6 months period and was calculated from total variable costs.

The sequence of operations performed are those used by the Tennessee farmers and is presented in Table 4. Table 5 presents the labor, power, and machine inputs used for the calculations in Table 2.

Table 1. Estimated machinery fixed and variable costs for an estimated annual use on a per hour basis, plus machine and labor time requirements per hectare for soybeans.[a]

Type of Machine	New Cost	Expected Life	Annual Fixed Costs	Estimated Hours per Year	Fixed Cost/ Hour	Repairs % of New Cost	Variable Costs per Hour	Total Costs/ Hour	Interest Cost per Hour	Hours per ha Machine	Hours per ha Labor
Plow, 5-16" mounted	2050	10	223	100	2.23	60	1.23	3.46	0.77	0.86	1.09
Cultimulcher, 20"	3400	10	387	70	5.53	40	1.94	7.47	1.82	0.27	0.35
Planter, 4-row	3045	10	333	70	4.75	40	1.74	6.49	1.63	0.74	0.91
Sod planter, 2-row	1459	10	158	70	2.26	40	0.83	3.09	0.78	1.48	1.98
Cultivator, 4-row	1669	10	198	60	3.17	60	1.67	4.84	1.04	0.74	0.91
Sprayer, with boom	504	8	70	40	1.76	60	0.94	2.70	0.47	0.49	0.62
Tractor, 60 PTO-HP	10465	10	1112	600	1.85	60	2.80	4.65	0.65	----	----
Tractor, 100 PTO-HP	16074	10	1703	600	2.84	60	4.93	7.77	1.00	----	----
Combine, 13' S.P.[b]	26250	8	3431	175	19.60	40	9.68	29.28	5.62	0.82	1.01
Truck, 2 ton w/hoist	10500	10	1135	300	3.78	60	4.61	8.39	1.31	0.82	1.01

[a]Adapted from "Farm Planning Manual" (16).

[b]S.P. means "self-propelled."

Table 2. Components of production costs of soybean per hectare under conventional tillage excluding the weed control operations.[a]

Item	Description	Unit	Quantity	Price (Dollar)	Amount (Dollar)
Variable Expenses					
Seed	----------	kg	44.83	0.33	14.83
Inoculation	Rhizobium	pkg	0.82	0.40	0.33
Fertilizer	P_2O_5	kg	44.83	0.35	15.81
	K_2O	kg	44.83	0.20	8.90
Lime	6.7 ton/4 yrs.	ton	1.68	11.03	18.53
Tractor	60 PTO—HP	hr	0.74	2.80	2.08
	100 PTO—HP	hr	1.14	4.93	5.60
Truck	2 ton	hr	0.82	4.61	3.76
Combine	13' S.P.	hr	0.82	9.68	7.89
Other machinery					2.87
		Total variable expenses			80.60
Fixed Expenses					
Tractor	60 PTO—HP	hr	0.74	1.85	1.37
	100 PTO—HP	hr	1.14	2.84	3.23
Truck	2 ton	hr	0.82	3.78	3.08
Combine	13' S.P.	hr	0.82	19.60	15.98
Other machinery					6.94
		Total fixed expenses			30.60
Interests					
Operational capital	6 mo. @ 9%	ha	1	3.63	3.63
Fixed capital	12 mo. @ 7.5%	ha	1	9.64	9.64
		Total interests			13.27
Labor					
----------	----------	hr	4.37	2.50	10.93
		Total labor expenses			10.93
		TOTAL PRODUCTION COST			135.40

[a]Adapted from "Farm Planning Manual" (16).

Table 3. Components of production costs of soybean per hectare under no-tillage cropping excluding the weed control operations.[a]

Item	Description	Unit	Quantity	Price (Dollar)	Amount (Dollar)
Variable Expenses					
Seed	----------	kg	44.83	0.33	14.83
Inoculation	Rhizobium	pkg	0.82	0.40	0.33
Fertilizer	P_2O_5	kg	44.83	0.35	15.81
	K_2O	kg	44.83	0.20	8.90
Lime	6.7 tons/4 year	ton	1.68	11.03	18.53
Tractor	60 PTO—HP	hr	1.48	2.80	4.15
Truck	2 ton	hr	0.82	4.61	3.76
Combine	13' S.P.	hr	0.82	9.68	7.89
Other machinery	---------------	---	-----	-----	1.24
		Total variable expenses			75.42
Fixed Expenses					
Tractor	60 PTO—HP	hr	1.48	1.85	2.74
Truck	2 ton	hr	0.82	3.78	3.08
Combine	13' S.P.	hr	0.82	19.60	15.98
Other machinery	---------------	---	-----	-----	3.36
		Total fixed expenses			25.16
Interests					
Operational capital	6 mo. @ 9%	ha	1	3.39	3.39
Fixed capital	12 mo. @ 7.5%	ha	1	7.76	7.76
		Total interests			11.15
Labor					
----------------------------------		hr	4.00	2.50	10.00
		Total labor expenses			10.00
		TOTAL PRODUCTION COST PER HECTARE			121.73

[a]Adapted from "Farm Planning Manual" (16).

Table 4. Sequence of operations performed for soybean production under conventional tillage cropping excluding the weed control operations.[a]

Operations	Equipment	Hours per hectare	
		Machine	Labor
Plow	5-16" plow	0.86	1.09
Disk	20" do all (cultimulcher)	0.27	0.35
Plant	4-row (planter)	0.74	0.91
Harvest	13' S.P. (combine)	0.82	1.01
Haul	2 ton truck	0.82	1.01
	Total	3.75	4.37

[a]Adapted from "Farm Planning Manual" (16).

Table 5. Labor, power, and machine inputs for soybean production under conventional tillage cropping excluding the weed control operations.[a]

Machine	Hours/ ha	Inter- est/h	Inter- est/ha	Cost per hour		Cost per ha	
				Fixed	Variable	Fixed	Variable
Tractor 100 HP	1.13	1.00	1.13	2.84	4.83	3.21	5.57
Tractor 60 HP	0.74	0.65	0.48	1.85	2.80	1.37	2.07
Plow	0.86	0.77	0.66	2.23	1.23	1.92	1.06
20" do-all	0.27	1.82	0.49	5.53	1.94	1.49	0.52
Planter	0.74	1.63	1.21	4.75	1.74	3.52	1.29
Combine	0.82	5.62	4.61	19.60	9.68	16.07	7.94
Truck	0.82	1.31	1.07	3.78	4.61	3.10	3.78
Total			9.64			30.60	22.23

[a]Adapted from "Farm Planning Manual" (16).

The same inputs above are presented in Tables 6 and 7 for no-tillage cropping.

Table 6. Labor, power, and machine inputs for soybean production under no-tillage cropping excluding the weed control operations.[a]

Machine	Hours/ ha	Inter- est/h	Inter- est/ha	Cost per hour		Cost per ha	
				Fixed	Variable	Fixed	Variable
Tractor 60 HP	1.48	0.65	0.96	1.85	2.80	2.74	4.14
Planter	1.48	0.78	1.15	2.26	0.83	3.34	1.23
Combine	0.82	5.62	4.61	19.60	9.68	16.07	7.94
Truck	0.82	1.31	1.07	3.78	4.61	3.10	3.78
Total	7.76					25.25	17.14

[a]Adapted from "Farm Planning Manual" (16).

Table 7. Sequence of operations performed for soybean production under no-tillage cropping excluding the weed control operations.[a]

Operation	Equipment	Hours per hectare	
		Machine	Labor
Plant	Sod planter 2-row	1.48	1.98
Harvest	13' S.P. (combine)	0.82	1.01
Haul	2 ton truck	0.82	1.01
	Total	3.12	4.00

[a]Adapted from "Farm Planning Manual" (16).

Operations of cultivation, spraying, and herbicide incorporation were considered weed control operations and their costs were calculated separately and presented in Tables 8, 9, and 10 respectively.

Table 8. Components of the total cost of one cultivation per hectare.[a]

Item	Description	Unit	Quantity	Price (Dollar)	Amount (Dollar)
Variable Expenses					
Cultivation	4-rows cultivator	hr	0.74	1.67	1.24
Tractor	60 PTO—HP	hr	0.74	2.80	2.08
		Total variable expenses			3.32
Fixed Expenses					
Cultivator	4-rows cultivator	hr	0.74	3.16	2.35
Tractor	60 PTO—HP	hr	0.74	1.85	1.37
		Total fixed expenses			3.72
Interests					
Operational capital	6 mo. @ 9%	ha	1	0.15	0.15
Fixed capital	12 mo. @ 7.5%	ha	1	1.26	1.26
		Total interests			1.41
Labor					
-------------------------------------		hr	0.91	2.50	2.29
		Total labor expenses			2.29
		TOTAL COST OF ONE CULTIVATION			10.74

[a]Adapted from "Farm Planning Manual" (16).

Table 9. Components of the total cost of one herbicide spray per hectare.[a]

Item	Description	Unit	Quantity	Price (Dollar)	Amount (Dollar)
Variable Expenses					
Spraying	with boom	hr	0.49	0.94	0.46
Tractor	60 PTO—HP	hr	0.49	2.80	1.38
		Total variable expenses			1.84
Fixed Expenses					
Sprayer	with boom	hr	0.49	1.76	0.87
Tractor	60 PTO—HP	hr	0.49	1.85	0.91
		Total fixed expenses			1.78
Interests					
Operational capital	6 mo. @ 9%	ha	1	0.08	0.08
Fixed capital	12 mo. @ 7.5%	ha	1	0.54	0.54
		Total interests			0.62
Labor					
-----------------------------------		hr	0.62	2.50	1.55
		Total labor expenses			1.55
		TOTAL COST OF ONE SPRAYING			5.79

[a]Adapted from "Farm Planning Manual" (16).

Table 10. Components of the total cost of one herbicide incorporation per hectare.[a]

Item	Description	Unit	Quantity	Price (Dollar)	Amount (Dollar)
Variable Expenses					
Disk and harrow	Cultimulcher 20"	hr	0.27	1.94	0.53
Tractor	100 PTO—HP	hr	0.27	4.93	1.34
		Total variable expenses			1.87
Fixed Expenses					
Disk and harrow	Cultimulcher 20"	hr	0.27	5.53	1.50
Tractor	100 PTO—HP	hr	0.27	2.84	0.77
		Total fixed expenses			2.27
Interests					
Operational capital	6 mo. @ 9%	ha	1	0.08	0.08
Fixed capital	12 mo. @ 7.5%	ha	1	0.77	0.77
		Total interests			0.85
Labor		hr	0.35	2.50	0.86
		Total labor			0.86
	TOTAL COST OF ONE HERBICIDE INCORPORATION				5.85

[a]Adapted from "Farm Planning Manual" (16).

The total costs of production were calculated by adding all components presented separately in Tables 2 and 3, pages 15 and 16, and Tables 8, 9, and 10, and then by adding the herbicide costs plus interests.

Gross returns were calculated by multiplying the average price of U.S. No. 1 grade soybeans by the adjusted yields.

Net returns were those revenues that remained after the total costs of production were paid, or the difference between gross return and total cost of production.

Costs per hectare for weed control for the weed free check are incomplete because they do not include costs for hand hoeing to control weeds not removed by cultivation. The time spent for hand hoeing was not recorded. It is an unknown value and vary from one field to another. Labor to perform this task is usually unavailable on a large scale basis. The weed free check was included only to give an estimate of yield potential for each experiment.

Least squares regression equations of the quadratic form were used to estimate the effects of percent late common cocklebur control (percent late weed control for the no-tillage experiment) on adjusted soybean yields, total cost of production, and net returns. The percentage data were transformed to arc sine (%/100) to improve normality of their error terms.

CHAPTER IV

RESULTS

I. CONVENTIONAL TILLAGE EXPERIMENTS

Experiment at Milan 1975

Yield. All herbicide practices significantly increased soybean yields when compared to the untreated control (Table 11). The most effective cocklebur control systems produced the highest soybean yields. In most cases neither bentazon applied when the soybeans were 30-40cm tall nor cultivation at this stage were necessary to increase yields. When Dyanap was applied at the cracking stage or when it was applied preemergence followed by dinoseb applied at the second trifoliate stage, bentazon and/or cultivation were necessary at the 30-40cm stage if highest yields were to be obtained. Also either cultivation or bentazon applied when soybeans were 30-40cm was necessary to obtain maximum yield when a single preemergence treatment with linuron was applied.

A single application of bentazon when the soybeans were 30-40cm tall followed by cultivation later in the season with no prior treatment was enough to produce maximum yield.

The predicted adjusted yield with no control of common cocklebur was 599 kg/ha (Figure 1). In contrast, 100% control of common cocklebur resulted in a calculated average adjusted yield of 2528 kg/ha. Estimated soybean yields were increased about 8% for each 10% increase in cocklebur control in the range above 60%.

Table 11. Common cocklebur control, soybean yields, costs and returns for various weed control systems in soybeans grown at Milan TN, 1975.

	Treatments—Time of Application				% Control[a]		Soybean	Costs $/ha		Returns $/ha[a]	
Preemergence	Cracking Stage	Second Trifoliate	30-40cm Tall	Later in the Season	Early	Late	Yield[a] (kg/ha)	Weed Control	Produc-tion	Gross	Net
Dyanap[b]	none	bentazon	bentazon	cultivation	73cde	100a	2542abcde	100.95	236.35	514abcde	278bcde
Dyanap	none	bentazon	**cultivation**	cultivation	78bcd	100a	2510abcdef	86.12	221.52	507abcdef	286bcde
Dyanap	none	bentazon	none	none	77bcde	90de	2315def	64.64	200.04	468def	268cde
Dyanap	none	dinoseb	bentazon	cultivation	88bc	100a	2575abcd	78.98	214.38	520abcd	306abcd
Dyanap	none	dinoseb	cultivation	cultivation	87bc	98ab	2559abcd	64.15	199.55	517abcd	318abc
Dyanap	none	dinoseb	none	none	88bc	62f	2026g	42.67	178.07	409g	231e
Dyanap	none	Dyanap	bentazon	cultivation	96ab	100a	2449abcdef	86.84	222.24	495abcdef	273bcde
Dyanap	none	Dyanap	cultivation	cultivation	96ab	100a	2457abcdef	61.27	196.67	497abcdef	300bcd
Dyanap	none	Dyanap	none	none	94ab	94bc	2538abcde	50.53	185.93	513abcde	327ab
Dyanap	none	none	bentazon	cultivation	48def	77de	2351bcdef	81.80	217.20	475bcdef	258de
Dyanap	none	none	cultivation	cultivation	73cde	88cd	2254fg	63.96	199.36	456fg	256de
Dyanap	none	none	none	cultivation[c]	67cde	97ab	2526abcdef	63.96	199.36	511abcdef	311abcd
linuron	none	none	bentazon	cultivation	72cde	88cd	2490abcdef	70.28	205.68	503abcdef	298bcd
linuron	none	none	cultivation	cultivation	35f	68ef	2420abcdef	52.44	187.84	489abcdef	301bcd
linuron	none	none	none	cultivation[c]	72cde	82de	2323cdef	41.70	177.10	469cdef	292bcd
none	Dyanap	none	bentazon	cultivation	50ef	100a	2600abc	77.50	212.90	525abc	313abcd
none	Dyanap	none	cultivation	cultivation	73cde	83d	2266efg	59.66	195.06	458efg	263cde
none	Dyanap	none	none	none	58def	25g	980h	27.44	162.84	198h	35f
none	none	none	bentazon	cultivation	0g	95bc	2628ab	39.32	174.72	531ab	356a
Weedy check	------	-------	-----------	-----------	0g	0h	675i	------	135.40	137i	1f
Weed free check	------	-------	-----------	-----------	100a	100h	2652a	42.96[d]	178.36	536a	358a

[a]Means within a column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Dyanap is a commercial formulation of naptalam + dinoseb.

