

ERADICATION OF WEEDS BY MECHANICAL
METHODS IN CENTRAL INDIA

by

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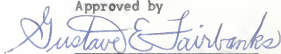
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INTRODUCTION

From times immemorial, the farmer has had to contend with unfavorable climatic and edaphic factors, pests and diseases, as well as certain unwelcome and undesirable species of plants known as weeds, which interfere with his operations, increase his labor, reduce his output and also cause losses in many other ways.

The war between man and weeds, which encroach on his land, had begun since the primitive man eschewed his nomadic life, in favor of sedentary cultivation. In the context of the complexities of the world food scarcity, the part played by weeds becomes particularly significant.

The weeds are defined as plants growing out of place. Sometimes they are described as plants which do more harm than good. According to Muenscher (40) [1947], whether a plant of a given species is considered a weed, depends, not only on its characteristics or habits, but also on its relative position with reference to other plants and man.

Like other crop plants, weeds vary in general size, from the minute water bloom,¹ which pollutes water and spoils rice fields, to gigantic parasitic trees like the wild figs,² which normally grow independently, but smother full grown trees of other species, if fig seeds are excreted on them by birds.

Most weeds are herbaceous in form, but some are woody. Some of them are climbing or creeping vines like wild morning glory, milk weed, dodder etc.; shrubs or bushes like sumac, Zizyphus etc.; or even trees like osage orange,

¹Micro-cystis flosaque.

²Ficus bangalensis, Ficus religiosa, Ficus glomerata etc.

willow etc.

Their habits of growth, morphology and physiology range, all the way from total parasites like dodder, to semiparasites like striga, loranthus etc., or to plants living an independent existence. They grow almost anywhere on earth, surviving severe frost or drought, high temperature and humidity, widely varying soil and climatic conditions. Some produce an enormous number of seeds (50, 61), which remain viable for years under the most adverse conditions. They multiply rapidly and disperse widely by the most astonishing means, to astounding distances. They are ubiquitous, cosmopolitan in tastes, equally at home in a rice field or on a railway platform, on manure heaps or on mango branches, in tobacco fields or on playgrounds.

However, of the quarter million plants flourishing on earth, few have essentially weedy habits, and seldom does one species have all the undesirable characters attributed to weeds.

Some, like the wild species of oats, rice, sugarcane (23, 52) et., are closely related to valuable crops, and are used by plant breeders for introducing new characteristics or developing resistance to insects or diseases. A number of species of grasses and legumes are useful as food, fodder (35), shelter etc. Many of them are sources of valuable drugs and medicines or industrial raw material. Some of them provide good soil cover and are valuable soil binders which help in checking erosion (50, 61).

Effect of Weeds on Human Affairs

The menace of weeds is not restricted to farming enterprise alone. Not only farmers and land owners, but railways, highways, irrigation, navigation,

plumbing and buildings, parks, playgrounds and even cemeteries are affected by the insidious presence of weeds. So much so, that implements and chemicals have been specially developed and manufactured to keep them at bay. Governments all over the world have drafted special laws, to outlaw, control and destroy them (8). Consequently an appraisal of the damage done by weeds, is a necessary precursor for any comprehensive study of weed problems.

Losses Caused by Weeds

The losses due to weeds, though generally recognized, are far greater than usually realized. The United States of America Chamber of Commerce estimated that the annual losses due to weeds were greater in magnitude than losses caused by diseases and pests of plants and animals; being 3,000,000,000 dollars and 2,565,000,000 dollars respectively (8). Latest estimates by Zahnley et al. (61) [1957], put the annual losses in the United States of America, due to weeds at \$5 billion averaging to \$104 million per state. The losses in Kansas have been estimated to be \$132 million, or \$6 per acre of all crops harvested, exclusive of pasture and range land, or \$3.22 per acre including pastures. Woolney [1908], in Bavaria estimated the overall losses due to weeds to be 30% of the crop value. Iyengar [1935] computed the loss equivalent to be 1/12th of crop value. Percival [1910] found clean plots to yield 50% more than weed infested plots. Chaugule and Khuspe (19) [1956] noticed that the tall growing crops were affected only 10% while dwarf crops like peanuts were affected as much as 80%. The Kans weed alone is reported to cause a loss of 2.2 million rupees in Central India (8).

An accurate overall picture of the losses incurred directly or indirectly on account of weeds in India, is hard to find. The few scattered pieces of

information available, about the crop-weed relationship, however, gives some idea about the magnitude of the weed problem in Indian crop husbandry.

Losses in plant food. The nutrient uptake of weeds is found to be much greater than crops. Robbins (50) [1942] found that charlek¹ needs twice as much nitrogen and phosphorus, and four times as much potash and water, as a well developed oat plant. He also found that rough pig weed² progressively absorbed nitrogen and stored it. Call et al. [1918] studied a three foot layer of soil and found that the nitrates in the weed free plots were 413.3 lbs. per acre while the weed infested plots showed only 81.61 lbs. of nitrates.

Losses in soil water. The water requirement of weeds has been found to be very high. Experiments at Cornell University, show that sunflower requires twice as much water as corn to produce the same amount of dry matter. The ragweed took three times as much water as millets while lamb's quarter took nearly twice as much. Kanitkar [1944] studied the transpiration coefficient of sorghum in relation to weeds. He estimated the transpiration coefficient for sorghum to be 430, while the same for Bermuda grass was 813, and as high as 1402 for Kamarmodi.³

Reduction in crop quality. Robbins [1942] estimated that there was 1% reduction in price due to "dockage." In India, this percentage is likely to be higher.

Poisonous effects. In the United States of America, the losses due to cattle poisoning were estimated at 200 million dollars (8). In India, legislative measures had to be taken in Uttar Pradesh and Bihar states,

¹Brassica campestris

²Amarantus retroflexus

³Tridax procumbens

where adulteration by prickly poppy seeds with mustard had given rise to diseases like dropsy and beri-beri among people who consumed the oil, due to the alkaloid "argemonin" (43).

Parasitic weeds. Losses due to parasitic weeds like witchweed,¹ broomrape² etc. showed wide fluctuations being 5% in Bengal to 70% in Madras (8).

WEED PROBLEM IN INDIA

The population of the India Union is estimated to be 439 million. The area of cultivated land per capita, is 0.67 acres while cultivable fallow land is estimated to be 0.26 acres per capita (48).

