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Dr. SB Vekariya
Associate Research Scientist, Department of Agricultural Economics, Junagadh Agricultural University, Junagadh, Gujarat, India

VL Gondaliya
Assistant Research Scientist, Department of Agricultural Economics, Junagadh Agricultural University, Junagadh, Gujarat, India

Shri Haresh Chavda
Agricultural Officer in the Department of Agricultural Economics, Junagadh Agricultural University, Junagadh, Gujarat, India

Correspondence
Dr. SB Vekariya
Associate Research Scientist, Department of Agricultural Economics, Junagadh Agricultural University, Junagadh, Gujarat, India

An economic analysis of herbicide used on groundnut crop in Saurashtra region of Gujarat state

Dr. SB Vekariya, VL Gondaliya and Shri Haresh Chavda

Abstract
Herbicide/s, also commonly known as weed killers, are chemical substances used to control unwanted plants. There are two types of herbicides, viz, selective herbicides which control specific weed species, while non-selective herbicides kill all plant materials with which they come into contact.
Groundnut (*Arachis hypogaea* L.) crop is highly susceptible to weed infestation in the initial stages upto 40 days. Groundnut productivity in India is low due to serious problems of weeds. Groundnut yield losses due to weeds have been estimated as high as 24 to 70 percent. This study is an attempt to ascertain the adoption of herbicide recommendations by the farmers, to estimate the impact of herbicidal weed management on the yield and net return of groundnut and to identify the constraints faced by the farmers in adoption of herbicides.
The Rajkot and Junagadh being the major districts in groundnut cultivation in Gujarat were selected purposively for the study. Two talukas from each district, two villages from each taluka and ten herbicide users (adopter) and ten non herbicide users (non-adopter) farmers were selected randomly. Thus constituting a total sample size of 160 respondents in the year 2017. Tabular analysis and Cobb-Douglas production function was finally selected using statistical criteria and economic criteria.
The research shows that total cost incurred by the adopter group was lower than the non-adopter because of relatively optimum utilization of input resources. More than 50 per cent of the farmers were using "Targa Super" herbicide. Farmers in study area were using lower quantity of herbicide than recommended by the university and respected company. Farmers were believed that higher the dose of herbicide would inversely affect the crop production. Adopter group of farmers' reaped higher yield as well as low production unit cost than the non-adopter group. Majority of farmers in adopter group faced constraint ***was*** crop foliage abrasion in using of herbicides.

Keywords: Groundnut, weed management, herbicide, constraints

Introduction
Herbicide/s, also commonly known as weed killers, are chemical substances used to control unwanted plants. There are two types of herbicides, viz, selective herbicides which control specific weed species, leaving the desired crop relatively unharmed, while non-selective herbicides (sometimes called "total weed killers" in commercial products) can be used to clear waste ground, industrial and construction sites, railways and railway embankments as they kill all plant materials with which they come into contact.
There are various application methods for treating weeds with herbicides. It's important to choose the right method for particular weed problem and the types of chemicals. In foliar spraying, the herbicide is diluted with water at a specific rate, and sprayed over the foliage until every leaf is wetted. While in basal barking foliar spray, oil-soluble herbicides are mixed in diesel and spray on the trunk or stem of the weed. On large areas, herbicides may be applied aerially using helicopters or airplanes, or through irrigation systems. In this way herbicides were found to be selective in controlling many weeds in mono cropping as well as in cropping systems.
In 2007, world pesticide expenditures totaled about $39.4 billion; herbicides were about 40% of those sales and constituted the biggest portion, followed by insecticides, fungicides, and other types. Smaller quantities are used in forestry, pasture systems, and management of areas set aside as wildlife herbitat.
In many advanced countries, the average annual consumption of herbicides is 675 to 1350 gm / ha. In Japan, it is as high as 5000 gm / ha. Against these high figures, in India, at present, the average annual herbicide use is hardly 40 gm / ha. This is largely because of poor purchasing power of most of our farmers and also due to lack of technical knowledge about use of herbicides. The cost of certain herbicides is also very high as the basic ingredients for manufacturing herbicides are imported from the developed countries.

The present annual installed capacity of herbicide production in India is about 6000 tonnes. About ¾ of the available herbicides in India are used in plantation crops.