[c]This system was cultivated by mistake when other late season treatments were made.

[d]It does not include costs incurred for hand hoeing needed to control weeds not removed by cultivation.

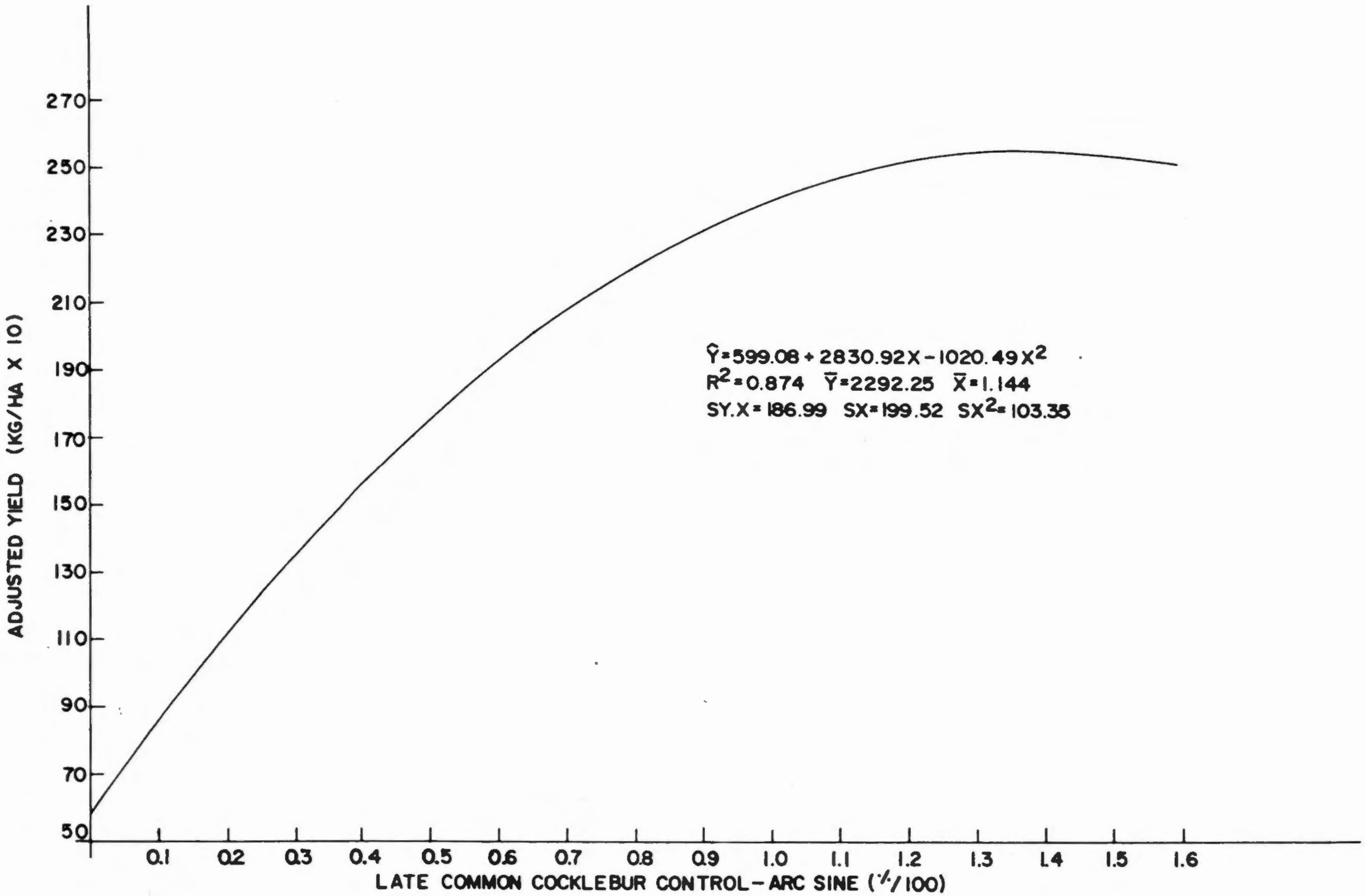

Figure 1. Effects of levels of common cocklebur control on adjusted yields for soybean production under conventional tillage cropping at Milan Tn, 1975.

Costs and returns. The total cost of production ranged from $142/ha without control of common cocklebur to $207/ha for 100% control according to the predicted equation (Figure 2). Based on these data, an additional $21/ha or 105 kg/ha of soybean was required to increase common cocklebur control from 60 to 95%.

Increased net returns were obtained from all systems of common cocklebur control when compared to the weedy check, except when Dyanap was applied at the cracking stage followed by no further treatment. Even those systems where no treatment occurred at the time the soybean plants were 30-40cm tall gave positive net returns.

Cultivation or a bentazon application at the 30-40cm tall stage of the soybeans increased net returns only when Dyanap was applied either at the cracking stage or preemergence followed by dinoseb at the second trifoliate stage.

A single treatment of bentazon applied when the soybeans were 30-40cm tall followed by cultivation later in the season provided maximum net returns. Maximum net returns were also obtained (1) by application of Dyanap at the cracking stage followed by bentazon at the 30-40cm tall stage of the soybeans followed by cultivation later in the season, or (2) by application of Dyanap followed by dinoseb at the second trifoliate stage plus cultivation later in the season, or (3) by Dyanap followed by Dyanap applied at the second trifoliate stage with no further treatment, or (4) by Dyanap followed by cultivation when soybeans were 30-40cm tall and continued later in the season.

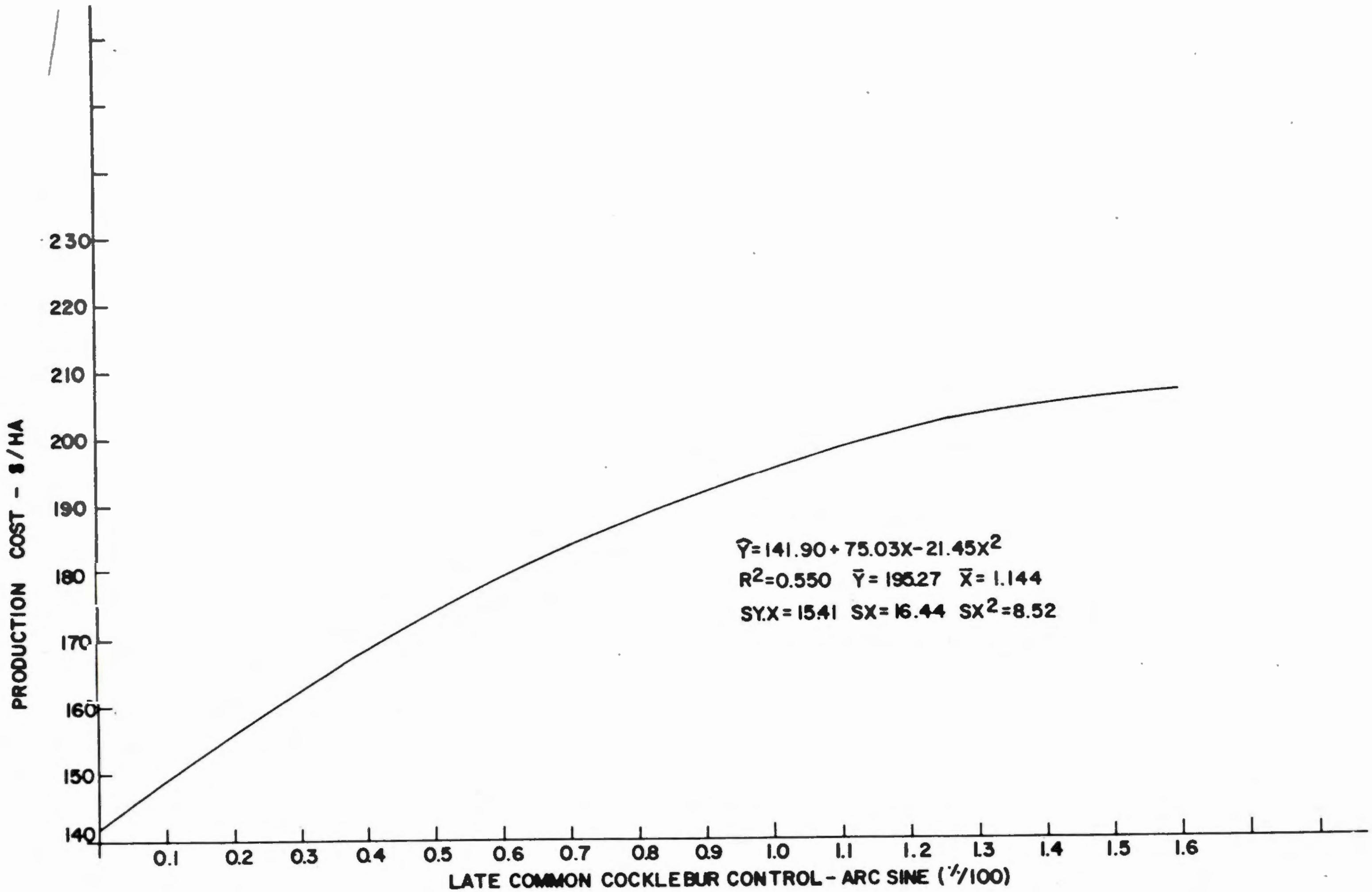

Figure 2. Effects of levels of common cocklebur control on total production costs for soybean production under conventional tillage cropping at Milan TN, 1975.

Cultivation or bentazon applied when soybeans were 30-40cm tall was necessary to increase returns only when Dyanap was applied preemergence, followed by dinoseb at the second trifoliate stage or when Dyanap was applied at the cracking stage.

Failure to provide any control of common cocklebur resulted in a net return of $21/ha (Figure 3). Control of 95% of common cocklebur resulted in a net return of $312/ha, according to the quadratic regression equation developed to estimate the effects of these two variables.

Experiment at Milan 1976

Yield. Increased yields were obtained with all systems of common cocklebur control when compared to the untreated control, except for Dyanap applied at the cracking stage or applied preemergence, with no further treatment. Highest yields were produced with practices that were most effective for common cocklebur control (Table 12).

A treatment of bentazon applied when the soybean was 35cm tall and followed by cultivation later in the season was necessary to increase the common cocklebur control to 98-100% and to produce maximum yield, except when Dyanap was applied preemergence and followed by Dyanap applied at the second trifoliate stage.

Postemergence treatment at the second trifoliate stage was not necessary for maximum yield if a preemergence treatment was followed by bentazon when the soybeans were 35cm tall plus cultivation later in the season.

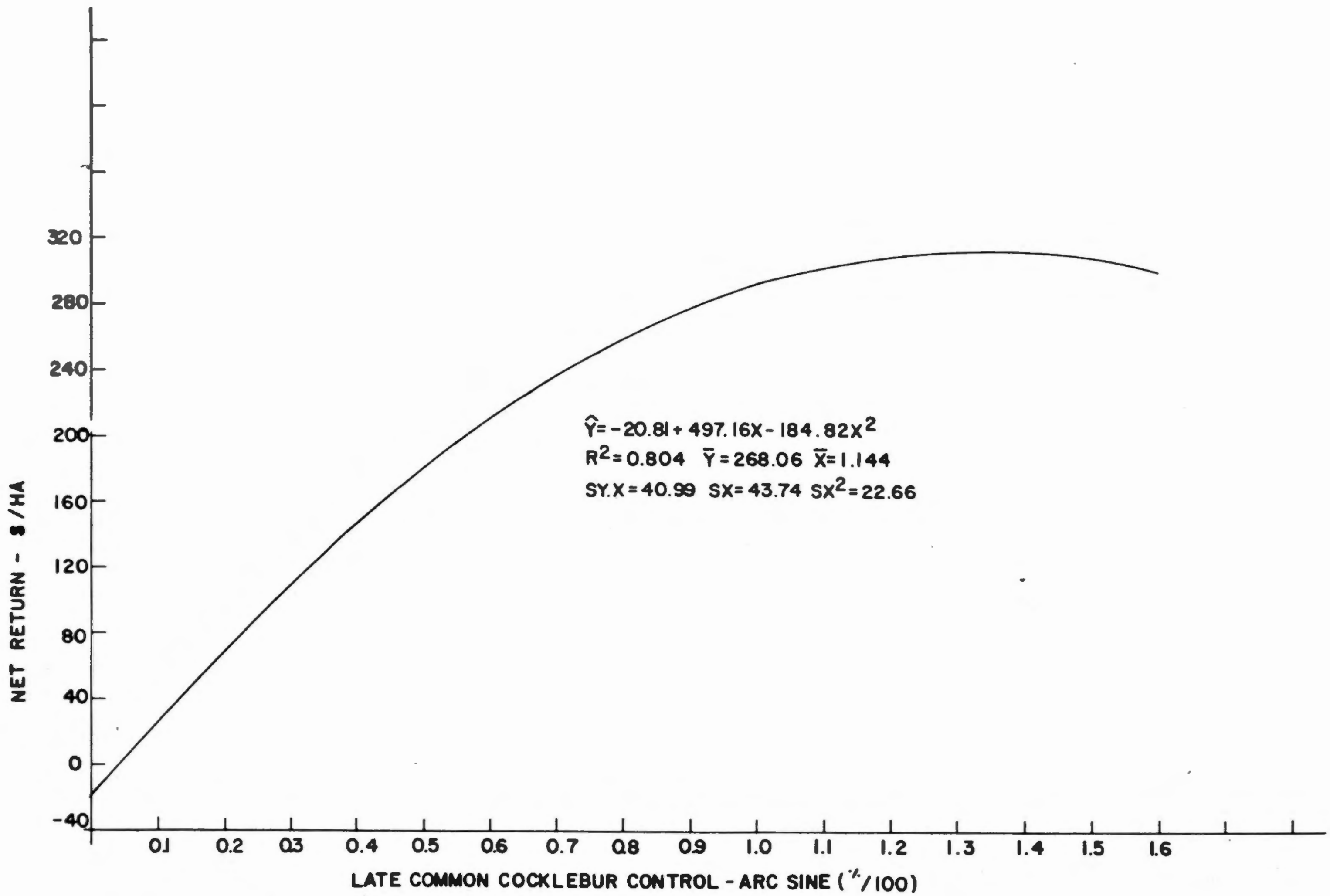

Figure 3. Effects of levels of common cocklebur control on net returns for soybean production under conventional tillage cropping at Milan TN, 1975.