The Food Grain Policy Committee, set up by the Government of India has estimated that the food grain production has to be increased by 10 million tons to make India self sufficient in food. Out of this target of 10 million tons, 3 million tons are expected to be met by reclamation of wastelands (48). The total area rendered uncultivable due to weeds, salinity etc. is estimated to be 87 million acres. Out of this area, it has been found that an area of 10 million acres can be reclaimed. Most of this area is infested with "Kans" grass, and is located in Central India.

The vegetation pattern of any region is closely related with its soil and climatic characteristics, and it will not be out of place to have a brief background of soil, climate and crop pattern of Central India, the region under study. The Central India, implied here, is however the

¹ *Striga densiflora*

² *Orobancha*

geographical central India¹ and not the political state as it existed till 1956.

Soil, Climate and Crops of Central India

Soil. The soil of Central India is heavy black clay, which absorbs and retains moisture from the rainfall during the four months of June to September, and makes it available for the winter crops which grow from October to March. During summer, which occurs from February to May, the soil progressively dries up and becomes extremely hard like a rock. Indigenous wooden implements fail to penetrate the soil.

Climate. Like the whole of India, the central part receives most of its rainfall during the four months of June to September. The monsoon winds from a southwest direction brings the rain. In January sporadic showers from northeast monsoons may bring one or two inches of rain. The overall annual rainfall ranges between 45 to 50 inches and most of it occurs between June to September. Annual temperature ranges between 50°F to 110°F.

Table 1. Rainfall distribution in Central India (53).

Season	Months	No. of average rainy days
Winter	Dec.-March	1.3
Pre-Monsoon	April and May	0.7
Monsoon	June-Sept.	43.0
Post Monsoon	Oct. and Nov.	3.0
TOTAL FOR THE YEAR		48.0

¹See map on page 8.

EXPLANATION OF PLATE I

Map of India showing areas of central region affected by Kans.

POLITICAL MAP OF INDIA

(Sikkim and Bhutan States are attached to India by special treaties)



Crops. There are two distinct cropping seasons in this region and most of the crops are not irrigated.

a. Rainy season crops (commonly called KHARIF crops). These are sown in the month of June and are harvested in November or December. The chief crops are cotton, sorghum (grain), peanuts, millet, pigeon-pea,¹ sann-hemp,² rice, and other pulses or beans. Out of the above, cotton and pigeon pea continue till February or March.

b. Winter season crops (commonly called RABI crops). These are sown in October and are harvested in March. They include wheat, flax (linseed), Gram (chick pea), safflower, sesame, peas, etc.

In addition to the above unirrigated crops, areas irrigated by wells grow tangerines, bananas, guavas,³ and vegetables. This region is specially noted for the tangerines. During summer, no regular crops can be taken but melons, cantaloupes and cucumbers are grown in river beds.

It is evident from the above, that annual weeds grow abundantly in the rainy season. Frequent intercultivations have to be done to kill weeds and conserve moisture. Fields due for winter crops are given light cultivation between breaks in the rains to help maximum absorption of rain water.

The winter fields are mostly free from weeds and the number of weeds growing, is comparatively small. They are however, equally harmful as this crop has to grow entirely on moisture retained by the soil, and any loss through weeds will affect the crop adversely.

The perennial weeds make maximum growth during the rainy season and

¹Cajanus indicus

²Crotalaria juncea

³Psidium gujava

store food material in their rhizomes for the remaining eight months. It is evident that the perennial weeds constitute the major obstacle in Indian agriculture and the control of these becomes the most important problem.

In general it may be said that if pests and vermin are a serious menace to crop production, weeds and other noxious vegetation are equally as serious. In the United States of America losses due to weeds rank only next to erosion and this may be so in India too. The seriousness of all other agencies has already been widely recognized and adequate measures are being taken to control them. But little attention has been paid to the menace of weeds. Many take weeds as an unavoidable nuisance or a necessary corollary or compliment to crop husbandry. This attitude of apathy and indifference of the farmer and the public, adds to the complexities of the weed problem.

METHODS OF WEED CONTROL

The method of weed control, adopted in a particular area will be influenced by the nature of the plants as well as by their life cycle. A different approach may be necessary for grasses and dicots than for annual and perennial weeds.

The weed control methods can be broadly divided into two classes (1) preventive and (2) curative.

Preventive Weed Control

This method aims at preventing the weeds from getting introduced in a particular area. Good farm sanitation may help to achieve this. We may start from weed free fields and prevent new weeds from getting introduced and from

spreading. Preventive methods include the use of clean seed, cleaning contaminated equipment, keeping weeds from fence rows and ditchbanks from seeding and spreading and spot treating small localized infestations within the fields. Most of the advanced countries have seed laws which aim at preventive weed control.

Curative or Positive Control

These measures are generally adopted after the weeds get established, to control them and if economically possible, completely eradicate them. Weed eradication aims at complete destruction or removal of all weed plants including regenerative plant parts like rhizomes, tubers etc. Complete eradication may sometimes be possible and justifiable as in the case of small new infestations of particularly troublesome weeds even at a relatively high cost per unit area (13). But complete eradication of all weeds may not be practicable nor necessary. Suppression of weeds or "weed control," may be, in most cases the reasonable approach. Many weeds are so wide spread that complete eradication, though desirable, may be economically impractical. But the infestation can be reduced to a level, which will permit the production of a crop profitably, in spite of the weeds.

Control Methods

Mechanical control. Mechanical weed control includes cultivation, mowing, burning, spraying, dusting, hoeing and even hand pulling may be justified under certain conditions. In the past, the term mechanical control was restricted only to cultivation practices while chemical control was treated

as an independent branch. But under the present highly mechanized agricultural practices it is difficult to separate these two important methods. Complicated highly specialized equipment is used in spraying, granular application, dusting and flame cultivation and all these will have to be included under the mechanical method.

Cropping control. Cropping control takes the advantage of crop rotation to obtain changes in the environment which will keep weeds down. Often the new crop successfully competes with the weeds from the previous crop. Growing a tall thick growing cover crop may help to smother the weeds. This could be a green manuring crop or a fodder crop. Marudrajan [1950], Hussain (28) [1944], Tambe and Wad (55) [1938] reported complete control of Kans by growing a thick crop of Sannhemp,¹ and plowing it in a flowering stage. Singh (51) [1953] advocated growing of basket grass,² which is a good fodder, for the purpose of smothering Kans.

Flooding. Allowing water to stand on the weed infested area for some time has been advocated by some workers. Bhargava (17) [1942] advocates the flooding of Kans affected lands for two days, followed by the removal of rhizomes with the help of a toothed implement. Finfrock et al. (26) [1958] in California, have recommended this method for controlling grassy weeds in rice.