Groundnut crop is highly susceptible to weed infestation because of its slow growth in the initial stages upto 40 days, short plant height and underground pod bearing habit. Groundnut- initial stages upto 40 days, short plant height and underground pod bearing habit. Groundnut weeds comprise diverse plant species from grasses to broad-leaf weeds and sedges, and cause substantial yield losses (15-75%). Besides this, weeds are preferred host of several insect-pests, and the vectors of many important vectors of many important organisms causing diseases in groundnut. (Jat *et al* 2011) [2].

Groundnut (*Arachis hypogaea* L.) productivity in India is low, because of many problems beset in its cultivation. One of the serious problems is weeds. Groundnut yield losses due to weeds have been estimated as high as 24 to 70 percent. This has created a scope for using herbicides in groundnut crop.

Due to intensive agriculture and development of technology in the field of agriculture, there is vast scope for controlling weeds by using herbicides, At present, due to expanding industrial areas, the villages workers are attracted towards the industries for seeking the employment and created shortage of labourers for cultivation of land. At present, there is lot of scope for use of herbicide due to shortage of labourers and increases in wages of farm labourers.

New generation is diverting towards industrial areas and due to shortage of labourers and also increases in wages of agricultural labours, there will be vast scope for control of weeds by using herbicides. Certain herbicides have also proved very effective for control of noxious perennial weeds in combination with mechanical methods.

Objectives

- To ascertain (find out) the adoption of herbicide recommendations by the farmers
- To estimate the impact of herbicidal weed management on the yield and net return of groundnut
- To identify the constraints faced by the farmers in adoption of herbicides

Research Methodology

The Rajkot and Junagadh being the major districts in groundnut cultivation in Gujarat were selected purposively for the study. Further, two talukas namely Junagadh and Keshod from Junagadh district while Upaleta and Jetpur from Rajkot district were randomly selected for the study. Two villages were selected randomly from each of the selected taluka. Ten herbicide users (adopter) and ten non herbicide users (non-adopter) farmers were selected from each village, thus constituting a total sample size of 160 respondents in the year 2017.

Collection of Data:

The primary data were collected by visiting each of the selected farmers personally and interviewing them with a set of structured questionnaire. The information collected pertains to the year 2017-18.

Computation Procedure for Input Costs

The value of purchased input was taken into account as reported by the cultivators with due verification. Some of the inputs used in the production process come from family sources. The procedure adopted for deriving imputed value of these inputs is as under:

1. The value of family labour was worked out at the wage rate prevailing for different agricultural operations in the selected villages.
2. The cost of bullock labour utilized in cultivation of the crop was reckoned as per the prevailing market rate in the villages.
3. The value of farm produced manure and seeds were computed as the rates prevailing in the concerned villages.
4. The costs of irrigation, tractor and owned machinery charges, (*viz*; thrasher/opener, *etc*.) were considered at the market rate custom service.
5. The kind payments are evaluated at prices prevalent in the village at the time of those operations done.
6. Interest on working capital was charged at the rate of 12 per cent per annum, according to duration of the crops.
7. Interest on owned fixed capital was charged at the rate of 10 per cent per annum.
8. Depreciation of owned farm buildings was calculated at the rate of five per cent for kuchcha and two per cent for pucca buildings per annum.
9. Rental value of farmers' owned land was charged at the rate of 16 per cent of gross income as the case may be.
10. Management charges were calculated at the rate of 10 per cent of total cost (Cost C_1).

Apportionment of Joint Costs

The apportionment of total cost of cultivation between the main product and the by-product was done in proportion to their contribution to the total value of output, when the value of by-product is greater than or equal to 10 per cent. But when the value of by-product is less than 10 per cent, it is deducted from the total cost.

Cost Concepts

Cost A: The cost concepts and the items of costs included under each concept are given below:

i	Value of hired human labour.
ii	Value of hired bullock labour.
iii	Value of owned bullock labour.
iv	Value of use of owned machinery.
v	Hired machinery charges.
vi	Value of seed (both farm produced and purchased).
vii	Value of manure (owned farm and purchased).
viii	Value of fertilizer.
ix	Value of insecticides and pesticides.
x	Irrigation charges.
xi	Depreciation on farm buildings and implements.
xii	Interest on working capital.
xiii	Other paid out expenses, if any.
Cost B :	Cost A plus rental value of owned land and interest on value of owned fixed capital assets (excluding land revenue).
Cost C_1:	Cost B plus imputed value of family labour.
Cost C_2:	Cost C_1 plus 10 per cent of cost C_1 as a managerial charge.