Table 12. Common cocklebur control, soybean yields, costs and returns for various weed control systems in soybeans grown in Milan TN, 1976.

	Treatments—Time of Application				% Control[a]		Soybean	Costs $/ha		Returns $/ha[a]	
Preemergence	Cracking Stage	Second Trifoliate	35cm Tall	Later in the Season	Early	Late	Yield[a] (kg/ha)	Weed Control	Production	Gross	Net
Dyanap[b]	none	bentazon	bentazon	cultivation	100a	100a	3149a	129.16	264.56	639a	372ab
Dyanap	none	bentazon	cultivation	cultivation	100a	100a	2725abc	114.33	249.73	551abc	301abcd
Dyanap	none	bentazon	none	none	100a	83e	2327cd	92.45	227.85	470cd	242cde
Dyanap	none	dinoseb	bentazon	cultivation	100a	100a	3067ab	107.19	242.59	620ab	377ab
Dyanap	none	dinoseb	cultivation	cultivation	100a	98bc	2907abc	92.36	227.76	567abc	340abc
Dyanap	none	dinoseb	none	none	100a	65f	2017de	70.88	206.28	408de	201de
Dyanap	none	Dyanap	bentazon	cultivation	100a	100a	3190a	115.05	250.45	645a	394a
Dyanap	none	Dyanap	cultivation	cultivation	100a	98bc	2929abc	100.22	235.62	592abc	356abc
Dyanap	none	Dyanap	none	none	100a	91de	2969ab	78.74	214.14	600ab	386ab
Dyanap	none	none	bentazon	cultivation	62c	100a	3026ab	85.52	220.92	612ab	391ab
Dyanap	none	none	cultivation	cultivation	62c	88e	2311cd	70.69	206.09	467cd	261bcde
Dyanap	none	none	none	none	62c	36g	888f	49.21	184.61	178f	-7f
linuron	none	none	bentazon	cultivation	92b	100a	3043ab	77.01	212.41	615ab	403a
linuron	none	none	cultivation	cultivation	92b	97cd	2441bcd	59.17	194.57	493bcd	299abcd
linuron	none	none	none	none	92b	67f	1700e	37.69	173.09	344e	171e
none	Dyanap	none	bentazon	cultivation	58c	100a	3059ab	99.27	234.67	618ab	384ab
none	Dyanap	none	cultivation	cultivation	58c	85e	2091de	81.43	216.83	423de	206de
none	Dyanap	none	none	none	58c	7h	846f	59.95	195.35	171f	-24f
none	none	none	bentazon	cultivation	0d	97cd	2937abc	56.79	192.19	594abc	401a
Weedy check	------	--------	-----------	-----------	0d	0d	586f	------	135.40	118f	-17f
Weed free check	------	--------	-----------	-----------	100a	100a	2978ab	42.96[c]	178.36	602ab	424a
metribuzin	none	none	bentazon	cultivation	88b	100a	3043ab	81.16	216.56	615ab	399a
metribuzin	none	none	cultivation	cultivation	88b	98bc	2978ab	63.32	198.72	602ab	403a
metribuzin	none	none	none	none	88b	85e	2416bcd	41.84	177.24	488bcd	311abcd

[a]Means within a column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Dyanap is a commercial formulation of naptalam + dinoseb.

[c]It does not include costs incurred for hand hoeing needed to control weeds not removed by cultivation.

A single application of bentazon when soybeans were 35cm tall followed by cultivation later in the season was enough to provide 97% control of common cocklebur and maximum yield.

Bentazon applied at the 35cm stage of soybeans followed by cultivation later in the season was just as effective as cultivation alone except when Dyanap was applied at the cracking stage or preemergence, with no treatment at the second trifoliate stage.

An adjusted yield of 509 kg/ha was predicted when common cocklebur was not controlled. In contrast, an adjusted yield of 3072 kg/ha was predicted when common cocklebur was completely controlled (Figure 4).

Estimated soybean yields increased approximately 10% for each 10% increase in common cocklebur control in the range above 60% of control.

Costs and returns. The total predicted production costs ranged from $166/ha with zero control of common cocklebur to $227/ha with 100% control (Figure 5). Based on these data, an additional investment of $24/ha or a yield increase of 120 kg/ha of soybeans was required to increase common cocklebur control from 60 to 95%.

All systems of common cocklebur control increased net returns when compared to the untreated control, except for Dyanap applied at the cracking stage or preemergence with no further treatment.

The inclusion of the last treatment of bentazon when the soybeans were 35cm tall followed by cultivation later in the season was necessary for maximum net returns, except when Dyanap applied preemergence was followed by Dyanap applied at the second trifoliate stage, or when metribuzin was applied preemergence (Table 12).

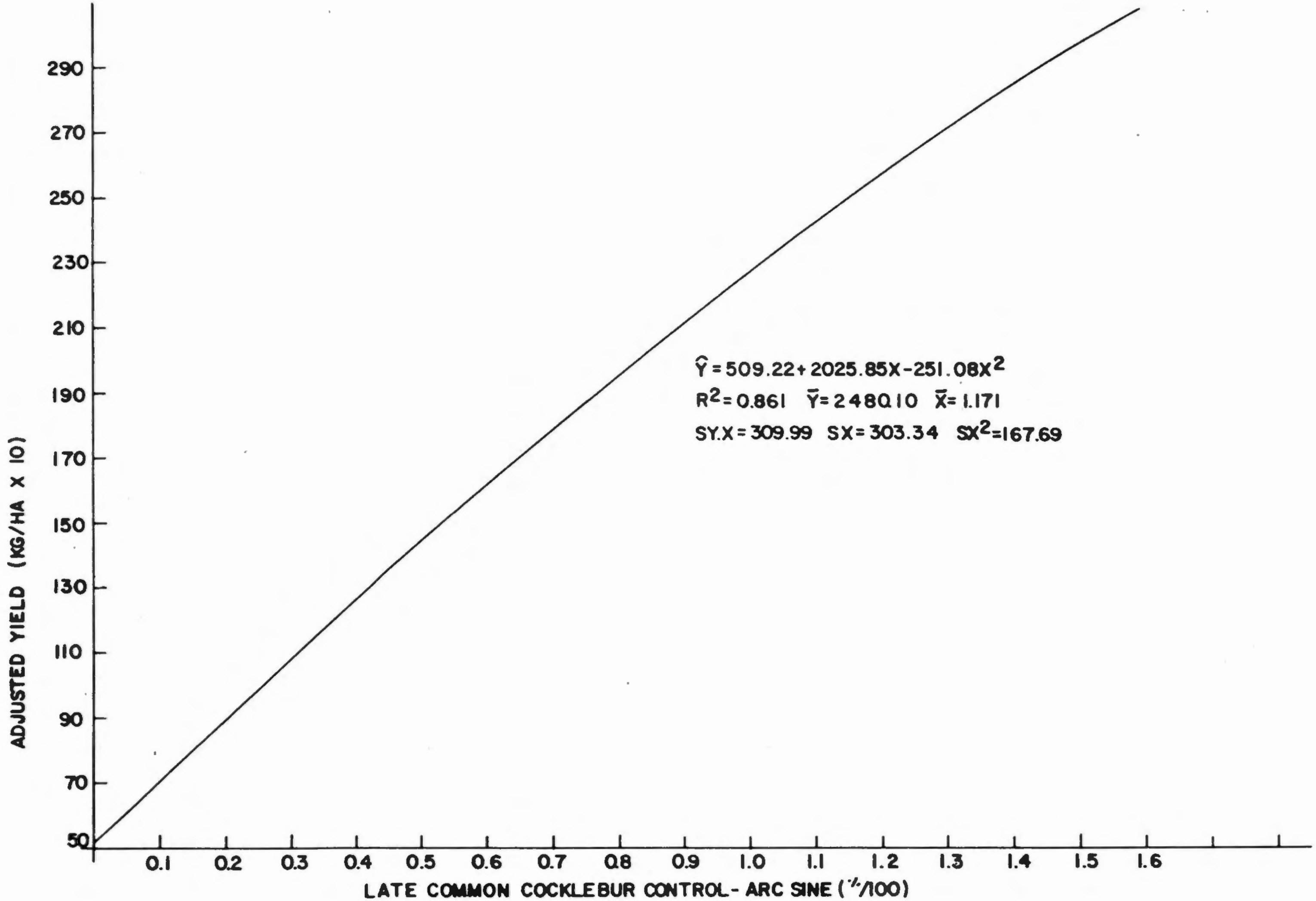

Figure 4. Effects of levels of common cocklebur control on adjusted yields for soybean production under conventional tillage cropping at Milan TN, 1976.

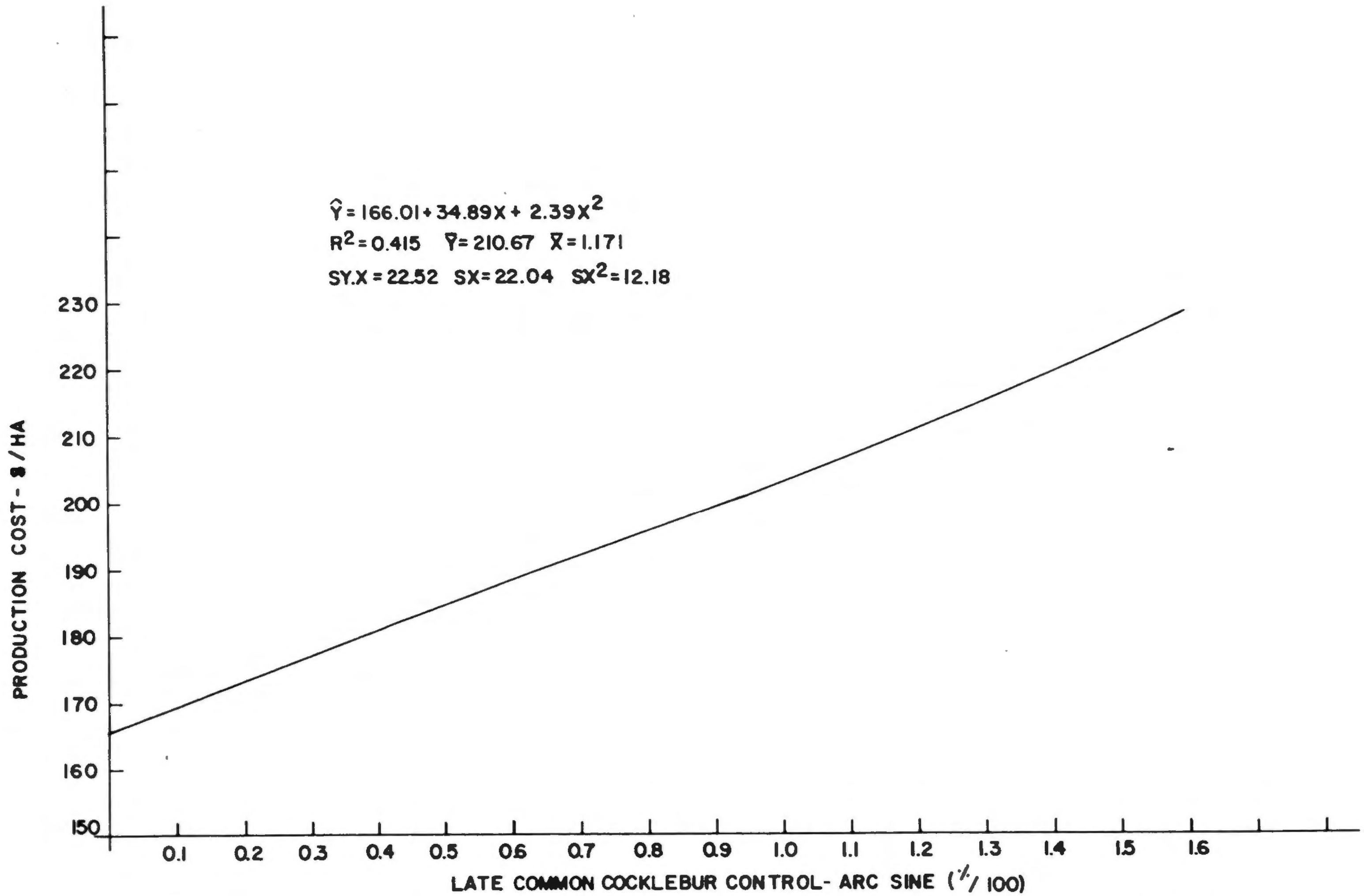

Figure 5. Effects of levels of common cocklebur control on total production costs for soybean production under conventional tillage cropping at Milan TN, 1976.

Highest net returns varied from \$424/ha to \$299/ha and were produced with most weed control practices except for those that did not differ from the untreated control and when Dyanap applied preemergence was followed by bentazon or dinoseb at the second trifoliate stage with no further treatment, or when Dyanap applied at the cracking stage or preemergence was followed by cultivation at and after soybeans were 35cm tall, or when linuron was applied preemergence with no further treatment.

Failure to provide any control of common cocklebur resulted in a net return of \$-63/ha (Figure 6). Greatest net returns were achieved when cocklebur control was complete. Control of 95% of cocklebur resulted in a net return of \$322/ha.