Biological method. In biological control, use is made of insects or fungus organisms, or some other biological agencies against weeds. The most notable examples in India are control of prickly pear³ by the cochineal insect,

¹Crotalaria juncea

²Rottloettia myurus

³Opuntia dillenii

or control of Lantana by *Platyptillia* sp (59). In Australia, prickly pear was controlled by *Cactoblastis cactorum*, while control of Lantana in Hawaii by similar means has been noted. The latest research by Holloway and Huffaker¹ [1962], has succeeded in isolating a selective weevil against puncture vine² in the United States of America.

In India, however, cultivation is still the most common method for weed control, particularly against the annual weeds. Large schemes like the Central Tractor Organization, or State Tractor Organizations have been established to fight perennial weeds like Kans, by nine to fourteen inches deep cultivation with heavy crawler tractors.

The chemical and biological methods are just being introduced. With the increase in the production of chemicals and spraying equipment, it may be possible to replace indiscriminate deep plowing by specific chemical control.

CLASSIFICATION OF WEEDS

Various basis may be used to classify weeds e.g. longevity, botanical characteristics, origin etc. are some of the important basis. On the basis of longevity they may be classified as annuals, biennials or perennials (50, 61). On botanical characteristics, they may be divided into two groups called Monocots and Dicots. These classifications help in determining the control measures to be adopted against particular weeds.

Annual weeds live only one season, bear seed and die. They reproduce by seed each year. The primary object in controlling the annuals is to

¹ Pest against pest. Time. Aug. 31, 1962.

² *Tribulus terrestris*

reduce their competition with crops and to keep them from going to seed. This may be achieved by mowing, tillage, burning or application of herbicides. Mowing is most effective just before the weeds bloom. If mowed earlier, the weeds may grow again. If mowed while in bloom, some weed seeds may be mature enough to grow. Many grass family weeds continue to grow and produce seed, even when mowed closely before blooming. Mowing is a practical way of controlling broad leaved annual weeds in pastures and other nontillable lands.

Tillage is still the most practical way of controlling annual weeds on crop lands. All weeds are killed easily when young, particularly in the seedling stage, by only slightly disturbing the surface soil. In countries like India, where wind erosion is not a problem, a blade harrow (Bakhar), or a light cultivator may be considered an effective implement to kill weeds, before planting a crop. After emergence of the crop, the space between rows can be tilled with a bladed hoe or a tined hoe to keep weeds down. Killing weeds in the early stage is most economical.

Under Indian cropping seasons, the annual weeds are divided into two groups: rainy season (Kharif) weeds and winter (Rabi) weeds. Of these, the rainy season weeds are most abundant and difficult to control. Winter weeds are few and do not cause much harm except depleting the valuable soil moisture.

Biennial weeds complete their life cycle in two years. They reproduce by seeds borne in the second year. In the first year, they develop vegetative parts and generally store food material in a fleshy or tuberous root. Under the peculiar seasons in India, very few biennial weeds are found, and do not constitute a problem.

Perennial weeds live three or more years and usually produce seed every year after getting established. These may be further subdivided into simple, bulbous and creeping perennials. Of these the creeping perennials like Kans,

Bermuda grass etc. are most noxious and difficult to control because in addition to seed, they spread by vegetative modifications like runners, rhizomes, tubers etc.

The seeding of perennials can be prevented by frequent mowing, burning or chemicals used to destroy the top growth. But the underground stems still continue to grow. Frequent removal of green top growth, depletes their food reserve in the roots or rhizomes and such a program, continued for two or three years will kill most perennial weeds. Tamhane and Tamhane (56) [1947] have recommended this as the most effective method of "Kans" control. Use of translocated chemicals, which are carried to the roots, result in their destruction. The perennial weeds become a menace especially in countries like India, where the light, indigenous, wooden implements fail to remove them and the infestation assumes such a proportion that the land goes out of cultivation.

Except cocklebur and prickly poppy, which have special characteristics, very few annual weeds have developed a noxious character. Most of the noxious weeds like Kans, Zizyphus, Nut grass, Bermuda grass etc. are perennials.

Common Noxious Weeds of Central India

The common noxious weeds of central India can be divided into two main classes i.e. annuals and perennials. The number of annual weeds in this region may run into the thousands but only two or three among them are considered noxious due to certain characteristics exhibited by them. These are (1) cockle bur - Gokharu - *Xanthium strumarium* and (2) prickly poppy -- *Argemone mexicana*.

Among the perennials, the Kans or wild sugar-cane is most prominent and

wide spread. Next in importance comes the thorn berry (*Zizyphus rotundifolia*). Bermuda grass - *Hariali* or Doob (*Cynodon dactylon*) and Nut grass - *Nagar motha* (*Cyperus rotundus*) are widely spread all over the region but they have not resulted in land going out of cultivation.

As the control measures will largely depend upon the characteristics of these weeds, it will not be out of place to study their outstanding features.

Kans or wild sugarcane. Monocot - Family: Glumifloresae. This is a hardy grass closely related to sugarcane. Normally the plants are erect and three to four feet tall. But prostrate varieties of this plant have been identified (Plate III) and varieties growing even to a height of ten to twelve feet have been isolated. (Plate II). The inflorescence is white and feathery like sugarcane. Propagation is by seeds as well as by underground rhizomes. These underground rhizomes are the real obstacles in cultivation of land particularly with the indigenous wooden plow. An intricate network of these rhizomes renders the land uncultivable and the area goes on increasing every year. These rhizomes may be red or yellow in color and may range up to one-half inch in thickness. They taste sweet like sugarcane and have been found to contain 8 to 9% sucrose (39).

Sachharum spontaneum has been widely used as a parent plant for breeding sugarcane (23) and in 1946 a special scheme called the Spontaneum Expedition Scheme was organized by the Sugarcane breeding station Coimbatore, Madras, India, to make an extensive study of *Sachharum spontaneum* and other wild sugarcane species.

The Spontaneum Expedition Scheme (39) succeeded in isolating 215 different wild species of sugarcane of which 125 were identified as *Sachharum spontaneum*. The studies of Spontaneum Expedition Scheme revealed that the *Sachharum spontaneum* could tolerate from 20 to 200 inches of rainfall and a

EXPLANATION OF PLATE II

An unusually tall stand of Kans. (*Saccharum spontaneum*).

Source. Indian Farming, Vol. XI, No. 9, Sept., 1950. (Plate 73, Fig. 7).