The expenses incurred towards land revenue, transport charges, charges paid for hiring thrasher/opener, tractor charges, charges to contract work, etc., were included under the head of miscellaneous cost.

Data analysis

Tabular analysis was used extensively for data analysis. The cost of cultivation and returns were estimated using cost concepts *viz*: Cost A, Cost B, Cost C_1 and Cost C_2.

In order to determine the relationship between the adoption of technology i.e herbicide, multiple linear regression model and Cobb-Douglas production functions were tried with the expenditure on inputs and yield as a dependent variable. Cobb-Douglas production function was finally selected using statistical criteria and economic criteria. The functional form is given below:

$Y = aX_i^{bi}$

Where
Y = Yield (Rs./farm),
a = Intercept,
X_1 = Area under groundnut cultivation(ha)
X_2 = Human labour (Rs./farm),
X_3 = Bullock labour (Rs./farm),
X_4 = Seeds (Rs./farm),
X_5 = Manure (Rs./farm),
X_6 = Chemical fertilizers (Rs./farm),
X_7 = Irrigation (Rs./farm),
X_8 = Insecticides (Rs./farm),
X_9 = Other paid out costs (Rs./farm).
i = 1 to 9

Results and Discussion

The details of herbicide dosage recommended by the Junagadh Agricultural University and respected manufacturing company are presented in Table 1. It is apparent from the tables that most of the farmers were using "Targa Super" i.e. more than 50 per cent in the study area. Table also shoes that the farmers under study area were using low rate of the dose of herbicides as recommended by both, the Junagadh Agricultural University and respected manufacturing company. Generally farmers were believed that higher the dose of herbicide would inversely affected the on yield production.

Table 1: Herbicide dosage recommended and farmer's use (ml/hectare)

Name of Herbicide	Recommended dose by		Farmer's use
	Junagadh Agricultural University	Respected Company	
Targa Super	800	750-1000	757(44)
Pursuit	750	1000-1500	772(3)
Patela	1000	1000	716(21)
Shaked	1000	1000	794(5)
Agil	700	750-1000	680(2)
Iris	1000	1000	795(5)

* Figures in parentheses are indicate the numbers of farmers

The details of cost of cultivation and yield of groundnut crop for both adopter and non-adopter groups of groundnut production are presented in Table 2 and 3, respectively. It is apparent from both the tables that the average total costs (Cost C_2) for adopter and non-adopter groups were Rs. 66113 and Rs. 69176 per hectare, respectively. The operating cost (Cost A) was observed to be 62.82 per cent (Rs. 41533/ha) of the total cost for adopter group of farmers which was lower than the non-adopter group of farmers. i.e. Rs. 43979/ha. The cost incurred on human labour was highest in both the group of farmers among all the items of expenditure. The average yields of groundnut per hectare for adopter and non-adopter groups were 23.12 and 21.80 quintals, respectively. It can be observed from the tables that the average gross returns were higher (Rs. 115681/- per hectare) in adopter group as compared to non-adopter group of farmers (Rs. 107484). It is also apparent from the tables that the average per hectare net returns over Cost C_2 were Rs. 49568/- from the adopter group of farmers which was higher than the non-adopter group (Rs. 38308/-). The results showed that the average cost per quintal of production (Cost C_2) was lower in the adopter group (Rs.2469/-) than the non-adopter group (Rs. 2768/-). On the basis of quality point of view, adopter group of farmers reaped higher per quintal average farm harvest price (Rs. 4320.32) compared to non-adopter group (Rs. 4300.45), indicating that the cultivation of groundnut was found highly remunerative to the farmers of adopter as well as non-adopter groups. The input-output ratio over Cost C_2 was worked out to be 1:1.74 and 1:1.55 for adopter and non-adopter groups, respectively, which indicates that farmers obtained Rs. 1.74 and Rs. 1.55 from the one rupee investment in groundnut cultivation, respectively.

Different types of algebraic forms *viz*., linear and non-linear were tried for regression analysis. Cobb-Douglas production function was turned out to be a good fit. The results of regression analysis of inputs used and output per farm in adopter and non-adopter groups of groundnut production technology are presented in Table 4.