Experiment at Ames Plantation 1975

Yield. All common cocklebur control practices increased soybean yields when compared to the untreated control, except for Dyanap applied as cracking stage treatment, or applied as a preemergence treatment, or linuron used as a preemergence application, with no sequential treatment. Highest soybean yields were produced with practices that were most effective for common cocklebur control (Table 13).

Bentazon applied when the soybeans were 70cm tall followed by cultivation later in the season, was not necessary for maximum yields when a postemergence treatment applied at the second trifoliate stage following a preemergence herbicide treatment was included.

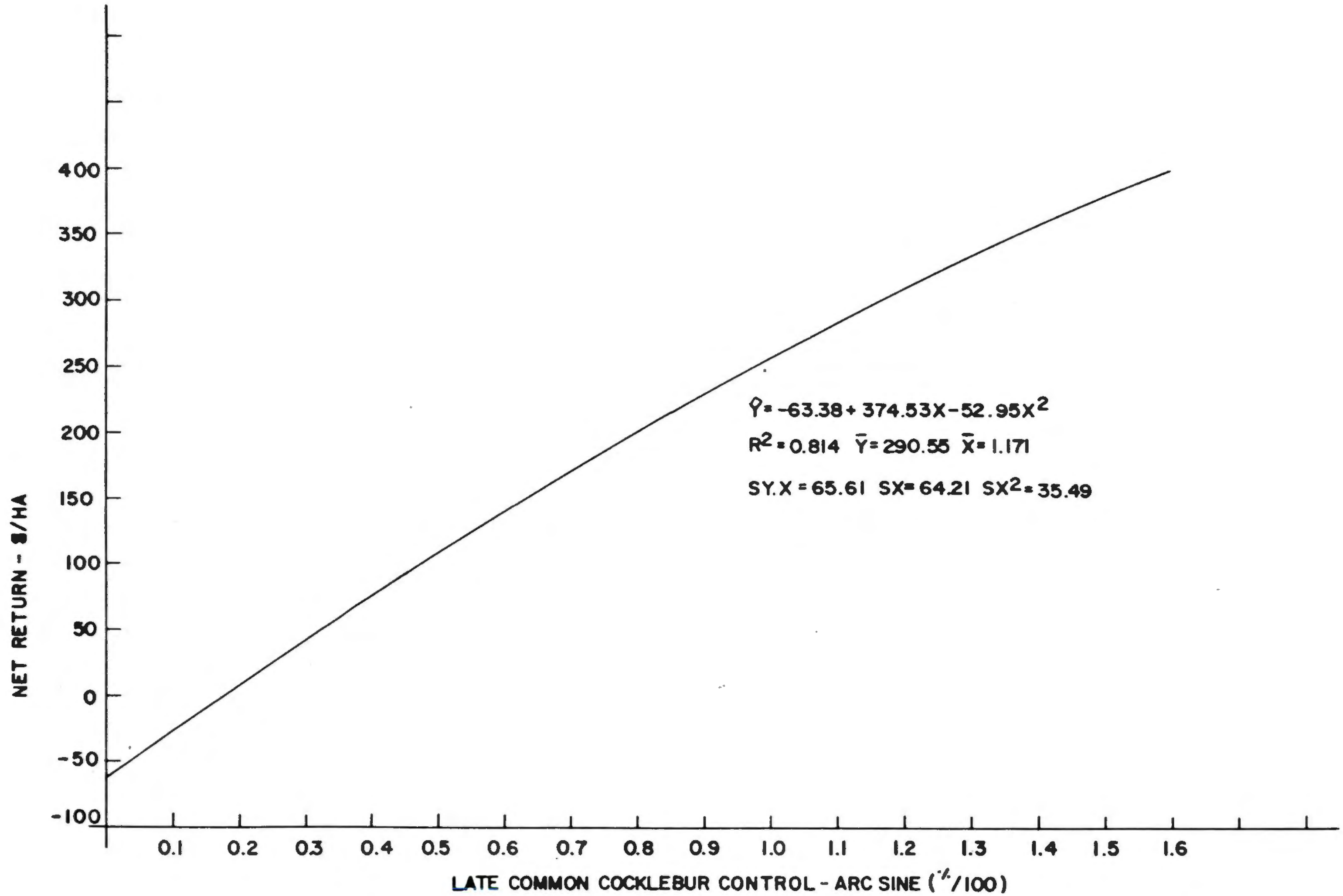

Figure 6. Effects of levels of common cocklebur control on net returns for soybean production under conventional tillage cropping at Milan TN, 1976.

Table 13. Common cocklebur control, soybean yields, costs and returns for various weed control systems in soybeans grown at Ames Plantation TN, 1975.

	Treatments—Time of Application				% Control[a]		Soybean	Costs $/ha		Returns $/ha[a]	
Preemergence	Cracking Stage	Second Trifoliate	70cm Tall	Later in the Season	Early	Late	Yield[a] (kg/ha)	Weed Control	Production	Gross	Net
Dyanap[b]	none	bentazon	bentazon	cultivation	100a	100a	3148a	107.68	243.06	639a	393ab
Dyanap	none	bentazon	cultivation	cultivation	99a	100a	3136a	92.85	228.25	633a	406ab
Dyanap	none	bentazon	none	none	95abc	96ab	2990a	82.11	217.51	604a	387ab
Dyanap	none	dinoseb	bentazon	cultivation	100a	99a	3161a	85.71	221.11	638a	431a
Dyanap	none	dinoseb	cultivation	cultivation	98a	98ab	3242a	70.88	206.26	655a	449a
Dyanap	none	dinoseb	none	none	84bc	97abc	2872ab	60.14	195.54	580ab	385ab
Dyanap	none	Dyanap	bentazon	cultivation	100a	100a	3124a	93.57	228.95	631a	402ab
Dyanap	none	Dyanap	cultivation	cultivation	100a	100a	3035a	78.74	214.14	613a	399ab
Dyanap	none	Dyanap	none	none	73cd	94abc	3234a	68.00	203.40	654a	450a
Dyanap	none	none	bentazon	cultivation	95ab	99ab	3089a	88.53	223.93	624a	400ab
Dyanap	none	none	cultivation	cultivation	80cd	55de	2783ab	70.69	206.09	526ab	356abc
Dyanap	none	none	none	none	3e	8f	2066cd	49.21	184.61	418cd	233cd
linuron	none	none	bentazon	cultivation	98a	100a	3096a	77.01	212.41	626a	413ab
linuron	none	none	cultivation	cultivation	89abc	66cd	2587abc	59.17	194.57	523abc	328abc
linuron	none	none	none	none	27e	22ef	2205bcd	37.69	173.09	446bcd	273bcd
none	Dyanap	none	bentazon	cultivation	98a	100a	3079a	88.53	223.93	622a	399ab
none	Dyanap	none	cultivation	cultivation	97ab	80bcd	2653abc	70.69	206.07	536abc	330abc
none	Dyanap	none	none	none	27e	20ef	1826d	49.21	184.61	369d	185d
none	none	none	bentazon	cultivation	58d	69cd	2750ab	43.05	178.45	556ab	377ab
Weedy check	------	--------	-----------	-----------	0e	0f	1818d	------	135.40	368d	232cd
Weed free check	------	--------	-----------	-----------	100a	100a	2982a	42.96[c]	178.36	603a	424a

[a]Means within a column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Dyanap is a commercial formulation of naptalam + dinoseb.

[c]It does not include costs incurred for hand hoeing needed to control weeds not removed by cultivation.

The postemergence treatment of bentazon, dinoseb, or Dyanap at the second trifoliate stage was necessary for maximum yield if the preemergence treatment was Dyanap and the last treatment with bentazon and/or cultivation was not included.

Bentazon applied at the 70cm tall stage was just as effective as cultivation.

A single application of bentazon when the soybean plants were 70cm tall followed by cultivation later in the season was enough to provide maximum yield, even when no other treatment was included.

The predicted adjusted yield with zero control of common cocklebur was 1748 kg/ha. In contrast, 100% common cocklebur control resulted in an estimated average yield of 3089 kg/ha (Figure 7). The proportional reduction in yield as a result of common cocklebur infestation was approximately linear. Estimated soybean yields were increased approximately 8% for each 10% increase in common cocklebur control.

Costs and returns. Production costs ranged from $167/ha with no control of common cocklebur to $216/ha with 100% control according to the quadratic regression equation developed to estimate the effects of these two variables (Figure 8). Based on these data, an additional investment of $17/ha or a yield increase of 87 kg/ha of soybeans was required to increase common cocklebur control from 60 to 95%.

All weed control practices increased net returns when compared to the untreated control, except when Dyanap or linuron were sprayed as preemergence applications or Dyanap was applied at the cracking stage, with no further treatment.

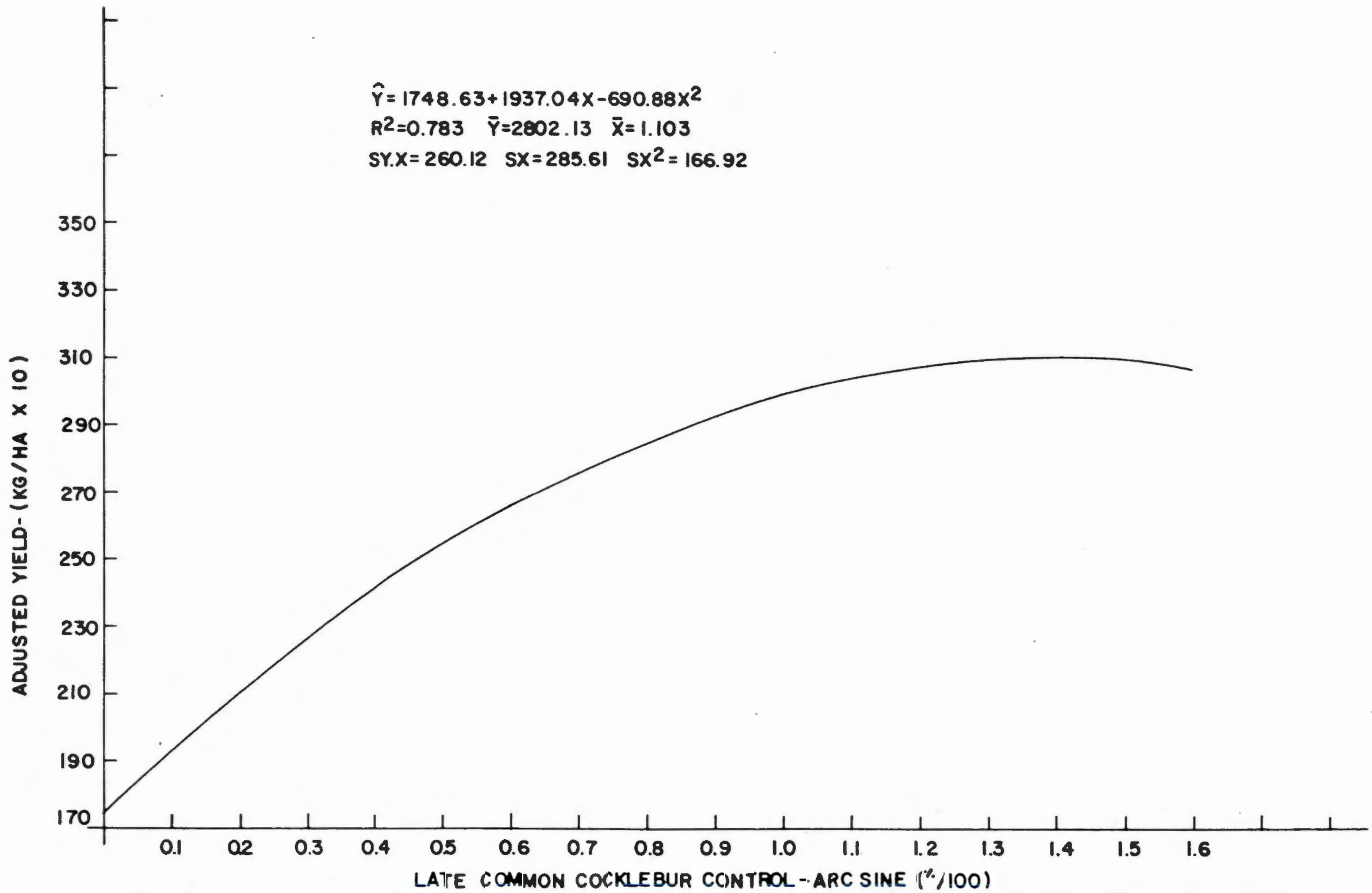

Figure 7. Effects of levels of common cocklebur control on adjusted yields for soybean production under conventional tillage cropping at Ames Plantation TN, 1975.