PLATE II



EXPLANATION OF PLATE III

A prostrate variety of Kans.

Source. Indian Farming, Vol. XI, No. 9, Sept., 1950. (Plate 74, Fig. 8.)

PLATE III



wide temperature range of 30°F to 124°F. It is found to grow equally well in saline to acid soils and from sandy loams to clayey soils. The plants were found even at an elevation of 8000 ft. in Northern India whereas in Southern India this limit was 4000 ft. (39).

Thorn berry. (*Zizyphus rotundifolia*). Dicot - Family: Rhamnace. This is a woody shrub of bushy nature two to three feet high. The leaves are oval or round and branches are covered with curved spines. The fruits are round 1 to 1½ cm in diameter and are sweetish sour. Propagation is by seeds as well as by underground rhizomes. The tender leafy branches of this plant are chopped and widely used to supplement green fodder (35), particularly for water buffaloes.

The bush generally grows near fence rows and is difficult to deal with, on account of the spiny branches. The fruits are widely eaten by children and jackals. These two agencies play an important role in dissemination of seeds.

In spite of the fact that very large areas in central India have been rendered incultivable due to this bush, it is rather surprising to notice that this plant has not attracted the attention of agronomists for eradication. The edible nature of fruit and use of tender branches for fodder may be responsible for overlooking the noxious nature of this plant. The extent of the area rendered uncultivable by this weed has not been estimated but by personal knowledge of the area, it is possible to rank this weed only next to Kans in this region. *Zizyphus* is known in Africa and South America but does not exhibit the tendency of being a weed.¹

Bermuda grass. This is a prostrate grass belonging to Poaceae family. Propagation is both by seeds as well as underground rhizomes. Every node is

¹Collier's Encyclopedia, Vol. 19, p. 693.

EXPLANATION OF PLATE IV

Bush of Thornberry. *Zizyphus rotundifolia*.

Courtesy: U. C. Upadhyaya, Asst. Prof. of Agronomy, College of Agriculture, Nagpur.

PLATE IV



EXPLANATION OF PLATE V

Bermuda Grass.

Source: Weeds of the north central states, page 16.

PLATE V



capable of striking roots and developing into an independent plant. Like Kans it is capable of tolerating wide variations in conditions of rainfall, temperature, soil condition and type and altitude. This makes the eradication of this plant difficult. One single plant is capable of making 12 to 15 feet of growth along the ground in one season. Apart from being a weed Bermuda grass is known to be a good lawn grass as well as a good fodder. It is also a valuable cover crop for checking soil erosion (50).

Nut grass. This is a grass belonging to the family cypera-cee. The plants are erect 10 to 12 inches high with an erect central shoot crowned with the inflorescence. The propagation is by seeds and underground tubers which make the eradication difficult. Poorly drained water logged soils are particularly infested with this weed.

Cockle bur. This is an erect dicot rainy season shrub belonging to the compositae family. It is reported to have been introduced in India from the United States in shipments of grain following World War II. Within a short period it has covered the whole country and the problem became so acute that some states had to organize special eradication campaigns to fight this weed. The spiny burr which sticks to hairs of animals helps the dissemination while the peculiar germination characteristics render its eradication difficult (47). The burr contains two seeds, one of which germinates in the first year while the second one remains dormant till the next year. This peculiar nature involves systematic and persevering efforts for eradication of this weed. Introduction of chemicals like 2,4-D¹ is likely to help in control of this weed (16).

Prickly poppy. This is an erect dicot winter weed, one to three feet

¹2,4-Dichlorophenoxyacetic acid.

EXPLANATION OF PLATE VI

Nut Grass.

Source: Weeds of the north central states, page 34.

PLATE VI

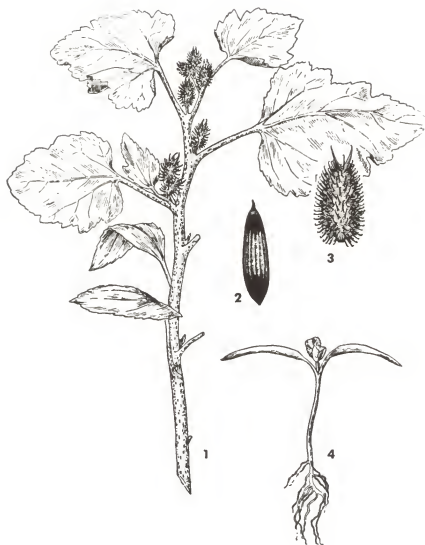


EXPLANATION OF PLATE VII

Cockle Bur.

Source: Weeds of the north central states, page 216.

PLATE VII

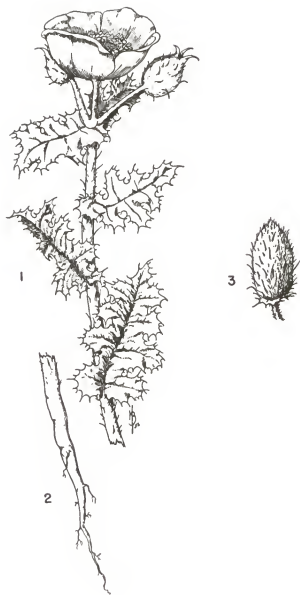


EXPLANATION OF PLATE VIII

Prickly Poppy.

Source: Weeds of the north central states, page 72.

PLATE VIII



high. The leaves, fruits and stem are covered with spines. The fruit is a dehiscent capsule and contains small black seeds which look exactly like mustard. The seeds generally germinate after the germination of winter crops and mature and shed seeds before their harvest. This feature, along with the spiny nature of the plant, makes eradication of this weed difficult. The seeds of this plant were largely used for adulterants with mustard and were considered responsible for wide spread trouble of Beri-Beri and Dropsy (8) diseases in states consuming mustard oil for cooking.

In 1950-51, the states of Uttar Pradesh and Bihar had to pass a law laying down severe penalty against persons using these seeds for adulteration (8, 43).

The yellow acrid smelling exudate from this plant is used in medicine against skin diseases.

ROLE OF TILLAGE FOR WEED CONTROL

Tillage is still considered to be the most practical and economical way of controlling annual weeds. But in countries with primitive agriculture, it still is the only way of fighting weeds. Lack of specialized equipment, paucity of chemicals and scarcity of trained personnel can be indicated as the main cause of this. In the western world, with highly specialized and mechanized agriculture, the role of tillage for weed control is almost becoming obsolete and outmoded. Development of selective chemical herbicides like 2,4-D; 2,4,5-T;¹ Dalapon,² etc. have revolutionized the whole perspective of

¹2,4,5-Trichlorophenoxyacetic acid (Amine salts and esters).