It is apparent from the table that more than 82 and 76 per cent of the variation on adopter and non-adopter groups of groundnut production, respectively, were explained by the variables included in the model as indicated by the values of the adjusted coefficient of multiple determination (R^2). Significant and positive value of regression coefficient of human labour, manure and insecticides were observed in adopter group whereas, irrigation in both the group adopter and non-adopter have the significant with negative effect. In pooled analysis, the regression coefficients of area as well as human labour were observed significant and positive impact of groundnut production technology. Non-significance of variable indicates optimum use of inputs for both the groups of farmers.

Table 2: Details of cost of cultivation of groundnut crop per hectare in study area (adopter)

Sr. No.	Items	Physical unit	Value (Rs.)	% to Cost C_2
1	Human labour:			
	A: Family (man days)	19.97	5424	8.21
	B: Hired (man days)	42.62	11491	17.38
2	Bullock labour (pair days)	5.92	1991	3.01
3	Seeds (kgs)	154.40	10752	16.26
4	Manures (kgs)	1083.18	1030	1.56
5	Chemical fertilizers (kgs) N	20.73	2037	3.08
	P	37.59		
	K	2.42		
6	Herbicide		1093	1.65
7	Irrigation		708	1.07
8	Insecticides/pesticides		2776	4.20
9	Miscellaneous costs		7767	11.75
10	Depreciation cost		291	0.44
11	Interest on working capital		1597	2.42
12	Rental value of owned land		12321	18.64
13	Interest on owned fixed capital		822	1.24
14	Management cost		6013	9.09
15	Cost A		41533	62.82
16	Cost B		54676	82.70
17	Cost C_1		60100	90.91
18	Cost C_2		66113	100.00
	Yield: A: Main product (qn/ha)	23.12		
19	B: By-product (qn/ha)	29.17		
	A: Farm harvest price of main product (Rs./qn)		4320.32	
20	B: Income from by-product (Rs./ha)		15795	
21	Gross income: main product + by-product (Rs./ha)		115681	

Summary results

Sr. No	Costs	Returns/ha over Costs (Rs.)	Costs/qn (Rs.)	Input-output ratio over costs
1	Cost A	77148	1551	1:2.78
2	Cost B	61005	2042	1:2.11
3	Cost C_1	55581	2244	1:1.92
4	Cost C_2	49568	2469	1:1.74

Table 3: Details of cost of cultivation of groundnut crop per hectare in study area (non-adopter)

Sr. No.	Items	Physical Unit	Value (Rs.)	% to Cost C_2
1	Human labour:			
	A: Family (man days)	22.22	5908	8.54
	B: Hired (man days)	48.46	12716	18.38
2	Bullock labour (pair days)	2.31	2132	3.08
3	Seeds (kgs)	160.31	11515	16.65
4	Manures (kgs)	1399.31	1467	2.13
5	Chemical fertilizers (kgs) N	23.87	2441	3.10
	P	38.59		
	K	3.64		
6	Herbicide		0	0.00
7	Irrigation		873	1.26
8	Insecticides/pesticides		2676	3.87
9	Miscellaneous costs		8442	12.20
10	Depreciation cost		299	0.43
11	Interest on working capital		1718	2.48
12	Rental value of owned land		12076	17.45
13	Interest on owned fixed capital		925	1.34
14	Management cost		6288	9.09
15	Cost A		43979	63.58
16	Cost B		56980	82.37
17	Cost C_1		62888	90.91
18	Cost C_2		69176	100.00
	Yield: A: Main product (qn/ha)	21.80		
19	B: By-product (qn/ha)	26.74		
	A: Farm harvest price of main product (Rs./qn)		4300.45	
20	B: Income from by-product (Rs./ha)		13734	
21	Gross income: main product + by-product (Rs./ha)		107484	

Summary results

Sr. No	Costs	Returns/ha over Costs (Rs.)	Costs/qn (Rs.)	Input-output ratio over costs

1	Cost A	63505	1760	1:2.44
2	Cost B	50504	2280	1:1.88
3	Cost C_1	44596	2516	1:1.70
4	Cost C_2	38308	2768	1:1.55

Table 4: Resource use efficiency in adopter and non-adopter groups of groundnut production (Per farm)