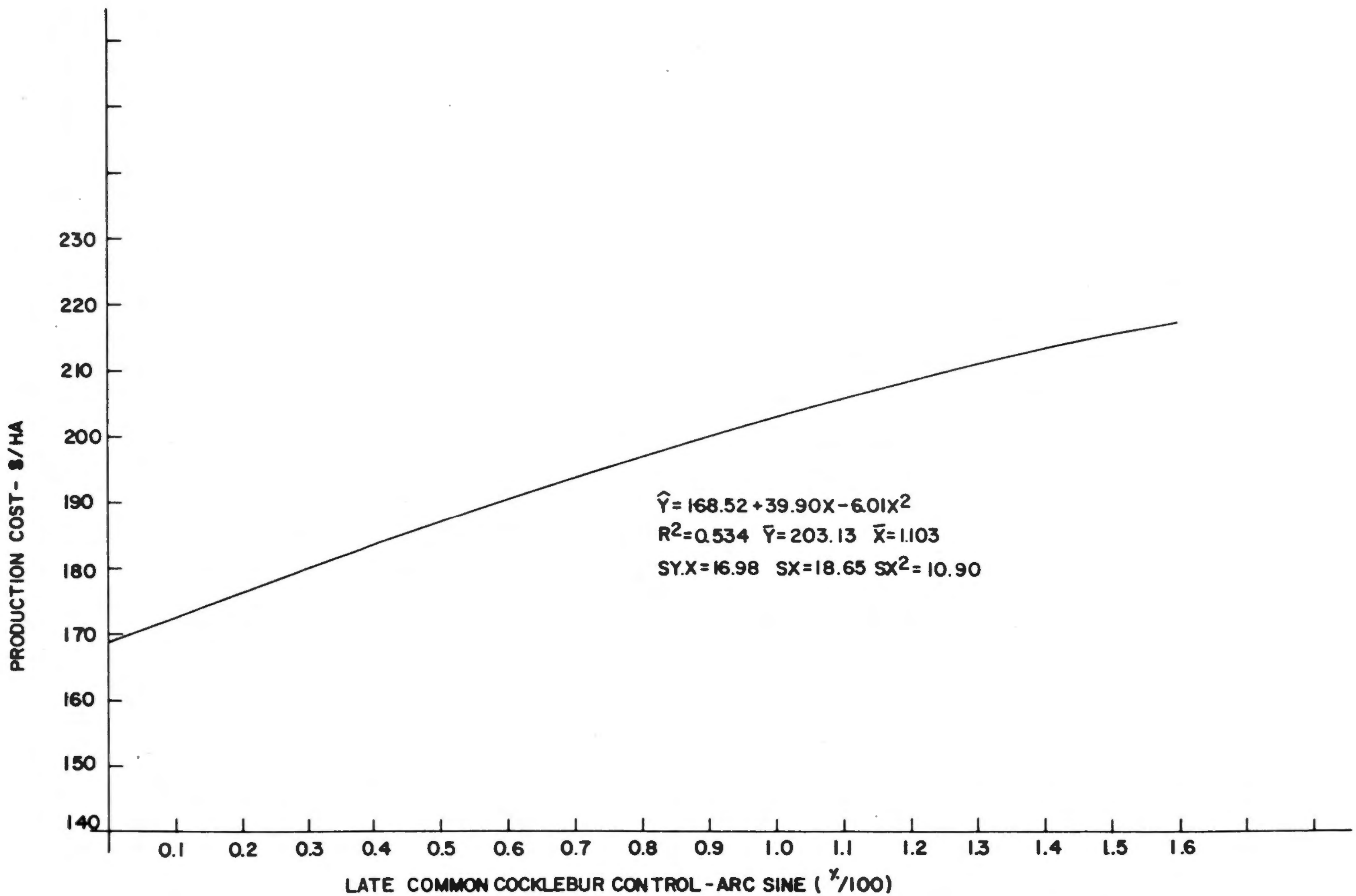

Figure 8. Effects of levels of common cocklebur control on total production costs for soybean production under conventional tillage cropping at Ames Plantation TN, 1975.

The last treatment with bentazon or cultivation when the soybeans were 70cm tall followed by cultivation later in the season, was not necessary to provide maximum net returns except when the postemergence treatment at the second trifoliate stage was not used.

The postemergence treatment at the second trifoliate stage of the soybeans was necessary for maximum net returns if the last treatment with bentazon and/or cultivation when soybeans were 70cm tall was not included.

All weed control systems used produced maximum net returns, except for those that did not differ significantly from the untreated control.

The predicted net return with no control of common cocklebur was \$185/ha (Figure 9). Greatest net returns were achieved when cocklebur control was complete. Control of 95% of common cocklebur resulted in a calculated net return of \$416/ha, more than twice that obtained with zero control.

Experiment at Ames Plantation 1976

Yield. Increased soybean yields were obtained with all weed control systems when compared to the untreated control, except for Dyanap applied preëmergence followed by Dyanap or no treatment when the soybean was in the second trifoliate stage, and then no further treatment, or for linuron applied preemergence with no further treatment. Highest soybean yields were produced with practices that were most effective for common cocklebur control (Table 14).

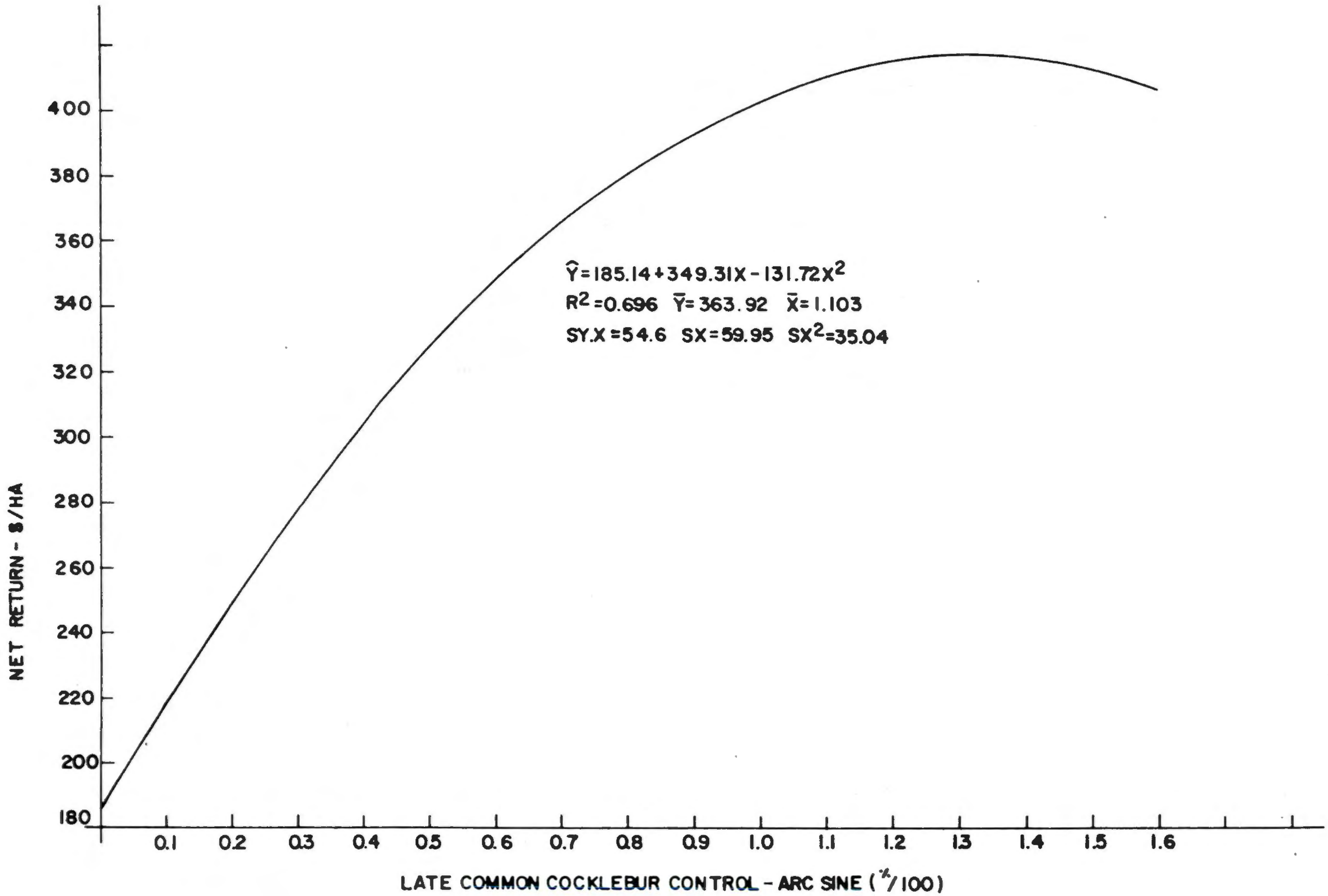

Figure 9. Effects of levels of common cocklebur control on net returns for soybean production under conventional tillage cropping at Ames Plantation TN, 1975.

Table 14. Common cocklebur control, soybean yields, costs and returns for various weed control systems in soybeans grown at Ames Plantation TN, 1976.

Preemergence	Treatments—Time of Application: Cracking Stage	Second Trifoliate	30-50cm Tall	Later in the Season	% Control: Early[a]	Late[b]	Soybean Yield[a] (kg/ha)	Costs $/ha: Weed Control	Production	Returns $/ha[a]: Gross	Net
Dyanap[c]	none	bentazon	bentazon	cultivation	100a	----	3238ab	118.42	253.82	654ab	401bcd
Dyanap	none	bentazon	cultivation	cultivation	97abc	----	2982abc	103.59	238.99	603abc	364bcde
Dyanap	none	bentazon	none	none	76d	----	2213e	82.11	217.51	447e	230gh
Dyanap	none	dinoseb	bentazon	cultivation	99a	----	3006abc	96.45	231.85	608abc	376bcde
Dyanap	none	dinoseb	cultivation	cultivation	77d	----	1762fghij	81.62	217.02	356fghi	139jkl
Dyanap	none	dinoseb	none	none	20ef	----	1448ijk	60.14	195.54	293ijk	97jkl
Dyanap	none	Dyanap	bentazon	cultivation	99ab	----	2876bcd	104.31	239.71	581bcd	242cde
Dyanap	none	Dyanap	cultivation	cultivation	75d	----	1928efg	89.48	224.88	390efg	165hij
Dyanap	none	Dyanap	none	none	22ef	----	1346jkl	68.00	203.40	272jkl	691
Dyanap	none	none	bentazon	cultivation	97abc	----	2693cd	93.26	228.66	544cd	316e
Dyanap	none	none	cultivation	cultivation	73d	----	1839fgh	81.43	216.83	372fgh	155ijk
Dyanap	none	none	none	none	13ef	----	9971	49.21	184.61	2011	-15m
linuron	none	none	bentazon	cultivation	98a	----	2986abc	87.75	223.15	604abc	380bcde
linuron	none	none	cultivation	cultivation	80d	----	2221e	69.91	205.31	449e	244fg
linuron	none	none	none	none	11ef	----	1261kl	37.69	173.09	255kl	82kl
none	Dyanap	none	bentazon	cultivation	100a	----	3283a	99.27	234.67	664a	429ab
none	Dyanap	none	cultivation	cultivation	93bc	----	2685cd	81.43	217.83	543cd	326de
none	Dyanap	none	none	none	35e	----	1517hijk	49.21	184.61	307hijk	122jkl
none	none	none	bentazon	cultivation	70d	----	2046ef	56.79	192.19	414ef	221ghi
Weedy check	------	------	-----------	-----------	0f	----	10371	------	135.40	2101	741
Weed free check	------	------	-----------	-----------	100a	----	3324a	53.70[d]	189.10	672a	483a
metribuzin	none	none	bentazon	cultivation	100a	----	3181ab	91.90	227.30	643ab	416abc
metribuzin	none	none	cultivation	cultivation	92c	----	2563d	74.06	209.46	518d	309ef
metribuzin	none	none	none	33e	----	1643ghij		41.84	177.24	332ghij	155ijk

[a]Means within a column followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test.

[b]All values for percentage late cocklebur control are missing.

[c]Dyanap is a commercial formulation of naptalam + dinoseb.

[d]It does not include costs incurred for hand hoeing needed to control weeds not removed by cultivation.

Bentazon treatment when the soybeans were 30-50cm tall followed by cultivation later in the season was necessary to produce maximum yields regardless of prior herbicide treatment combination applied preemergence at the cracking stage, or postemergence at the second trifoliate stage, except when Dyanap applied preemergence was followed by Dyanap or no treatment at the second trifoliate stage that did not produce maximum yields.

Bentazon plus cultivation as a third treatment was more effective than cultivation alone, except when applied following the treatment where Dyanap was applied preemergence plus bentazon applied at the second trifoliate stage, which also produced maximum yields.

The postemergence treatment at the second trifoliate stage was not necessary for maximum yield when linuron applied preemergence was followed by bentazon applied when the soybeans were 30-50cm tall and followed by cultivation later in the season.

An adjusted yield of 1106 kg/ha was predicted when common cocklebur was not controlled. In contrast, an average yield of 3161 kg/ha was predicted when 100% cocklebur control was obtained (Figure 10).

Estimated soybean yields were increased about 11% for each 10% increase in common cocklebur control.

Costs and returns. The total cost of production ranged from $166/ha without cocklebur control to $228/ha with 100% control, according to the predicted quadratic regression equation developed to estimate the effects of these variables (Figure 11). Based on this equation, an

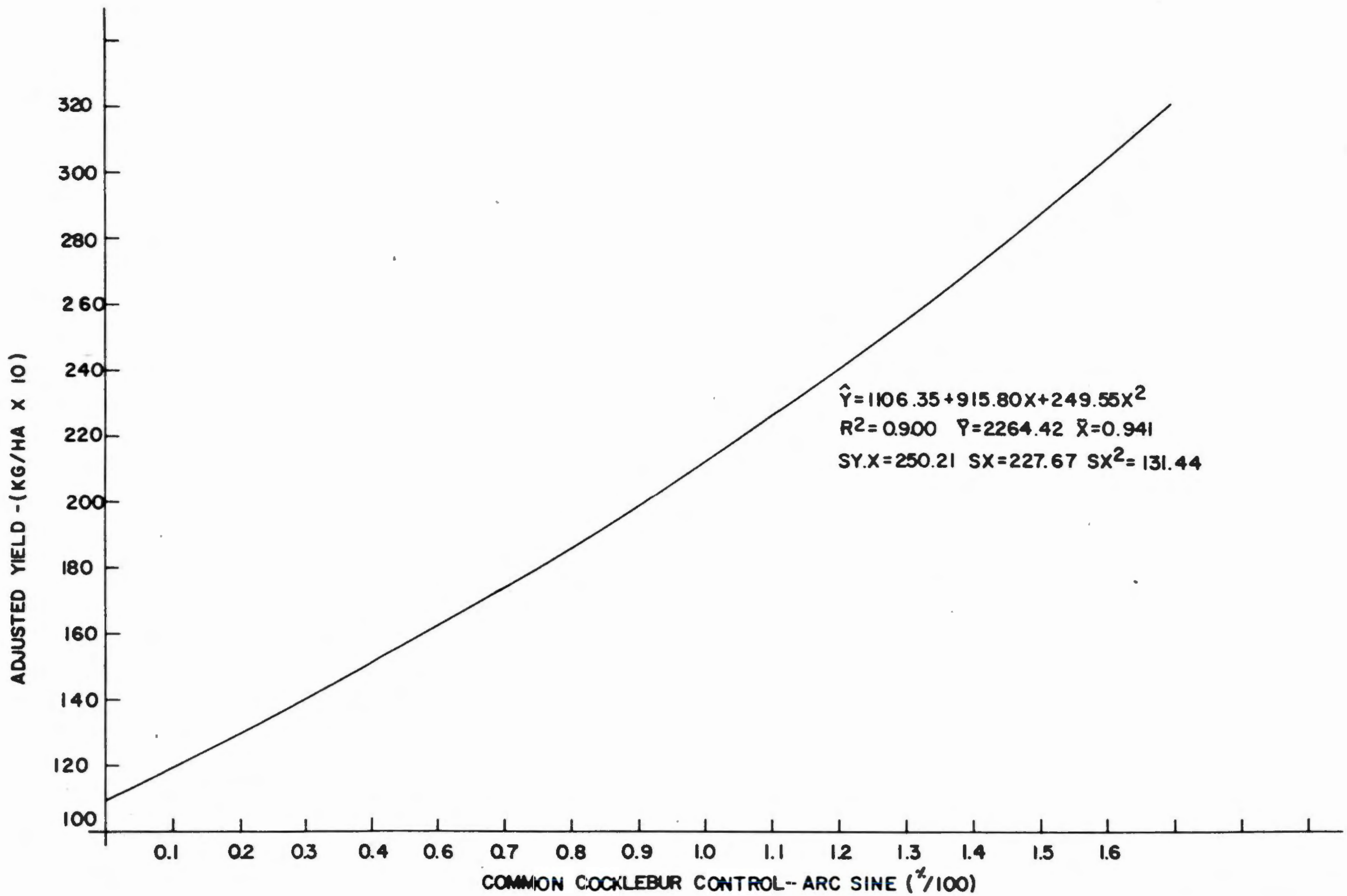

Figure 10. Effects of levels of common cocklebur control on adjusted yields for soybean production under conventional tillage cropping at Ames Plantation TN, 1976.