²2,2-Dichloropropionic acid.

weed control. However, it will not be out of place to study in brief the efforts done in India for the control of perennial weeds by tillage. Since Kans has been the number one enemy of the Indian farmer in general, and the Central Indian farmer, in particular, the efforts done to eradicate Kans may be studied below.

Howard (27) [1927], Anonymous (5, 6) [1937, 1946], and Hussain (28) [1944] reported partial control of "Kans" by deep plowing. Deep plowing is a relative term, and in India, plowing more than eight to nine inches deep is termed deep plowing. Khan (34) [1953] advocated tillage accompanied by heavy manuring for Kans control. Tamhane and Tamhane (56) [1947] reported the presence of Kans rhizomes even up to five feet depth, and emphasized the futility of deep plowing. In their opinion, repeated harrowing, with a blade harrow, twice a week for eight to twelve months, brought about complete eradication of Kans. Barooah (14) [1955] praised the work of the Central Tractor Organization, but cautioned that unless proper "follow-up" practices were adopted, Kans was likely to raise its head again.

Steam Tackle Units

Long before the establishment of the Central Tractor Organization, the British Administration in Central India, (then called Central Provinces and Berar) had realized the magnitude of the "Kans" menace. In 1935, "steam tackle" plowing was undertaken in the Kans infested areas and thousands of acres of land were brought back under the plowing. Each unit consisted of two heavy steam engines on wheels, located at the two ends of the field opposite of each other. These engines had revolving drums under them over which a flexible steel cable 1 to 1½ inches thick could be wound. This

cable was attached to a two way gang plow with two sets of reversible bottoms. Generally four to five bottoms were used. As one engine wound the cable, and pulled the plow, the other engine unwound the cable on its drum. When the furrow was completed, the engine moved forward along the edge of the field.

This method was very cumbersome and after World War II, when heavy crawler tractors from war surplus became available, this scheme was discontinued.

The Central Tractor Organization (54)

During World War II, India experienced an acute shortage of food and the people started realizing the importance of increasing its food production. In 1947, when India achieved independence, the influx of refugees from Pakistan made the problem more acute. In addition to enhanced food production, the resettlement of these refugees was also a problem. Giving suitable employment to disbanded soldiers was also a problem.

The Government of India decided to reclaim Kans infested lands in Central India and Terai regions of Uttar Pradesh. The rendering of these lands cultivable, could provide more food and the refugees could be settled on these newly reclaimed lands. The machinery for clearing these lands was to be obtained from the huge number of heavy crawler tractors, bulldozers and other land and jungle clearing equipment used by the allies. Consequently the Ministry of Food and Agriculture was established. In 1947-48 the work started with a fleet of 100 tractors and 32,000 acres were reclaimed. The number of tractors rose steadily as more tractors were purchased by the Government of India. In 1951, the International Bank for Reconstruction and Development,

EXPLANATION OF PLATE IX

Heavy crawler tractor in C.T.O. unit.

Source: Indian Farming, Vol. IX, No. 6, June, 1948. (Cover page)

PLATE IX



Washington D.C., sanctioned a loan of 10 million dollars to the Government of India for the purchase of heavy crawler tractors and jungle clearing equipment. With the help of this loan 180 new tractors were purchased to assist the 375 already on hand. With the help of these new tractors, up to 1954-55, an area of 1,400,000 acres along with 49,550 acres of jungle had been cleared. It was estimated that this land would yield an additional 200,000 tons of food grains.

State Tractor Scheme

In 1947, the State Government of Central Provinces and Berar, established an organization of its own for supplementing the work of Central Tractor Organization. The Central Tractor Organization, had the drawback that it could operate in large continuous blocks and could not undertake small isolated fields. The rates of the Central Tractor Organization were also very large being Rs 50 (approximately ten dollars) per acre. The depth of plowing was 12 to 14 inches.

The State Organization undertook to plow small isolated areas to a depth of nine to ten inches and charged only Rs 30 (six dollars) per acre. The tractors of the State Organization were a medium, crawler type with 40 to 80 H.P. as against the heavy crawler tractors of the Central Tractor Organization which were 80 H.P. or above.

Success of Central and State Organizations

The lands cleared by the Central and State organizations showed a definite increase in food production. The yield of wheat, which had dropped

EXPLANATION OF PLATE X

Wheel type tractor of State Tractor Scheme on government farm.

Source: Indian Farming, Vol. IX, No. 8, August, 1948. (Plate 22, Fig. 1).

PLATE X



down to 200 lbs./acre on Kans infested lands rose to 750 to 1520 lbs./acre on Kans free lands (48). In spite of such a phenomenal increase in food production, certain defects were noticed. The technicians in charge of the central and state organizations were people without any agricultural background whatsoever. This resulted in lands being plowed along the slope, which resulted in accelerated soil erosion. The big clods brought up by deep plowing could not be broken up by indigenous plows. The inefficient "follow-up" practices by farmers resulted in the reemergence of Kans as predicted by Barooah (14) [1955] and Tamhane (56) [1947].

The Follow-up-Cultivation Scheme

The Government of the Central region had realized the importance of "follow-up" practices in checking the reinfestation of Kans cleared lands and as early as in 1951, a large fleet of machinery was purchased. These consisted mostly of heavy disc harrows, disc tillers, rigid and spring tine cultivators, seed drills etc. The indiscriminate purchase of machinery without any idea of its usefulness rendered the machinery useless. The problem of "follow-up" cultivation was most urgent in the wheat growing regions of the state. The cultivators and disc tiller (one way disc) were found useful but the sowing machinery i.e. seed drills and sowing mechanism of the disc tiller, were a total failure. This could again be attributed to the lack of agricultural knowledge on the part of the technicians, who controlled these organizations.

Scope for Mechanical Methods Other Than Tillage

These include flame cultivation and use of chemicals.

Flame cultivation, or killing of weeds by burning has a limited scope in the Indian agriculture. The bushes of Zizyphus are generally set on fire during the months of summer, when no crops are standing. Burning is particularly helpful as these plants have curved spines. The present crude practice can be improved by the use of modern equipment like the "flame gun" or "flame thrower." During the rainy season or winter, when crops are standing, flame cultivation has less application. An Indian farm has a lot of inflammable material and almost no fire fighting equipment. Under such circumstances the use of flame would be hazardous. The crop is also likely to be affected by flame. Lacey (37) [1950] reported severe damage to a cotton crop in Texas and recommended chemical control instead.