Sr. No.	Variables	Adopter	Non-adopter	Pooled
1	Constant	4.6586*	6.2496	7.0494**
		(1.8247)	(3.4027)	(1.7031)
2	Area	0.3727*	0.6286	0.6964**
		(0.1756)	(0.3561)	(0.1688)
3	Human labour	1.0141**	0.3678	0.7557**
		(0.1761)	(0.2397)	(0.1451)
4	Bullock labour	-0.1017*	0.1194	-0.03165
		(0.0517)	(0.0834)	(0.0469)
5	Seed	-0.1817	-0.4046	-0.2940*
		(0.1340)	(0.3102)	(0.1411)
6	Manure	0.01164*	0.0004	0.0042
		(0.0058)	(0.0090)	(0.0054)
7	Chemical fertilizers	-0.0239	-0.0152	-0.01239
		0.0127	(0.0187)	(0.0117)
8	Irrigation	-0.0230**	-0.0216*	-0.0235**
		(0.0052)	(0.0092)	(0.0052)
9	Insecticides	0.0662**	0.1294	0.0463
		(0.0224)	(0.1491)	(0.0260)
10	Other paid out cost	-0.0989*	0.3889*	-0.0317
		(0.04765)	(0.1683)	(0.0561)
11	R^2	0.8491	0.7882	0.7814
12	Adjusted R^2	0.8297	0.7610	0.7682

* Indicate five per cent level of significance

** Indicate one per cent level of significance

Figures in parentheses are the standard errors of regression coefficients

Majority of farmers in adopter group of faced constraint were crop foliage abrasion, followed by loss in soil fertility, higher price of herbicides, higher labour cost for herbicide application etc. in using of herbicides on groundnut crop (Table 5).

Table 5: Constraints in using herbicides in groundnut production by the adopter group of farmers

Sr. No.	Reason	Taluka				All (80)	Rank
		Jetpur (20)	Upleta (20)	Keshod (20)	Junagadh (20)		
1	Higher Labour cost for herbicide application	9	12	7	4	32	IV
2	Higher price of herbicides	7	13	6	7	33	III
3	Crop foliage abrasion	14	14	7	3	38	I
4	Loss in soil fertility	11	12	7	4	34	II
5	Poor results of herbicides	7	6	4	5	22	VI
6	Stunted crop growth	8	10	4	8	30	V
7	Timely unavailability of labourers	10	11	7	4	32	IV
8	Reduced crop productivity	7	9	2	3	21	VII

Perceptions of the adoption of herbicides in groundnut production of non-adopter group of farmers are presented in Table 6. Table revealed that majority of farmers did not adopt the herbicides due to their belief that it is costly, followed by harmful to Groundnut crop, reduce the crop productivity.

Table 6: Perceptions for not using herbicides in groundnut crop by non- adopter group of farmers

Sr. No.	Reason	Taluka				All (80)	Rank
		Jetpur (20)	Upleta (20)	Keshod (20)	Junagadh (20)		
1	Cheaper hand weeding	11	12	8	7	38	IV
2	Harmful to Groundnut crop	13	12	11	6	42	II
3	Land degradation	10	14	8	6	38	IV
4	Harmful to soil organisms	8	13	4	5	30	VII
5	Regular inter-culturing	9	14	2	5	30	VII
6	Higher price of herbicides	12	11	20	20	63	I
7	Reduces crop productivity	11	12	8	10	41	III
8	Lack of information	2	4	2	1	9	IX
9	Sufficient family labourers	2	5	13	12	32	VI
10	Easy availability of labourers	10	9	12	6	37	V
11	Lesser weed infestation	--	--	7	14	21	VIII

Conclusion

The major findings of the study are listed below

- Total cost (Rs.66113/ha) incurred by the adopter group of farmers was lower than the non-adopter (Rs.69176/ha) because of relatively optimum utilization of input resources.
- More than 50 per cent of the farmers were using "Targa Super" herbicide.
- Farmers in study area were using lower quantity of herbicide than recommended by the university and respected company.
- Generally farmers were believed that higher the dose of herbicide would inversely affected the crop production.
- Adopter group of farmers reaped higher yield as well as low production unit cost than the non-adopter group.
- Higher seed yield, disease resistance, bold grain size and short duration varieties were most preferred by the farmers in study area.
- Majority of farmers in adopter group faced constraint were crop foliage abrasion, followed by loss in soil fertility, higher price of herbicides, higher labour cost for herbicide application etc. in using of herbicides on groundnut crop

Perceptions of the adoption of herbicides in groundnut production of non-adopter group of farmers were costly, followed by harmful to Groundnut crop, reduce the crop productivity.

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