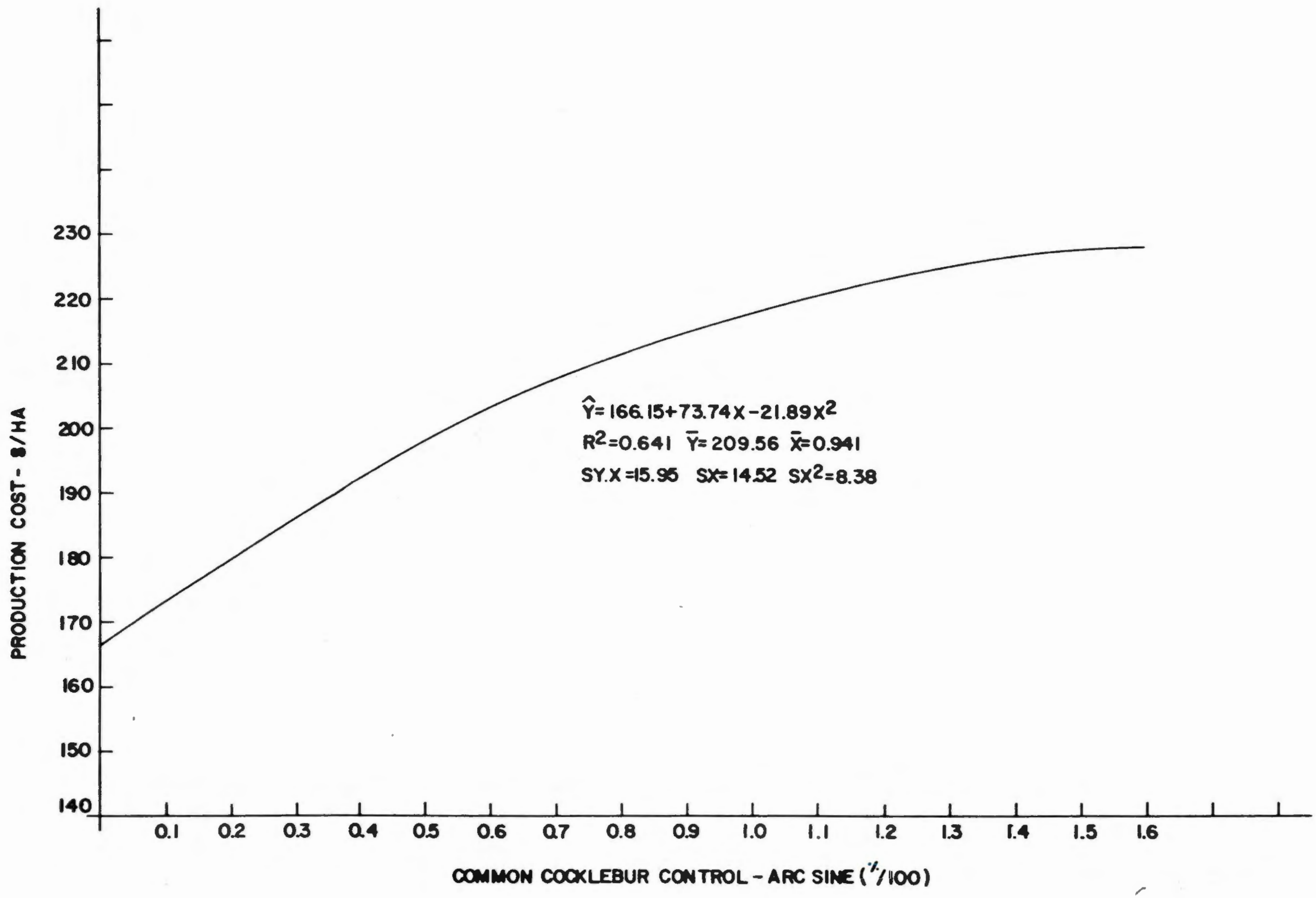

Figure 11. Effects of levels of common cocklebur control on total production costs for soybean production under conventional tillage cropping at Ames Plantation TN, 1976.

additional investment of $20/ha or a yield increase of 100 kg/ha of soybeans was required to increase common cocklebur control from 60 to 95%.

Most of the systems of common cocklebur control increased net returns when compared to the weedy check. The untreated control or weedy check provided a net return of $74/ha. Those cocklebur control systems which did not provide greater returns were: Dyanap or linuron applied as preemergence treatments and Dyanap applied as a cracking stage treatment and not followed by any other control measure, and Dyanap applied as a preemergence treatment followed by dinoseb applied at the second trifoliate stage regardless of whether it was cultivated later in the season.

Greatest net returns were obtained when Dyanap applied at the cracking stage or metribuzin applied preemergence were followed by a postemergence treatment of bentazon applied at the 30-50cm tall stage of the soybeans and then cultivated later in the season.

The addition of bentazon applied when soybeans were 30-50cm tall plus cultivation later in the season increased net returns. Cultivation alone at that phase also increased net returns, except when Dyanap applied preemergence was followed by dinoseb at the second trifoliate stage of the soybeans.

Bentazon plus cultivation carried out at 30-50cm tall stage of the soybeans was more effective than cultivation alone, except when Dyanap applied preemergence was followed by bentazon applied at the second trifoliate stage.

A single application of bentazon when the soybeans were 30-50cm tall followed by cultivation later in the season did not control sufficient cockleburs to produce maximum net returns.

A failure to provide any control of common cocklebur resulted in a net return of $51/ha according to the predicted regression equation developed to estimate the effects of these two variables (Figure 12). Greatest net returns were achieved when common cocklebur control was complete. Control of 95% of cocklebur resulted in a net return of $310/ha, more than 6 times that obtained with zero control.

II. NO-TILLAGE EXPERIMENT

Experiment at Knoxville Plant Science Farm 1978

Yield. None of the herbicide combinations tested significantly increased soybean yields when compared to the weedy check. Greatest yields were obtained with the "conventional tillage check" kept weed-free during the whole season by periodic cultivation and hand hoeing (Table 15).

The main weeds occurring at the experimental area were: *Ipomoea purpurea* (L.) Roth (tall morningglory), *Mollugo verticillata* L. (Carpetweed), *Xanthium pensylvanicum* Wallr. (Common cocklebur), and *Amaranthus hybridus* L. (Smooth pigweed).

The regression equation of the quadratic form developed to estimate the effects of late weed control on adjusted yields predicted an average yield of 509 kg/ha with no weed control compared to 1547 kg/ha with 100% weed control (Figure 13).

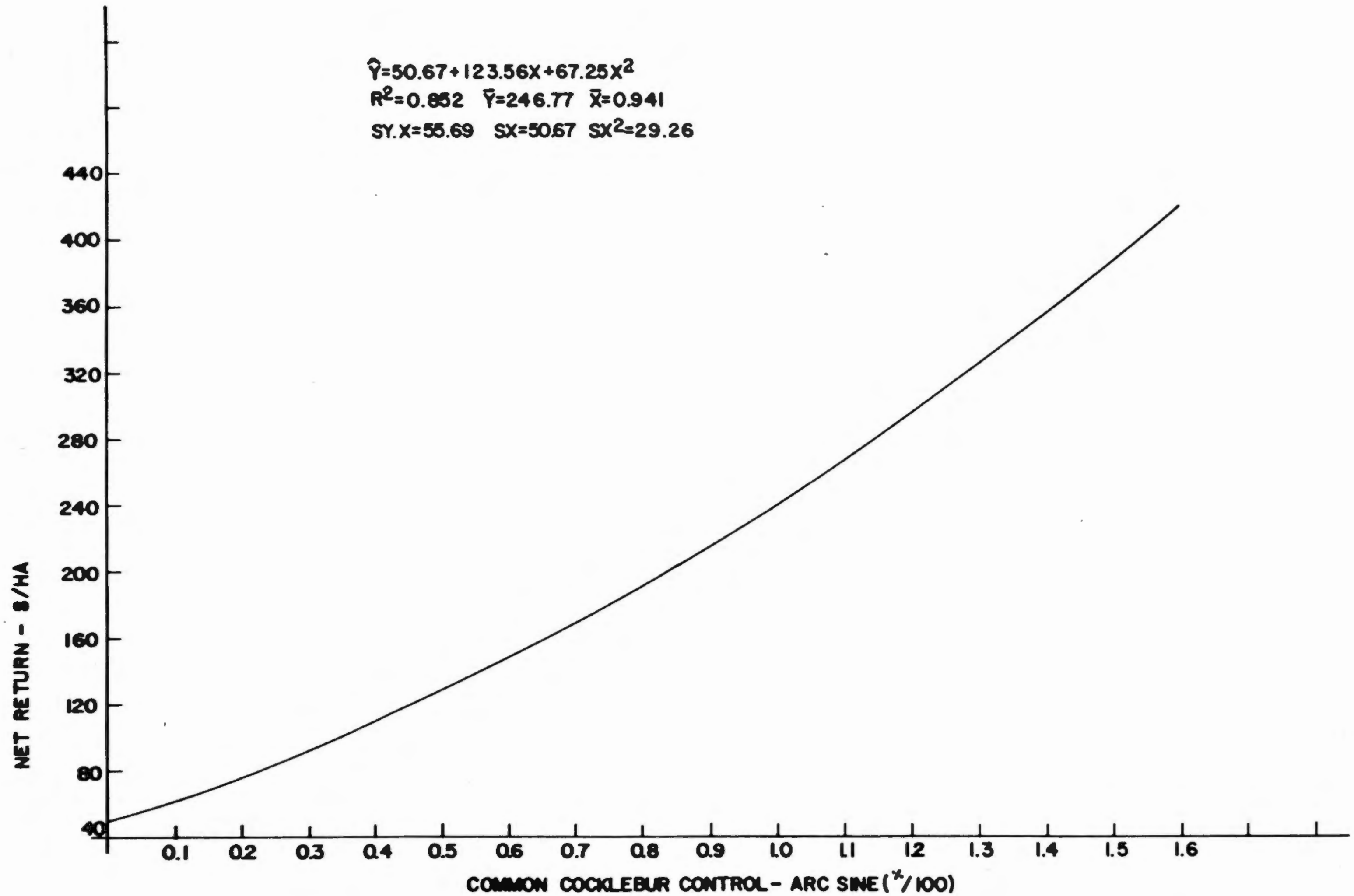

Figure 12. Effects of levels of common cocklebur control on net returns for soybean production under conventional tillage cropping at Ames Plantation TN, 1976.

Table 15. Weed control, soybean yields, costs and returns for various weed control systems in soybeans grown under no-tillage cropping at Knoxville Plant Science Farm TN, 1978.

Treatments	% Control[a]		Soybean Yields[a]	Costs $/ha		Returns $/ha[a]	
	Early	Late		Weed Control	Production	Gross	Net
glyphosate + metribuzin	77bc	54e	305bcd	84.39	206.11	62bc	-145bc
glyphosate + alachlor	53d	29g	287bcd	85.18	206.91	61bc	-149bc
glyphosate + RH-6201	6e	69d	357bcd	83.89	205.62	72bc	-133bc
glyphosate + HOE-29152	8e	16h	469bcd	83.89	205.62	95bc	-111bc
glyphosate + metribuzin + alachlor	76bc	26gh	421bcd	103.78	225.49	85bc	-140bc
glyphosate + metribuzin + RH-6201	80bc	95b	591bcd	102.47	224.20	119bc	-105b
glyphosate + metribuzin + HOE-29152	80bc	53e	399bcd	102.47	224.20	81bc	-144bc
glyphosate + alachlor + RH-6201	55d	92bc	780b	103.26	224.99	158b	-67b
glyphosate + alachlor + HOE-29152	47d	41f	436bcd	103.26	224.99	88bc	-137bc
glyphosate + metribuzin + alachlor + RH-6201	82bc	92bc	604bcd	121.84	243.57	122bc	-121bc
glyphosate + metribuzin + alachlor + HOE-29152	75c	61de	159d	121.84	243.57	32c	-211c
glyphosate + alachlor + RH-6201 + HOE-29152	53d	89c	697bc	121.34	243.07	141b	-102b
glyphosate + metribuzin + RH-6201 + HOE-29152	83b	91bc	649bcd	139.92	261.65	130bc	-132bc
glyphosate + metribuzin + alachlor + RH-6201 + HOE-29152	82bc	90bc	649bcd	139.92	261.65	130bc	-132bc
glyphosate check	8e	26gh	249cd	60.02	181.75	50bc	-131bc
weedy check	0e	0i	255bcd	------	121.73	52bc	-70b
conventional tillage check	100a	100a	1843a	42.96[b]	164.69	372a	208a

[a]Means within a column followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test.

[b]It does not include costs incurred for hand hoeing needed to control weeds not removed by cultivation.