Chemical control. With the completion of the third five year plan in 1968, the production of chemicals and spraying equipment is likely to get a boost. It may be possible to eradicate Zizyphus by the use of 2,4,5-T which has been found valuable on woody shrubs. Isolated patches of Kans could be eradicated by chemicals like Dalapon or T.C.A.¹ which have proved useful against Johnson grass. Control of Bermuda grass is also possible by the use of chemicals like T.C.A. while several chemicals like C.M.U.², Fernoxone etc. were found effective on nut grass. Eradication of Prickly poppy by M.C.P.³ has already been established while 2,4-D has been found very effective on cocklebur.

As the fields in India are of a very small size, it may not be advisable to recommend large scale tractor mounted sprayers. Small infestations of

¹Trichloroacetic acid, salts.

²3(P-chlorophenol)-1,1 dimethyl urea.

³2-Methyl-4 chlorophenoxyacetic acid.

local nature may be tackled with the help of a small pneumatic knapsack sprayer (Plate XI).

CHEMICAL WEED CONTROL

Weed control by chemicals offers the greatest potential. It is not new but has been extensively developed only for the past several years. Bolley¹ [1908] of North Dakota is considered the pioneer in the field of chemical weed control. The chemicals used earlier, were mostly soil sterilents, which rendered the soil useless for any vegetation. Their use in farming practices was limited. The contact herbicides which followed, were preferable in the fact that they killed weeds without affecting the soil. But the real big strides, in this direction were taken in 1942, when the synthesis of 2,4-D by Boyce Thomson Institute, revolutionized the whole aspect of chemical weed control. Development of 2,4-D, 2,4,5-T, Dalapon, T.C.A. and other selective translocated herbicides have made it possible to destroy a specific class of weeds without affecting the crop plants. The use of highly specialized mechanical equipment for the application of these chemicals, has interlinked mechanical and chemical weed control together, so intimately, that these two can no longer be treated separately. They are so vitally interdependent that the study of one of these branches without studying the other will be incomplete.

¹Lecture notes, Weed Control Course, Prof. L. E. Anderson.

EXPLANATION OF PLATE XI

A knapsack sprayer in operation against bushy weeds.

Source: Chemical Control of Woody Plants in California Bulletin
No. 755. Page 3, August, 1956, California Agri. Expt. Stn.

PLATE XI



Use of Herbicides in Chemical Control

The herbicides are substances which can kill plants at various stages of growth. They may be used either on the foliage or in the soil.

Foliage applications. These treatments are made to leaves of growing plants, usually as liquid sprays. They may kill plants either by contact or translocation.

Contact. This treatment kills only the plant parts actually contacted by the herbicide. However the non contacted parts like roots, etc. may die because they are deprived of the essential contacted organs e.g. the leaves. Adequate distribution of the herbicide over the foliage is essential. Selectivity may depend upon the arrangement and angle of leaves, differential wetting, thickness of cuticle, location of the growing point, or upon spray placement. Contact herbicides are most useful in controlling seedlings (13).

Translocation. This treatment kills the entire plant since the herbicide moves within the plant. For example, when applied to the leaves the herbicide is translocated to the roots. It may also move from older leaves to young growing shoots. Therefore herbicides of this type are used on perennial plants as well as annuals. Selectivity depends primarily on physiological differences between plants but in some instances upon timing of the application in relation to planting the crop.

Soil applications. These treatments are usually applied to the surface of the soil but may also be incorporated into the soil by cultivation, or placement below the soil surface.

Timing of the application, in relation to growth stage of the weeds and crop, is important. The application may be made pre-plant, pre-emergence or post emergence as related to the growth stage of the crop plant.

Surface moisture must follow surface treatments for soil applied herbicides to be effective, best results can be obtained when these herbicides are carried into the soil by rainfall, overhead irrigation, or flood irrigation. A physical incorporation of the surface applied herbicide into the top two inches of soil followed by the furrow irrigation is usually as effective as rainfall or overhead irrigation. The soil application may be in the form of liquid or granules. If a liquid is used, it will involve the use of a sprayer while a granular applicator may have to be adopted for the granules.

Complete coverage. This aims at application of the liquid or granular chemical over the entire surface giving an overall control.

Band application. In this method the chemical may be applied in strips of land which are to be sown. This controls the weeds in the crop rows but the space between the rows may have to be kept weed free by intertillage or chemical application between rows after the emergence of the crop.

The method of application largely determines the type of equipment to be used. Quantity of chemical may be determined by the depth of sowing of the crop and its susceptibility to the chemical being used.

Scope for chemical control in India. Verma, et al. (60) [1958]¹, have shown that the chemical weed control has ample application in India. Cultivation which is the chief method in India today, has many draw-backs. With indigenous implements it is difficult to control perennial weeds like Kans, Bermuda grass etc. Indiscriminate deep cultivation has resulted in serious erosion. Baver [1961]¹ has drawn attention to the loss of soil fertility, attributable to unnecessary deep tillage. Most of the workers have only reported partial control of Kans by tillage alone. So any efficient and

¹Soil physics, pages 418, 421.

effective method, which can replace cultivation and still be economic, will be appreciated by the farmers. The small scattered patches of infestations, which render economic tillage almost impossible, may be successfully tackled by the use of handy knapsack sprayers. Government organizations may use bigger tractor drawn or mounted sprayers to fight large scale infestations. As wheel type tractors will be used for this purpose, the initial cost involved will also be cheaper than crawler tractors.

From the point of view of a small scale farmer, the knapsack sprayer appears to have a promising future. The five year plans are aiming at increasing the production of chemicals and equipment. If these are easily available the farmer will not be required to seek the help of the government for solving his weed problem.

CONSIDERATIONS IN THE APPLICATION OF CHEMICALS

As selectivity is relative, it is often possible to injure the crop or fail to obtain good weed control if the selective herbicide is not used properly. The manufacturers of herbicides have gone to a considerable expense and effort to prepare a precise label indicating the crops the herbicide may safely and legally be used on, what weeds will be controlled, what rate should be used and what special techniques may be required in the application of the chemical. It will always be wise to read and understand thoroughly the instructions on the label and to follow them carefully.

Equipment

The crop, and the weeds, to be controlled largely determine the chemical

EXPLANATION OF PLATE XII

Bullock cart equipped with spraying outfit. (Maharashtra State
Department of Agriculture, Poona, India.)

PLATE XII



to be used, and also the required rate of application. The chemical in its turn governs the type of equipment, while the size of equipment is determined by the area and degree of infestation.

Equipment like sprayers, dusters, granular applicators etc. may be used for application of chemicals. They may range in size from a small knapsack sprayer carried on the back to a tractor mounted sprayer with a boom coverage of several feet.

Many farm operations require the distribution of some definite amount of material such as seed or chemicals over a given area. The uniformity and accuracy of application often has great influence on results. For example some weed control herbicides are so potent that as little as a cupful is sufficient to treat an acre, provided the chemical is uniformly distributed over the area, properly placed on the weeds to be killed and the application is timely. Likewise, for a given set of soil and moisture conditions there is an optimum seeding rate to obtain maximum yields.

Calibration may be defined as checking the rate of distribution of a machine. It makes no difference whether it be a sprayer, planting machine or dry fertilizer or chemical applicator, the problem is the same. In each case we are interested in measuring the quantity of a material which is being distributed over a certain area. The quantity may need to be expressed as gallons per acre, pounds per acre, seeds per acre or whatever is appropriate.

If we are to profit by calibration we must check the rate of application before the field operation is performed. It is usually possible to calibrate a field machine before ever taking the machine to the field and without wasting any of the material which is to be distributed.

The basic principle of calibration remains the same for all machines but different techniques are adopted for ground driven machines like seed drills

granular applicators etc. and sprayers.

Calibration of ground driven machines. In the case of seed drills, granulator applicators, etc. which are ground driven, it may be necessary to determine the number of turns of the ground drive wheel for covering a specific area. The width of swath and circumference of the ground drive wheel must be known or measured. The number of turns necessary for covering one acre can be estimated as follows.

$$\text{Number of turns of ground drive wheel for covering one acre} = \frac{43560}{\text{width of swath in feet} \times \text{circumference of ground drive wheel in feet}}$$

After finding the number of turns of the ground drive wheel for covering one acre, the machine is jacked up and paper bags or cloth bags may be attached to individual discharge tube. The drive wheel is rotated through the required number of turns to give 1/10 acre. The quantity from each tube is noted separately and compared for uniformity. Total of all tubes will give the rate for 1/10 acre. This can be compared with the rate indicated by the setting of the index lever.

If the rate actually obtained differs from the rate indicated by the index lever setting, the setting will have to be altered to give the desired rate. The following formula is used for this purpose.

$$\frac{\text{Present index setting}}{\text{Desired index setting}} = \frac{\text{Present amount discharged}}{\text{Desired amount}}$$

After this re-adjustment, it is desirable to repeat the calibration procedure to check the accuracy of the new setting.

Calibration of a sprayer. This is a little different than the calibration of a ground driven machine. It differs only in the fact that the element of time is involved. We catch the discharge for a given time and then determine the amount of area which would be covered in a like amount of time while traveling at a certain rate. The discharge from each individual nozzle is caught in a separate container which gives a comparative idea of the nozzle performance. From the time of discharge and quantity obtained, the rate of discharge in gallons per minute (G.P.M.) can be estimated.

The rate of application by a sprayer is usually expressed in gallons per acre (G.P.A.). Once the rate of sprayer discharge has been determined, the rate of spray application can be found from the following relationship.

$$\text{G.P.A.} = \frac{\text{G.P.M.}}{\text{Acres Per Minute (A.P.M.)}}$$

or

$$\frac{\text{G.P.M.}}{\text{Boom coverage in feet}} \times \frac{\text{Ground speed in M.P.H.}}{88 \text{ ft./Minute/M.P.H.}}$$

From the calibration data, curves may be drawn to show the relationship of sprayer discharge to pressure, and rate of application to ground speed. The accompanying curves (Fig. 1 and 2)¹ were made for a 19 nozzle boom sprayer with 20 inch nozzle spacing, operating in a range of 20 P.S.I. to 50 P.S.I. pressure and up to 10 M.P.H. ground speed. These curves are good only for the machine they are made for. Each sprayer would need its own individual set of curves.

¹Pages 54, 55.

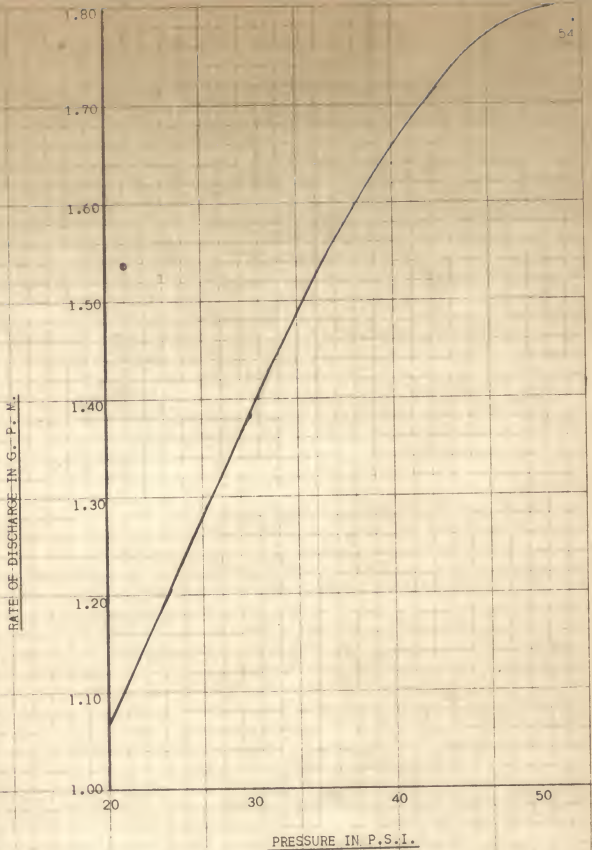


Fig. 1. Relationship of Pressure in Pounds per Square Inch to Rate of Discharge in Gallons per Minute for a Particular Sprayer.

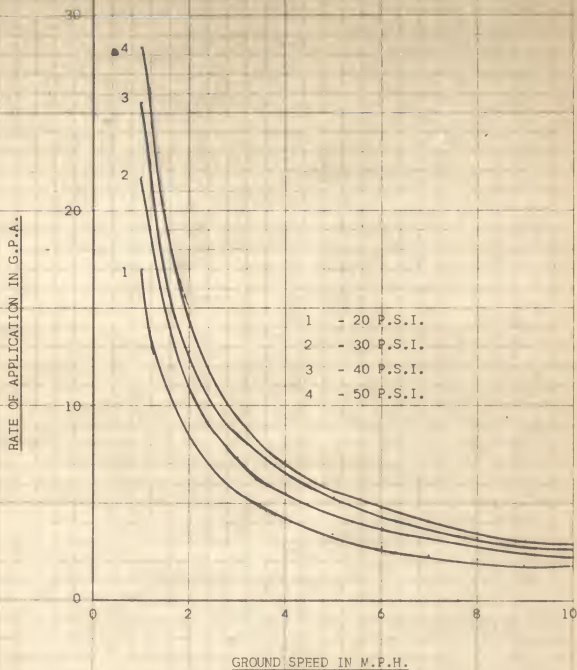


Fig. 2. - Relationship of Ground Speed in Miles per Hour to Rate of Application in Gallons per Acre at Various Spraying Pressures for a Particular Sprayer.