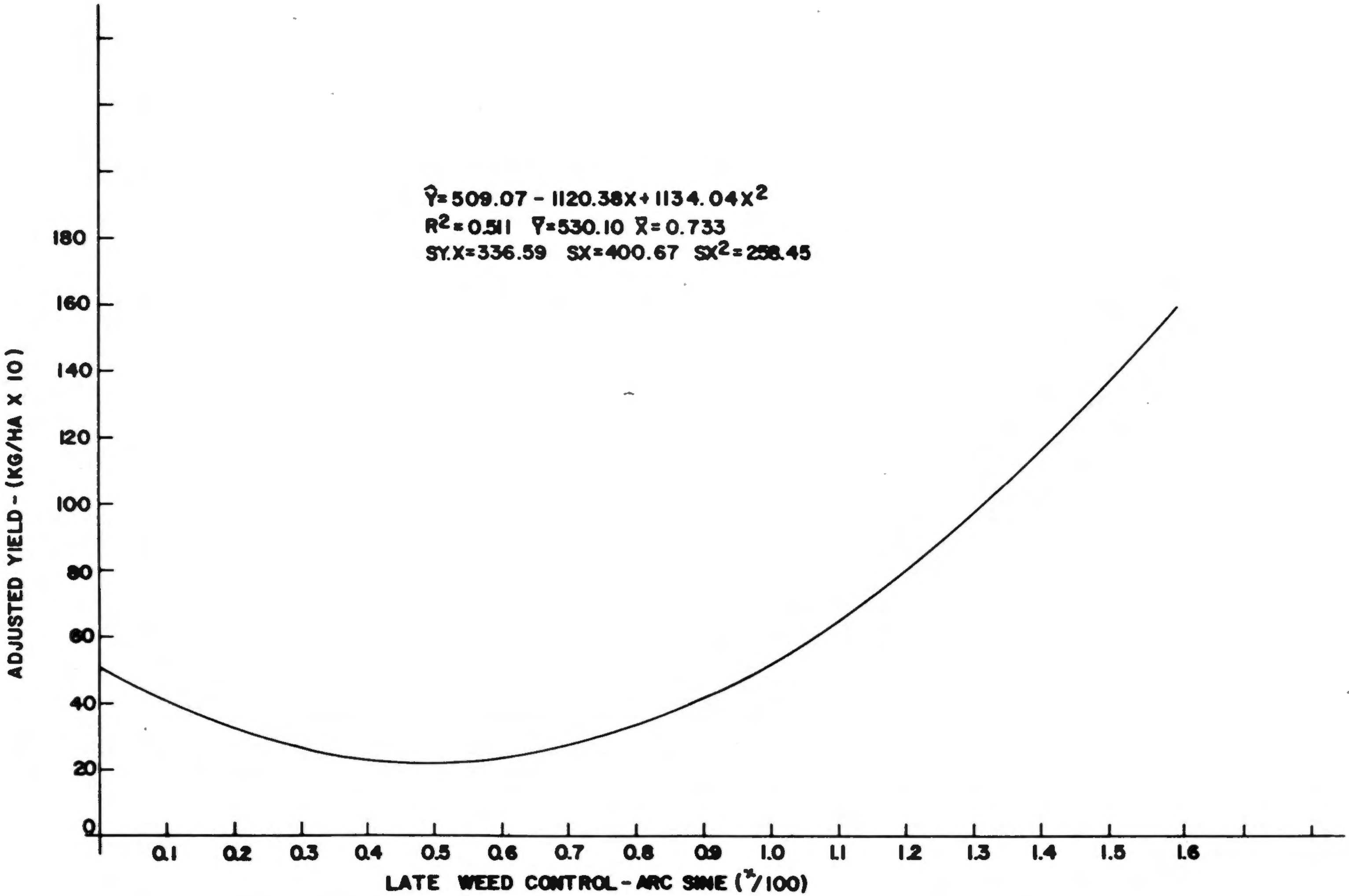

Figure 13. Effects of levels of weed control on adjusted yields for soybean production under no-tillage cropping at Knoxville TN, 1978.

The greatest weed control was provided by all herbicide combinations that included metribuzin plus RH-6201, which provided an average of 90% weed control.

Costs and returns. The total costs of production ranged from $149/ha without weed control to $242/ha with 73% weed control, according to the predicted regression equation developed to estimate the effects of these two variables. Based on these results, an additional $14/ha was required to increase weed control from 50 to 73% (Figure 14). These values are not representative of the control techniques used in general by the farmers but limited strictly to those used in this experiment.

None of the herbicide treatments used provided positive net returns. The conventional tillage check provided a net return of $208/ha (Figure 15).

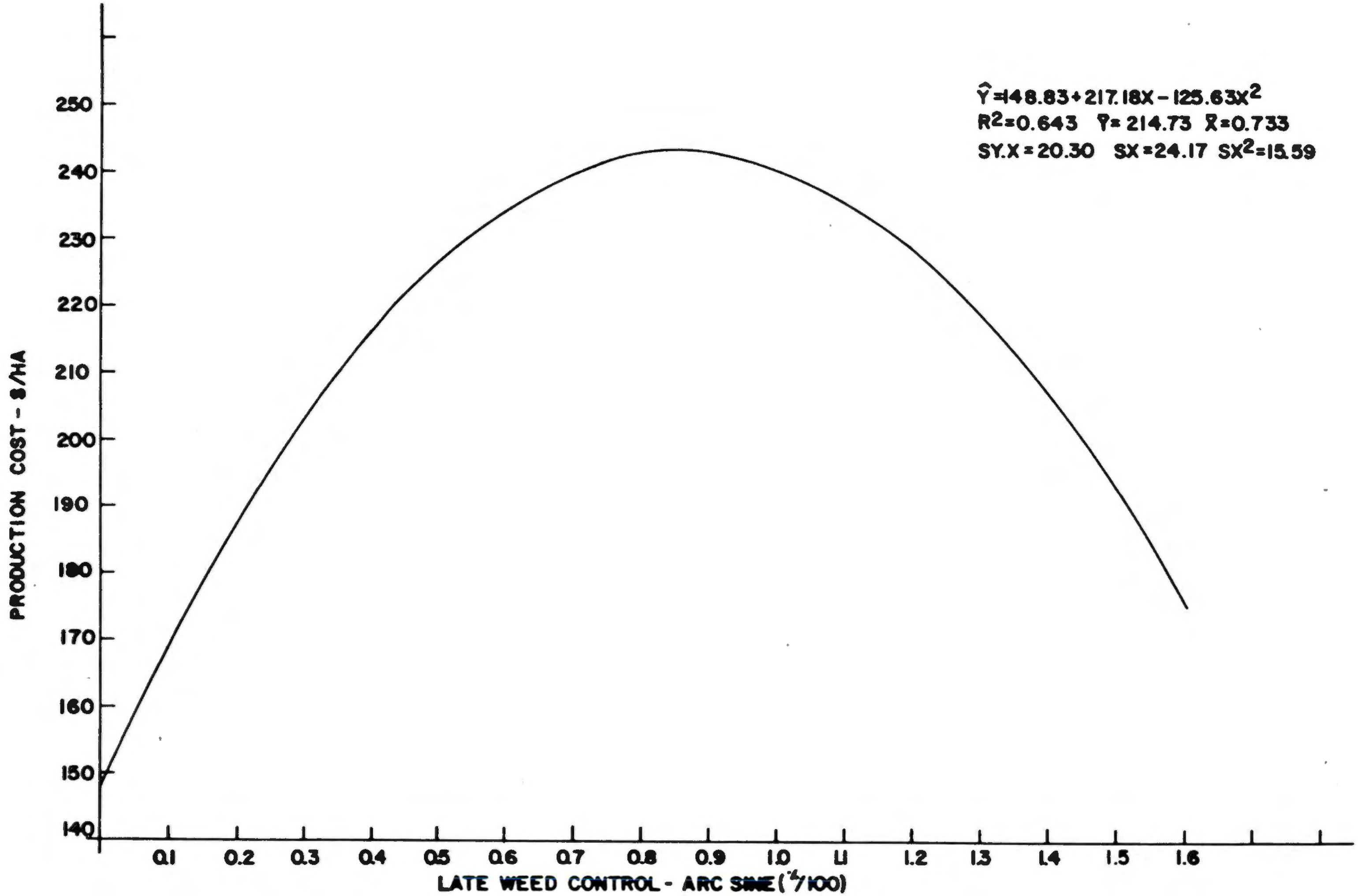

Figure 14. Effects of levels of weed control on total production costs for soybean production under no-tillage cropping at Knoxville TN, 1978.

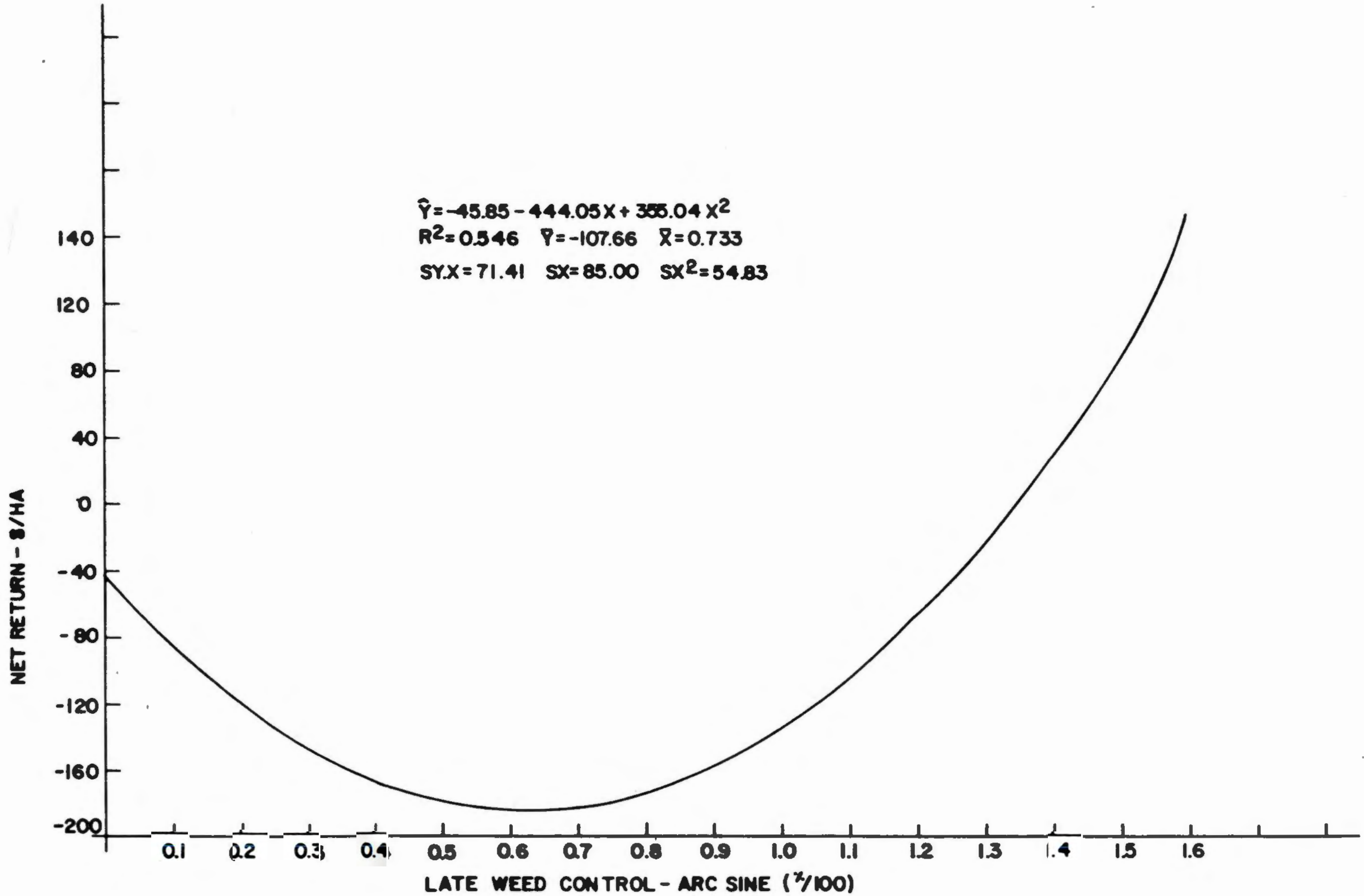

Figure 15. Effects of levels of weed control on net returns for soybean production under no-tillage cropping at Knoxville TN, 1978.

CHAPTER V

DISCUSSION

I. CONVENTIONAL TILLAGE EXPERIMENTS

In general greatest soybean yields were produced with practices that were more effective for common cocklebur control.

Increased soybean yields when compared to the untreated control or weedy check were produced with the weed control systems presented in Table 16.

The only common cocklebur control system that did not increase soybean yields when compared to the untreated control was Dyanap applied preemergence with no further treatment.

Maximum yields were produced with the weed control practices presented in Table 17.

Bentazon gave poor control of common cocklebur in some experiments when soybeans were 30-70cm tall at the time of application. This may be attributed to the advanced stages of the weeds at the time of application that was usually the same size of the soybeans. It was noticed that at the more advanced stages of the cocklebur growth the less efficient was their control, and consequently lower soybean yield increase occurred. Bentazon was particularly ineffective when applied at the 70cm tall stage of the soybeans.

This study demonstrates how important it is to use proven technology for controlling common cocklebur in soybeans when control

Table 16. Treatments that produced increased soybean yields when compared with the untreated control—conventional tillage experiments—TN 1975-76.

		Treatments—Time of Application—Rate						
Preemergence	kg/ha	Cracking Stage	kg/ha	Second Trifoliate	kg/ha	30-70cm Tall	kg/ha	Later in the Season
Dyanap[a]	5.0	none	-----	bentazon	0.8	bentazon	0.8	cultivation
Dyanap	5.0	none	-----	bentazon	0.8	cultivation	-----	cultivation
Dyanap	5.0	none	-----	bentazon	0.8	none	-----	none
Dyanap	5.0	none	-----	dinoseb	0.8	bentazon	0.8	cultivation
Dyanap	5.0	none	-----	dinoseb	0.8	cultivation	-----	cultivation
Dyanap	5.0	none	-----	dinoseb	0.8	none	-----	none
Dyanap	5.0	none	-----	Dyanap	2.5	bentazon	0.8	cultivation
Dyanap	5.0	none	-----	Dyanap	2.5	cultivation	-----	cultivation
Dyanap	5.0	none	-----	none	-----	bentazon	0.8	cultivation
Dyanap	5.0	none	-----	none	-----	cultivation	-----	cultivation
linuron	0.8	none	-----	none	-----	bentazon	0.8	cultivation
linuron	0.8	none	-----	none	-----	cultivation	-----	cultivation
none	-----	Dyanap	4.2	none	-----	bentazon	0.8	cultivation
none	-----	Dyanap	4.2	none	-----	cultivation	-----	cultivation
none	-----	none	-----	none	-----	bentazon	0.8	cultivation
weedy free check	-----	------	-----	--------	-----	-----------	-----	-----------
metribuzin	0.6	none	-----	none	-----	bentazon	0.8	cultivation
metribuzin	0.6	none	-----	none	-----	cultivation	-----	cultivation
metribuzin	0.6	none	-----	none	-----	none	-----	none

[a]Dyanap is a commercial formulation of naptalam + dinoseb.

Table 17. Treatments that produced maximum yields—conventional tillage experiments—TN 1975-76.

	Treatments—Time of Application—Rate							
Preemergence	kg/ha	Cracking Stage	kg/ha	Second Trifoliate	kg/ha	30-70cm Tall	kg/ha	Later in the Season
Dyanap[a]	5.0	none	-----	bentazon	0.8	bentazon	0.8	cultivation
Dyanap	5.0	none	-----	bentazon	0.8	cultivation	-----	cultivation
Dyanap	5.0	none	-----	dinoseb	0.8	bentazon	0.8	cultivation
linuron	0.8	none	-----	none	-----	bentazon	0.8	cultivation
none	-----	Dyanap	4.2	none	-----	bentazon	0.8	cultivation
weed free check	-----	------	-----	--------	-----	-----------	-----	-----------
metribuzin	0.6	none	-----	none	-----	bentazon	0.8	cultivation

[a]Dyanap is a commercial formulation of naptalam + dinoseb.

measures are timely. A modest investment of $57/ha to control common cocklebur will significantly increase net returns. Higher investments may be necessary for higher returns.

Gross returns from a given land area are directly related to adjusted yield and price of soybeans. Because a fixed price of $0.20/kg (price of U.S. No. 1 grade soybeans) was assumed for the yield from each treatment, gross returns were response in a fashion similar to adjusted yields.

Net returns were increased when compared with the untreated control for the following treatments presented in Table 18.

The only common cocklebur control system that did not increase net returns when compared to the untreated control was when Dyanap was applied at either the cracking stage followed by no further treatment, or was applied preemergence followed by no further treatment.

Maximum net returns were obtained by Dyanap applied at the cracking stage followed by bentazon applied when the soybeans were 30-70cm tall followed by cultivation later in the season. Maximum net returns were also obtained when metribuzin was applied preemergence followed by bentazon at the 30-70cm tall stage of the soybeans followed by cultivation later in the season.

The highest investment in soybean production, other than cost of land, is the fixed and variable costs with machinery, labor, and seed. The costs of weed control represent 30 to 80% of this amount, yet these investments may result in more than 1000% increase in net returns or profits. It follows an almost geometric pattern.

Table 18. Treatments that provided increased net returns when compared to the untreated control—conventional tillage experiments—TN 1975-76.

		Treatments—Time of Application—Rate						
Preemergence	kg/ha	Cracking Stage	kg/ha	Second Trifoliate	kg/ha	30-70cm Tall	kg/ha	Later in the Season
Dyanap[a]	5.0	none	-----	bentazon	0.8	bentazon	0.8	cultivation
Dyanap	5.0	none	-----	bentazon	0.8	cultivation	-----	cultivation
Dyanap	5.0	none	-----	bentazon	0.8	none	-----	none
Dyanap	5.0	none	-----	dinoseb	0.8	bentazon	-----	cultivation
Dyanap	5.0	none	-----	Dyanap	2.5	bentazon	0.8	cultivation
Dyanap	5.0	none	-----	Dyanap	2.5	cultivation	-----	cultivation
Dyanap	5.0	none	-----	none	-----	bentazon	0.8	cultivation
Dyanap	5.0	none	-----	none	-----	cultivation	-----	cultivation
linuron	0.8	none	-----	none	-----	bentazon	-----	cultivation
linuron	0.8	none	-----	none	-----	cultivation	-----	cultivation
none	-----	Dyanap	4.2	none	-----	bentazon	0.8	cultivation
none	-----	Dyanap	4.2	none	-----	cultivation	-----	cultivation
none	-----	none	-----	none	-----	bentazon	0.8	cultivation
weed free check	-----	------	-----	--------	-----	-----------	-----	-----------
metribuzin	0.6	none	-----	none	-----	bentazon	0.8	cultivation
metribuzin	0.6	none	-----	none	-----	cultivation	-----	cultivation
metribuzin	0.6	none	-----	none	-----	none	-----	none

[a]Dyanap is a commercial formulation of naptalam + dinoseb.

The small differences in behavior of some of the common cocklebur control methods among years, and locations that brought about significant interactions may be accounted for mainly by either differences in the distribution of precipitation between those locations and along those years, or by differences in stage of common cocklebur growth at time of herbicide application. Other metereological factors did not change very much. Figure 16 shows the precipitation distribution during the first 50 days after planting for each location in each year.

II. NO-TILLAGE EXPERIMENT

None of the herbicide combinations tested significantly increased soybean yields when compared to the untreated control or weedy check, or provided positive net returns from the soybean production. The main reason was due to the low yields obtained. The high coefficient of variation found for this variable was due to extensive and irregular damage caused to the soybean stand by rabbits during the early phase of the soybean growth.

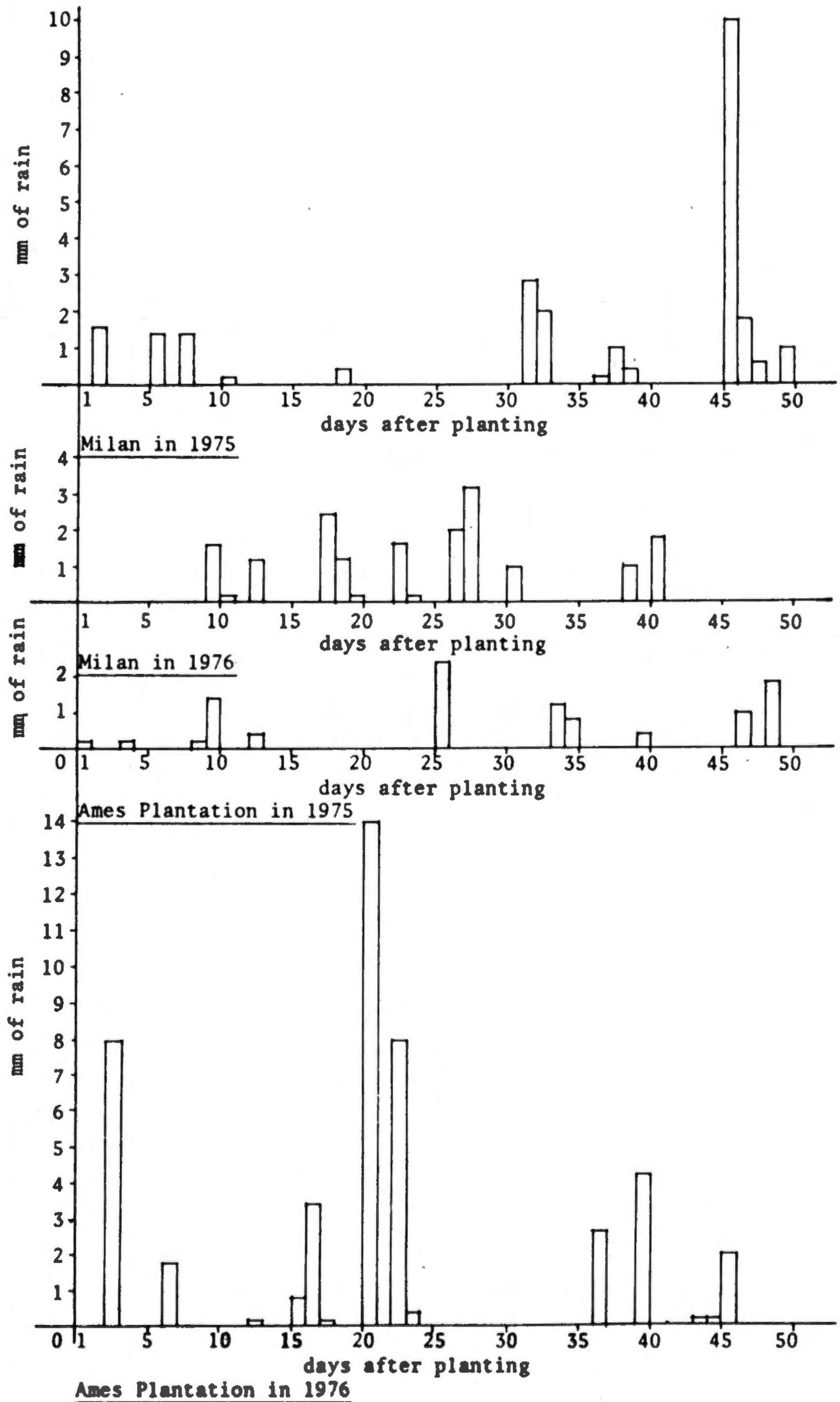

Figure 16. Precipitation distribution during the 50 days after planting of soybeans at Ames Plantation and Milan in 1975 and 1976.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Research was carried on to:

1. Determine the efficiency of various weed control systems for control of common cocklebur in conventional tillage farming;
2. Determine the effects of various levels of control of common cocklebur on soybean yields, costs, and returns from soybean production under conventional tillage cropping;
3. Determine the individual and combined effects of various components (herbicides) of a total weed control system on weeds and soybean yields in a small grain-soybean double cropping program under no-tillage cropping;
4. Determine the effects of various levels of weed control on soybean yields, production costs, and returns from soybean production under no-tillage cropping.

Field experiments were conducted at two locations in 1975, and 1976, and at one location in 1978. Data on percent of early and late common cocklebur control, and soybean seed yields grown under conventional tillage at Milan Field Station and at Ames Plantation were collected in 1975 and 1976. At the Knoxville Plant Science Farm data on early and late weed control (by species) and soybean seed yields grown under no-tillage conditions were collected in 1978.

Weed control systems were composed of sequential treatments applied at either the preemergence or cracking stage, at the second trifoliate stage of soybean growth, at the 30 to 70cm stage of soybean growth and subsequently cultivated or some combination of these times of control.

Analysis of data from the conventional tillage experiments at Milan and Ames Plantation showed that all weed control systems increased soybean yields when compared to the untreated control, except where Dyanap (naptalan + dinoseb) was applied preemergence and followed by no further treatment. Greatest soybean yields were produced with practices that gave the most effective common cocklebur control.

In most cases the third treatment of either bentazon plus cultivation or cultivation alone when the soybean plants were 30-70cm tall, followed by cultivation later in the season, was needed to obtain maximum yields.

The postemergence treatment when the soybeans were in the second trifoliate stage was not necessary if a preemergence application of linuron was followed by a postemergence treatment with bentazon when the soybeans were 30-70cm tall followed by cultivation later in the season.

A single postemergence application of bentazon when the soybeans were 30-70cm tall followed by cultivation later in the season was enough to provide maximum yields each year, except at Ames Plantation in 1976.

The regression equation of the quadratic form developed to estimate the effect of late common cocklebur control and adjusted yield predicted average yields ranging from 509 to 1748 kg/ha with no cocklebur control to 2528-3161 kg/ha with 100% control.

When the quadratic regression equations used to estimate the effects of common cocklebur control and production costs, the predicted total cost of production ranged from $142 to $167/ha with zero percent of cocklebur control to $207-$228/ha with 100% control. Based on this assumption, an additional investment of $18 to $24/ha was required to increase common cocklebur control from 60 to 95%. This increase represents a 90 to 120 kg/ha increase in soybean production.

All common cocklebur control measures increased net returns, except when Dyanap was applied preemergence or at the cracking stage followed by no sequential treatment.

The postemergence treatment with bentazon when the soybeans were 30-70cm tall followed by cultivation later in the season contributed for maximum net returns only when Dyanap was applied at the cracking stage.

Maximum net returns were obtained in all experiments by Dyanap applied at the cracking stage and metribuzin applied preemergence, both followed by bentazon applied when the soybeans were 30-70cm followed by cultivation later in the season.

A single application of bentazon when the soybeans were 30-70cm tall followed by cultivation later in the season with no prior treatments was enough to produce maximum net returns in each case, except at Ames Plantation in 1976.

Failure to provide any control of common cocklebur resulted in net returns ranging from $-21 to $+185/ha according to the predicted regression equations of the quadratic form developed to estimate the effects of cocklebur control and net returns. Control of 95% of common cocklebur resulted in a net return ranging from \$310 to \$416/ha.

According to these results we concluded that the best weed control systems for conventional tillage soybeans are: Dyanap applied at the cracking stage or metribuzin applied preemergence, both followed by bentazon applied when the soybeans were 30-70cm tall followed by cultivation later in the season.

Analysis of data from the no-tillage experiment showed that none of the herbicide combinations tested significantly increased the soybean yields as compared to the untreated control. Greatest yields were obtained with the conventional tillage check kept weed free during the season by periodic cultivation and hand hoeing.

A predicted adjusted yield of 509 kg/ha with no weed control and 1547 kg/ha with 100% control were calculated by the predicted regression equation of the quadratic form developed to estimate the effect of levels of weed control and adjusted yields.

Maximum weed control was provided by all herbicide combinations that included metribuzin + RH-6201, which provided an average of 90% weed control.

Costs of production ranged from \$149/ha without weed control to \$242/ha with 73% control. Additional investments of \$14/ha was required to increase weed control from 50 to 73%.

None of the weed control measures provided positive net returns.

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LITERATURE CITED

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VITA

Harri Jose Lorenzi was born in Corupa County, Santa Catarina, Brazil, on October 19, 1949. He was reared on a farm in that county. He attended a rural elementary school in his county and graduated from high school in the city of Florianopolis—Santa Catarina in 1969.

In February of 1970 he entered the Federal University of Parana at Curitiba—Parana to study agronomic engineering. He graduated from the Federal University of Parana in December of 1973. Upon graduation, he accepted a position working on agricultural extension service for a private company—Nestle in the state of Sao Paulo. He worked one year when he received an invitation to work for the state agricultural research institute—Instituto Agronomico do Parana (IAPAR) in the city of Londrina—Parana. He has conducted weed control field research for 2.5 years. Also he has written a book on weed identification for the state of Parana entitled "Principais Ervas Daninhas do Estado do Parana." In 1977, while working for IAPAR, he received a scholarship to pursue study toward a Master of Science degree in the United States. He entered the Plant and Soil Science Department of the University of Tennessee in September 1977. He received the Master of Science degree with specialization in weed science in August of 1979.

He is married to Vera Samartin and they have one daughter, Gabriela.