Fairbanks and Reece [1957] have simplified the procedure by developing a nomograph for sprayer calibration (Plate XIII). In order to use this nomograph, it is necessary to first determine the rate of sprayer discharge in G.P.M. as before. Once this is done, the nomograph can be used for any sprayer and set of conditions within the limits of the scales as shown.

Drift Hazard

The drift of herbicides on to sensitive crops, has long been a problem. This hazard can be minimized by using shielded booms and low pressure nozzles.

Application of chemicals under extreme conditions of rainfall, soil, humidity, temperature, wind, etc. may strongly affect the weed control results. Extreme conditions should be avoided if possible.

Necessary permits may be obtained wherever essential or laid down by local laws.

SUMMARY

It has been universally accepted that weeds constitute the second largest menace to agriculture, all over the world, first being soil erosion.

Weeds compete with the crop plants for all essential factors and since the weeds are more hardy and resistant, they bring the crop yields down. In absence of any help from the farmer the weeds will dominate and completely smother the crop.

From the point of view of the world food problem in general, and Indian food problems in particular, it is very important to fight successfully the menace of weeds.

EXPLANATION OF PLATE XIII

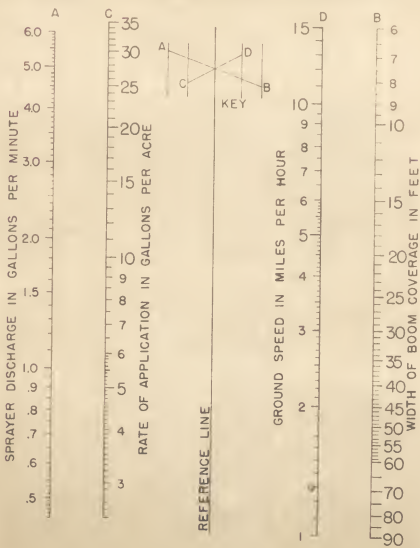
Sprayer calibration alignment chart.

Source: How to Determine Rate of Application of Field Sprays.
Circular 350, August, 1957, page 4. Agri. Expt. Stn. K.S.C.,
Manhattan.

PLATE XIII

KANSAS CIRCUIT No. 350

Sprayer Calibration Alignment Chart



In India vast areas of fertile soil have gone out of cultivation, due to the infestation of Kans and Zizyphus. Many lands are so much covered with Bermuda grass and nut grass that they are barely able to produce any crop. Cockle burr, prickly poppy and other annual weeds are causing harm to crops, livestock and human beings in their own ways.

Considering all the above points, it is extremely necessary to control and if possible, eradicate these noxious weeds.

The present efforts of fighting the weed menace by tillage alone does not seem to produce a lasting effect. Combining tillage practices with chemical control may have to be adopted to some extent.

CONCLUSION

Workers with chemical control have already realized the efficacy of chemicals for fighting the menace of weeds, particularly the perennial ones.

It has also been established beyond doubt that cultivation alone, will not solve the problem of perennial weeds.

Production of chemicals on a large scale and the manufacture of equipment in larger numbers may help to reduce the prices of these and bring them within easy reach of the farmer.

Last but not the least in importance is the education of the farmer in the use of these methods. This can be accomplished by setting up and developing a program for training of the personnel in the use of this equipment and also a corresponding program of extension, for carrying the methods to the common farmer.

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The meagre vocabulary of the author fails to find enough words of appreciation for his wife Vijayanti and sons Ashutosh and Harshavardhan, whose personal sacrifices made this venture possible.

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ERADICATION OF WEEDS BY MECHANICAL
METHODS IN CENTRAL INDIA

by

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AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

in

Farm Mechanics

Department of Agricultural Engineering

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Of all the problems facing free India today, achieving self-sufficiency in food, is of prime importance. The population of India is increasing at a rapid rate and measures like education of people, family planning etc. are being adopted to check the rapid rise. Along with this program, the production of food grains has to be enhanced to feed those who are already in existence. An increase of ten million tons of food grains per year is necessary to accomplish this, and there is no alternative other than adopting modern agricultural practices.

This desired aim can be achieved by various aspects of modern farming like irrigation, soil conservation, better seed, fertilizing practices, reclamation of waste lands, and better cultivation and weed control practices.

In many parts of India, vast stretches of fertile lands have been encroached upon, by perennial weeds and this problem is particularly acute in Central India, which is the food basket of India. In this region alone, 12,000,000 acres of fertile wheat lands have gone out of cultivation due to the infestation of Kans grass, a wild cousin of the sugarcane. Bermuda grass, nut grass etc. are rampant all over the country and the role of annual weeds like cocklebur, in reducing crop yields is of no less importance.

Cultivation is the only method adopted in India for control of weeds. The chemical method, though known to the scientists, is still in infancy. Huge schemes like the Central Tractor Organization have been launched to fight the menace of perennial weeds, by plowing 12 to 14 inches deep with the help of heavy crawler tractors. The annual weeds are being controlled with indigenous animal drawn implements as well as by hand tools; but these methods are very costly, yet essential.

Under the "Five Year Plans," a great emphasis has been laid on the abundant and cheap production of chemicals and agricultural equipment.

Education of the farmer, through a nationwide extension program, has also been undertaken.

Armed with education, cheap and easily available chemicals and equipment, the farmer should be able to tackle his own weed problem and enhance the food production by about 30%.

The chemical method is particularly suitable against perennial weeds like Kans or Zizyphus in small isolated patches which are very common. Modern science has already proved that unnecessary tillage is harmful to the soil fertility and under modern practices emphasis is being laid on minimum tillage.

Achieving efficient weed control with chemicals and minimum tillage, will not only conserve the soil fertility but also check the erosion. This will also increase the food production indirectly.

It can be realized that chemical weed control with mechanical appliances, has a tremendous potential under Indian conditions.